| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 1 | TOPIC | Resultant of perpendicular vectors | Lesson | 1 |
|-------|----|---------|-------------------|------|---|-------|-----------------------------------|--------|---|

| LESSON SUMMARY FOR:  DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|
| **LESSON OBJECTIVES** | At the end of this lesson learners should be able to : <br> • Describe  resultant of perpendicular vector <br> • Draw a sketch of the vectors on the Cartesian plane <br> • Add co-linear vectors along the parallel and perpendicular direction to obtain the net parallel component($R_X$) and the net perpendicular component ($R_Y$) <br> • Sketch $R_X$ and $R_Y$ | | |

| TEACHER ACTIVITIES | LEARNER ACTIVITIES | TIMING | RESOURCES NEEDED |
|---|---|---|---|
| **1.   TEACHING METHODS USED IN THIS LESSON** <br> Question and answer, Explanation <br> **2.   LESSON DEVELOPMENT:** <br> **2.1 Introduction** <br> • Introduce the lesson with the baseline questions <br>   Pre-knowledge <br> • Vectors, Scalar and addition of vectors in straight line <br> **BASELINE ASSESSMENT** <br> • Baseline questions <br> ▪ Define vector? <br> ▪ Define a scalar <br> ▪ Give examples of each of a vector and a scalar <br> **2.2 Main Body (Lesson presentation)** <br> • Lesson starts with the educator asking the learners the baseline questions. <br> • Educator and learners discuss the following answers of the baseline assessment <br> ▪ Vector is a physical quantity with both direction and magnitude( e.g.: force, velocity, displacement etc) <br> ▪ A scalar is a physical quantity with only the magnitude ( e.g.: mass, time, temperature etc) <br> • Educator explain and discuss with learners the following | 1.   Learners answer the baseline questions. <br> 2.   Learners take notes from the board. <br> 3.   Learners write the classwork. <br> **CLASSWORK** <br> Two forces are applied to an object : 3 N to the right and 5 N downwards. Sketch the forces on the Cartesian plane and draw the resultant force using these methods <br>   1.   Tail to head method <br>   2.   Parallelogram method <br> **SOLUTIONS** <br> Note : size of the sketch will depend on the scale chosen. | 10 min <br><br> 25 min <br><br> 15 min | Chalkboard for notes, discussions and classwork <br> Protector <br> Metre ruler <br><br><br> Reference:1. Help U Science. Carlo Cohen <br> 2. Study and Master. Karin H. Kelder CAPS gr.11 <br> 3. Platinum. E. De Vos et al. Grade 11 CAPS |

Representing the resultant of co-linear forces/vectors

- Two persons are lifting a heavy box by pulling it upwards using two ropes. The total vertical pulling force is the combined pulling force of the two men
- A vector is represented by arrows drawn to scale
- There are different ways of indicating direction of a vector
    1. Points of a compass
    2. Bearing: the angle is measured in a clockwise direction from a south to north base line. This vertical base line is taken as $0^0$
    3. The angle made to a given direction or point of reference ( e.g. $50^0$ east of north or $50^0$ E of N)

- Displacement – a straight line drawn from the starting point to the ending point indicating both magnitude and directions
- Resultant-(R) (vector sum) of a number of vectors is that single vectors which will have the same effect as the original vectors acting together
- Example:

    30,E        6N, E
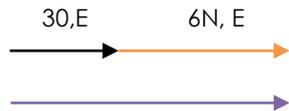
Resultant: 90 , E

- ADDING VECTORS THAT ARE PERPENDICULAR TO EACH OTHER
- Cartesian plane – a flat plane with the x-axis and y-axis as perpendicular reference lines
- Example : two boys, Rulani and Tshepo are pulling their boat to shore. Rulani pulls in an easterly direction and Tshepo pulls in a southerly direction with forces 500N and 600N respectively. Since this is two forces acting from a single point. Three methods can be used to calculate the resultant of the two forces.
    Method 1 :graphical representation- Tail to Head
- 1 choose a suitable scale e.g. 10mm = 10 N
- 2 Accurately draw the first vector as an arrow according to the chosen scale and in the correct direction

1

R= 5.8 N

R = 5.8 N, South of East

2

R =5.8 N
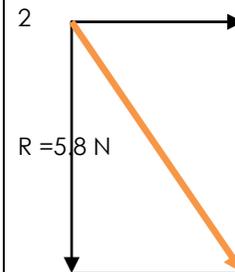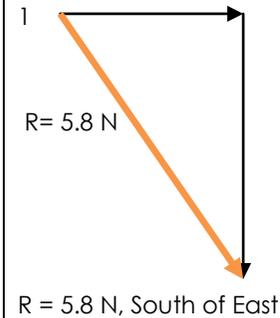
- 3 draw the second accurate vector by placing the tail of the second vector at the tip of the first vector
- 4 complete the diagram by drawing (the resultant) a straight line from the tail of the first vector to the head of the second vector
- 5 measure the length and direction of the resultant vector. Use the scale to determine the actual/ real magnitude of the resultant. Use the protector to measure the angle of the resultant

$R_x = 500N$

$a = 50,2^0$

$R = 781 N$        $R_y = 600 N$
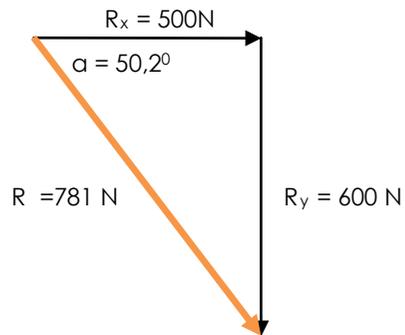
- Method 2 : parallelogram method

  1 choose an accurate scale e.g. 10mm = 10 N

  2 accurrately draw the first vector as an arrow according to the chosen scale and in the correct direction ( east)

  3 draw the second accurate vector by placing the tail of the second vector on the tail of the first vector and in the correct direction( south)

Rx = 500N

Ry =600N    R = 781N
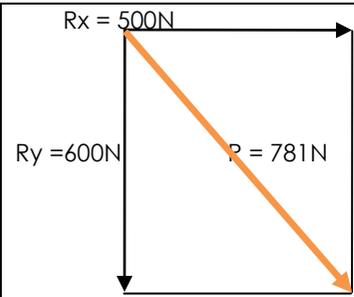
- Form a rectanagle by drawing two lines parallel to Rx and Ry repectively and with the same length
- Lastly draw R being a diagonal line starting from the tails of $R_X$ and $R_Y$

**2.3  Conclusion**

- Ask learners about the main aspects of the lesson
- Give learners classwork

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 1 | TOPIC | Resultant of perpendicular vectors | Lesson | 2 |
|-------|----|---------|-------------------|------|---|-------|-----------------------------------|--------|---|

| LESSON SUMMARY FOR:  DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|
| **LESSON OBJECTIVES** | At the end of this lesson learners should be able to:<br>• Draw graphically the resultant vector using the tail to head method<br>• Determine the magnitude of the resultant using the Theorem of Pythagoras. | | |

| TEACHER ACTIVITIES | LEARNER ACTIVITIES | TIMING | RESOURCES NEEDED |
|---|---|---|---|
| **1.  TEACHING METHODS USED IN THIS LESSON**<br>Question and answer, Explanation<br>**2.  LESSON DEVELOPMENT:**<br>**2.1 Introduction**<br>• Introduce the lesson recap of the previous class work<br>**BASELINE ASSESSMENT**<br>• Baseline questions<br>▪ Check for misconception and address question and knowledge gaps<br>**2.2 Main Body (Lesson presentation)**<br>• Lesson starts with the educator checking on the class work done previously.<br><br> **METHOD 3:  ADDING VECTORS THAT ARE PERPENDICULAR TO EACH OTHER BY CALCULATION**<br>• Inform learners that we can calculate the magnitude of thew resultant of two perpendicular vectors with Pythagoras's Theorem<br>• In, mathematics learners have learnt that the square of the hypotenuse is equal the sum of the squares of the two sides | 1.  Learners answer the baseline questions.<br>2.  Learners take notes from the board.<br>3.  Learners write the classwork.<br>**CLASSWORK**<br>**An object's weight is caused by a downward force of gravity of 10 N. A man lifts the object by applying an upward force of 30 N. At the same time the second man applies a horizontal force of 50 N on the object by pulling it along the ground**<br>1.  Draw a labelled force diagram to indicate how the forces are applied on the object.<br>2.  Draw a labelled free body diagram showing all the forces exerted on the object<br>3.  Calculate the resultant force on the object. | 10 min<br><br>25 min<br><br>15 min | Chalkboard for notes, discussions and classwork<br><br><br>Reference:1. Platinum. E. De Vos et al. Grade 11 CAPS pg 6<br>2.powerpoint presentation – unknown source |

## By calculation – quicker & more accurate

$Sin\ A =$ $\dfrac{Opposite}{Hypotenuse}$

$Cos\ A =$ $\dfrac{Adjacent}{Hypotenuse}$
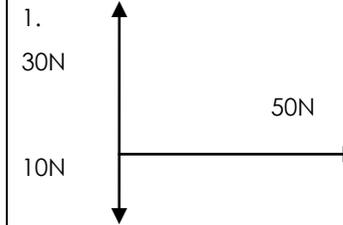
Hypotenuse $F$

Opposite $F_y$

Adjacent $F_x$

A
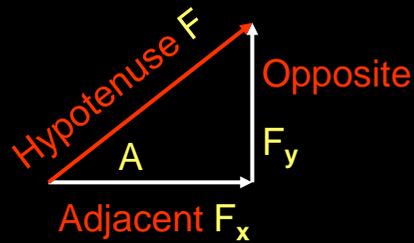
$F_x = F\ Cos\ A$         $F_y = F\ Sin\ A$

Obviously, the above can only be used for right-angled triangles.

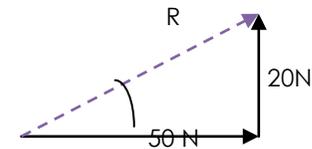The sine rule and the cosine rule are used for triangles that are not right-angled.

- Example : two boys, Rhulani and Tshepo are pulling their boat to shore. Rulani pulls in an easterly direction and Tshepo pulls in a northerly direction with forces 500N and 600N respectively.
- Draw the sketch according to correct directions
- A scale is NOT a priority in this method therefore sketch can be drawn not according to scale
- $F_x$ = will be Rhulani's vector easterly and $F_Y$ will be Tshepo's vector towards North

- The Hypotenuse will be the Resultant vector (F)
- Pythagoras Theorem : $R = \sqrt{F^2_x\ +\ F^2_y}$    $= \sqrt{(500)^2 + (600)^2} = 781.02\ N$

- Then calculate the direction of the vector using the function tan = opp/adja

SOLUTIONS

1.

30N

50N

10N

2   same as above

3.

R

20N

50 N

Magnitude of the resultant=

$R = \sqrt{F^2_x\ +\ F^2_y}$

$= \sqrt{(50)^2 + (20)^2}$

$= 53.85\ N$

**Direction** $_\circ = tan^{-1}\ (20/50) = 21.8\ ^0$.

So, the Resultant Force R = 53.85 N at 21.8 $^0$ to the horizontal

| | | | |
|---|---|---|---|
| 600/ 500 = 1.2 therefore, $\theta = \tan^{-1} (1.2) = 50.2^0$.<br>• The final answer is : Resultant = 781.02 N at 50.2 $^0$ to the horizontal<br><br>**2.3 Conclusion**<br>• Ask learners about the main aspects of the lesson<br>• Give learners class work | | | |

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 1 | TOPIC | Resultant of perpendicular vectors | Lesson | 3 |
|-------|----|---------|----|----|----|----|----|----|----|

| LESSON SUMMARY FOR:  DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|
| **LESSON OBJECTIVES** | At the end of this lesson learners should know: <br>• The resultant of perpendicular vectors continued. <br>The following results will be the outcome of this lesson: <br>• Learners must be able to understand what is a closed vector diagram <br>• Learners must be able to determine the direction of resultant using simple trigonometric rations. | | |

| TEACHER ACTIVITIES | LEARNER ACTIVITIES | TIMING | RESOURCES NEEDED |
|---|---|---|---|
| **1.  TEACHING METHODS USED IN THIS LESSON** <br>Question and answer, Explanation <br>**2.  LESSON DEVELOPMENT:** <br>**2.1 Introduction** <br>• Introduce the lesson recap of the previous class work <br>**BASELINE ASSESSMENT** <br>• Baseline questions <br>▪ Check for misconception and address question and knowledge gaps <br>**2.2 Main Body (Lesson presentation)** <br>• Lesson starts with the educator checking on the class work done previously. | 1.  Learners answer the baseline questions. <br>2.  Learners take notes from the board. <br>3.  Learners write the classwork. <br><br>**CLASSWORK** <br>A brick layer on top of a building runs short of bricks. He lowers a bucket horizontally to the right to bring it close to the truck. The worker holds the bucket stationary so that it makes an angle of $30^0$ to the vertical. Another worker then fills with bricks until the total mass of the bucket and the bricks is 96 Kg. <br>1)  What is the weight of the loaded bucket? <br>2)  Are the forces acting on the bucket in equilibrium? Explain? | 10 min <br><br>25 min <br><br>15 min | Chalkboard for notes, discussions and classwork <br><br>A force board <br>Two pulleys <br>Mass pieces <br>Mass pieces hanger <br>String <br>Mirror <br>A4 paper <br>Prestik <br> Three spring balances <br>Strings <br>Ring |

**DETERMINE the resultant of two non-parallel forces**

## Finding the resultant

On a large sheet of paper, taped to the desk, connect 3 spring balances by means of string to a ring as in diagram below.

Pull the springs in the directions indicated.

$F_1$

$F_2$

$F_3$

Make marks on the paper – showing the position of the ring and the directions of the strings.

## Finding the resultant

Remove 2 balances and connect one balance pulling in the direction indicated with a force $F_4 = F_1$.

The force F4 is thus the resultant of forces $F_3$ and $F_2$.

$F_1$

$F_2$

$F_3$    $F_4$

Readings:

$F_1 = 8$ N

$F_4 = 8$ N

Thus $F_4 =$ Resultant of $F_3$ & $F_2 = 8$ N

- Or alternative use the activity 1 in pg 31 (physical sciences Study and Master)
- When two or more forces act on an object and the resultant is zero, the forces are in

3) Draw a fully labelled force diagram showing all the forces acting on the bucket

4) Draw a labelled vector diagram showing the relationship between the forces

5) Determine the

a) Horizontal force exerted on the bucket by the worker to hold it in place?

b) Tension in cable.

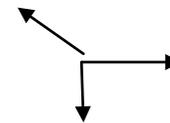Solutions

1    W = mg = 96 x 9.8 = 940.8 N

2    Bucket not moving –resultant = 0N

3



4.



w                    T

F
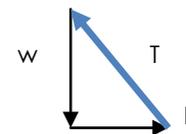
5. A same diagram above

5 B horizontal force = 550 N (to the right)

Tension = 1110N ( up the cable)

equilibrium
- Equilibrant is equal in magnitude, but in opposite direction to the resultant.
- When three forces are acting at a point are in equilibrium, they can be represented in both magnitude and direction by the three sides of the triangle taken in order.
- The equilibrant of two or more forces is that single force which keeps the forces in equilibrium.
- **TRIANGLE LAW**: when three forces are in equilibrium, they can be represented in magnitude and direction by the sides of a triangle taken in order.

### 2.3 Conclusion
- Ask learners about the main aspects of the lesson
- Give learners classwork

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 1 | TOPIC | Resolution of vectors into its parallel and perpendicular components | Lesson | 4 and 5 |
|---|---|---|---|---|---|---|---|---|---|

| LESSON SUMMARY FOR:  DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|

| LESSON OBJECTIVES | At the end of this lesson learners should be able to:<br>• Draw a sketch of a vector showing its magnitude and angle between the vectors and the axis<br>• Use $R_X = R\cos(Q)$ for the resultant x-component<br>• Use $R_Y = R\sin(Q)$ for the resultant y-component |
|---|---|

| TEACHER ACTIVITIES | LEARNER ACTIVITIES | TIMING | RESOURCES NEEDED |
|---|---|---|---|
| **1.  TEACHING METHODS USED IN THIS LESSON**<br>Question and answer, Explanation<br>**2.  LESSON DEVELOPMENT:**<br>**2.1 Introduction**<br>• Introduce the lesson recap of the previous class work<br>**BASELINE ASSESSMENT**<br>• Baseline questions<br>▪ Check for misconception and address question and knowledge gaps<br>**2.2 Main Body (Lesson presentation)**<br>• Lesson starts with the educator doing an activity with learners learners a question:<br><br>METHOD 4:  Resolution of a vector into components<br>Tie two front/back legs of a chair with two individual independent ropes<br>Let learner pull the robes simultaneously using the centre as the point of reference.<br>Start with one learner being perpendicular to the chair and allow the second one to pulls the chair at $10^0$, $20^0$,$30^0$,$45^0$,$90^0$ etc respectively.<br>Let them predict the direction that the chair will take with every angle chosen<br>Activity can continue with the repeat of the above angles wherby both learners are pulling at same angle OR different angle to the reference point.<br>Furthermore a third rope could be used opposite the other two, now using three learners pulling simultaneously at different angles. | 1.  Learners answer the baseline questions.<br>2.  Learners take notes from the board.<br>3.  Get involved in the class activity<br>4.  Learners write the class work.<br><br>**CLASSWORK**<br>1.  1. Determine the resultant force exerted on an object if three forces are exerted as given. F1 = 5.0 N downwards, F2 = 6.0 N at 300 to the horizontal and F3 = 10.0 N at 1350 from the positive x – axis<br>2.  A rowing boat is kept motionless in a fast flowing river by ropes held by two boys, A and B, on opposite banks. | 10 min<br><br><br><br>25 min<br><br><br>15 min | Chalkboard for notes, discussions and class work<br>Robes 3x per group |

**Explanation of the Activity**

Adding more than one vector, we resolve each vector onto its horizontal(x) and vertical(y) components.

We add the horizontal components of all the vectors to get a resultant horizontal component, then continue doing the same with the vertical component

Finally the resultant of the then calculated horizontal and the vertical component

This calculated resultant is the resultant of all the original vectors

Determine the resultant force on an object if the three forces showm below are exerted. The forces are exerted as follows. F1 =3N down, F2 = 4.2N at $45^0$ to the horizontal and F3 = 3,2N at $108^0$ from the positive x-axis
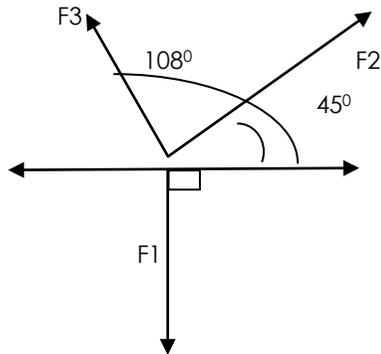


**SOLUTION**

Resolve each vector into its x-components and y-component

$F1x = 0$ N  and  $F1y = -3$N (since is towards the negative y-direction

$F2x = 4.2$N Cos $45^0 = 3$N      and   $F2y = 4.2$N Sin $45^0 = 3$N

$F3x = 3.2$N Cos $108^0 = -1.0$N ( since is towards the negative x-direction   and  $F3y = 3.2$N Sin $108^0 = 3.0$N

The water exerts a Force of 450N parallel to the bank, on the boat. The angles of the ropes connecting A and B to the boat, with respect to the bank, are $55^0$ and $35^0$ respectively.

a) Draw a fully labelled forces diagram indicating acting forces on the boat

b) By calculation determine the magnitude of the forces exerted by the boys on the boat.

**SOLUTIONS**

1.
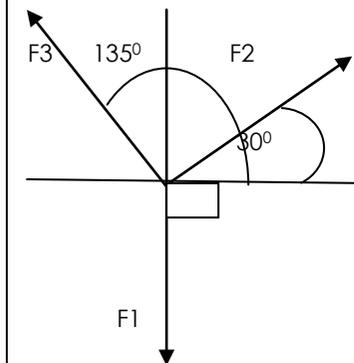


F1  =  5N vertically down

F2  =  3 N vert. Upward and 5.2 N horizontal to the right

Reference:1. Help U Science. Carlo Cohen

2. Study and Master. Karin H. Kelder CAPS gr.11

3. Platinum. E. De Vos et al. Grade 11 CAPS

Determine the resultant x-component and the y-components

Fx = 0 + 3 + (-1,0) = 2N

Fy = (-3) +3 + 3 = 3N

Determine the resultant of Fx AND Fy

Resultant vector
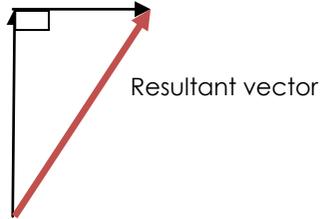
Fr = $\sqrt{2^2 + 3^2}$ = 3.6 N

tan$\theta$ (3/2), therefore $\theta$ = tan-1 (1.5) = 56,3 $^0$

therefore, the resultant of the three forces exerted on the object is 3.6 N at 56.3 $^0$ to the horizontal

### 2.3 Conclusion

- Ask learners about the main aspects of the lesson
- Give learners classwork

F3 = 7.1 N vert. Upwards and 7.1 N horizontal to the left

Resultant of vert. Component added together is 5.1 N vertically upwards

Resultant of horizontal components added together is 1.9 N to the left

Magnitude of final resultant is 5.4 N direction is 20.4$^0$ to the left/ 110,4$^0$ from positive x-axis

Resultant = 5.4 N at 110,4$^0$ from positive x-axis

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 2 | TOPIC | Different kinds of forces: Time 60 mins | Lesson | 1 |
|---|---|---|---|---|---|---|---|---|---|

| LESSON SUMMARY FOR: DATE STARTED: | | | DATE COMPLETED: | |
|---|---|---|---|---|

| LESSON OBJECTIVES | At the end of the lesson learners should be able to:<br>• Differentiate between friction, contact and non- contact forces<br>• Identify Normal and draw a free body diagram of an object resting on a level surface and on an incline<br>• Give examples of both contact and non- contact forces |
|---|---|

## TEACHING and LEARNING ACTIVITIES

**1. TEACHING METHOD/S USED IN THIS LESSON:**
Induction method, Demonstration method, Question and Answer method

**2. LESSON DEVELOPMENT**
**2.1 Introduction**

**a) PRE-KNOWLEDGE** learners need understanding of the following:
(i) Force definition
(ii) Examples of forces acting on an object
**b) BASELINE ASSESSMENT (educator to design a worksheet/ transparency or write questions on the board [preferably a worksheet to save time] to gauge the learners memory of their relevant prior knowledge)**

QUESTIONS for the **BASELINE ASSESSMENT** **[5 min]**

i) Define Force

ii) Give three common forces that you know

iii) Explain the effects of force on an object **at rest** and an object **in motion**

iv) What is the difference between contact and non-contact forces

**Corrections**

i) A force is a push or a pull upon an object that results from its interaction with another object.

ii) Magnetic force, Applied force, gravitational force, frictional force

iii) Object at rest may start to move and object in motion may accelerate if the force is enough to overcome inertia

iv) Contact forces are those types of forces that result when the two interacting objects are perceived to be **physically contacting each other** and Non- contact forces are those types of forces that result even when the two interacting objects are not in physical contact with each other, yet are able to exert a push or pull despite their physical separation

**2.2 Main Body (Lesson presentation) [30 min]**

A force is a push or a pull upon an object that results from its interaction with another object. For simplicity sake, all forces (interactions) between objects can be placed into two broad categories:

- **contact forces**, and
- forces resulting from action-at-a-distance(**non-contact forces**)

**Contact forces** are those types of forces that result when the two interacting objects are perceived to be **physically contacting each other**. Examples of contact forces include **frictional forces, tensional forces, normal forces, air resistance forces, and applied forces.**

A Normal is a contact force  exerted  at right angle to the surface by both objects in contact.
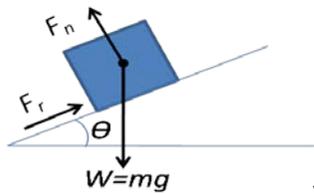
Weight ($W$), the frictional force ($F_f$), and the normal force ($F_N$) impacting a cube. Weight is mass ($m$) multiplied by gravity ($g$).

www.wikipedia.org

**For an object on a slope, Normal is not equal to the weight**  of an object, but can be calculated from

$$N = mg \cos(\theta)$$
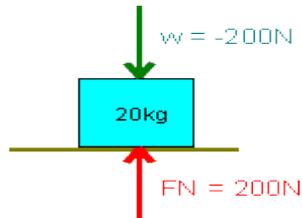
| | |
|---|---|
| | When an object is sitting on a level surface then the normal force is always equal and opposite of the weight of the object. |
| www.wikipedia.org | On an inclined surface notice that...<br><br>• The angle of the incline and the angle of the weight away from the normal is the same size..<br>• The weight continues to act straight down toward the centre of the earth.<br>• The normal force is equal and opposite to the perpendicular force. |

**Action-at-a-distance forces (Non- contact forces)** are those types of forces that result even when the two interacting objects are not in physical contact with each other, yet are able to exert a push or pull despite their physical separation. Examples of action-at-a-distance forces include **gravitational forces and magnetic forces**. For example, the sun and planets exert a gravitational pull on each other despite their large spatial separation.

 Even when your feet leave the earth and you are no longer in physical contact with the earth, there is a gravitational pull between you and the Earth. Electric forces are action-at-a-distance forces. For example, the protons in the nucleus of an atom and the electrons outside the nucleus experience an electrical pull towards each other despite their small spatial separation.

And magnetic forces are action-at-a-distance forces. For example, two magnets can exert a magnetic pull on each other even when separated by a distance of a few centimetres. Examples of contact and action-at-distance forces are listed in the table below.

| Contact Forces | Action-at-a-Distance Forces(non-contactforces) |
|---|---|
| Frictional Force | Gravitational Force |
| Tension Force | Electrical Force |
| Normal Force | Magnetic Force |
| Air Resistance Force | |
| Applied Force | |

### 2.2  Learners Activities  [15 min]

2.2.1  What is the difference between contact and noncontact forces?

2.2.2  Give three examples of contact and three examples of noncontact forces

2.2.3  Describe a normal force and  draw a diagram  showing  the forces acting on the bird resting on its nest

2.2.4  Draw a free body diagram  indicating all the forces experienced  by a car driving  down  the hill that makes an angle θ with the horizontal.

2.2.5   A child is pulling a sled across a stretch of level ice. The ice has a coefficient of kinetic friction, μk = 0.28. The rope makes an angle θ = 23° with the horizontal, the sled has a mass of 16 kg. If the sled is accelerating at a rate of 0.018 m·s⁻², draw a free body diagram of the sled.

### Corrections

2.2.1  **Contact forces** are those types of forces that result when the two interacting objects are perceived to be **physically contacting each other** and **Non- contact forces)** are those types of forces that result even when the two interacting objects are not in physical contact with each other, yet are able to exert a push or pull despite their physical separation.

2.2.2  Examples of contact forces are Frictional Force , Tension Force  and  Normal Force
        Examples of non-contact forces are  Gravitational Force , Electrical Force , and  Magnetic Force



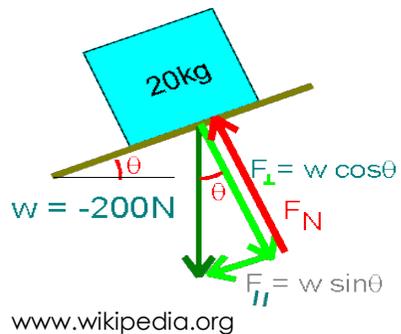2.2.3   A Normal is a contact force  exerted  at right angle to the surface by both objects in contact.

2.2.4
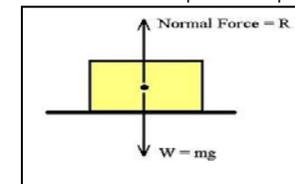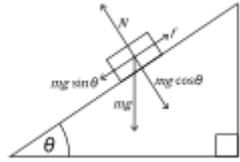
N = Normal force that is perpendicular to the plane, W=mg, where m = mass, g = gravitational acceleration, and θ (theta) = Angle of inclination of the plane

2.2.5

### 2.3 Conclusion

**Activity to Re-enforce lesson** (Educator may summarise the main aspects of the lesson) [**5 min.**]

**HOMEWORK QUESTIONS/ ACTIVITY** (educator must give learners a few questions to answer at home by either writing them on the chalkboard or giving an exercise from the prescribed textbook) [30 min]

**RESOURCES USED:  worksheet**

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 2 | TOPIC | Friction forces - Static and kinetic friction:  Time 60 mins | Lesson | 2 |
|-------|----|---------|-------------------|------|---|-------|-----------------------------------------------------------|--------|---|

| LESSON SUMMARY FOR:  DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|

| **LESSON OBJECTIVES** | At the end of the lesson learners should be able to:<br>• Distinguish between Static and  Kinetic (dynamic)  friction<br>• Explain the difference between static and dynamic friction<br>• Discuss static friction and dynamic friction |
|---|---|

## TEACHING and LEARNING ACTIVITIES

1. **TEACHING METHOD/S USED IN THIS LESSON:**
Induction method, Question and Answer method

2. **LESSON DEVELOPMENT**
**2.1  Introduction**
**a)  PRE-KNOWLEDGE**  learners need understanding of the following:
(i) Mass, weight and Normal force
 ii) Gravitational acceleration
**b)  BASELINE ASSESSMENT (educator to design a worksheet/ transparency or write questions on the board [preferably a worksheet to save time] to gauge the learners memory of their relevant prior knowledge)**
QUESTIONS for  the **BASELINE ASSESSMENT  [5 min]**

(i)  Define friction

(ii)  Determine the weight of a 20 kg box resting on the table top

(iii) What is the difference between weight and mass? Is it scientifically correct for Nursing staff to write weight = 67,5 kg on the patient's card?

**Corrections**

i)  Friction is a force that resists the relative motion of objects that are in contact with each other.Weight also known as force due to gravity   $F_g = mg$        $= 20 \times 9.8$        $=  196\ N$

   i)     Weight (a force due to gravity) is a vector quantity and it is measured in Newton  whereas mass is a scalar quantity measured in measured in kg

**2.2  Main Body   (Lesson presentation)  [30 min]**

**Frictional force** is a force that resists the relative motion of objects that are in contact with each other ( or Friction is a force which opposes relative motion when two solid bodies are in contact). Frictional forces exist between surfaces of two objects being in contact. The direction is always parallel to that surface and opposite to the direction of the intended motion  of an object.  There are two basic types of friction: static and kinetic.

**Static friction ($f_s$)** - The friction that exists between two surfaces, but the object is at rest (not moving)/motionless.  The direction of the force of static friction is along the plane of contact, and is opposite to the direction in which there would be relative motion if there was no friction (for example, if one of the surfaces suddenly turned to ice).

When a force is applied to a mass in contact with a rough surface and the mass does not move. It means an opposition force appears which equals the applied force in size. $f_s$ prevents an object from moving along a surface; keeps a motionless object at rest. The $f_s$ would be equal and opposite to the force applied (up to a certain point). For example, if a person, who could only exert 90N, tried to push a dresser across carpet, which has a maximum static friction of 100N, the dresser would not move at all. The dresser would not move because the $f_s$ between the dresser and carpet can exert a max of 100N of force back. Static friction is actually a relationship between two surfaces that are in contact and at rest. The maximum static frictional force of two objects in contact is equal to the smallest amount of force required to start motion between them. Static friction is defined mathematically as:

( $f_s = \mu_s N$)

**$f_s$ is less than or equal to μ N** Where **$f_s$** is the static frictional force, **μ** is the coefficient of friction of that surface , and **N** is the force required to create motion. The coefficient of friction is a value that is less than 1 and is a function of the surface properties. Rougher surfaces would have a lower coefficient value, whereas smooth or lubricated surfaces would have higher values.

**Kinetic Friction ($f_k$) -** The friction that exists between two surfaces that are moving relative to each other

 Kinetic friction is a relationship between the two surfaces of the objects involved. The kinetic frictional force of the two objects that are in relative motion is mathematically defined as: ( $f_k = \mu_k N$)

Where $f_k$ represents kinetic frictional force, μ represents coefficient of friction, and N (Normal force) is force required to create motion.

 The table below shows some comparison between static and kinetic friction of different materials.  Generally, The static coefficient is higher than the dynamic coefficient. Kinetic friction is a dissipative (non-conservative) force: it dissipates energy (mainly through heat and sound), and energy lost by moving in one direction cannot be recovered by moving in the opposite direction.  The direction of the force of dynamic friction is always opposite to the direction of relative motion.

**Generally static friction > kinetic friction. When static friction is overcomed, the object starts to move and thereafter it has kinetic friction when it is moving.  Below  are some friction constants:**

| Surfaces | Static Friction | Kinetic Friction |
|---|---|---|
| Steel on steel (dry) | 0.6 | 0.4 |
| Steel on steel (greasy) | 0.1 | 0.05 |
| Brake lining on cast iron | 0.4 | 0.3 |
| Rubber tires on dry pavement | 0.9 | 0.8 |
| Metal on ice | - | 0.02 |
| Maximum static friction is given by: $F_s = \mu_s N$ |  | |
| Kinetic frictional force is reasonably constant but smaller than maximum static friction. |  | |
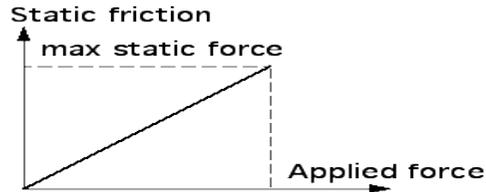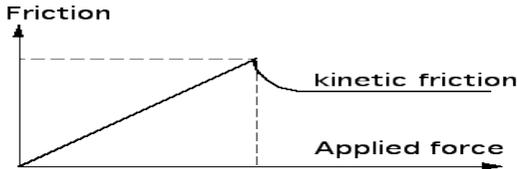
**Importance of friction**

**ABS Brakes**  Anti-lock brake systems (ABS), an excellent safety feature, are rapidly becoming standard on today's automobiles. The ABS system consists of two sub-systems:

1. The hydraulic system, consisting of the master cylinder, calipers, wheel cylinders, pads, shoes and associated connecting valves, lines and hoses, as in a conventional brake system.

2. The ABS controller (computer), its associated sensors (INPUTS), actuators (OUTPUTS), required wiring and connectors.

The computer receives signals from the individual wheel sensors regarding the speed of each wheel. It then compares the speed of each wheel with that of the others. If that comparison indicates wheel lockup is present, appropriate signals are sent to the various valves and actuators to raise or lower hydraulic pressure to the individual wheels to correct the skid. This action is repeated thousands of times per second, producing maximum stopping ability under all conditions. All of this activity goes unnoticed by the driver unless a component fault is detected by the computer and the "BRAKE" or "ABS" warning lights are illuminated on the dashboard.

**Example**

A 12kg piece of wood is placed on top of another piece of wood. There is 35N of static friction measured between them. Determine the coefficient of static friction between the two pieces of wood.  Hint (If the surface is completely horizontal, $F_N$ = Fg.)

**Solution**

$F_N = F_g = mg$

$= (12kg) (9.8m·s^{-2})$

$F_N = 117,6 \ N$

$f_f = \textbf{μ}_s \ F_N$

$\textbf{μ}_s = f_f \ / \ F_N$

$= (35N) \ / \ (117.6N)$

$= 0,30$

**2.2  Learners Activities  [15 min]**

2.2.1   A 3 kg block lies at rest on a rough horizontal table. The table is raised slowly on one side till it makes an angle of 37° with the horizontal. At this angle the block is at the point of moving. Find the coefficient of friction for the block on the plane.

2.2.2    A steel box (mass of 10 kg)  is sitting on a steel workbench. They try to push the box out of the way…

a)   **Sketch** a free body diagram of the box.

b)   If they push against the box with a force of 25 N. **Determine** if anything will happen.
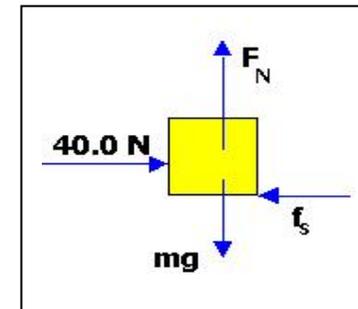
Determine if pushed with a force of 58,8 N, anything will happen.

2.2.3   A force of 40.0 N is needed to move a 5.0-kg box across a horizontal concrete floor.

(a) What is the coefficient of static friction between the box and the floor, just before the box moves?

(b) If the 40.0 N force continues to act on the box, the box accelerates at 0.70 m·s$^{-2}$. What is the coefficient of kinetic friction?

**Corrections**

2.2.1   $\mu_s = \tan 37°$

$= 0.75$

2.2.2   A free body diagram is a drawing that shows **all** of the forces acting on an object. You draw these forces as vector arrows, and label each one.
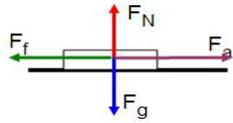


b) $F_N = F_g = mg$

$= (10 \text{ kg}) (9.8 \text{ m·s}^{-2})$

$F_N = 98 \text{ N}$

$F_f = \mu_s F_N$

$= 0.6 (98 \text{ N})$

$F_f = 58,8 \text{ N}$

This exactly equals the **maximum** static frictional force between these two surfaces.

So, does this mean that when it's pushed with $F_a = 25$ N, the friction will push back with 58,8 N?

- No. That wouldn't make sense, since that would mean that if the box is gently pushed, it would actually start to accelerate back towards the force pushing it!

- The force due to static friction can go up to a maximum of 58,8 N, but can also be less.

- It will be equal to whatever the $F_a$ is, up to the maximum calculated here.

$F_a$   = 25 N (they just point in opposite directions!)

$F_{NET} = $ Zero

With no net force acting on it, the box will not start to move.

$F_f = F_a$ = 58,8 N (but in opposite directions!)

$F_{NET}$ = Zero, therefore nothing will happen to the still box

2.2.3  a) The system is in equilibrium, therefore:

$\Box F_x = 0 \ \Box F_y = 0$

40.0 N = $f_s$  $F_N$ = mg = 49.0 N

$f_s = \Box F_N$

$\Box = f_s/F_N = (40.0 N)/(49.0 N) =$ **0.816**

b)  The system is in not in equilibrium in the x-direction, therefore:

$\Box F_x = ma \ \Box F_y = 0$

40.0 N - $f_k$ = ma  $F_N$ = mg = 49.0 N

$f_k = \Box F_N$

$\Box = f_k/F_N = (40.0 N - 3.50 N)/(49.0 N) =$ **0.745**

## 2.3  Conclusion

**Activity to Re-enforce lesson** (Educator may summarise the main aspects of the lesson) [**5 min.**]

**HOMEWORK QUESTIONS/ ACTIVITY** (educator must give learners a few questions to answer at home by either writing them on the chalkboard or giving an exercise from the prescribed textbook) [30 min]

**RESOURCES USED:**

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 2 | TOPIC | Normal and Static friction: Time 60 min | Lesson | 3 |
|-------|----|---------|-------------------|------|---|-------|------------------------------------------|--------|---|

| LESSON SUMMARY FOR:  DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|
| **LESSON OBJECTIVES** | At the end of the lesson learners should be able to:<br>• Investigate the relationship between the normal force and the maximum static friction<br>• Apply equation to solve problems | | |

## TEACHING and LEARNING ACTIVITIES

1.  **TEACHING METHOD/S USED IN THIS LESSON:**
Question and Answer

2.  **LESSON DEVELOPMENT**
2.1  **Introduction**

**a)PRE-KNOWLEDGE** learners need understanding of the following:
(i)   Normal  force on the horizontal and on the slope
(ii)  Frictional  forces
**b)BASELINE ASSESSMENT**(educator to design a worksheet/ transparency or write questions on the board [preferably a worksheet to save time] to gauge the learners memory of their

relevant prior knowledge)

QUESTIONS for  the **BASELINE ASSESSMENT** **[5 min]**

i)      Define static friction

ii)A 5 kg wooden block is resting on the surface of the horizontal table.  Find the magnitude and direction Normal  force on the block

 iii) Write an equation used to calculate coefficient of static friction

**Solutions**

i) Is the maximum force  needed  to change the object's state of  rest

ii) Normal  force for an object  lying on the horizontal  surface is equal to weight of an object but opposite in direction.

   weight (w)  =  mg

             =  5  x  9,8

             = 49 N  downwards

∴  Normal force (N)  =  49 N  upwards

## 2.2  Main Body (Lesson presentation)  [30 min]

**Theory revision**

The force needed to start motion is numerically equal to the maximum static friction. [$F_{s(max)}$]) (include the  laws governing friction such as static friction is greater than kinetic friction etc.)

The normal force is equal to the weight of the object.

The coefficient of the static friction ($\square_s$) can be solved using this equation:

$$\square_s = \frac{Maximum\ static\ friction}{Normal\ Force}$$

**Aim**                   :To  investigate the relationship between a Normal  force and  the maximum static friction

**Apparatus**            :wooden block, wooden board, spring balance, 100 g  mass  pieces

**Method/Procedure :**



**Fig. 1: Experimental set-up for determining force and friction**

- Place a block of wood on a wooden board  and attach the spring balance on the side with a hook as in the diagram above
- The maximum static  friction was determined by slowly pulling the spring scale until the stationary block of wood moved.
- Record  the maximum static friction
- The group repeated the procedure three (3) times and recorded their readings (in Newtons) on a table.

**Results**

This table shows the reading of the maximum static friction and kinetic friction (in Newtons)

| Trial no. | $F_{smax}$ |
|-----------|------------|
| 1         |            |
| 2         |            |
| 3         |            |
| 4         |            |

- For the second experiment, the block of wood was weighed using the spring scale. (in grams)
- The group then added 100g on the block of wood and didthe same procedure in the first experiment.
- The group do 4 trials for this experiment. After recording the readings, the group then solved for the coefficient of static friction

$$\square = \frac{Maximum\ static\ friction}{Normal\ Force}$$

This table shows the reading of the maximum static friction and kinetic friction (in Newtons)

| Trial no. | $F_{smax}$ |
|-----------|------------|
| 1         | 0.80N      |
| 2         | 1.00N      |
| 3         | 0.90N      |

| Normal force | $F_{smax}$ | $\square$ |
|--------------|------------|-----------|
| 2.80N        | 1.40N      |           |
| 3.00N        | 1.20N      |           |
| 3.00N        | 1.40N      |           |
| 2.80N        | 1.20N      |           |

The table shows the reading of the Normal force, kinetic friction (in Newtons). The table also shows the coefficient of static friction  which was solved using the formula. (Note that the coefficient doesn't have units since dividing the friction from the normal force will cancel out the unit Newtons.) Weight of block: 1.8 Newtons

**Activity 2**

For the this experiment, a block of wood, a wooden board, tiles (on the table), a plastic cover, paper, and the sand-paper side of the block of wood were used. The same

procedure was also done but varied on the surface which the block of wood was placed. The following surfaces were: wood to wood, wood to tile, wood to sand paper, wood to

plastic cover and wood to paper. The group recorded their readings on a table

The table shows the readings of the static friction and kinetic friction on wood, tile, sand paper, plastic cover and paper. The group saw that when the surface is smooth, the static

and kinetic frictions are lower and higher when the surface is rough.

| Surface in Contact | F$_{smax}$ |
|---|---|
| Wood and wood | 0.80N |
| Wood and tile | 0.70N |
| Wood and sand paper | 1.20N |
| Wood and plastic cover | 0.50N |
| Wood and paper | 0.50N |

**Analysis of results**      :interpret  graph

**Sources of  errors**      :What can be done differently to improve the results

**Conclusion**               :How are the results of the experiment related to the aim of experiment

**2.2  Learners Activities  [15 min]**

[  Educators need to add more questions such as one word and multiple choice questions which could not be included because of space ]

A 50 kg box is at rest on a horizontal surface. When an 80 N force is applied to the box, it slides on the surface with a constant velocity.

50  kg

2.2.1 .1  Define static friction

2.2.1.2  Draw a labelled free body diagram for the box when it is ... moving at constant velocity.

2..2.3Calculate the coefficient of friction.

2.2.4How will the force of friction change if:

2.2.4.1    an identical box is placed on top of the 50 kg box

2.2.4..2the same force is applied on another 50 kg box with a larger surface area?

Write only INCREASES, DECREASES or STAYS THE SAME.

| Answers |
|---|

2.2.1 static friction is the maximum force that is needed to change the object's state of rest

2.2.2



2.2.3     $Ff = \mu kN$
          $80\ N = \mu k 500\ N$
          $\mu_k = 0{,}16$

2.2.4.1 Increases

2.2.4.2 Stays the same

## 2.3 Conclusion

**Activity to reinforce lesson** (Educator may summarise the main aspects of the lesson) [**5 min.**]

**HOMEWORK QUESTIONS/ ACTIVITY** (educator must give learners a few questions to answer at home by either writing them on the chalkboard or giving an exercise from the prescribed textbook) [30 min]

**RESOURCES USED:** see apparatus above

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

   

**Aim**                    :  To investigate the relationship between a Normal force and the maximum static friction

**Apparatus**              :  wooden block, wooden board, spring

| Surface in Contact | $F_{smax}$ |
|---|---|
| Wood and wood | 0.80N |
| Wood and tile | 0.70N |
| Wood and sand paper | 1.20N |
| Wood and plastic cover | 0.50N |
| Wood and paper | 0.50N |

**Method/Procedure :**

Spring scale

BLOCK OF WOOD

**wooden surface**

**Fig. 1: Experimental set-up for determining force and friction**

- Place a block of wood on a wooden board and attach the spring balance on the side with a hook as in the diagram above
- The maximum static friction was determined by slowly pulling the spring scale until the stationary block of wood moved.
- Record the maximum static friction
- The group repeated the procedure three (3) times and recorded their readings (in Newtons) on a table.

**Results**

This table shows the reading of the maximum static friction (in Newtons)

| Trial no. | $F_{smax}$ |
|---|---|
| 1 | 0,80 N |
| 2 | 1,00 N |
| 3 | 0,90 N |
| | |

- For the second experiment, the block of wood was weighed using the spring scale. (in grams)
- The group then added 100g on the block of wood and did the same procedure in the first experiment.
- The group do 4 trials for this experiment. After recording the readings, the group then solved for the coefficient of static friction

$$\mu_s = \frac{Maimum\ static\ friction}{Normal\ Force}$$

This table shows the reading of the maximum static friction

| Normal force | $F_{smax}$ | $\mu_s$ |
|---|---|---|
| 2.80N | 1.40N | 0.5 |
| 3.00N | 1.20N | 0.4 |
| 3.00N | 1.40N | 0.47 |
| 2.80N | 1.20N | 0.43 |

**Analysis of results    :**



**www.nd.edu**                                                                                                              static friction will increase as the applied force

increases  until  a maximum static  friction wherein the object will start to move.  As soon as the object  starts to move,  static  friction stops existing and  kinetic

friction exists. Kinetic friction is constant  , has only one value which is lower than maximum static friction

**Sources of  errors      :**accuracy in using spring balance, faulty spring balance, uneven surfaces

**Conclusion**            $:\mu_s = \dfrac{Maimum\ static\ friction}{Normal\ Force}$

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 2 | TOPIC | Normal and kinetic friction: Time 60mins | Lesson | 4 |
|---|---|---|---|---|---|---|---|---|---|

| LESSON SUMMARY FOR: DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|
| **LESSON OBJECTIVES** | At the end of the lesson learners should be able to:<br>• State the relationship between Normal force and the kinetic friction<br>• Describe the behaviour of kinetic friction once the object starts moving | | |

## TEACHING and LEARNING ACTIVITIES

1. **TEACHING METHOD/S USED IN THIS LESSON:**
   Question and Answer

2. **LESSON DEVELOPMENT**
2.1 **Introduction**

a)**PRE-KNOWLEDGE**learners need understanding of the following:
(i) Normal force on the horizontal and on the slope
(ii) Frictional forces

b)**BASELINE ASSESSMENT**(educator to design a worksheet/ transparency or write questions on the board [preferably a worksheet to save time] to gauge the learners memory of their

relevant prior knowledge)

QUESTIONS for the **BASELINE ASSESSMENT** [5 min]

i)        Define the kinetic friction

ii)       Compare kinetic friction with maximum static friction. Substantiate your answer with a rough sketch

iii)      State the relationship between a Normal force and the kinetic friction

solutions

2.2 **Main Body (Lesson presentation) [30 min]**

When maximum static friction is exceeded the surfaces start to slide past each other and kinetic friction takes over. Kinetic frictional force is reasonably constant but smaller than maximum static friction.

The normal force is equal to the weight of the object where weight is equal to the product of mass and gravitational acceleration.. w = mg

The force needed to move an object with constant velocity is numerically equal to the kinetic friction. ($F_k$)

The coefficient of the kinetic friction ($\square_k$)can be solved using this equation:

$$\square_k = \frac{Kinetic\ friction}{Normal\ Force}$$

**Aim** : To investigate the relationship between the Normal friction and the kinetic friction

**Apparatus** : wooden block, wooden board, spring balance, 100 g mass pieces

**Method/Procedure :**



Spring scale

BLOCK OF WOOD

wooden surface

**Fig. 1: Experimental set-up for determining force and friction**

- Place a block of wood on a wooden board and attach the spring balance on the side with a hook as in the diagram above
- The maximum kinetic (dynamic) friction is determined by pulling the spring balance until the block moves with constant velocity

- The kinetic friction is determined by pulling the spring balance allowing the block to move with a constant velocity.
- Record the kinetic friction

- The group repeated the procedure three (3) times and recorded their readings (in Newtons) on a table.

| Trial no. | $F_k$ |
|-----------|-------|
| 1 | |
| 2 | |
| 3 | |

- For the second experiment, the block of wood was weighed using the spring scale. (in grams)

- The group then added 100g on the block of wood and did the same procedure in the first experiment.

- The group did 4 trials for this experiment.

| Normal force | $F_k$ | ▱ |
|--------------|-------|---|
| 2.80N | 1.40N | |
| 3.00N | 1.20N | |
| 3.00N | 1.40N | |
| 2.80N | 1.20N | |

- After recording the readings, the group then solved for the coefficient of static friction

$\square_k = \dfrac{Kinetic\ friction}{Normal\ Force}$

**Results:**

This table shows the reading of the maximum static friction and kinetic friction (in Newtons)

| Trial no. | $F_k$ |
|---|---|
| 1 | 0.60N |
| 2 | 0.60N |
| 3 | 0.50N |

The table shows the reading of the Normal force  and kinetic friction (in Newtons). The table also shows the coefficient of  coefficient of kinetic friction which was solved using the formula. (Note that the coefficient doesn't have units since dividing the friction from the normal force will cancel out the unit Newtons.) Weight of block: 1.8 Newtons

| Normal force | $F_k$ | $\square_k$ |
|---|---|---|
| 2.80N | 0.80N | 0.29 |
| 3.00N | 0.80N | 0.27 |
| 3.00N | 0.70N | 0.23 |
| 2.80N | 0.70N | 0.25 |

**Activity 2**

For the this experiment, a block of wood, a wooden board, tiles (on the table), a plastic cover, paper, and the sand-paper side of the block of wood were used. The same

procedure was also done but varied on the surface which the block of wood was placed. The following surfaces were: wood to wood, wood to tile, wood to sand paper, wood to

plastic cover and wood to paper. The group recorded their readings on a table

The table shows the readings of the static friction and kinetic friction on wood, tile, sand paper, plastic cover and paper. The group saw that when the surface is smooth, the static and kinetic frictions are lower and higher when the surface is rough.

| Surface in Contact | $F_k$ |
|---|---|
| Wood and wood | 0.60N |
| Wood and tile | 0.60N |
| Wood and sand paper | 0.90N |
| Wood and plastic cover | 0.50N |
| Wood and paper | 0.50N |

**Analysis of results**      :When maximum static friction is exceeded the surfaces start to slide past each other and kinetic friction takes over. Kinetic frictional force is reasonably constant but smaller than maximum static friction

## Friction



**Sources of  errors**      : what can be done to improve accuracy and results of this experiment?

**Conclusion**               :  Relate the results with the  theory and the aim of this experiment

### 2.3  Conclusion

**Activity to reinforce lesson**(Educator may summarise the main aspects of the lesson) [**5 min.**]

**HOMEWORK QUESTIONS/ ACTIVITY** (educator must give learners a few questions to answer at home by either writing them on the chalkboard or giving an exercise from the prescribed textbook) [30 min]

**RESOURCES USED:**

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

**Memo**

**Aim** : To investigate the relationship between the Normal friction and the kinetic friction

**Apparatus** : wooden block, wooden board, spring balance, 100 g mass pieces

**Method/Procedure :**



Spring scale

BLOCK OF WOOD

**wooden surface**

**Fig. 1: Experimental set-up for determining force and friction**

- Place a block of wood on a wooden board and attach the spring balance on the side with a hook as in the diagram above
- The maximum kinetic (dynamic) friction is determined by pulling the spring balance until the block moves with constant velocity

- The kinetic friction is determined by pulling the spring balance allowing the block to move with a constant velocity.
- Record the kinetic friction

- The group repeated the procedure three (3) times and recorded their readings (in Newtons) on a table.

- For the second experiment, the block of wood was weighed using the spring scale. (in grams)

- The group then added 100g on the block of wood and did the same procedure in the first experiment.

- The group did 4 trials for this experiment.

- After recording the readings, the group then solved for the coefficient of static friction

$$\mu_k = \frac{Kinetic\ friction}{Normal\ Force}$$

**Results:**

This table shows the reading of the maximum static friction and kinetic friction (in Newtons)

| Trial no. | $F_k$ |
|:---:|:---:|
| 1 | 0.60N |
| 2 | 0.60N |
| 3 | 0.50N |

The table shows the reading of the Normal force and kinetic friction (in Newtons). The table also shows the coefficient of coefficient of kinetic friction which was solved using the formula. (Note that the coefficient doesn't have units since dividing the friction from the normal force will cancel out the unit Newtons.) Weight of block: 1.8 Newtons

| Normal force | $F_k$ | $\mu_k$ |
|:---:|:---:|:---:|
| 2.80N | 0.80N | 0.29 |
| 3.00N | 0.80N | 0.27 |
| 3.00N | 0.70N | 0.23 |
| 2.80N | 0.70N | 0.25 |

**Activity 2**

For the this experiment, a block of wood, a wooden board, tiles (on the table), a plastic cover, paper, and the sand-paper side of the block of wood were used.

The same procedure was also done but varied on the surface which the block of wood was placed. The following surfaces were: wood to wood, wood to tile,

wood to sand paper, wood to plastic cover and wood to paper. The group recorded their readings on a table

The table shows the readings of the static friction and kinetic friction on wood, tile, sand paper, plastic cover and paper. The group saw that when the surface is smooth, the static and kinetic frictions are lower and higher when the surface is rough.

| Surface in Contact | $F_k$ |
|:---|:---:|
| Wood and wood | 0.60N |
| Wood and tile | 0.60N |
| Wood and sand paper | 0.90N |
| Wood and plastic cover | 0.50N |
| Wood and paper | 0.50N |

**Analysis of results** **:** When maximum static friction is exceeded the surfaces start to slide past each other and kinetic friction takes over. Kinetic frictional force is reasonably constant but smaller than maximum static friction

Friction

kinetic friction

Applied force

**Sources of errors** **:** accuracy in using spring balance, faulty spring balance, uneven surfaces

**Conclusion** **:** $\mu_k = \dfrac{Kinetic\ friction}{Normal\ Force}$

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 3 | TOPIC | Vector, force and free body diagrams: Time 60 mins | Lesson | 1 and 2 |
|-------|-----|---------|-------------------|------|---|-------|---------------------------------------------------|--------|---------|

| LESSON SUMMARY FOR: DATE STARTED: | | DATE COMPLETED: | |
|-----------------------------------|---|-----------------|---|

| LESSON OBJECTIVES | At the end of the lesson learners should be able to:<br>• Draw vector, force and free body diagrams for objects at rest, moving with constant velocity and accelerating object<br>• Discuss  vector, force and free body diagrams for objects at rest, moving with constant velocity and accelerating |
|-------------------|---|

## TEACHING and LEARNING ACTIVITIES

1.   **TEACHING METHOD/S USED IN THIS LESSON:**
 Induction method, Question and Answer method

2.   **LESSON DEVELOPMENT**
**2.1  Introduction**
**a)   PRE-KNOWLEDGE**  learners need understanding of the following:
(i)  Motion and object's state of rest
(ii)  Forces acting on the object at rest, moving at constant velocity and accelerating object
**b)  BASELINE ASSESSMENT (educator to design a worksheet/ transparency or write questions on the board [preferably a worksheet to save time] to gauge the learners memory of**

**their relevant prior knowledge)**

QUESTIONS for  the **BASELINE ASSESSMENT**  [5 min]

 i)  Define a force

 ii)  Mention two forces acting on the book resting on the table

iii)  Why does an object remain at rest?

iv)  In which standard unit is the force measured? And which derived unit is it equivalent to the SI unit of force?

**Corrections**

i) Force is that vector quantity which tends to change the object's state of rest or state of motion.(Usually defined as a push or a pull)

ii)  Gravitational force  and  Normal force (force of the table on the book)

iii)  Forces acting on an object are in equilibrium  if the object was not moving   or even inertia

iv)  Newton(N)  and it is equivalent to kg·m·s$^{-2}$


**2.2  Main Body   (Lesson presentation)  [30 min]**

**A free body diagram** consists primarily of a sketch of the body in question and arrows representing the forces applied to it. It is not  necessarily drawn to scale but magnitude and

direction are important. All arrows point away from the dot. The following tips need to be considered when drawing a free body diagram.


1 Draw a **dot** or a **box** to represent the object.

2 Draw a surface of contact if there is one.
3 Draw arrows LEAVING the dot, roughly with a length proportional to the size of the force acting on the dot.
4 Start with force weight, then force normal(if there is a surface of contact)
5 Next include friction, or force applied or  tension force
6 Find  Net Force in x and y direction. Usually one of these is zero.

$$F_g = m\mathbf{g}$$
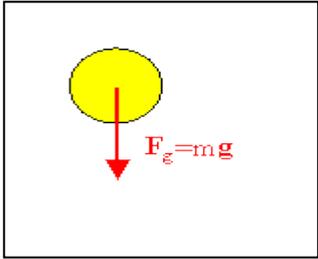
Example

Ffree-body diagram for a freely falling ball:

Neglecting air friction, the only force acting on the ball is gravity.

NB  If the object is not resting on a surface, normal force is omitted like in the example above, since resultant force is required for this ball to freely fall.  Normal applies to an object that is not moving.

$$\mathbf{n}$$
$$F_g = m\mathbf{g}$$
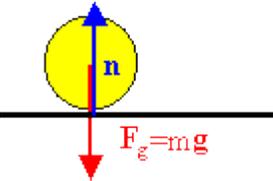
A free-body diagram for a ball resting on the ground:

Gravity is acting downward. The ball is at rest. The ground must exert a force equal in magnitude and opposite in direction to the gravitational force on the ball . This force is called the normal force, N, since it is normal to the surface. The resultant force in this case is zero

A free-body diagram for a mass on an inclined plane:
Gravity acts downward. The component of $\mathbf{F}_g$ perpendicular to the surface is cancelled out by the normal force the surface exerts on the mass. The mass does not accelerate in the direction perpendicular to the surface. The component of $\mathbf{F}_g$ parallel to the surface causes the mass to accelerate in that direction.
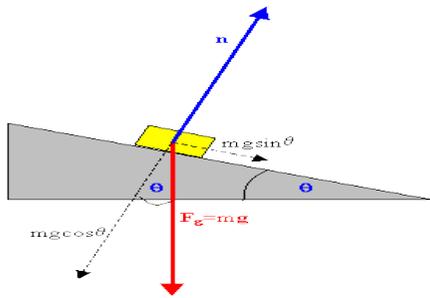
**Example**

A woman at an airport is towing her 20 kg suitcase at constant speed by pulling on a strap at an angle of θ above the horizontal. She pulls on the strap with a 35 N force, and the frictional force on the suitcase is 20 N.

(a) Draw a free body diagram of the suitcase.
(b) What angle does the strap make with the horizontal?
(c) What normal force does the ground exert on the suitcase?



(a) See the diagram

(b) The suitcase moves with constant velocity, the net force on the suitcase is zero.

Fx = 0 implies (35 N)cosθ = 20 N, or cosθ = 20/35, θ = cos-1(20/35) = 55.15o.

(c) Fy = 0 implies mg = n + (35 N)sinθ, (20 kg)(9.8 m/s2) = n + (35 N)0.82, n = 167.3 N.

A force diagram is simply a diagram showing all the forces acting on an object, the force's direction and its magnitude. It is a simplification of the picture that shows just the forces.
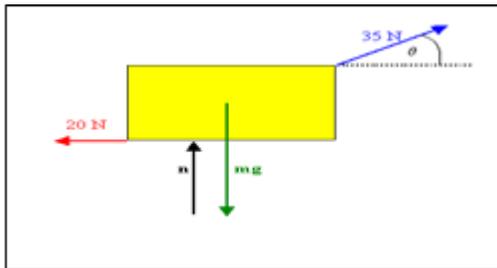
In the example below, the first image is a picture of a climber on the side of a cliff. The second image shows just the object of interest (the climber) and has vectors drawn

representing the different forces on the climber, which are labelled with everyday language. The third image is a force diagram; the object of interest is simply represented by a

dot, and the vectors are labelled by the type of force, the object exerting the force, and the object receiving that force.

Forces may even be drawn          with the arrows pointing into the object.

$F_A$  $F_G$
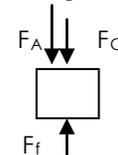
For an object pushed downwards,   it also experiences gravitational force and air resistance.          $F_f$
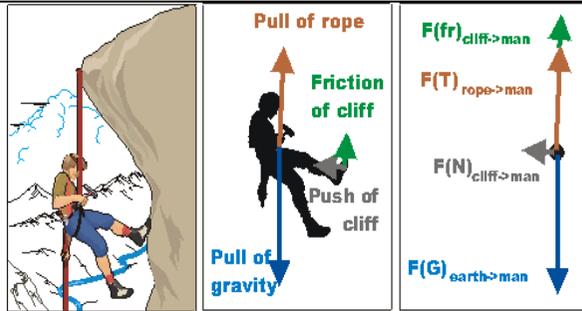
**Vector diagrams** are diagrams that depict the direction and relative magnitude of a vector quantity by a vector arrow. In a vector diagram, the magnitude of a vector quantity is represented by the size of the vector arrow. If the size of the arrow in each consecutive frame of the vector diagram is the same, then the magnitude of that vector is constant.
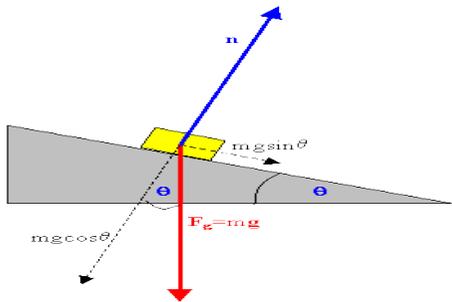


A free-body diagram for a mass on an inclined plane: Gravity acts downward. The component of $F_g$ perpendicular to the surface is cancelled out by the normal force the surface exerts on the mass. The mass does not accelerate in the direction perpendicular to the surface. The component of $F_g$ parallel to the surface causes the mass to accelerate in that direction.

www.utk.edu.org

**2.2  Learners Activities  [15 min]**

2.2.1   )  www.wikipedia.org
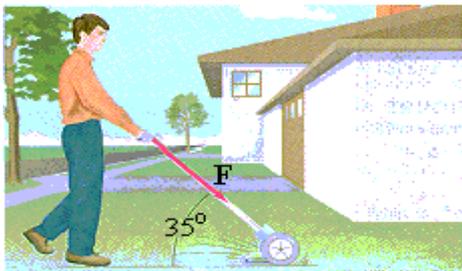


A person pushes a 20-kg lawn mower at constant speed with a force of 100N directed along the handle, which is at an angle of 35.0° to the horizontal along the handle (see figure). (a) Draw the free-body diagram showing all forces acting on the mower, Calculate (b) the horizontal retarding force on the mower, then (c) the normal force exerted vertically upward on the mower by the ground.

2.2.2  A flying squirrel is gliding (no wing flaps) from a tree to the ground at constant velocity. Consider air resistance and draw a free-body diagram for this situation.

2.2.3  A box weighing 70 N rests on a table. A rope attached to that box runs up over a pulley and a second box is attached to the other end. Draw a free body diagram for the box  labelling  the forces on it .

**Corrections**



a)
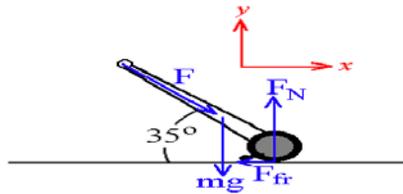
(b)  x – motion :

$$F_x = F \cos 35° - F_{fr}$$
$$= 100 \cos 35° - F_{fr}$$
$$= 81.92 - F_{fr}$$

Constant veloc ity $\Rightarrow a_x = 0 \, m/s^2$
$F_x = ma_x \Rightarrow F_x = 0$
$\Rightarrow 81.92 - F_{fr} = 0$
$\Rightarrow F_{fr} = 81.92 \, N$

Direc tion of $F_{fr}$: horizonta l, opposite to the pus hing direc tion.
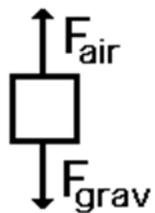


2.2.2

2.2.3  See on the right

(c) y - motion:

$$F_y = F_N - F \sin 35° - mg$$
$$= F_N - 100 \sin 35° - 20 \times 9.8$$
$$= F_N - 253.4$$

Mower not movin g up and d own $\Rightarrow a_y = 0 \, m/s^2$
$\therefore F_N - 253.4 = 0 \Rightarrow F_N = \underline{253.4 \, N}$ (upward)
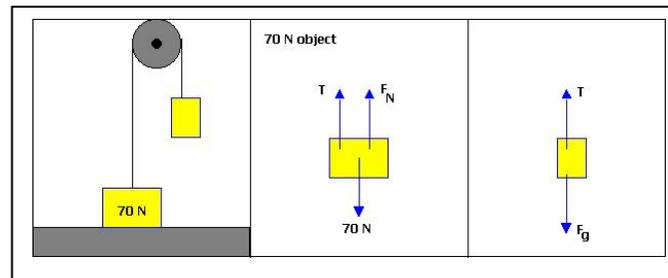
## 2.3 Conclusion

**Activity to Re-enforce lesson** (Educator may summarise the main aspects of the lesson) [**5 min.**]

**HOMEWORK QUESTIONS/ ACTIVITY** (educator must give learners a few questions to answer at home by either writing them on the chalkboard or giving an exercise from the prescribed textbook) [30 min]

**RESOURCES USED: worksheets**

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 2 | TOPIC | Normal and Static friction: Time 60mins | Lesson | 3 |
|-------|----|---------|-------------------|------|---|-------|------------------------------------------|--------|---|

| LESSON SUMMARY FOR: DATE STARTED: | | | DATE COMPLETED: | |
|-----------------------------------|--|--|-----------------|--|

| LESSON OBJECTIVES | At the end of the lesson learners should be able to:<br>• Investigate the relationship between the normal force and the maximum static friction<br>• Apply equation to solve problems |
|-------------------|--------------------------------------------------------------------------------------------------|

## TEACHING and LEARNING ACTIVITIES

**1. TEACHING METHOD/S USED IN THIS LESSON:**
Question and Answer

**2. LESSON DEVELOPMENT**
**2.1 Introduction**

**a) PRE-KNOWLEDGE** learners need understanding of the following:
(i) Normal force on the horizontal and on the slope
ii) Frictional forces
**b) BASELINE ASSESSMENT (educator to design a worksheet/ transparency or write questions on the board [preferably a worksheet to save time] to gauge the learners memory of

their relevant prior knowledge)**

QUESTIONS for the **BASELINE ASSESSMENT** **[5 min]**

i) Define static friction

ii) A 5 kg wooden block is resting on the surface of the horizontal table. Find the magnitude and direction Normal force on the block

iii) Write an equation used to calculate coefficient of static friction

**Solutions**

i) Is the maximum force needed to change the object's state of rest

ii) Normal force for an object lying on the horizontal surface is equal to weight of an object but opposite in direction.

$$\text{weight (w)} = \text{mg}$$
$$= 5 \times 9{,}8$$
$$= 49 \text{ N downwards}$$
$$\therefore \text{Normal force (N)} = 49 \text{ N upwards}$$

### 2.2   Main Body   (Lesson presentation)   [30 min]

**Theory revision**

The force needed to start motion is numerically equal to the maximum static friction. [$F_{s(max)}$]) (include the  laws governing friction such as static friction is greater than kinetic friction etc.)

The normal force is equal to the weight of the object.

The coefficient of the static friction ($\square$) can be solved using this equation:

$$\square_s = \frac{Maximum\ static\ friction}{Normal\ Force}$$

**Aim**                      :   To  investigate the relationship between a Normal  force and  the maximum static friction

**Apparatus**            :   wooden block, wooden board, spring balance, 100 g  mass  pieces

**Method/ Procedure :**



**Fig. 1: Experimental set-up for determining force and friction**

- Place a   block of wood on a wooden board  and attach the spring balance on the side with a hook as in the diagram above
- The maximum static  friction was determined by slowly pulling the spring scale until the stationary block of wood moved.
- Record  the maximum static friction
- The group repeated the procedure three (3) times and recorded their readings (in Newtons) on a table.

**Results**

This table shows the reading of the maximum  static friction and kinetic friction (in Newtons)

| Trial no. | $F_{smax}$ |
|-----------|------------|
| 1 | |
| 2 | |
| 3 | |
| 4 | |

- For the second experiment, the block of wood was weighed using the spring scale. (in grams)
- The group then added 100g on the block of wood and did the same procedure in the first experiment.
- The group do 4 trials for this experiment. After recording the readings, the group then solved for the coefficient of static friction

$$\square = \frac{Maximum\ static\ friction}{Normal\ Force}$$

This table shows the reading of the maximum static friction and kinetic friction (in Newtons)

| Trial no. | $F_{smax}$ |
|-----------|------------|
| 1 | 0.80N |
| 2 | 1.00N |
| 3 | 0.90N |

| Normal force | $F_{smax}$ | $\square$ |
|--------------|------------|-----------|
| 2.80N | 1.40N | |
| 3.00N | 1.20N | |
| 3.00N | 1.40N | |
| 2.80N | 1.20N | |

The table shows the reading of the Normal force, kinetic friction (in Newtons). The table also shows the coefficient of static friction which was solved using the formula. (Note that the coefficient doesn't have units since dividing the friction from the normal force will cancel out the unit Newtons.) Weight of block: 1.8 Newtons

**Activity 2**

For the this experiment, a block of wood, a wooden board, tiles (on the table), a plastic cover, paper, and the sand-paper side of the block of wood were used. The same

procedure was also done but varied on the surface which the block of wood was placed. The following surfaces were: wood to wood, wood to tile, wood to sand paper, wood to

plastic cover and wood to paper. The group recorded their readings on a table

The table shows the readings of the static friction and kinetic friction on wood, tile, sand paper, plastic cover and paper. The group saw that when the surface is smooth, the static and kinetic frictions are lower and higher when the surface is rough.

| Surface in Contact | $F_{smax}$ |
|--------------------|------------|
| Wood and wood | 0.80N |
| Wood and tile | 0.70N |
| Wood and sand paper | 1.20N |
| Wood and plastic cover | 0.50N |

| Wood and paper | 0.50N |
|---|---|

**Analysis of results** : interpret graph

**Sources of errors** : What can be done differently to improve the results

**Conclusion** : How are the results of the experiment related to the aim of experiment

**2.2 Learners Activities [15 min]**

[ Educators need to add more questions such as one word and multiple choice questions which could not be included because of space ]

A 50 kg box is at rest on a horizontal surface. When an 80 N force is applied to the box, it slides on the surface with a constant velocity.

50 kg

2.2.1 .1 Define static friction

2.2.1.2 Draw a labelled free body diagram for the box when it is ... moving at constant velocity.

2..2.3 Calculate the coefficient of friction.

2.2.4 How will the force of friction change if:

2.2.4.1 an identical box is placed on top of the 50 kg box

2.2.4..2 the same force is applied on another 50 kg box with a larger surface area?

Write only INCREASES, DECREASES or STAYS THE SAME.

**Answers**

2.2.1 static friction is the maximum force that is needed to change the object's state of rest

2.2.2

$F_{friction}$ ← → $F_{applied}$

N (up), $F_{gravity}$ (down)

2.2.3     $Ff = \mu kN$

      $80\ N = \mu k500\ N$

      $\mu_k = 0,16$

2.2.4.1 Increases

2.2.4.2 Stays the same

**2.3 Conclusion**

   

**Activity to reinforce lesson** (Educator may summarise the main aspects of the lesson) [**5 min.**]

**HOMEWORK QUESTIONS/ ACTIVITY** (educator must give learners a few questions to answer at home by either writing them on the chalkboard or giving an exercise from the prescribed textbook) [30 min]

**RESOURCES USED:  see apparatus above**

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

**Aim** : To investigate the relationship between a Normal force and the maximum static friction

**Apparatus** : wooden block, wooden board, spring [

**Method/ Procedure :**

| Surface in Contact | $F_{smax}$ |
|---|---|
| Wood and wood | 0.80N |
| Wood and tile | 0.70N |
| Wood and sand paper | 1.20N |
| Wood and plastic cover | 0.50N |
| Wood and paper | 0.50N |

Spring scale

BLOCK OF WOOD

wooden surface

**Fig. 1: Experimental set-up for determining force and friction**

- Place a block of wood on a wooden board and attach the spring balance on the side with a hook as in the diagram above
- The maximum static friction was determined by slowly pulling the spring scale until the stationary block of wood moved.
- Record the maximum static friction
- The group repeated the procedure three (3) times and recorded their readings (in Newtons) on a table.

**Results**

This table shows the reading of the maximum static friction (in Newtons)

| Trial no. | $F_{smax}$ |
|---|---|
| 1 | 0,80 N |
| 2 | 1,00 N |
| 3 | 0,90 N |
| | |

- For the second experiment, the block of wood was weighed using the spring scale. (in grams)
- The group then added 100g on the block of wood and did the same procedure in the first experiment.
- The group do 4 trials for this experiment. After recording the readings, the group then solved for the coefficient of static friction

$$\mu_s = \frac{Maimum\ static\ friction}{Normal\ Force}$$

This table shows the reading of the maximum static friction

| Normal force | $F_{smax}$ | $\mu_s$ |
|---|---|---|
| 2.80N | 1.40N | 0.5 |
| 3.00N | 1.20N | 0.4 |
| 3.00N | 1.40N | 0.47 |
| 2.80N | 1.20N | 0.43 |

**Analysis of results   :**



**www.nd.edu**                                                                                     static friction will increase as the applied force

increases  until  a maximum  static  friction wherein the object will start to move.  As soon as the object  starts to move,  static  friction stops existing and  kinetic

friction exists. Kinetic friction is constant  , has only one value which is lower than maximum static friction

**Sources of  errors      :** accuracy in using spring balance, faulty spring balance, uneven surfaces

**Conclusion               :** $\mu_s = \dfrac{Maimum\ static\ friction}{Normal\ Force}$

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 3 | TOPIC | Newton's First Law:  Time 60 mins | Lesson | 3 |
|-------|----|---------|-------------------|------|---|-------|-----------------------------------|--------|---|

| LESSON SUMMARY FOR: DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|
| **LESSON OBJECTIVES** | At the end of the lesson learners should be able to: <br> • State Newton's First Law in words <br> • Solve problems on horizontal surface and on an incline | | |

## TEACHING and LEARNING ACTIVITIES

1.   **TEACHING METHOD/S USED IN THIS LESSON:**
Induction method, Demonstration method, Question and Answer method

2.   **LESSON DEVELOPMENT**
**2.1  Introduction**
**a)  PRE-KNOWLEDGE**  learners need understanding of the following:
(i)  Object's state of rest or motion
(ii)  Resultant force
**b) BASELINE ASSESSMENT (educator to design a worksheet/ transparency or write questions on the board [preferably a worksheet to save time] to gauge the learners memory of**

**their relevant prior knowledge)**

QUESTIONS for  the **BASELINE ASSESSMENT**  **[5 min]**

i)        Define resultant force

ii)        What causes motion or acceleration of an object?

iii)       Illustrate each of the following terms:

•    Uniform motion in a straight line

•    External force

**Corrections**

i)        Is the single force that has the same effect as two or more forces acting together

ii)       Resultant  force  acting on the body

iii)      Uniform motion in a straight line: An object in the situation has a constant velocity. An object at rest has a constant velocity of zero.

•    External force: This is any force from outside the object

**2.2  Main Body   (Lesson presentation)  [30 min]**

**Newton's  First Law of Motion**: An object will remain at rest *or* in uniform motion in a straight line unless acted on by an external unbalanced force.

or

**Newton's First law of motion**: A body continues in a state of rest or uniform motion in a straight line unless, it is acted upon by external forces. **Force** is the push or pull, which changes the state of rest , of a body, or that of uniform motion in a straight line. Force has both magnitude and direction so it is a **vector** quantity.

WITH NO OUTSIDE FORCES
THIS OBJECT WILL
NEVER MOVE

WITH NO OUTSIDE FORCES
THIS OBJECT WILL
NEVER STOP

Let's take a look at a couple of terms in this law.

- **Uniform motion in a straight line:** An object in the situation has a constant velocity. An object at rest has a constant velocity of zero. Basically what this means is that if these objects are left alone, they will continue to move at the same speed and direction as they are right now (or lack of).

- **External force**: This is any force from outside the object. For instance, a moving car will stop if it hits another moving car, but not if you step on the floorboard because stepping on the floorboard is an internal force.

- Unbalanced forces: These are forces that are not equal and cause motion. If the forces were balanced, there would be no motion.

- At rest: The object is not moving at all (or seemingly).

When you put these terms together and translate them, it basically means that an object which is not moving will remain still until something comes in contact with it and has the force to move it. By the same rule, a moving object will keep going in a straight line until something comes in contact with it and has the force to impact its movement.

Place a coin on a smooth card over a water glass. Give the edge of the card a sharp blow with the flat side of a ruler. The card will be knocked off the glass, but the coin will fall into it.
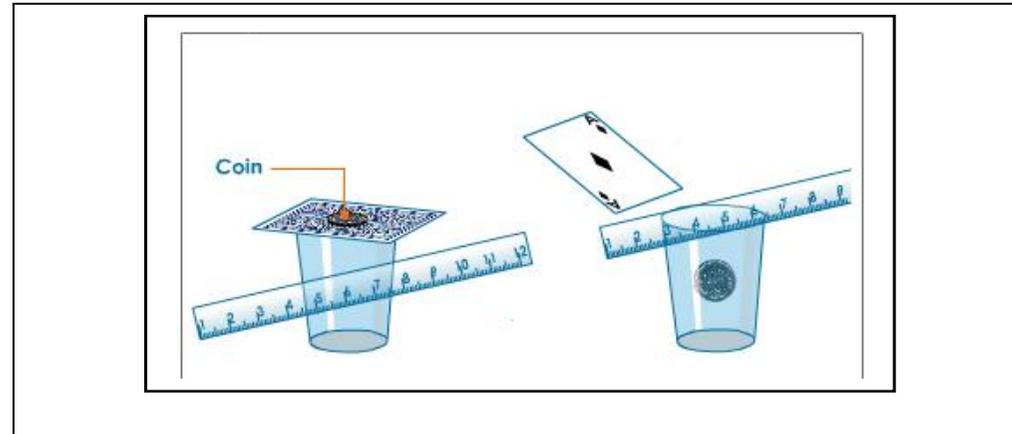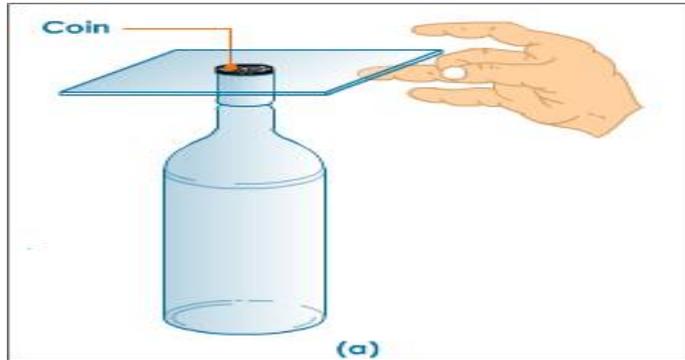
(b) Pile up smooth blocks and give the bottom one a sharp rap with the edge of a ruler. The bottom block will sail out, and the rest of the stack will not be toppled but will drop down still in a pile.
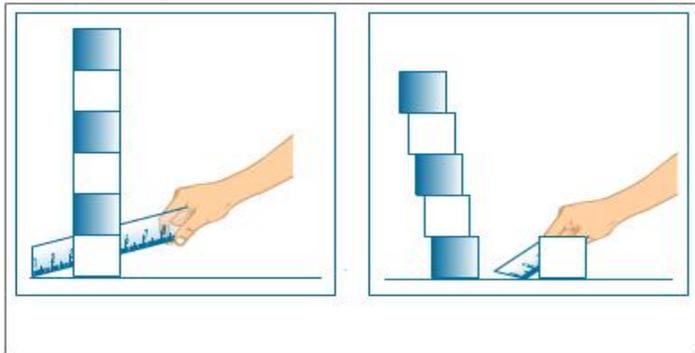


Inertia: A body, on its own, is unable to change its state of rest or of uniform motion in a straight line. This property is its inertia. It is a natural resistance to acceleration that all objects have. The greater the object's mass, the greater this resistance.

Examples of Inertia For example:

• You are in a car that comes to a sudden stop. Your body wants to keep going at its original speed, and you feel like you are being pushed

forward, into the seatbelt. Actually, the seatbelt is exerting a backwards force on you, slowing you down.

- You are trying to get ketchup out of a bottle. What do you do? You shake the bottle, bringing the upside-down bottle towards the plate and
- stopping it suddenly, hoping the inertia of the ketchup will cause it to keep going and come out of the bottle. (If the ketchup is thick or the bottle opening narrow, it might not work.)
- You are rolling a cart with an object on top of it. If you push on the cart to start or stop it, the object on top may fall off. (I did this once with a very expensive computer monitor on a cart. CRASH!)
- You are in a vehicle moving with constant velocity, and toss a ball straight up. To you, it appears to rise straight up, stop, and fall straight down back into your hand, just as it would if you and the car were stationary. To an observer standing by the road, however, the ball lands in your hand because, when it was in the air, its inertia carried it forward at the same speed it had when you were holding it.

**2.2 Learners Activities [15 min]**

2.2.1 Why should you use seat belt when driving in a car?

2.2.2 While you are riding in the front passenger seat of a car, the driver suddenly turns left. What about you?.

2.2.3 Imagine you are in a stopped car (say, at a red light) and another car strikes yours from behind, what will happen? Explain using Newton's laws.

2.2.4 State Newton's First law in words.

2.2.5 If you are seated in a train moving at constant velocity, and toss a sweet straight up, where shall the sweet land on its way down? Behind you, on your hand or on the passenger in front of you?

**Corrections**

**2.2.1** Riding in a car you and the car have the same motion. When the brakes are applied, the brakes stop the car but you remain moving at the same speed . What stops you? Eventually the steering wheel, the dashboard, or the window unless they are replaced by a seat belt, which stops your body to avoid major injuries

2.2.2 You continue to move in a straight line until the door to your right, turning left, eventually runs into you. In the car it may appear to you that you slid outward and hit the door

2.2.3 you may suffer whiplash. Your body is accelerated forward by the force of the seat, but your head wants to stay stationary. If there is no headrest, your head will be accelerated forward by your very overstretched and bent neck. To you, it feels as if your head is snapped backwards, but what's really happening is your body is being accelerated forward and your head is being left behind.

2.2.4 A body continues in a state of rest or uniform motion in a straight line unless, it is acted upon by external forces. Force is the push or pull, which changes the state of rest , of a body, or that of uniform motion in a straight line

2.2.5 To you, it appears to rise straight up, stop, and fall straight down back into your hand, just as it would if you and the train were stationary. To an observer standing by the road, however, the ball lands in your hand because, when it was in the air, its inertia carried it forward at the same speed it had when you were holding it.

**2.3 Conclusion**
**Activity to Re-enforce lesson** (Educator may summarise the main aspects of the lesson) [**5 min.**]

**HOMEWORK QUESTIONS/ ACTIVITY** (educator must give learners a few questions to answer at home by either writing them on the chalkboard or giving an exercise from the prescribed textbook) [30 min]

**RESOURCES USED: worksheet**

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 4 | TOPIC | Newton's Second Law:  Time  60 mins | Lesson | 1 |

| LESSON SUMMARY FOR:  DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|

| **LESSON OBJECTIVES** | At the end of the lesson learners should be able to: <br> • State Newton's Second Law <br> • Express Newton's  Second Law in symbols |
|---|---|

## TEACHING and LEARNING ACTIVITIES

**1.    TEACHING METHOD/S USED IN THIS LESSON:**
 Induction method, Demonstration method, Question and Answer method

**2.    LESSON DEVELOPMENT**
**2.1  Introduction**
**a)  PRE-KNOWLEDGE**
learners need understanding of the following:
(i)  Resultant force / net force
(ii)  Momentum and rate of change of momentum
**b)  BASELINE ASSESSMENT (educator to design a worksheet/ transparency or write questions on the board [preferably a worksheet to save time] to gauge the learners memory of

their relevant prior knowledge)**

QUESTIONS for  the **BASELINE ASSESSMENT**  **[5 min]**

i)     Define momentum

ii)    Explain the meaning of resultant force

iii)    What is meant by constant net force?

iv)    What are the effects of the net force exerted on the object

**Corrections**

i) Momentum is the product of mass and velocity

ii) Resultant force is that single force that has the same effect as two or more forces that are acting together  (jointly)

iii) Unchanging resultant force acting on an object

iv)  Resultant (net) force will produce acceleration

**2.2  Main Body   (Lesson presentation)  [30 min]**

Newton's Second Law of Motion states that **the rate of change in momentum of the body is directly proportional to the net force applied**  or The **net force on an object** (or system of

objects) **equals to the rate at which the object's momentum changes**. This is the general form of Newton's second law.  By definition, momentum (**p** )= $mv$, and Newton's second

law can be expressed as :

$$F_{net} = \frac{m\Delta v}{\Delta t}$$     where F$_{net}$ is the net force in Newton (N)

m$\Delta$v is the momentum in kg·m·s$^{-1}$

and   $\Delta$t is the change in time in second

$$F_{net} = \frac{m\Delta v}{\Delta t}$$ can be written as $F_{net} = \frac{\Delta p}{\Delta t}$.   Thus, a force changes the momentum of an object. A large force will change the momentum rapidly,

whereas a small force will change the momentum slowly. Newton's 2nd law therefore agrees with  everyday experience with momentum: it takes a large force to affect a big change in momentum in a short period of time.  A ping Tennis ball moving at 5 km/h can be stopped quickly with a small force (you can catch it in your hand), whereas to stop a 10 ton truck moving at the same speed would either take a much larger force, or a longer time:

There must be net Force ( unbalanced  forces) in order for the object to experience change in velocity (acceleration).  The presence of an unbalanced force will accelerate an object - changing its speed, its direction, or both its speed and direction. And the change in velocity will give the object a change in momentum.  Important aspect with respect to Newton's second law are:

- There must be a  net force exerted on the object which will cause a change in object's state of motion
- For the net force that is in the same direction as the direction of motion, the object will accelerate positively
- If the net force is in the opposite direction to that of the motion, then the object will experience a negative acceleration

**If an unbalanced force acts on an object then its velocity will change - it will either speed up, slow down, and that includes stopping, or the object will change direction**


**2.2  Learners Activities  [15 min]**

2.2.1 A tennis ball of mass 50 g is thrown towards the wall at 20  m·s$^{-1}$and rebounds at 16  m ·s$^{-1}$. Calculate the :

a)  The ball's change in momentum

b)  How much force does the wall exert on the ball if the ball and the wall are in contact for 0,1 s?

c)  State Newton's second law of motion in terms of momentum

2.2.2  Explain in terms of F$_{net}$, $\Delta$p and  $\Delta$t why a cricket player pulls his hands back when catching ball that is very hard.

2.2.3 An Audi with  2 260 kg of mass was observed driving at 52 m·s$^{-1}$ to the south. 15 s later the car was brought to stopped. Calculate the average net force that brought the car to rest if it was uniformly brought to stop.

2.2.4   A baseball of mass 200 g moving with a velocity of 15 m·s$^{-1}$ is brought to rest by a player in 0.05 second. What is the change of the ball's momentum and the average force applied by the player?

2.2.5   A 25 g tennis ball at 15 m·s$^{-1}$ is moving towards a boy standing and the boy boy kicks it back at 30 m·s$^{-1}$. Calculate :

(a)   the magnitude and the direction of the change in momentum of the ball.

(b) The average force exerted on the ball during the collision if the ball and the foot were in contact for 0,5 s.

**Corrections**

2.2.1 a) $\Delta p = m\Delta v$    Consider towards the wall as positive. $\Delta p = m(v_f - v_i)$    $\Delta p = \dfrac{50}{1000}(-16 - 20)$    $\Delta p$ = -1,8 kg m·s⁻¹

   $\Delta p$ = 1,8 kg m·s⁻¹ away from the wall

b) $F_{net} = \dfrac{m\Delta v}{\Delta t}$    ;    $F_{net} = \dfrac{-1,8}{0,1}$    ;    = -18 N    $\therefore$    $F_{net}$ = 18 N away from the wall

c) Newton's Second Law of Motion states that the rate of change in momentum of the body is directly proportional to the net force applied.

2.2.2 Pulling the hands back on catching the cricket ball increases the contact time and reduces the force. The velocity is slowly reduced till the ball is stationary .Therefore the hard cricket ball will be less painful to catch.

2.2.3   $F_{net} = \dfrac{m\Delta v}{\Delta t}$   ; $F_{net} = \dfrac{2260(0 - 52)}{15}$   ;   $F_{net}$ = -7834,67 N  ;   $F_{net}$ = 7834,67 N   North

2.2.4   $\Delta p = m\Delta v$ ;         $\Delta p$ = 0,2 ( 0 - 15) ;    = -3,0 kg m·s⁻¹ ;    $\Delta p$ = 3,0 kg m·s⁻¹ backwards

   $F_{net} = \dfrac{m\Delta v}{\Delta t}$   ; = $\dfrac{-3,0}{0,05}$   ;   $F_{net}$ = 60 N in opposite direction

2.2.**5(a)** $\Delta p = m\Delta v$
          = 0,025 (30 – 15)
          = 0,375 kg m·s⁻¹ towards the boy

b)   $F_{net} = \dfrac{\Delta p}{\Delta t}$   ;                  $F_{net} = \dfrac{0,375}{0,5}$

$F_{net}$ =  **0,75N**  towards the ball

## 2.3  Conclusion

**Activity to Re-enforce lesson** (Educator may summarise the main aspects of the lesson) [**5 min.**]

**HOMEWORK QUESTIONS/ ACTIVITY** (educator must give learners a few questions to answer at home by either writing them on the chalkboard or giving an exercise from the prescribed textbook) [30 min]

**RESOURCES USED:**

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 4 | TOPIC | Newton's Second Law : Time 60 mins | Lesson | 2 |

| LESSON SUMMARY FOR: DATE STARTED: | | DATE COMPLETED: | |

| **LESSON OBJECTIVES** | At the end of the lesson learners should be able to:<br>• Discuss the relationship between net force and change in momentum<br>• State Newton's Law in a special case of constant mass<br>• Add all the forces in x – direction and y – direction for uniform velocity and static situations |

## TEACHING and LEARNING ACTIVITIES

1.  **TEACHING METHOD/S USED IN THIS LESSON:**
    Induction method, Demonstration method, Question and Answer method

2.  **LESSON DEVELOPMENT**
2.1 **Introduction**

   a)  **PRE-KNOWLEDGE** learners need understanding of the following:

   b) **BASELINE ASSESSMENT (educator to design a worksheet/ transparency or write questions on the board [preferably a worksheet to save time] to gauge the learners memory of their relevant prior knowledge)**

QUESTIONS for the **BASELINE ASSESSMENT** [5 min]

   (i)  How will the momentum change if the force on the object is increased?

   (ii) What is the vector sum of the weight and the normal force of an object at rest?

   (iii) Under which condition(s) will the motion and the momentum of an object change?

   (iv)  Compare the force acting on an object with the momentum of an object

**Corrections**

i) The momentum of an object will also increase

ii) They add up to zero since Normal force and the weight of an object are equal in magnitude and are different in their directions

iii) If there is net (resultant) force acting on the object./ Unbalanced forces acting on the object

iv) There is a direct relationship between Momentum and Force. The rate at which momentum changes is equal to the net force applied to the object. A net force acting for a certain time produces change in momentum in the direction of net force

### 2.2 Main Body (Lesson presentation) [30 min]

From the definition of Newton's second law: The net force on an object (or system of objects) equals to the rate at which the object's momentum changes,

$$F_{net} = \frac{m\Delta v}{\Delta t}$$

There is a direct relationship between Momentum and net Force. The rate at which momentum changes is equal to the net force applied to the object. A net force acting for a certain time produces change of momentum in the direction of net force. Change in momentum comes as a result of change in velocity, and therefore acceleration is produced. Another definition of Newton's second Law : **Constant (net) resultant force produces acceleration in the direction of force. Acceleration is directly proportional to the net force , and acceleration is inversely proportional to the mass of an object**.

**For a constant mass**

When an object accelerates, net Force applied is directly proportional to the acceleration it produces. If the force is increased, the rate of change of velocity increases. The acceleration of an object is inversely proportional to the mass of an object. If mass is increased, acceleration of an object will decrease . For the constant mass of an object, the equation

$$F_{net} = ma$$

becomes relevant and appropriate. And must be applied separately in the x- and y -direction s. In systems with more than one object of interest, a free body diagram for each object must be drawn and Newton second law must be applied to each object separately.

For objects that are stationary and objects with zero acceleration (uniform velocity), all forces in the x-direction together with all the forces in y-direction must add up to zero.

How is **principle of superposition used with Newton's 2nd Law**?

F1 + F2 + F3 + ---- = F(total) if m is constant and then a1 +a2 + a3 +------ = a(total

**Example**

Solve the following force problems

1.  What force is needed to accelerate a child on a sled (total mass = 60.0 kg) at 1.15 m·s$^{-2}$?

    $F_{net}$ = ma

    = (60.0 )(1.15 )

    = **69.0 N**

2 . A net force of 225 N accelerates a bike and rider at 2.20 m·s⁻². What is the combined   mass of the bike and rider?

$F_{net}$ = ma ,

225 = (2.20 ) m

   = **102 , 27kg**

### 2.2  Learners Activities  [15 min]

2.2.1    A box weighing 70 N rests on a table. A rope attached to that box runs up over a pulley and a second box is attached to the other end. Determine the Normal force on the box on that table if the hanging box weighs (a) 30 N, (b) 60 N, and (c) 90 N.

2.2.2    Two blocks on a horizontal surface are in contact with each other as shown. The surface has friction. A force **F** is applied to block 1

2.2.3   calculate the mass of a body when a force of 225 N produces an acceleration of 2.5 m·s⁻²?

2.2.4   What is the acceleration of a 4 kg box if an unbalanced force of 12 N acts on it?

2.2.5  When an object of unknown mass has an unbalanced force of 200N acting on it , it accelerates at 2 m·s⁻². What is its mass?

**Corrections**
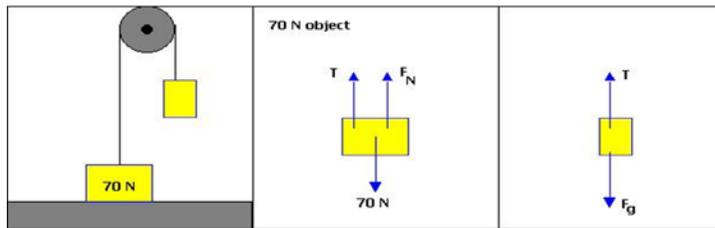


2.2.1  For the 70 N block: Since $\sum F = 0$, then T+ $F_N$ - 70 N = 0
$F_N$ = 70 N - T
For the hanging block: Since $\sum F = 0$, then T= $F_g$
Therefore: $F_N$ = 70 N - $F_g$
a) $F_g$= 30 N
$F_N$ = 70 N - $F_g$ = 70 N - 30 N = **40 N**
b) $F_g$= 60 N
$F_N$ = 70 N - $F_g$ = 70 N - 60 N = **10 N**

c) $F_g$= 90 N

$F_N$ = 70 N - $F_g$ = 70 N - 90 N = **-20 N** =0 The block has lifted off the table, therefore the normal force is equal to zero

2.2.2
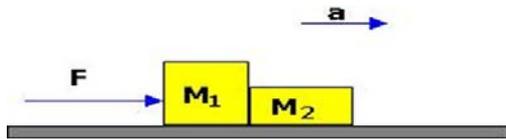


2.2.3   Force (F) = 225 N

Acceleration (a) = 2.5 m/s$^2$

Force (F) = ma

$$m = \frac{F}{a}$$

$$m = \frac{225}{2.5} = \frac{225 \times 10}{2.5 \times 10} = \frac{2250}{25} = 90 \text{ kg}$$

Mass of the body = 90 kg

2.2.4   F = ma

12 =  (4)a

a = 12/4

= 3 m·s$^{-2}$

2.2.5   F = ma

200  = m(2)

m = 200/2

= 100 kg

**2.3  Conclusion**

**Activity to Re-enforce lesson** (Educator may summarise the main aspects of the lesson) [**5 min.**]

**HOMEWORK QUESTIONS/ ACTIVITY** (educator must give learners a few questions to answer at home by either writing them on the chalkboard or giving an exercise from the prescribed textbook) [30 min]

**RESOURCES USED:**

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 4 | TOPIC | Newton's Second Law –Force and free body diagram: Time 60 mins | Lesson | 3 |
|-------|----|---------|-------------------|------|---|-------|--------------------------------------------------------------|--------|---|

| LESSON SUMMARY FOR: DATE STARTED: | | DATE COMPLETED: | |
|-----------------------------------|--|-----------------|--|

| LESSON OBJECTIVES | At the end of the lesson learners should be able to:<br>• Draw force diagrams for objects at rest, moving with constant velocity and acceleration<br>• Draw free body diagrams for objects at rest, moving with constant velocity and acceleration |
|-------------------|------------------------------------------------------------------------------------------------------------------------------------|

## TEACHING and LEARNING ACTIVITIES

**1. TEACHING METHOD/S USED IN THIS LESSON:**
Induction method, Demonstration method, Question and Answer method

**2. LESSON DEVELOPMENT**
**2.1 Introduction**

**a) PRE-KNOWLEDGE** learners need understanding of the following:
(i) Vector diagram, force diagram and free body diagram
(ii) Object's state of motion
**b) BASELINE ASSESSMENT** (educator to design a worksheet/ transparency or write questions on the board [preferably a worksheet to save time] to gauge the learners memory of their relevant prior knowledge)
    QUESTIONS for the **BASELINE ASSESSMENT** [5 min]

a) Describe a free body diagram

b) Describe how you can draw a free body diagram with given forces

c) Draw a free body diagram of a car stationary parked under the tree on a level ground.

**Corrections**

a) A free body diagram consists primarily of a sketch of the body in question and arrows representing the forces applied to it. It is not    necessarily drawn to scale but magnitude and direction are important. All arrows point away from the dot.

b)  Isolate Body from the system and find the force locations . Draw a box or a dot, indicate  forces acting on an object with the length of the line proportional to the magnitude and the arrow showing the direction of the vectors

c) Two forces since the car is stationary are  N(force of the earth on the car) and force due to gravity

N

$F_g$
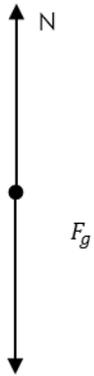
### 2.2  Main Body   (Lesson presentation)  [30 min]

A **force diagram** is simply a diagram showing all the forces acting on an object, the force's direction and its magnitude. It is a simplification of the picture that shows just the forces.

**A free body diagram** consists primarily of a sketch of the body in question and arrows representing the forces applied to it. It is not    necessarily drawn to scale but magnitude and direction are important. All arrows point away from the dot.  Only the forces acting on the BODY are included. These may include forces such as **friction, gravity, normal force, drag, or simply contact force due to pushing**. It is usually easy to determine the point of application of each force - contact points and the centre of gravity.

**A vector diagram** is a graphical representation of the magnitude and direction of  vectors (in this case forces)  acting  on the object  taken in order. This can be a scale drawing ,and angles need to be measured.  If an object is in equilibrium, this becomes a closed  geometric figure. Both force diagram and a free body diagram are examples of vector diagram.

To illustrate the difference, an example is given below:

A soldier is hoisted  by a cable from  helicopter in a rescue operation during heavy floods at constant velocity .The soldier  experiences air friction on his way up. Draw a force diagram and a  free body diagram and show all forces as the soldier moves up.

T                                                                 T

**Force diagram**
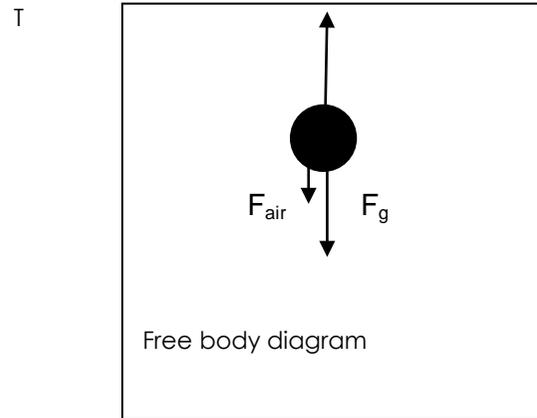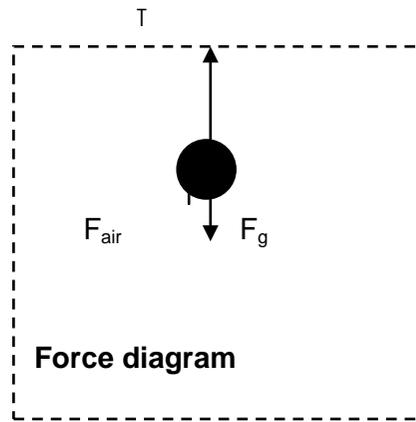
Free body diagram

See direction of the air friction in both diagrams

Hints on drawing a free body diagram

1. **Isolate Body**

There must be only one body.  Make sure you isolate the body exactly – as if you cut it out in a silhouette or outline. It is important to be very clear about the boundary you have made around the body.

2. **Find Force locations**

Forces are applied by contact, gravity or inertia. Identify all the points where forces are applied to the body. Gravity always acts through the centre of mass, pressure acts through the centre of pressure.

The only forces to consider are those that CROSS THE BOUNDARY. Ignore all other forces.

3. **Line of Action of Forces**

•Point contact: 'Smooth':  No friction. Force can only be applied perpendicular to smooth surface.

•Cable. Force can only be tensile (pulling). Force must be along direction of cable.

•Gravitational. Centre of gravity

• Inertial. Centre of inertia (not always the same as centre of gravity). These are due to acceleration.

**4. Direction of the Forces**

Include all the forces acting TO THE BODY. The direction is determined by thinking **TO the body**, or **ON the body**.  eg Gravity acts down ON the body, floor pushes up ON the body,

**2.2  Learners Activities  [15 min]**

2.2.1   Two blocks on a horizontal surface are in contact with each other as shown. The surface has friction. A force **F** is applied to block 1.
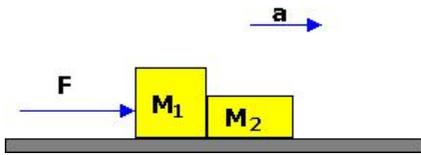


(a) Draw a force  diagram for each block: Note: $F_{N1}$ and $F_{N2}$ are the normal forces exerted by the surface on block 1 and block 2 respectively, $F_R$ is the reaction force caused by the blocks being in contact with each other, $f_{k1}$ and $f_{k2}$ are the frictional forces associated with block 1 and 2 respectively.

2.2.2      A skier slides down a slope to the left at a constant speed. Identify all forces acting on the object and draw a free-body diagram of the object

2.2.3  Consider the two-body situation at the right. A $3.50 \times 10^3$ kg crate (m1) rests on an inclined plane and is connected by a cable to a $1.00 \times 10^3$ kg mass (m2). This second mass (m2) is suspended over a pulley. The incline angle is 30.0° and the surface has a coefficient of friction of 0.210. Determine the acceleration of the system and the tension in the cable.

**www.wikipedia.org**

2.2.4 A car is coasting to the right and slowing down. A free-body diagram for this situation

2.2.5

**Corrections**

**2.2.2** Here the weight of skier = mg. It will be resolves into two components one is mg sinθ and another is mg cosθ. This mg cosθ is balanced with Normal force.

N    f

mg sin

mg cos

mg

**www.wikipedia.org**

$F_{N1}$    a

F    $F_R$

$f_{k1}$

$m_1g$

a

$F_{N2}$

$F_R$    $f_{k2}$

$m_2g$
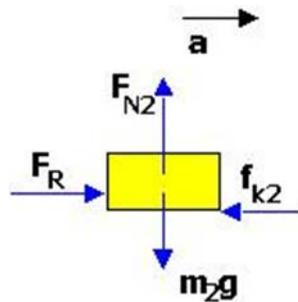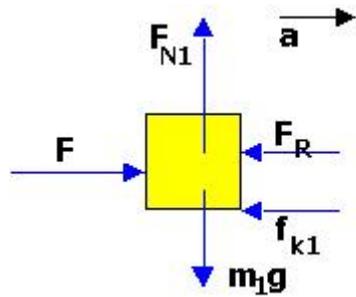
**2.2.1**

2.2.3 The solution here will use the approach of a free-body diagram and Newton's second law analysis of each individual mass. The free-body diagrams for the two objects are shown below.
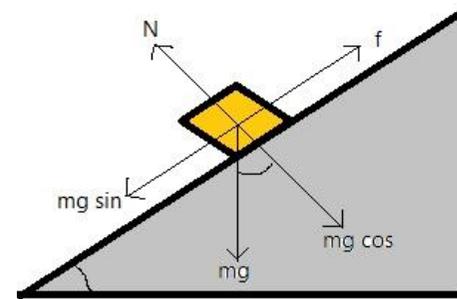
**Free-Body Diagrams for $m_1$ and $m_2$**
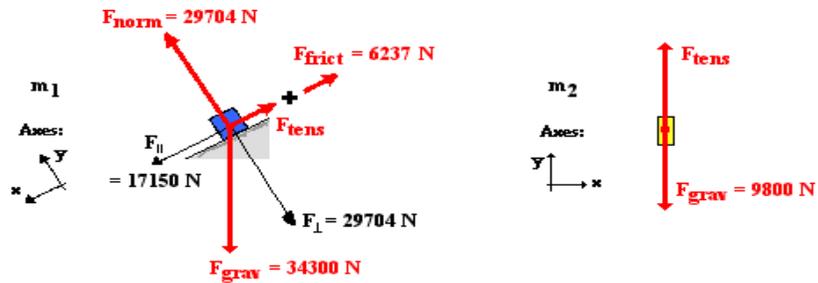
Because the parallel component of gravity on $m_1$ exceeds the sum of the force of gravity on $m_2$ and the force of friction, the mass on the inclined plane ($m_1$) will accelerate down it and the hanging mass ($m_2$) will accelerate upward.

For mass $m_1$:
$F_{grav} = m_1 \cdot g = (3500 \text{ kg}) \cdot (9.8 \text{ N/kg}) = 34300 \text{ N}$
$F_{parallel} = m_1 \cdot g \cdot sine(\theta) = 34300 \text{ N} \cdot sine(30°) = 17150 \text{ N}$
$F_{perpendicular} = m_1 \cdot g \cdot cosine(\theta) = 34300 \text{ N} \cdot cosine(30°) = 29704.67 \text{ N}$
$F_{norm} = F_{perpendicular} = 29704.67 \text{ N}$
$Ffrict = \mu \cdot F_{norm} = (.210) \cdot (29704.67 \text{ N}) = 6237.98 \text{ N}$

2.2.4



## 2.3  Conclusion

**Activity to Re-enforce lesson** (Educator may summarise the main aspects of the lesson) [**5 min.**]

**HOMEWORK QUESTIONS/ ACTIVITY** (educator must give learners a few questions to answer at home by either writing them on the chalkboard or giving an exercise from the prescribed textbook) [30 min]

**RESOURCES USED:**

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
| --- | --- | --- | --- |
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 4 | TOPIC | Newton second law-Acceleration:  Time 60 mins | Lesson | 4 |
|---|---|---|---|---|---|---|---|---|---|

| LESSON SUMMARY FOR:  DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|
| **LESSON OBJECTIVES** | At the end of the lesson learners should be able to:<br>• Calculate the acceleration of a single object on which several forces act simultaneously<br>• Calculate the acceleration of two objects that are joined together by a string | | |

## TEACHING and LEARNING ACTIVITIES

1.   **TEACHING METHOD/S USED IN THIS LESSON:**
Induction method, Demonstration method, Question and Answer method

2.   **LESSON DEVELOPMENT**
**2.1  Introduction**


**a)  PRE-KNOWLEDGE**  learners need understanding of the following:
(i)  Newton's laws of motion
(ii)  Free body diagram
**b)  BASELINE ASSESSMENT (educator to design a worksheet/ transparency or write questions on the board [preferably a worksheet to save time] to gauge the learners memory of

their relevant prior knowledge)**

QUESTIONS for  the **BASELINE ASSESSMENT**  **[5 min]**

  i)     State Newton's second law in two different ways

  ii)    What does constant resultant force do to an object

  iii)   What is the relationship between force and acceleration? Elaborate


**Answers**

  **i)**      Newton's Second Law of Motion states that the rate of change in momentum of the body is directly proportional to the net force applied

Constant resultant force produces acceleration in the direction of force.  Acceleration is directly proportional to the applied net force,  Acceleration is inversely proportional to

mass.

  **ii)**     Produces acceleration in the direction of force

  iii)   Acceleration is directly proportional to the applied net force .  If the force increases, acceleration will in turn increase

### 2.2 Main Body  (Lesson presentation)  [30 min]

From the equation $F_{net} = \dfrac{m\Delta v}{\Delta t}$ , it can be noted that $F_{net} = ma$ since $a = \dfrac{\Delta v}{\Delta t}$. This is only applicable when the mass is constant. When a resultant force is applied to a body it produces an acceleration that is directly proportional to the resultant force and inversely proportional to the mass of the body  But the former equation based on the rate of change of momentum is applies to both. From F= ma, Newton second law can be stated .

**An unbalanced or resultant force produces an acceleration** in the direction  of force. This acceleration is directly proportional to the  force that produced it, and acceleration is inversely proportional to the mass of an object.  It defines the relationship of  Force,  Mass and  Acceleration.

**Force = mass x acceleration**

**F = ma**

A force of one newton will give a mass of one kilogram an acceleration of 1 m·s⁻².

Examples


1. A trolley with a mass of 15 kg is accelerated at 3 m·s⁻². What force is needed to do this?

solution                F = ma

                     = 15 x 3

                     = 45 N

2.  A force of 20N is used to accelerate a 250 g mass. What is its acceleration?

        F = ma

$$20 \ = \ \frac{250}{1000} \times a$$

    a = 80 m·s⁻²

**2.2 Learners Activities [15 min]**

2.2.1 A car of mass 800kg is pulling a trailer of mass 200kg along a straight road. The car is connected to the trailer by a tow bar which can be modeled by a light inextensible rod. The driving force of the car is 2.6kN and the total resistance to motion of the car and trailer is 600N.

a) Determine the acceleration of the system.

b) Given that the resistances of the car and trailer are proportional to their masses. Determine the tension in the tow bar

c) The driver sees an accident ahead and applies the brakes causing the car to decelerate at $3m \cdot s^{-2}$. Determine the braking force applied and the force acting in the tow bar.

2.2.2 The dung beetle below is accelerating the dung ball at 0.1 m·s⁻². What is the force the dung beetle would have to apply to accelerate this 0.001 kg dung ball at 0.1 m·s⁻²?



2.2.3 A force of 625 N acts on a body of mass 25 kg. Find the acceleration of the body

.



2.2.4 An inventive child wants to reach an apple in a tree without climbing the tree. Sitting in a chair connected by a rope that passes over a frictionless pulley, he pulls on the loose end of the rope with such a force that the spring scale reads 250. N. The child's true weight is 320. N, and the chair weighs 160. N

a) Show that the acceleration is upward and find its magnitude

b) Find the force the child exerts on the chair.

www.wikipedia.org

2.2.5 Mass of weight 1.2kg and 1.0kg hang at the ends of a light rope passing over a light frictionless pulley. Find the acceleration of the mass and the tension in the rope.

**Corrections**

2.2.1 The total mass is $800 + 200 = 1000kg$.

Newton's Second Law states that $\text{Force} = \text{Mass} \cdot \text{Acceleration}$

$\therefore \qquad 26000 - 600 = 2000[= 1000 \times \text{Acceleration}$

Thus Acceleration $= \dfrac{2000}{1000} = 2 \; m/s^2$

As the resistance to motion of the car and trailer are proportional to the masses, then

The Resistance of the car is $= \dfrac{800}{1000} \times 600 = 480 \; N$

The Resistance of the trailer is $= \dfrac{200}{1000} \times 600 = 120 \; N$

Therefore the tension in the tow -bar is  Instead of considering the Trailer we could have applied Newton's Second Law to the Car

2.2.2     F = ma
        = 0,001 x 0,1
        = 1,00 x 10$^{-4}$m·s$^{-2}$ to the direction of motion

2.2.3     F = ma
      625 = 25a
        a = 25 m s$^{-2}$ forward

2.2.4    a) **Since the total weight of the system is 480.N,**
**the total mass of the system = 480. N / 9.81 m/s$^2$ = 49.0 kg**

**Taking upward as positive, the acceleration of the system is found using the second law.**
**$\sum F_y = 2T - mg = ma_y$**

**Solving for $a_y$,**
**$a_y = [(250. \; N + 250. \; N) - 480. \; N] / 49.0 \; kg$**
**$a_y = \underline{+ \; 0.408 \; m/s^2}$**
**(positive sign indicates upward)**
**b) The downward force the child exerts on the chair has the same magnitude**
**as the upward normal force exerted on the child by the chair.**

**Applying the second law,**
**$\sum F_y = T + F_n - m_{child}g = m_{child}a_y$**
**$F_n = m_{child}a_y + m_{child}g - T$**

          

$F_n$ **= (320. N / 9.8 m·s$^{-2}$)(0.408 m·s$^{-2}$) + (320. N) - (250. N)**

$F_n$ = <u>83.3 N</u>

$$F = 1.2g - T$$
$$F = 1.2a$$

**2..2.5**   $$1.2g - T = 1.2a$$

$$T = 1.0 \times 9.81 + 1.0 \times 0.892$$
$$= 10.7 \, N$$

$$F = T - 1.0g$$
$$F = 1.0a$$
$$T - 1.0g = 1.0a$$

$$1.2g - 1.0g = 2.2a$$
$$a = 0.2 \times \frac{9.81}{2.2}$$
$$a = 0.892 \, m/s^2$$

### 2.3  Conclusion

**Activity to Re-enforce lesson** (Educator may summarise the main aspects of the lesson) [**5 min.**]

**HOMEWORK QUESTIONS/ ACTIVITY** (educator must give learners a few questions to answer at home by either writing them on the chalkboard or giving an exercise from the prescribed textbook) [30 min]

**RESOURCES USED:**

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 5 | TOPIC | Newton's second law – Experiment (RECOOENDED EXPERIMENT) | Lesson | 1 and 2 |
|-------|----|---------|-------------------|------|---|-------|----------|--------|---------|

| LESSON SUMMARY FOR: DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|

| LESSON OBJECTIVES | At the end of the lesson learners should be able to:<br>• Verify Newton's second law<br>• Calculate acceleration from Newton's second law |
|---|---|

## TEACHING and LEARNING ACTIVITIES

1. **TEACHING METHOD/S USED IN THIS LESSON:**
Question and Answer

2. **LESSON DEVELOPMENT**
2.1 **Introduction**

**a)PRE-KNOWLEDGE**learners need understanding of the following:
(i)  Distance , velocity  and  acceleration
(ii)  Newton's  second law  definitions
 (ii) Equations associated with Newton's second law
**b)BASELINE ASSESSMENT**(educator to design a worksheet/ transparency or write questions on the board [preferably a worksheet to save time] to gauge the learners memory of

their relevant prior knowledge)

QUESTIONS for  the **BASELINE ASSESSMENT** [5 min]

   i)      Define acceleration

   ii)      What is the relationship between resultant force and the acceleration of an object?

   iii)      Calculate the force required to accelerate an toy car of mass 2kg  from rest to a velocity of 20 m·s$^{-1}$ in 5 s.

Answers

  ( i)    acceleration is the rate of change of velocity

  (ii)    Resultant force is directly proportional to acceleration

(iii)$F_r$ $= \dfrac{m\Delta v}{\Delta t}$

$= \dfrac{2(20-0)}{5}$

= 8 N  to the direction of motion

        © Gauteng Department of Education (CAPS  version)

2.2 **Main Body (Lesson presentation) [30 min]**

**Aim** : To determine the mathematical relationship between force and acceleration when mass is kept constant.

**Apparatus** : a trolley, variable mass pieces, pulley, clamp , string, plasticene, smooth table top/ trolley track, stopwatch or ticker-timer measuring tape

**Variables** : - **Dependent variable**

- **Independent variable**

- **Constant variable**

**Diagram**

up to the same time on each tape, we are comparing
the accelerations.

Power pack

Remaining masses

Cotton thread

Ticker-timer

Ticker-tape

Glass rod or pulley

Dynamics trolley

Falling masses
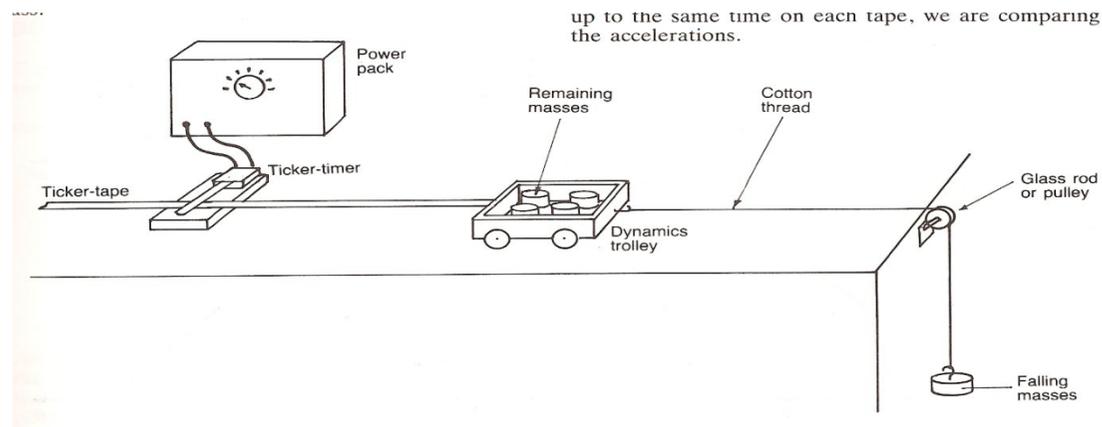
**Procedure**

1. Connect the ticker-timer to the A.C. terminals of the power pack.

2. Attach a 60 cm length of ticker-tape to one end of the trolley and pass the tape through the ticker timer. Useplasticene to hold the timer

in place.

3. To the other end of the trolley attach a length of cotton (enough to reach the floor). Attach the other end ofthe cotton to one of the

masses.

4. Use the pulley (or glass rod held in place by plasticene) to provide a nearly frictionless surface for the cotton

to run across at the edge of the bench.

5. The remaining four masses should be taped to the trolley so that they do not move or fall off.

6. Start the ticker-timer, release the trolley and allow the mass to fall to the ground. Discard any part of the tape  produced after the mass

has hit the ground. Label this tape 'Force 1'.

7. Transfer a mass from the trolley to the end of the cotton. Obtain a ticker-tape as in step 6 and label it 'Force 2'.

8. In a similar way obtain tapes for 'Force 3', 'Force 4', and 'Force 5' (with 3, 4, and 5 falling masses).

We assume that the acceleration is constant throughout the motion recorded on each tape. Hence distancetravelled is given by

$x = v_i t + ½ at^2$

For our tapes, $v_i = 0$   so x= ½ at²

If we choose the same initial time interval for each tape, then $a$ $a$ $x$. Hence by comparing the distances travelled from rest up to the same time on each tape, we are comparing their accelerations.

9. Begin your analysis with the tape 'Force 5'. Count the number of tick intervals from the first clear dot to near the end of the accelerating section. Measure the distance travelled in this time.

**Results**

10. Repeat step 9 for each of the other tapes using the initial section with the same number of tick intervals as above. Enter your results in a suitable table.

| Suspended Mass (kg) | Δt(s) Trial 1 | Δt(s) Trial 2 | Δt(s) Trial 3 | Ave Δt(s) | average acceleration |
|---|---|---|---|---|---|
| 0,1 | | | | | |
| 0,2 | | | | | |
| 0,3 | | | | | |
| 0,4 | | | | | |
| 0,5 | | | | | |
| 0,6 | | | | | |

- If mass suspended mass is in grams, convert to kg
- Weight ($F_g$)  =  mg

11. Plot a graph of force versus acceleration (i.e. force versus distance). Draw the line of best fit.

Include the following  topics in writing your lab report

**Analysis of results**          :  Plot a graph of force versus acceleration (i.e. force versus distance). Draw the line of best fit.

**Sources of errors**           :  Determine the percentage error. How did your experimental values compare to the theoretical values? Discuss any sources of error in this lab and describe ways that could improve the accuracy.

**Conclusion**                   :  Discuss the results , the relationship  between  hanging mass ($F_r$)  and the  distance ($a$)

**THEORY QUESTIONS ON DIFFERENT COGNITIVE LEVELS**

**Possible Memo**

**Newton's second Law - Force and acceleration**

**Aim :** To determine the mathematical relationship between force and acceleration of an object when mass is kept constant.

**Variables :** dependable variable - acceleration

**Independable variable** - Force

Constant variable - **mass** (mass of the system is not changing)

**Apparatus / diagrams**

( A learner may list the apparatus instead of labelling the on the diagram)
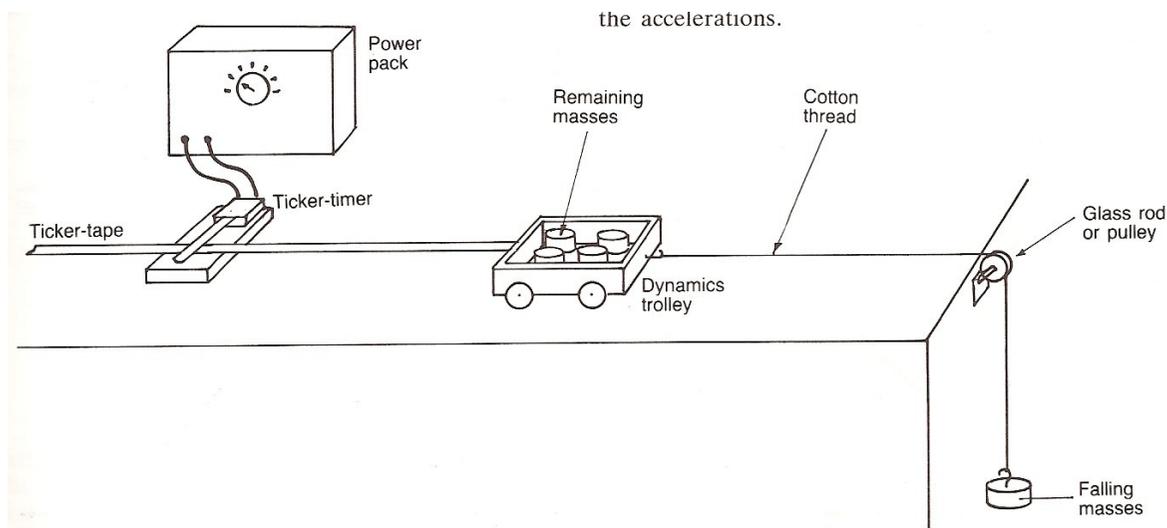


**Method / Procedure**

• Connect the apparatus as set in the diagram

• Start the ticker-timer and release the trolley simultaneously, allow the mass to fall to the ground. Discard any part of the tape produced after the mass has hit the ground. Label this tape 'Force 1'.

• Transfer a mass from the trolley to the end of the cotton. Obtain a ticker-tape as in step above and label it 'Force 2'.

• In a similar way obtain tapes for 'Force 3', 'Force 4', and 'Force 5' (with 3, 4, and 5 falling masses).

• We assume that the acceleration is constant throughout the motion recorded on each tape. If we choose the same initial time interval for each tape, then a a x.

- Enter your results in a suitable table.

**RESULTS**

Teachers should please fill in their own demonstration results in the table below

| Suspended Mass (kg) | $\Delta t(s)$ Trial 1 | $\Delta t(s)$ Trial 2 | $\Delta t(s)$ Trial 3 | Ave $\Delta t(s)$ | average acceleration |
|---|---|---|---|---|---|
| 0,1 | | | | | |
| 0,2 | | | | | |
| 0,3 | | | | | |
| 0,4 | | | | | |
| 0,5 | | | | | |
| 0,6 | | | | | |

**Analysis of results**

- Plot a graph of force versus acceleration (i.e. force versus distance) from results above. Draw the line of best fit.

Sample graph
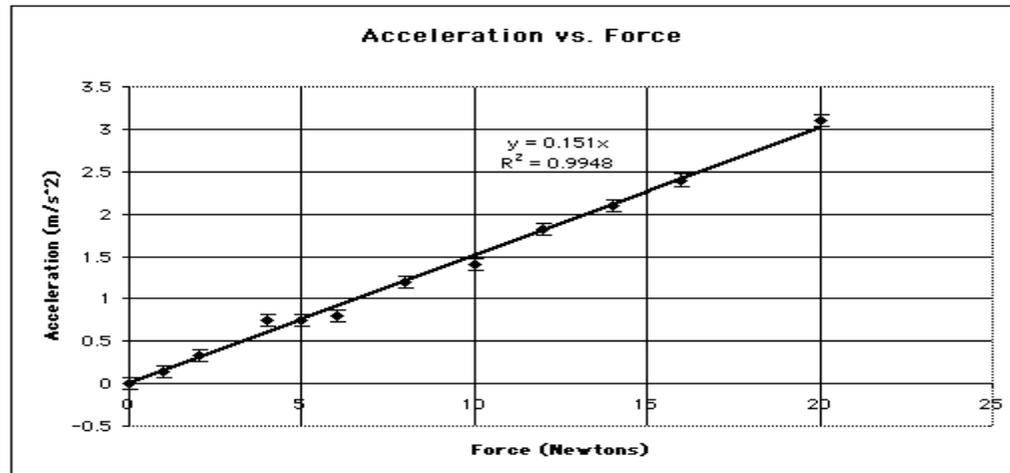


**Sources of error (Determine the percentage error if lab results do not perfectly match the theory)**

Even though this experiment has not included friction, it was present in between the cart's wheels and along the surface of the track. Surface is treated as frictionless, friction is always present everywhere, even if it is regarded as not present. Another force that we excluded was air resistance. During the experiment the windows in the classroom must be closed to avoid blowing wind, changing the air resistance in the room. The change in air resistance might be minor, it is still another source of error that can lead to miscalculation.

The last source of error overlooked is that the car was not always placed in the exact same place on the track. Since it was not placed on the same spot every time, the friction and air resistance was not always exactly the same but still close enough to prove Newton's Second Law.

**Conclusion** From the graph, acceleration increases as the force increases. The mass of the system was kept the unchanging. Therefore force is directly proportional to acceleration

**Answers to theoretical questions on different cognitive levels**

**2.3 Conclusion**

**Activity to reinforce lesson**(Educator may summarise the main aspects of the lesson) [**5 min.**]

**HOMEWORK QUESTIONS/ ACTIVITY** (educator must give learners a few questions to answer at home by either writing them on the chalkboard or giving an exercise from the prescribed textbook) [30 min]

**RESOURCES USED: see apparatus above**

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**Reflection/Notes:**

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| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 5 | TOPIC | Newton's Third Law:  Time 60 mins | Lesson | 3 |
|-------|----|---------|-------------------|------|---|-------|-----------------------------------|--------|---|

| LESSON SUMMARY FOR:  DATE STARTED: | | | DATE COMPLETED: | |
|---|---|---|---|---|

| LESSON OBJECTIVES | At the end of the lesson learners should be able to:<br>• State Newton's third law<br>• Apply Newton's third law in contact and non- contact forces |
|---|---|

## TEACHING and LEARNING ACTIVITIES

**1.    TEACHING METHOD/S USED IN THIS LESSON:**
Induction method, Demonstration method, Question and Answer method

**2.    LESSON DEVELOPMENT**
**2.1  Introduction**

**a)   PRE-KNOWLEDGE**  learners need understanding of the following:
(i)  Force pairs
(ii) Contact and non-contact forces
**b)  BASELINE ASSESSMENT (educator to design a worksheet/ transparency or write questions on the board [preferably a worksheet to save time] to gauge the learners memory of**

**their relevant prior knowledge)**

QUESTIONS for  the **BASELINE ASSESSMENT**  **[5 min]**

i)  What are the two forces acting on the book placed on top of the table?

ii) What is meant by the force pairs?

iii) Define a vector  and describe the vector nature of a force

**Corrections**

i)  Normal force and the weight

ii)  Two forces will be exerted at the same time and the two forces are equal but different in their directions

iii)  A vector is a physical quantity with both magnitude and a direction. The length of the line denotes the magnitude of force and the arrowhead  indicate the direction of the

force.

**Main Body   (Lesson presentation)  [30 min]**
**Newton's Third law**: When two bodies interact by exerting force on each other, these forces are equal in magnitude, but opposite in direction.

If object A exert a force on object B, then object B will simultaneously exert a force of equal magnitude but opposite in direction. The forces are acting at the same time

(simultaneously) and as pairs.
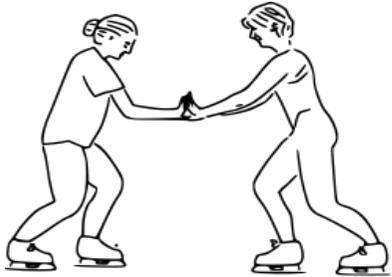
The skaters in the diagram exert forces on each other which are equal in magnitude, but act in opposite directions.

As Skater on the left exert a force on skater on the right, skater on the right will simultaneously exert a force of equal magnitude but opposite in direction (Avoid using action reaction forces since some learners misunderstand and they think one force is applied first and the second force follows later)

www.wikipedia.org

The third law states that for every force there is an equal and opposite force. For example, if you push on a wall, it will push back on you as hard as you are pushing on it. Same principle is used in swimming , rockets launch etc,

Consider the flying motion of birds. A bird flies by use of its wings. The wings of a bird push air downwards. Since forces result from mutual interactions, the air must also be pushing the bird upwards. The size of the force on the air equals the size of the force on the bird's wings; the direction of the force on the air (downwards) is opposite the direction of the force on the bird (upwards).

Consider the following three examples. One of the forces in the mutual interaction is described; describe the other force in the interaction force pair.

Baseball pushes glove leftwards. And the glove is pushing baseball to the right at the same time

**2.2 Learners Activities [15 min]**

2.2.1 a) Which other force can be detected from the diagram below except the force of the air particles on the balloon outwards? Explain
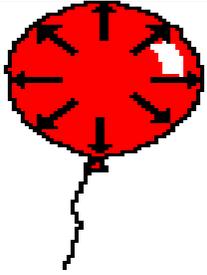
b) Is the force between air particles and the wall of a balloon contact or non-contact force? Motivate your answer.

2.2.2 Consider the interaction depicted below between foot A, ball B, and foot C. The three objects interact simultaneously (at the same time). Identify the two pairs of interacting forces. Use the notation "foot A", "foot C", and "ball B" in your statements.
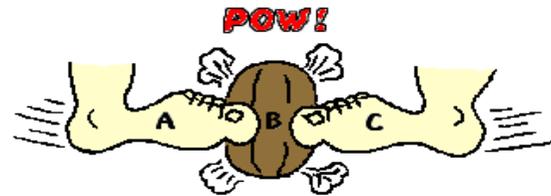
www.wikipedia.org

2.2.3 State Newton's Tird law in words and give example of your own.

2.2.4 Explain with the aid of Newton's third Law how the swimmer is able to move forward in the swimming pool.
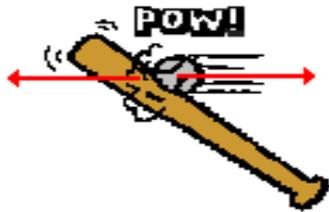
2.2.5 Explain what happens when the baseball hit the bat.

**Corrections**

2.2.1 a) Force of the wall of the balloon pushing air particles inwards. By definition as the air particles push the balloon wall outwards, the balloon wall pushes the air particles with the same force but in the direction opposite that of air particles
b) It is the contact force. The air particles come into physical contact with the wall of the balloon

2.2.2 Force of foot **A** on ball **B** and force of ball **B** on foot **A**

Force of foot **C** on ball **B** and force of ball **B** on foot **C**

2.2.3    Newton's third law states that as the pair of objects interact, they exert forces to each other – these forces are equal in size but the forces  are acting in opposite direction

2.2.4  The swimmer applies the force on the wall, but the wall is at the same time applying a force on the swimmer setting the swimmer into motion. To accelerate or to keep on moving the swimmer exerts the  force pushing water backwards and the water pushes the swimmer forward with the force of equal magnitude but opposite in direction

2.2.5 The baseball hits (exerts) a force on the bat and  the  bat exerts a force of equal magnitude abut different in direction

## 2.3  Conclusion

**Activity to Re-enforce lesson** (Educator may summarise the main aspects of the lesson) [**5 min.**]

**HOMEWORK QUESTIONS/ ACTIVITY** (educator must give learners a few questions to answer at home by either writing them on the chalkboard or giving an exercise from the prescribed textbook) [30 min]

**RESOURCES USED:**
Worksheet

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 5 | TOPIC | Newton's Third Law:  Time 60 mins | Lesson | 4 |
|-------|----|---------|-------------------|------|---|-------|-----------------------------------|--------|---|

| LESSON SUMMARY FOR:  DATE STARTED: | | | DATE COMPLETED: | |
|---|---|---|---|---|

| LESSON OBJECTIVES | At the end of the lesson learners should be able to:<br>• Identify Newton's third law pairs<br>• Refer to Newton's third law  to give reasons for occurrences |
|---|---|

## TEACHING and LEARNING ACTIVITIES

**1.    TEACHING METHOD/S USED IN THIS LESSON:**
Induction method, Demonstration method, Question and Answer method

**2.    LESSON DEVELOPMENT**
**2.1  Introduction**

**a)   PRE-KNOWLEDGE**  learners need understanding of the following:
(i)  Interaction force pairs
(ii)  Newton's third law of motion
**b)  BASELINE ASSESSMENT (educator to design a worksheet/ transparency or write questions on the board [preferably a worksheet to save time] to gauge the learners memory of**

**their relevant prior knowledge)**

**QUESTIONS for  the BASELINE ASSESSMENT  [5 min]**

a)   State Newton's third law of motion

b)   Identify force pairs acting on the donkey pulling a cart. Will the donkey or the cart exert more force to the other? Explain.

c)   A soccer ball is resting on the ground floor at the centre. Identify two forces (interacting pair) acting on the ball and explain why the ball is not moving.

**Corrections**

a)   Newton's 3rd law: When two bodies interact by exerting force on each other, these forces are equal in magnitude, but in opposite direction

b)   Force of the cart on the donkey and the force of donkey on the cart. They exert equal forces to each other. When two bodies interact by exerting force on each other, the
      forces are equal in magnitude, but opposite in direction

c)   Force of the ball on the ground and force of the ground on the ball. The two forces are equal and therefore but in opposite directions.

Therefore these two forces will have a resultant of zero Newton, and that result in no motion

**2.2  Main Body   (Lesson presentation)  [30 min]**

Newton's 3rd law states: When two bodies interact by exerting force on each other, these forces are equal in magnitude, but in opposite direction.

**Example 1**
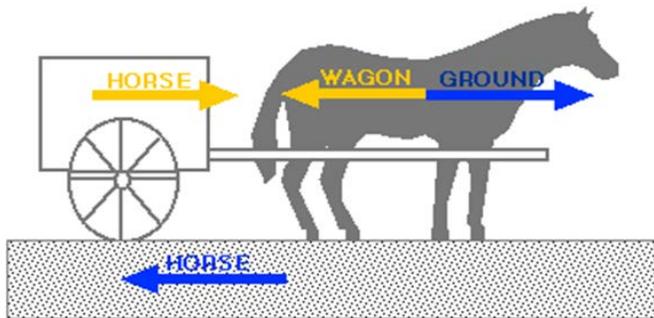


There is a classic problem that physicists like to ask students. A horse is pulling a carriage on a level ground. The horse knows the third law of motion. He tells the carriage that he will exert a force forward, and the carriage will exert a force equal to the horse's force but in opposite directions. Therefore, the horse explained, he can never pull the carriage forward. Can you explain to the horse that he is mistaken? How is he able to pull the carriage forward?

**Solution**

The equal and opposite forces referred to in Newton's third law of motion are acting on different objects. The horse will pull on the cart and the cart will pull on the horse. The cart will have an unbalanced net force acting on it (if neglecting friction) and would accelerate.

**What are the Newton's Third Law Force Pairs?**

The two forces coloured yellow in the diagram are a Newton's Third Law force pair - "horse pulls wagon" and "wagon pulls horse". They are equal in magnitude and opposite in direction.

The two forces coloured blue in the diagram are a Newton's Third Law force pair - "horse pushes ground" and "ground pushes horse". They are also equal in magnitude and opposite in direction.

**Why does the wagon accelerate?**

Newton's 2nd Law says that an object accelerates if there is a net (unbalanced) force on it. Looking at the wagon in the diagram above, you can see that there is just one force exerted on the wagon - the force that the horse exerts on it. The wagon accelerates because the horse pulls on it! The amount of acceleration equals the net force on the wagon divided by its mass (Newton's Second Law).

**Why does the horse accelerate?**

There are 2 forces that push or pull on the horse in the diagram above. The wagon pulls the horse backwards, and the ground pushes the horse forward. The net force is determined by the relative sizes of these two forces.

If the ground pushes harder on the horse than the wagon pulls, there is a net force in the forward direction, and the horse accelerates forward.

**Forward Net Force on the Horse**

WAGON 6 N   GROUND 10 N

Net Force 4 N

**Backward Net Force on the Horse**

WAGON 8 N   GROUND 5 N

Net Force 3 N

If the wagon pulls harder on the horse than the ground pushes, there is a net force in the backward direction, and the horse accelerates backward. (This wouldn't happen on level ground, but it could happen on a hill...)

**NO Net Force on the Horse**

WAGON 5 N   GROUND 5 N
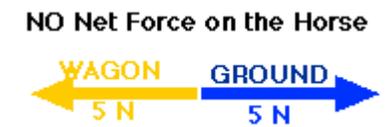
If the force that the wagon exerts on the horse is the same size as the force that the ground exerts, the net force on the horse is zero, and the horse does not accelerate.

In any case, the acceleration of the horse equals the net force on the horse divided by the horse's mass (Newton's Second Law).

**Why does the ground push on the horse, anyway?**

The force "ground pushes horse" is the Newton's Third Law reaction force to "horse pushes ground". These 2 forces are exactly the same size. If the horse wants the ground to push him forward, he just needs to push backwards on the ground.

These two forces do not cancel because they act on different objects. The force "ground pushes horse" tends to accelerate the horse, and the force "horse pushes ground" tends to accelerate the ground.

**What about the ground?**

Looking at the force diagram at the top of the page, you see that there is one horizontal force pushing on the ground - the horse pushes on the ground. Therefore, there is an net force on the ground, so the ground should accelerate. Does it?

Of course it does! However the amount of acceleration equals the size of the net force divided by the mass of the Earth - and the mass of the earth is about $6 \times 10^{24}$ kg. This means

that the acceleration of the ground is much, much too small to notice.

**Example 2**

*"When a rifle shoots a bullet, Newton's Third Law says that the force that the rifle exerts on the bullet is exactly the same size as the force that the bullet exerts on the rifle - yet the bullet gets a **much** greater acceleration than the rifle. How can this be?"*

It is absolutely true that the forces on the rifle and on the bullet are exactly the same size. However, don't forget that <u>Newton's Second Law</u> says that **two factors** affect the acceleration of an object - the <u>net force</u> on it and its mass (<u>inertia</u>).

The acceleration of the bullet equals the force that the rifle exerts on it divided by the mass of the bullet.

The acceleration of the rifle equals the force that the bullet exerts on the rifle divided by the mass of the rifle.

The two forces are equal, but since the mass of the rifle is much greater than the mass of the bullet, the acceleration of the rifle is much less than the bullet's acceleration.

**2.2  Learners Activities  [15 min]**

2.2.1   While a football is in flight, what forces act on it? What are the force pairs while the football is being kicked and while it is in flight?

2.2.2       Assume your team and an opposing team are pulling on a rope in opposite directions. The rope starts accelerating in the direction of the opposing team.

a)       What is the net force on the rope?

b)       Which team is exerting the greater force?

c)       Is there a net force on the rope if the rope is not accelerating, even so each team is pulling as hard as it can?
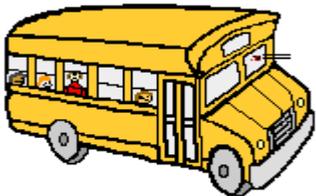
2.2.3  . While driving down the road, a firefly strikes the windshield of a bus and makes a quite obvious mess in front of the face of the driver. Identify the law of motion  and Explain why the firefly died there . Which of the two forces is greater: the force on the firefly or the force on the bus?

.www

2.2.4  Explain, in detail, using the third law of motion, how a person is able to walk forward.

**Corrections**

2.2.1      While in flight, gravity and air friction act on the ball.

          When the ball is being kicked, the earth pulls on the ball downward (gravity), the ball pulls on the earth upward (gravity). The foot pushes the ball forward, the ball pushes the foot backward.

          When the ball is in flight, the earth pulls on the ball downward (gravity), the ball pulls on the earth upward (gravity). The ball pushes the air forward and the air pushes the ball backward.

2.2.2(a)   It is the vector sum of the force of gravity and the forces exerted by the two teams.

    (b)  The opposing team, since the rope starts accelerating in their direction.

    (c)  No, there is no net force. However, there is **tension** in the rope. Tension results from different forces acting on different parts of the body. Tension can break things. A pure
(d) force, i.e. the same force acting on all parts of the body, cannot break things.

▪ If instead of pulling on the rope the two teams push on a heavy rock, but the rock does not move, then again the net force on the rock is zero. However, now the rock is under **compression**.

    2.2.3  This is a clear case of Newton's third law of motion. The firefly hit the bus and the bus hits the firefly . The force with which they hit each other was enough to smash and kill the firefly.

2.2.4  The walker must push off from the ground with both a downward and backward push to the ground from their feet. The opposite force (forward and upward) is returned back to the person from the ground, so the person walks forward.

### 2.3  Conclusion

**Activity to Re-enforce lesson** (Educator may summarise the main aspects of the lesson) [**5 min.**]

**HOMEWORK QUESTIONS/ ACTIVITY** (educator must give learners a few questions to answer at home by either writing them on the chalkboard or giving an exercise from the prescribed textbook) [30 min]

**RESOURCES USED: worksheet**

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 6 | TOPIC | Newton's Law of Universal Gravitation: Time 60 mins | Lesson | 1 and 2 |
|-------|----|---------|-------------------|------|---|-------|------|--------|---------|

| LESSON SUMMARY FOR: DATE STARTED: | | | DATE COMPLETED: | |
|-----------------------------------|--|--|-----------------|--|

| LESSON OBJECTIVES | At the end of the lesson learners should be able to:<br>• State Newton's Law of Universal Gravitation<br>• Calculate the force between two objects with masses  M and m, and  application of the Law |
|-------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

| TEACHING and LEARNING ACTIVITIES |
|----------------------------------|

**1.  TEACHING METHOD/S USED IN THIS LESSON:**
Induction method, Question and Answer method

**2.  LESSON DEVELOPMENT**
**2.1  Introduction**
**a)  PRE-KNOWLEDGE**  learners need understanding of the following:
( i)  Proportionality
(ii)  Force of attraction
**b)  BASELINE ASSESSMENT (educator to design a worksheet/ transparency or write questions on the board [preferably a worksheet to save time] to gauge the learners memory of**

**their relevant prior knowledge)**

QUESTIONS for  the **BASELINE ASSESSMENT**  **[5 min]**

i)    Explain what is meant by "directly proportional" and " inversely proportional"

ii)   If  $F \alpha\ m_1m_2$, as $m_1$ becomes doubled , what will the new force be?

iii)   Convert  50 g into kg

iv)    Is the force of attraction between the earth and the sun a contact or non-contact force? Explain

**Corrections**

i)          Directly proportional implies that when one quantity increased, the other quantity increases in the same ratio(NOT  SAME AMOUNT). And inversely proportional means when
            one quantity is increased, the other quantity  will decreased  in the same ratio

ii)         Force becomes two times bigger ( 2F)

iii)        $50\ g\ =\ \dfrac{50}{1000}kg\ =\ 0{,}05\ kg$

iv)         Non- contact force. The  Earth and the sun are not into the physical contact for them to exert a force on each other, but only exerting a force at a distance

### 2.2 Main Body (Lesson presentation) [30 min]

Newton's law of universal gravitation states that every point mass in the universe attracts every other point mass with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them. It was shown that large spherically symmetrical masses attract and are attracted as if all their mass were concentrated at their centres. Every point mass attracts every single other point mass by a force pointing along the line intersecting both points. The force is proportional to the product of the two masses and inversely proportional to the square of the distance between them:

$$F = G\frac{m_1 m_2}{r^2}$$ where r is replaced by d in CAPS

where:

- $F$ is the force between the masses,
- $G$ is the gravitational constant,
- $m_1$ is the first mass,
- $m_2$ is the second mass, and
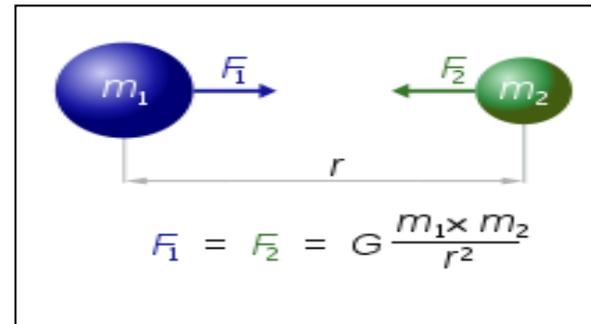
*r or d* is the distance between the centres of their masses.

SI units, F is measured in Newton (N), $m_1$ and $m_2$ in kilograms (kg), r in meters (m), and the constant G is approximately equal to $6.674 \times 10^{-11}$ N m² kg⁻²

From $F = G\frac{m_1 m_2}{r^2}$, it follows that force *F is directly proportional to the product of masses.* **If one mass is doubled,**

from **$F \alpha\, m_1 m_2$,  $F \alpha\, 2m_1 m_2$** then  the force becomes doubled.  **Similarly, If the mass is reduced to half, the force will also be halved,**

Second part of the definition states that *force F is inversely proportionally to the square of  distance between them.*

**$F \alpha \dfrac{1}{r^2}$  If the distance is doubled,   the force will  be  $\dfrac{1}{(2r)^2}$  $= \dfrac{1}{4}x\dfrac{1}{r^2}$.  Meaning the force will become  $\dfrac{1}{4}$  of the original force ,**

**and similarly if the distance is halved, force becomes *four times greater* as compared to force when objects were distance r apart.**

### 2.2 Learners Activities  [15 min]

2.2.1   What is the gravitational force between an object of 3 kilograms of mass and another object of 7 kilograms of mass that are 12 meters apart?

2.2.2    Calculate the force between an object of 9 grams of mass and another of 6 grams that are 50 centimetres  apart.

2.2.3     Determine the force of gravitational attraction between the earth (m = 5.98 x 10²⁴ kg) and a 70-kg physics student if the student is standing at sea level, a distance of 6.38 x 10⁶ m from earth's centre.

2.2.4  Suppose that two objects attract each other with a gravitational force of 16 N. If the distance between the two objects is reduced to half, what is the new force of attraction between the two objects at this new distance?

2.2.5 If the earth and apple falling from the tree are attracting each other with equal forces, why can't the earth move towards an apple?

**Corrections**

2.2.1  $F = G\dfrac{m_1 m_2}{r^2}$

$= 6,67x10^{-11}\dfrac{3x7}{12^2}$

= 9,73 x10⁻¹² N attraction

2.2.2  $F = G\dfrac{m_1 m_2}{r^2}$

$= \dfrac{6,67 \times 10^{-11}x\ 0,009\ \ x\ 0,006}{0,5^2}$

=    1,44  x 10⁻¹⁴  N  attraction

2.2.3                    $F = G\dfrac{m_1 m_2}{r^2}$

$F_{grav} = \dfrac{(6.673 \times 10^{-11}\ N\ m^2/kg^2) \cdot (5.98 \times 10^{24}\ kg) \cdot (70\ kg)}{(6.38 \times 10^6\ m)^2}$

$F_{grav}$ = 686 N

2.2.4  From $F\alpha\ \dfrac{1}{r^2}$ , force will be four times bigger.  64 N

2.2.5 The force is significantly small compared  to the mass of the earth that when the earth is displaced, it goes without notice.

### 2.3  Conclusion

**Activity to Re-enforce lesson** (Educator may summarise the main aspects of the lesson) [**5 min.**]

**HOMEWORK QUESTIONS/ ACTIVITY** (educator must give learners a few questions to answer at home by either writing them on the chalkboard or giving an exercise from the prescribed textbook) [30 min]

**Resources udes:**

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**Reflection/Notes:**

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| Name of Teacher: | | HOD: | |
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| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 6 | TOPIC | Gravitational Forces: Time 60 mins | Lesson | 3 |
|-------|----|---------|--------------------|------|---|-------|-------------------------------------|--------|---|

| LESSON SUMMARY FOR: DATE STARTED: | | DATE COMPLETED: | |
|-----------------------------------|--|-----------------|--|

| **LESSON OBJECTIVES** | At the end of the lesson learners should be able to:<br>• Discuss force between two masses on each other<br>• Define gravitational field strength on or near the earth's surface<br>• Define the weight of an object near the earth's surface |
|------------------------|---|

## TEACHING and LEARNING ACTIVITIES

1. **TEACHING METHOD/S USED IN THIS LESSON:**
Induction method, Demonstration method, Question and Answer method

2. **LESSON DEVELOPMENT**
**2.1 Introduction**
**a) PRE-KNOWLEDGE** learners need understanding of the following:
(i) Forces of attraction and repulsion
(ii) Gravity
**b) BASELINE ASSESSMENT (educator to design a worksheet/ transparency or write questions on the board [preferably a worksheet to save time] to gauge the learners memory of their relevant prior knowledge)**

QUESTIONS for the **BASELINE ASSESSMENT** **[5 min]**

i) Why do objects always fall downwards when thrown upward near the earth surface?

ii) Between the heavier and the lighter object, which one will fall quickly in a vacuum? Why do objects of unequal mass fall at different rate in air?

iii) What is the difference between weight and mass of an object?

**Corrections**

i) They are attracted towards the centre of the earth with a force of gravity. Objects near the earth surface experience more of this force and accelerate towards the centre of the earth.

ii) They will fall at the same time in a vacuum since there is no air resistance. In the presence of air resistance, lighter objects experience more air resistance (friction) and therefore the rate at which they fall is slower.

iii) Weight is a vector quantity which is the same as the product of inertial mass multiplied by gravitational acceleration. Mass is the measure of how difficult or easy will it be to change the object's state of rest or state of motion

### 2.2 Main Body (Lesson presentation) [30 min]

Any two objects with mass exert a **gravitational attractive force** on each other. This is an example of "force at a distance" (NON-CONTACT ) force, where the force between a pair of interacting objects is not dependent on any contact between the objects.

**A GRAVITATIONAL** FIELD exists wherever a **mass** experiences a f**orce** due to the presence, somewhere in space, of another mass.

$g = \dfrac{F}{m}$ from gravitational field strength and $g = 9{,}8 m \cdot s^{-2}$ on or near the earth's surface.

For example, the earth sets up a gravitational field, this is evident by the fact that objects are attracted to the centre of earth. Similarly, the sun has a gravitational field that keeps the planets in elliptical orbits around it.

The strength of the gravitational field will depend on the distance from the object setting up the field and the mass of that object. Every particle in the universe, however small, sets up a gravitational field, whose strength depends on the distance from the particle and its mass. The strength of the gravitational field at any point is the force that field exerts on test body of unit mass.

If it is postulated that the **inertial mass** and **the gravitational mass** are the same, then the acceleration due to gravity may be calculated by equating the weight of an object to the force exerted on the object by the earth's gravitational field:

$$mg = G\frac{Mm}{R^2}$$
$$\text{hence } g = GM/R^2$$

where **M** is the mass and **R** is the radius of the earth, and **m** is the mass of the object.

From this it is clear that the <u>**acceleration due to the earth's gravitational field is independent of the mass of the object**</u>.

The weight of an object is the force on the object due to gravity. Its magnitude (a scalar quantity), often denoted by an letter *W (Italic)*, is the product of the mass m of the object and the magnitude of the **local** gravitational acceleration g (meaning different planets will have different gravitational acceleration). Thus: W = mg. **NB. Gravitational acceleration is always acting downwards (towards the centre of earth) and it is independent of the mass of an object. Weight is the force that the earth exerts on the object on or near the surface of the earth.** When considered a vector, weight is often denoted by the letter **W (**bold**)**. The unit of measurement for weight is that of force, which in the International System of Units (SI) is the Newton (N).

For calculations and exam purpose, gravitational acceleration (g) = 9,8 m·s⁻²

**Example**

If man has a mass of 70 kg, What is his weight on Earth?

**Solution**

W = mg

W = (70 kg)(9.8 m/s2)

= 686 N. downwards

**2.2 Learners Activities  [15 min]**

2.2.1 Define weight and give its unit of measurement

2.2.2  Is  gravitational force a contact or non -contact force? explain

2.2.3   What is the difference between mass and weight?

2.2.4  Discuss force between two masses on each other

2.2.5  If the man's weight is 490 N on earth, calculate his weight on the moon that has a gravitational acceleration $\frac{1}{6}$ the gravitational acceleration of the earth.

**Corrections**

2.2.1   Weight is the force that the earth exerts on the object on or near the surface of the earth.  It is measured in Newton.

2.2.2   Gravitational force is a non-contact force since the surfaces of the two objects are not physically in contact

2.2.3    Mass is an inherent property measuring the amount of a substance; weight is the gravitational force acting on an object.

2.2.4   Gravitation is the phenomenon that between every two objects there is a force of attraction. **Newton's law of universal gravitation** describes the behaviour of this force.
Between any two point masses $m_1$ and $m_2$, the magnitude of the gravitational force on each mass due to the other is given by :

$$F = G \frac{m_1 m_2}{r^2},$$

where r is the distance between the two masses and **G** is a constant called the universal gravitational constant

2.2.5  The mass of the man on earth  $W = mg \quad \therefore m = \dfrac{W}{g}$

$$= \frac{490}{9,8}$$

$$= 50 \ kg$$

His weight I moon   $W = mg$
                 $=50 \times 1/6 \times 9,8$
                   $= 81,67 \ N$

*2.3* **Conclusion**

**Activity to Re-enforce lesson** (Educator may summarise the main aspects of the lesson) [**5 min.**]

**HOMEWORK QUESTIONS/ ACTIVITY** (educator must give learners a few questions to answer at home by either writing them on the chalkboard or giving an exercise from the prescribed textbook) [30 min]

**RESOURCES USED:**

Reflection/Notes:

| Name of Teacher: | | HOD: | |
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| Date: | | Date: | |

| GRADE | 11 | SUBJECT | PHYSICAL SCIENCES | WEEK | 7 | TOPIC | CHEMICAL BOND AS EXPLAIN BY LEWIS THEORY<br>Time: 60 minutes | Lesson | 1 |
|---|---|---|---|---|---|---|---|---|---|

| LESSON SUMMARY FOR:  DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|
| **LESSON OBJECTIVES** | The following results will be the outcome of the lessons: The learners will be able to:<br>• draw Lewis diagrams for simple molecules<br><br>• draw  Lewis diagrams  for  molecules with multiples bond | | |

| TEACHER ACTIVITIES | LEARNER ACTIVITIES | TIMING | RESOURCES NEEDED |
|---|---|---|---|
| 1.  **Teaching Methods:**<br><br>Telling, Explanation, Question and Answer, etc.<br>2.  **Lesson Development**<br>2.1  **Introduction:**<br>a.  Pre-knowledge required for the Lewis diagram lesson:<br>• Knowledge of Lewis diagram for atoms<br>• Knowledge of Lewis diagram for covalent bond using hydrogen atom.<br>b.  Baseline assessment:<br>•  Refer to the learner activity column.<br>c.  Do corrections on chalk board, explain and clarify the common mistakes.<br>2.2  **Main Body (Lesson Presentation):**<br>a.  Guide learners to draw Lewis diagram for simple molecules e.g. water, ammonia, methane | 1.  **Baseline:**<br>1.1  Draw Lewis diagram for the following: H, Na, C, O, S<br>1.2  Draw Lewis diagram for $H_2$<br><br>2.  **Lesson Presentation:**<br>2.1  Write Lewis diagram for the following: HF, HOCl<br><br>2.2  Draw Lewis diagram for the following: ethane($C_2H_4$), carbon dioxide($CO_2$)<br><br>2.3  draw Lewis diagram for the following: ethyne($C_2H_2$), HCN<br><br>3.  **Homework:**<br>3.1  Draw Lewis for the following molecules:<br>o  $OCl_2$<br>o  $CS_2$<br>o  $N_2$<br>o  $NH_3$ | - Baseline: 5 min<br>- Correction:10 min<br>- Lesson presentation/Exercise: 40 min<br>- Conclusion: 5 min<br>Homework: 20 min | • Periodic table<br>• Grade 11 Physical Sciences Textbook<br>• Charts<br><br>**Chalkboard summary**<br>• Chalks |
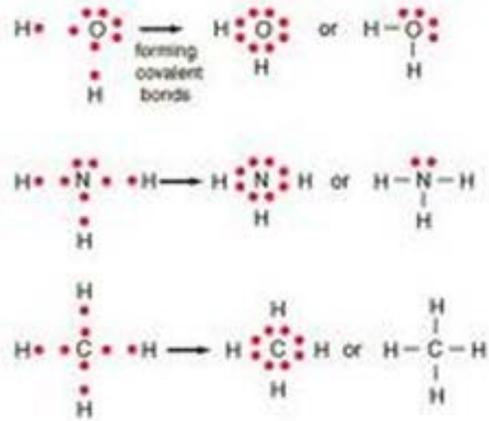
b. Ask learners to write Lewis diagrams for the following simple molecules e.g. HF, HOCl,

c. Explain to learners that some atoms need two or three electrons to complete their octet. Accordingly they are classified as:

- Double bonds - two electron pairs
- Triple bonds – three electron pairs

d. Explain how oxygen forms diatomic covalent bond e.g. 2 oxygen atoms share to two electrons each and thus complete their octet. They form covalent double bond.
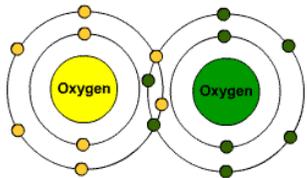


each oxygen has 8 electrons in the valence shell

e. Ask learners to draw Lewis diagram for the following: ethane($C_2H_4$) , carbon dioxide($CO_2$)

f.  Explain how nitrogen forms covalent triple bond e.g. nitrogen has 5 valence electrons hence need 3 more electrons to complete its octet. So, it combines with another nitrogen atom. They share 3 electrons each and complete they octet forming covalent triple bond.



g.  Ask learners to draw Lewis diagram for the following: ethyne($C_2H_2$), HCN

h.  **Conclusion:**

*   Revise the following concepts:

o   Lewis digrams for simple molecules.

o   Lewis digrams for molecules with multiples bond.

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
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| Date: | | Date: | |

| GRADE | 11 | SUBJECT | PHYSICAL SCIENCES | WEEK | 7 | TOPIC | BOND FORMATION<br>Time: 60 mins | Lesson | 3 |
|---|---|---|---|---|---|---|---|---|---|

| LESSON SUMMARY FOR: DATE STARTED: | | | DATE COMPLETED: | |
|---|---|---|---|---|
| **LESSON OBJECTIVES** | The following results will be the outcome of the lessons: The learners will be able to:<br>• describe and apply simple rules to deduce bond formation, viz.<br><br>o different atoms, each with an unpaired valence electron can share these electrons or form a chemical bond<br><br>o different atoms with paired valence electrons called lone pairs of electrons, cannot share these four electrons and cannot form a chemical bond<br><br>o different atoms, with unpaired valence electrons can share these electrons and form a chemical bond for each electron pair shared (multiple bond formation)<br><br>o atoms with an incomplete complement of electrons in their valence shell can share a lone pair | | | |

| TEACHER ACTIVITIES | LEARNER ACTIVITIES | TIMING | RESOURCES NEEDED |
|---|---|---|---|
| 1. **Teaching Methods:**<br>Telling, Explanation, Question and Answer, etc.<br>2. **Lesson Development**<br>2.1 **Introduction:**<br>a. Pre-knowledge required for the lesson:<br>• Knowledge of Lewis diagram for molecules with multiple bonds.<br>b. Baseline assessment:<br>• Refer to the learner activity column.<br>c. Do corrections on chalk board, explain and clarify the common mistakes.<br>2.2 **Main Body (Lesson Presentation):**<br>a. Explain to learners that an unpaired electron in an orbital is unstable and this is a reason for the formation of chemical bond. If two atoms, each with unpaired electron come close together, the orbitals containing the unpaired electrons overlap and a bond is formed. | 1. **Baseline:**<br>1.1 Draw Lewis for the following molecules:<br><br>o $OCl_2$<br><br>o $O_2$<br><br>o $N_2$<br><br><br>2. **Lesson Presentation:**<br>2.1 Explain what a lone pair of electron is.<br>2.2 Describe how a chemical bond is formed in water ($H_2O$). | -Baseline: 5 min<br>-Correction:10<br>-Lesson presentation/Exercise:<br>40 min<br>-Conclusion:<br>5 min<br>Homework:<br>20 min | • Grade 11 Physical Sciences Textbook<br>• Charts<br><br>**Chalkboard summary**<br>• Chalks |

blue X - valence electron from hydrogen;
red dot = valence electron from chlorine
[alextech / 4F eb2007]

● Electron from hydrogen
● Electron from carbon
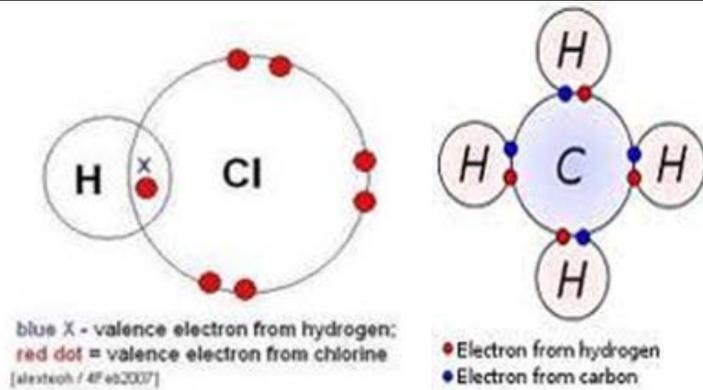
b.  Explain to learners different atoms with paired valence electrons called lone pairs of electrons, cannot share these four electrons and cannot form a chemical bond.

c.   Explain how different atoms, with unpaired valence electrons can share these electrons and form a chemical bond for each electron pair shared (multiple bond formation).
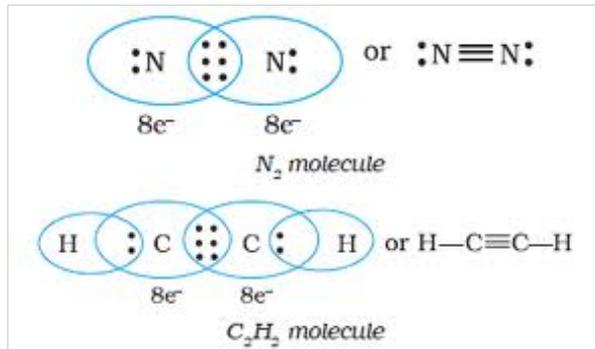


d.   Explain how atoms with an incomplete complement of electrons in their valence shell can share a lone pair

2.3 **Conclusion**:

● Revise the following concepts:

2.3   Apply the rule for bond formation and draw Lewis diagram for the following:
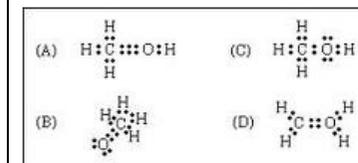
● $CO_2$

● $C_2H_2$

 **Home Work:**

Draw Lewis diagram for the following applying rules of bond formation:

● $H_2$

● $Cl_2$

● $SO_3$

Deduce from the following bond how each of these atoms is bonded.

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
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| Date: | | Date: | |

| GRADE | 11 | SUBJECT | PHYSICAL SCIENCES | WEEK | 7 | TOPIC | BOND ENERGY & STRENGTH<br>Time: 60 mins | Lesson | 3 |
|---|---|---|---|---|---|---|---|---|---|

| LESSON SUMMARY FOR:  DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|
| **LESSON OBJECTIVES** | The following results will be the outcome of the lessons: The learners will be able to:<br>• explain what is meant by bond strength<br>• describe ways in which atoms in a molecule can move (vibrate) relative to each other<br>•  explain the relationship between strength of bond between two chemically bonded atoms and<br>o   the length of the bond between them<br><br>o   the size of the bonded atoms<br><br>o   the number of bonds (single, double, triple) between the atoms | | |

| TEACHER ACTIVITIES | LEARNER ACTIVITIES | TIMING | RESOURCES NEEDED |
|---|---|---|---|
| **1.   Teaching Methods:**<br>Telling, Explanation, Question and Answer, etc.<br>**2.   Lesson Development**<br>**2.1   Introduction:**<br>a.   Pre-knowledge required for the lesson:<br>•   Knowledge of subatomic particles and their charges.<br>•   Knowledge of like and unlike charges.<br>b.   Baseline assessment:<br>•    Refer to the learner activity column.<br>c.   Do corrections on chalk board, explain and clarify the common mistakes.<br><br><br><br><br><br>**2.2   Main Body (Lesson Presentation):**<br>a.   Explain bond length. Tell learners that when the two atoms approach one another | **1.   Baseline:**<br>1.1   State the subatomic particles and their charges.<br>1.2   Explain what happen when two like charges approach each other.<br>1.3   Explain what happen when two unlike charges approach each other.<br><br>**2.   Lesson Presentation:**<br>2.1    What do they notice when the atoms are far apart at point 1?<br>2.2   What do they notice when as the atoms approach each other?<br>2.3   What is the possible reason for the lowest potential energy at | - Baseline: 5 min<br>- Correction:10 min<br>- Lesson presentation/Exercise: 40 min<br>-Conclusion: 5 min<br>Homework: 20 min | •   Periodic table<br>•   Grade 11 Physical Sciences Textbook<br>•   Charts<br><br>**Chalkboard summary**<br>•   Chalks |

the electron clouds can overlap. When this happens, under certain circumstances, the electrons that are between two nuclei can be attracted to both nuclei, holding them together. The force of attraction is known as **chemical bond**.

The electrons experience a force of attraction from both nuclei. This negative - positive - negative attraction holds the two particles together

Electron cloud (Negative)
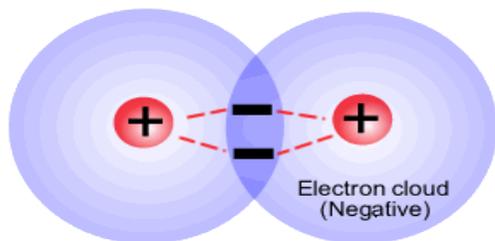
This attraction is called a chemical bond one pair of electrons constitutes ONE bond

b.  Explain bond length. Tell learners that when the bond is form a distance of separation is reached when the force of repulsion equals the force of attraction between the two atoms. This distance of separation is known as the **bond length**.

c.  Explain bond energy. Tell learners that amount of energy that an external energy must be transfer to the system in order to break the bond between the two atoms.

d.  Guide learners to interpret how the potential energy of a system of two hydrogen (H) atoms changes during the formation of hydrogen ($H_2$) molecules. Ask question such as:

*   What do they notice when the atoms are far apart at point 1?

*   What do they notice when as the atoms approach each other?

*   What is the possible reason for the lowest potential energy at point 3?

point 3?

2.4  Define the term bond strength.

2.5  Define the term bond energy.

2.6  Explain why H –F bond is stronger than the H – I bond.

3.  **Homework:**

3.1  Explain the following statement:

*   The H – I bond is stronger than the    I – I bond.

*   The O = O is stronger than the H – O bond.

*   The H – F bond is stronger than the    H – I bond.
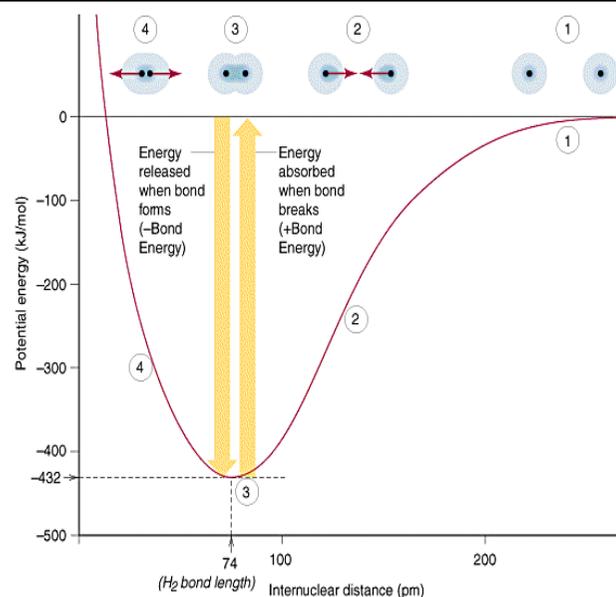
e. Explain what bond strength is. Explain the factors that influence the strength of the chemical bond.

- The type of bond e.g. the double bond (C = N) between two atoms is stronger than a single bond (C – N) between the same atoms
- The polarity of the bond e.g. polar bonds is stronger than the non-polar bond.
- Bond length e.g. the bond length increases with increase in the atomic radii. The smaller the bond length, the stronger is the bond. That is why H - H bond is stronger than C – C bond, stronger than double bond N=N.

### 2.3 Conclusion:

- Revise the following concepts:
  o Bond strength
  o Bond length
  o Factors that influences the bond strength

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | PHYSICAL SCIENCES | WEEK | 7 | TOPIC | ELECTRO-NEGATIVITY Time: 60 minutes | Lesson | 4 |
|---|---|---|---|---|---|---|---|---|---|

| LESSON SUMMARY FOR: DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|

| LESSON OBJECTIVES | The following results will be the outcome of the lessons: The learners will be able to:<br>• explain the concept electro-negativity.<br>• explain the concept polar and non-polar with examples.<br>• show polarity of bonds using partial charges.<br>• compare the polarity of chemical bonds using a table of electro-negativities<br>• show how polar bonds do not always lead to polar molecules. |
|---|---|

| TEACHER ACTIVITIES | LEARNER ACTIVITIES | TIMING | RESOURCES NEEDED |
|---|---|---|---|
| 1. **Teaching Methods:**<br>Telling, Explanation, Question and Answer, etc.<br>2. **Lesson Development**<br>2.1 <u>Introduction:</u><br>a. Pre-knowledge required for the lesson:<br>• Knowledge of Lewis diagram and Couper notation.<br>• Knowledge of valence electrons and octet rule.<br>• Knowledge of covalent and ionic bond.<br>b. Baseline assessment:<br>• Refer to the learner activity column.<br>c. Do corrections on chalk board, explain and clarify the common mistakes.<br>2.2 <u>Main Body (Lesson Presentation):</u><br>a. Introduce the concept using analogy e.g. in a tug-of–war the side with more people pulling the rope wins because it exert more force. This is exactly what happened in an atom. In bond between atom, when atom form a covalent bond they share a pair of electrons between them. This pair of electrons has a tendency to shift slightly to the atom with more | 1. <u>Baseline:</u><br>1.1 Draw the Lewis structure for each of the following substances: $N_2$, $H_2$, $NH_3$ and $CO_2$.<br>1.2 Explain how covalent bond is form $H_2$ and NaCl.<br><br>2. <u>Lesson Presentation:</u><br>2.1 Determine which one of the following atom is electro-negative in the following: HCl, CH, SCl, OH<br>2.2 Analyse the electro-negativity values on the periodic table.<br>2.3 Determine whether the | - Baseline: 5 min<br>- Correction:10 min<br>- Lesson presentation/Exercise: 40<br>- Conclusion: 5 min<br>Homework: 20 min | • Periodic table<br>• Grade 11 Physical Sciences Textbook<br>• Charts<br><br><u>Chalkboard summary</u><br>• Chalks |

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protons. The more the number of proton the more the atomic pull toward that atom. Such an atom is electro-negative because it pulls electron pairs.

b. Explain the term electro-negativity. Explain the tendency of hydrogen chloride (HCl) to share pair of electron (the chlorine nucleus has more proton than the hydrogen nucleus. So it pulls the electron pair towards it side hence chlorine is electro-negative).



Fig. 2.5. Transfer of electron pair towards more electronegative chlorine
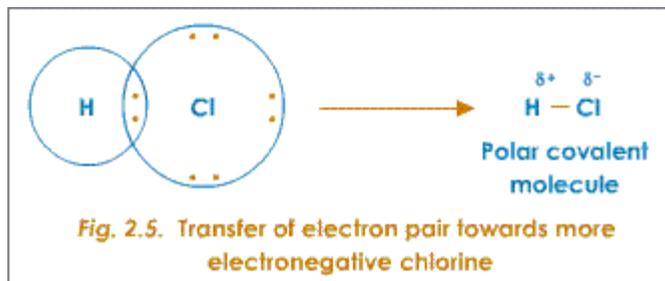
c. Ask learners to determine which one of the following atom is electro-negative e.g. HCl, CH, SCl, OH,

d. Analyse the periodic table with learners and help them to identify the electro-negativity values. Ask questions such as:
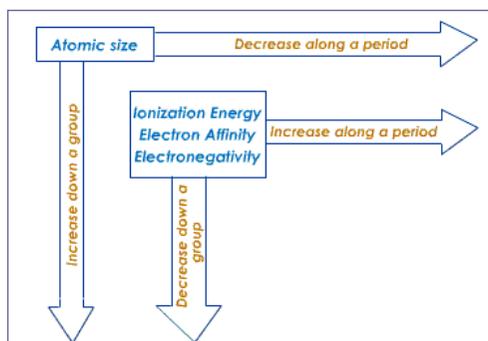


- What happens to the electro-negativity values from left to right across the period?
- What happens to the electro-negativity values from top to bottom in the group?

following molecules are polar or not:

o  $NH_3$

o  $BeCl_2$

o  $BF_3$

3.  **Homework:**

3.1  Refer to the Periodic Table, indicate the polarity of the following bond.

- C – H

- O – Br

- N – H

- F – C

- C – S

3.2 Using the Periodic Table, arrange the following bonds in order of increasing polarity.

- H – Cr

- Al – Cl

- S – Cl

- B – Cl

3.3 Determine whether the following molecules are polar or not.

| | |
|---|---|
| • Which element has the highest electro-negativity value? | • BeCl$_2$ |
| e. Explain to learners how to determine the polarity of a bond base on the electro-negativity of the atoms forming the bond. | • PCl$_5$ |
| | • CH$_3$OCH$_3$ |
| • Non-polar bonds: e.g. H$_2$ is non-polar because the two atoms are identical, there is even or symmetrical distribution of charge. The electro-negativity between the two atoms is zero. H – H | |
| • Polar bonds: e.g. HCl is polar because the atoms have different electro-negativities. The charge distribution is slightly uneven, or unsymmetrical. | |
| **2.3 Conclusion:** | |
| • Revise the following concepts: | |
| o Electro-negativity | |
| o Polar bond | |
| o Non-polar bond | |

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

    

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 8 | TOPIC | Intermolecular forces: Intermolecular forces and interatomic forces (chemical bonds). | Lesson | 1 |

| LESSON SUMMARY FOR:  DATE STARTED: | | DATE COMPLETED: | |

| LESSON OBJECTIVES | **At the end of the lesson learners should:**<br>• Have revised the concept of a **covalent molecule**.<br>• Be able to describe the difference between **intermolecular forces** and **interatomic forces** by using a diagram of small molecules and in words.<br>• Understand the importance of forces between molecules and the significant role that it plays in the physical properties of chemical substances. |

## TEACHING and LEARNING ACTIVITIES

1. **TEACHING METHOD/S USED IN THIS LESSON:**
Question and answer, explanation, demonstration

2. **LESSON DEVELOPMENT**

2.1. **Introduction [5 min]**

• Educator explains the fact that physical properties allow us to classify and identify chemical substances.

• Physical properties are: colour, state of matter, melting and boiling point, density, solubility, electric and heat conductivity, volatility, surface tension, viscosity and capillary action.

• Educator demonstrates a few of the physical properties of different substances, e.g. compare the boiling points of water and pentane (or any non-polar organic substance); compare the viscosity of olive oil and water; compare the shiny surface of metals with the dull colours of ionic salts – the demonstration depends on the availability of chemicals in the school laboratory.

**PRE-KNOWLEDGE**
A basic understanding of the following:

• The difference between atoms, ions and molecules.
• The meaning of electronegativity ($\chi$, chi) that determines the polarity of a bond.
• Sharing or transfer of electrons by atoms in order to obtain a noble gas structure. (Covalent bond and ionic bond models).
• The important role of molecular geometry in determining the polarity of a single molecule.

2.2. **Main Body   (Lesson presentation)  [30 min]**

• Atoms of non-metal elements bond by sharing electrons – covalent bonds are formed. In the example below, two H-atoms each provides an electron for sharing between the two nuclei.
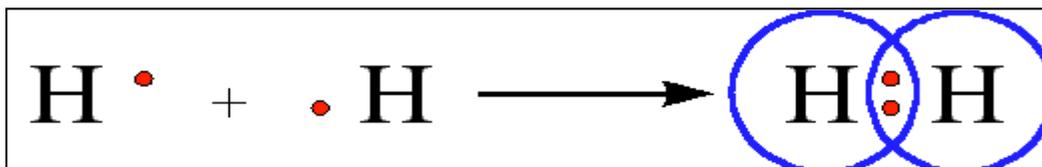
- The covalent bond is considered as an **interatomic force**. The product is a single small molecule.

- Covalent bonds are exceptionally strong and require a great amount of energy to be broken.

- The significant difference in the physical properties of molecular substances is closely related to the difference in the forces between their molecules. These forces are called **intermolecular forces**. It is important to understand the difference between intermolecular forces and interatomic forces (Also called intra-molecular forces).

- Molecules can be polar or non-polar.

- The polarity of a molecule is determined by two factors:

  ✓ The electronegativity of the bonds between atoms.

  ✓ The geometry (shape) of the molecule.
- The electronegativity difference of the two single bonds between the O-atom and the two H-atoms in the $H_2O$-molecule is determined as follows:
  $\Delta \chi = 3,5 - 2,1 = 1,4$ The two bonds are polar and because the molecule has an angular shape, there is a nett dipole molment in the molecule. The O – end of the molecule is $\delta^-$ and the H – end of the molecule is $\delta^+$. The water molecule can be considered as a polar molecule. Information about the dipole moment of a molecule is important to determine the type of bond between the molecules.
- **Non-polar molecules** have no net dipole moment.
  In **polar molecules** there are a positive and a negative end causing a definite dipole moment.
- **Ions** are negatively charged (anions) or positively charged (cations).
- Examples of simple molecules are: $H_2(g)$, $O_2(g)$, $CO_2(g)$, $NH_3(g)$, $H_2O(\ell)$, $I_2(s)$.
- The symbols in brackets refer to the phase (gas, liquid or solid) of the substance at a specific temperature.
- In the liquid and solid phases, the molecules are kept together with **intermolecular** forces. Although there are different types of intermolecular forces, they are all **electrostatic** and result from electrostatic attractions and repulsions between positive nuclei and negative electrons.
- The diagram of a number of water molecules can be used to explain the difference between interatomic- and intermolecular forces.
  - Each molecule consists of an oxygen atom and two hydrogen atoms. These non-metal atoms are bonded with strong covalent bonds:        Covalent bonds are **interatomic** forces.
  - The molecules are bonded with hydrogen bonds
  - Hydrogen bonds are **intermolecular forces**.
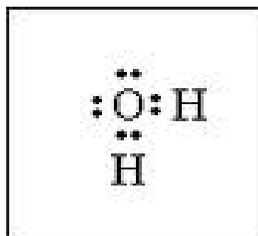
| Lewis structure of a $H_2O$-molecule | Hydrogen bond between two polar $H_2O$ molecules | Interatomic- and intermolecular forces between groups of $H_2O$-molecules |
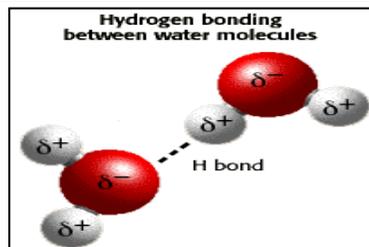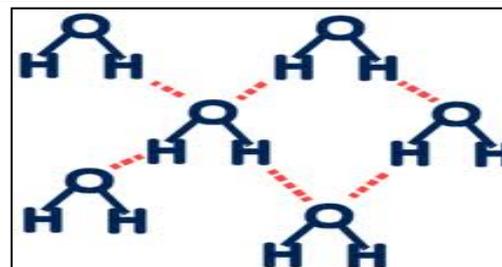
- The diagram below shows water molecules in the three different phases:

Solid                    Liquid                    Gas



- The size of the atoms in a molecule (determined by atomic mass) plays an important role in the strength of intermolecular forces. Alkanes like methane ($CH_4$) and octane ($C_8H_{18}$) consist of H-atoms and C-atoms, but methane is in the gaseous phase at room temperature, while octane is a liquid. Both these molecules are non-polar and bonded with similar intermolecular forces, but the bonds in octane (molar mass: 114 g·mol$^{-1}$) are stronger than in methane (molar mass:16 g·mol$^{-1}$).
- The following elements and molecules can also be used as examples to explain the influence of atomic and molecular size on the strength of intermolecular forces:

   He(g), $O_2$(g), $C_8H_{18}$($\ell$) (petrol) and $C_{23}H_{48}$(s) (wax)

**LEARNER ACTIVITY**[15 min]

**CLASSWORK ACTIVITY**

1    Explain the difference between interatomic and intermolecular forces.
2    Classify covalent bonding as an interatomic- or intermolecular force.
3    Which one of the two forces mentioned in question 1 is the strongest?
4    It is possible that only interatomic forces can be present in crystal lattice. A macro molecule is formed.
   a    Give two examples of macro molecules.
   b    In which phase will macro molecular structures most probably be at room temperature? (25 $^0$C)?
   c    Give a reason for your answer in question 4 b.

5    Are the physical properties of matter related to interatomic - or intermolecular forces?

**ANSWERS for the CLASSWORK ACTIVITY**

1.    Interatomic forces are covalent bonds. These forces are extremely strong and need a great amount of energy to be broken. Intermoleculer forces exist between molecules and vary from very weak to relative strong forces.

2.    Interatomic forces.

3.    Interatomic forces.

4.

   a.    Diamond; graphite

   b.    In the solid phase

   c.    The forces that bond the atoms in the giant structure together, are covalent bonds, which are very strong bonds.

5.    Intermolecular properties

**2.3    Conclusion [10 min]**

- Educator discusses the answers of the classwork activity.

**HOMEWORK ACTIVITY**

1    Noble gases are considered as stable particles that don't partake in chemical bonding. How is it possible that these gases can exist in the liquid phase at low temperatures?

2    Water boils at 100 $^0$C compared to ethanol that has a boiling point of 78,3 $^0$C.

   a    Is the difference in boiling points related to a difference in intra- or intermolecular forces?

   b    In which of the two liquids are the forces the strongest? Explain your answer.

3    In the table below, covalent bonds are present in substances P, Q, R and S.

| Substance | Melting point ($^0$C) | Boiling point ($^0$C) |
|-----------|----------------------|----------------------|
| P | -125 | -90 |
| Q | 5 | 170 |
| R | 2200 | 3900 |
| S | 55 | 325 |

   a    Which substance is a giant molecule? Explain.

   b    Which substance is a gas at room temperature?

   c    Which substance is a liquid at room temperature?

   d    Which of the substances have the weakest intermolecular forces? Explain your choice.

**HOMEWORK QUESTIONS/ ACTIVITY** Educator can choose any appropriate homework activity from one of the prescribed text books or use the activity provided in the lesson plan.

**Recourses:** Models to explain the difference between interatomic and intermolecular forces, power point presentation, and transparencies; prescribed text books, CAPS-document (page 71, 72).

**NOTE: The following experiment is prescribed for formal assessment:**

Investigate and explain the effects of intermolecular forces on evaporation, surface tension, solubility, boiling points and capillarity.

Use the guidelines in Oxford Successful Physical Sciences Grade 11 p 95 and complete the five individual experiments in consecutive lessons

Learners can complete the write-up once all the experiments have been done.

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 8 | TOPIC | Intermolecular forces: Intermolecular forces and interatomic forces (chemical bonds). | Lesson | 2 |
|-------|----|---------|-------------------|------|---|-------|--------------------------------------------------------|--------|---|

| LESSON SUMMARY FOR:  DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|

| **LESSON OBJECTIVES** | **At the end of the lesson learners should:**<br>• Be able to name and explain different intermolecular forces: ion-dipole forces; ion-induced dipole forces; dipole-dipole forces, dipole-induced dipole forces, induced dipole forces, hydrogen bonds.<br>• Understand that the term **Van der Waals forces**, includes dipole-dipole forces, dipole-induced dipole forces and induced dipole forces.<br>• Be able to explain hydrogen bonds as a special case of dipole-dipole forces. |
|---|---|

## TEACHING and LEARNING ACTIVITIES

1. **TEACHING METHOD/S USED IN THIS LESSON:**
Question and answer, explanation

2. **LESSON DEVELOPMENT**

2.1. **Introduction [10 min]**

Educator discusses the homework activity and provides the correct answers.

**ANSWERS TO HOMEWORK ACTIVITY**

1. Weak intermolecular (interatomic) forces exist between the atoms of a noble gas at low temperatures.

2.
   a. Intermolecular forces.
   b. In water. The higher boiling point of water indicates that more energy is needed to break the stronger intermolecular forces between water molecules.

3.
   a. P – The melting and boiling points are low. This indicates weak intermolecular forces.
   b. P
   c. Q
   d. P – Lowest melting and boiling points indicate that only a small amount of energy is needed to break the intermolecular forces – forces are therefore weak.

**PRE-KNOWLEDGE**
A basic understanding of the following:

• An understanding of the difference between interatomic forces and inter molecular forces.
• The different interatomic forces: ionic bonds, metallic bonds and covalent bonds.
• The difference between atoms, ions and molecules (polar and non polar).

2.2. **Main Body   (Lesson presentation)  [40 min]**

• Interatomic forces are stronger than intermolecular forces.
• When the bonds between **atoms** (interatomic forces) are broken, the **chemical properties** of the compound are changed.

$$2H_2O(\ell) \longrightarrow 2H_2(g) + O_2(g)$$

H - atom

O - atom
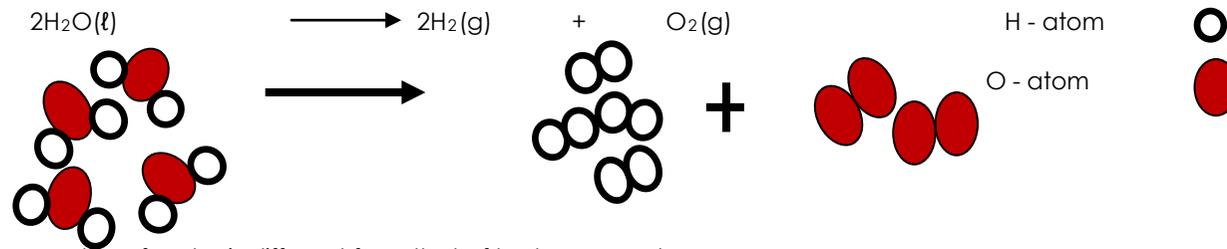
The properties of water is different from that of hydrogen and oxygen

- When intermolecular forces are broken, there is a change in the **physical properties** of the compound.

$$H_2O(s) \longrightarrow H_2O(g)$$
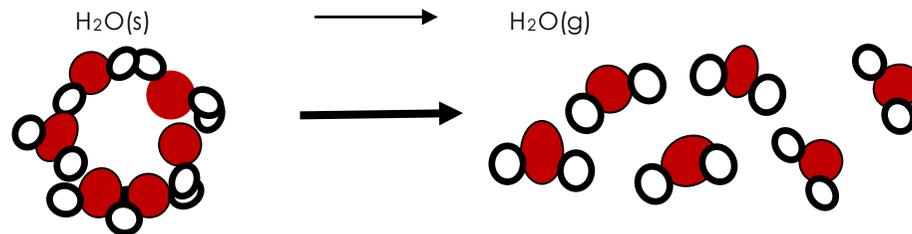
- The polarity of molecules determines the strength of the different intermolecular forces. These forces include:
  - ✓ Ion-dipole interactions
  - ✓ Ion-induced dipole interactions
  - ✓ Van der Waals forces
    - ▪ dipole-dipole interactions  (hydrogen bonds as a special case of dipole-dipole interaction)
    - ▪ dipole-induced dipole interactions
    - ▪ induced dipole interactions
- **Ion-dipole interaction**

  The distribution of bonding electrons in a molecule often results in a permanent dipole moment. Polar molecules therefore have positive and negative ends and when a polar molecule and ionic compound are mixed, the negative end of the dipole will be attracted by the positive cation and the positive end of the molecule by the negative anion.
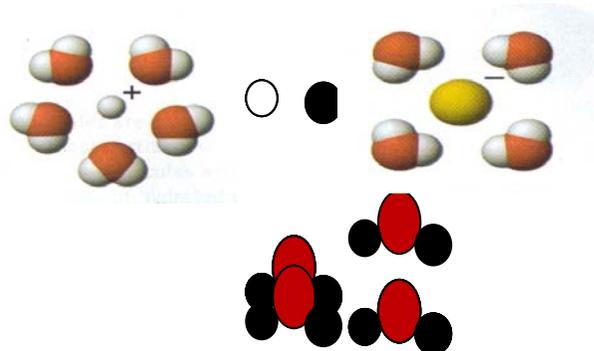
  Dissolution of ionic solids in polar solvents is called **dissociation**. Sodium chloride is used in the following example:
  $NaC\ell(s) \rightarrow Na^+(aq) + C\ell^-(aq)$   where (aq) is used when water is the solvent.

A cation surrounded
by water molecules

An anion surrounded
 by water molecules

- **Ion-induced dipole interactions**

  Induced dipoles form when a positive ion attracts the electrons to the end of a non-polar molecule closest to the ion. This end of the molecule becomes slightly positive (delta positive - $\delta^+$). The other end of the molecule becomes $\delta^-$. A negative ion induces a slightly positive charge in the end of the molecule closest to the ion by repelling the valence electrons. **Dipoles** can be induced momentarily in neighbouring atoms and molecules.

  Ion-induced dipole interaction explains the dissolution of sodium chloride ($NaC\ell(s)$) in octane ($C_8H_{18}(\ell)$). $NaC\ell$ is an ionic solid and $C_8H_{18}$ (molar mass = 114 g·mol$^{-1}$) a non-polar liquid. The higher the molar mass the greater the ability to polarize a molecule. The strength of the intermolecular forces increase with an increase in molar mass. Note that $NaC\ell(s)$ will not dissolve in pentane ($C_6H_{14}$), The molecule is too small (molar mass 86 g·mol$^{-1}$) to form induced dipoles.

- **Van der Waals forces**

  ✓ **Dipole-dipole interaction**

  When a polar molecule encounter a polar molecule, of the same or different kind, the positive end of one molecule is attracted to the negative end of the other polar molecule.

  Dissolution of polar substances in polar solvents is called **ionization**. Hydrochloric acid is used in the following example:

  $HC\ell(g) + H_2O(\ell) \rightarrow H_3O^+(aq) + C\ell^-(aq)$
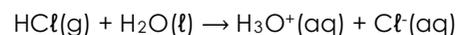
  Ions are formed in this proses and the solution acts as an electrolyte.
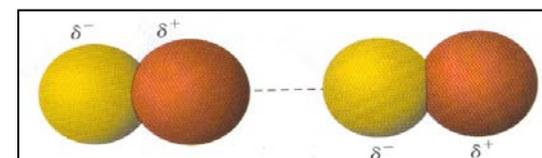
  **Hydrogen bonds**

  A number of **polar molecules** that contain an H-atom have exceptional properties. The melting and boiling points of molecular substances normally increase as the molar mass of the molecules increase. This tendency proves the relation between molar mass and the strength of the intermolecular forces.

  Water ($H_2O$), ammonia ($NH_3$) and hydrogen fluoride (HF) have melting and boiling points that are significantly higher than predicted by the normal dipole-dipole bond model, although these molecules are the **smallest** of the hydrides in their group.

  To explain the difference in bond strength we must take into account the unique character of the hydrogen atom, which consists only of a proton and an electron. The atom has no inner shell of non-bonding electrons. The electronegativities of N (3,0), O (3,5) and F (4,0) are among the highest of all the elements whereas the electronegativity of the H-atom is much lower (2,2). The N-H, O-H and F-H bonds are very polar and the more electronegative element takes on a significant negative charge.

  The proton of the H-atom can get very close to the negative end of another dipole so that the electrostatic attraction between them is unusually strong.

  The H-atom becomes a bridge between the two electronegative atoms in the adjacent molecules.

This type of interaction is called a hydrogen bond.

✓ **Dipole-induced dipole forces**

A polar molecule can **induce** or create a dipole in a non-polar molecule.
The diagram shows a polar $H_2O$-molecule approaching a non-polar $O_2$-molecule.
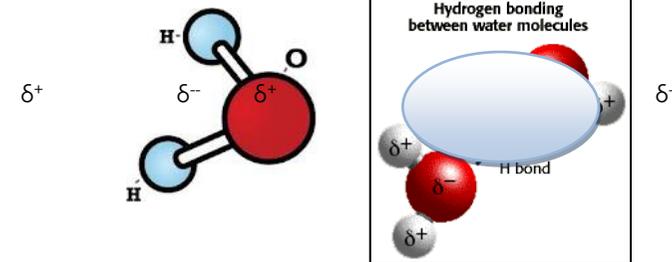
The electron cloud of the $O_2$-molecule is symmetrically distributed between the two oxygen atoms, but as the negative end of the polar water molecule approaches, the electron cloud becomes distorted. The $O_2$ -molecule itself becomes polar and as a result, the $H_2O$ and $O_2$ molecules attract each other although the electrostatic force is weak.

This **dipole-induced-dipole interaction** explains why non-polar substances can dissolve in polar solvents.

✓ **Induced dipole interactions (London-dispersion forces)**

Iodine ($I_2$) and carbon dioxide ($CO_2$) are non-polar molecules and in the solid state around room temperature. This illustrates that non-polar molecules also experience intermolecular forces. The physical properties of non-polar solids and liquids suggest that these forces can range from very weak ($N_2$, $O_2$, $CH_4$ and the noble gases) to more substantial ($I_2$ and $C_{12}H_{22}O_{11}$).

The electrons in atoms and molecules are always in a state of constant motion.

When two non-polar molecules or atoms approach each other, forces of attraction and repulsion between their nuclei and electrons lead to distortion of their electron clouds.

**Dipoles** can be induced momentarily in neighbouring:

- atoms (noble gases)
- diatomic molecules ($H_2$, $N_2$, $O_2$, $F_2$, $C\ell_2$, $Br_2$, $I_2$)
- non-polar molecules (e.g. $CH_4$, $CC\ell_4$, $CO_2$, $C_{12}H_{22}O_{11}$)

✓ **Learners have to understand that all molecules are attracted by London-dispersion forces. Dipole-dipole interactions and hydrogen bonds are not alternatives for dispersion forces, but additional interactions.**

## 2.3 Conclusion [10 min]

Educator allows learners to start with the homework activity and assist where help is needed.

### LEARNER ACTIVITY

1  What is the difference between covalent bonds and Van der Waals forces.
2  What is the relation between the strength of Van der Waals forces and molecular mass?
3  Explain the difference between dipole-dipole interaction and hydrogen bonds.
4  Iodine ($I_2$) is a solid at room temperature that sublimates easily. Chlorine ($C\ell_2$) exists in the gaseous phase. Both the elements are diatomic.

   a  Explain the meaning of the terms sublimation and diatomic.
   b  Classify $I_2(s)$ and $C\ell_2(g)$ as polar or non-polar molecules.
   c  Name the type of intermolecular forces present in $I_2(s)$.
   d  Explain why the two substances exist in different phases at the same temperature.
5  Which elements can bond to hydrogen to form hydrogen bonds?
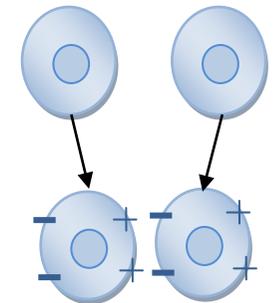
6      Classify hydrogen bonds as inter- or intra molecular forces.

7      Use the water molecule as an example to explain how hydrogen bonds are formed.

8      Sugar ($C_{12}H_{22}O_{11}$) and butane ($C_4H_{10}$) are non-polar organic molecules.

      a      Name the type of intermolecular forces present between the atoms of one molecule of each substance.

      b      In which phases does each substance exist at room temperature?

      c      It is observed that sugar and butane are in different phases at room temperature. Explain, in terms of intermolecular forces, why the phases are different.

9.What type of intermolecular forces is most important in each of the following substances:

      a      Ar (g)

      b      $H_2O$ (s)

      c      $H_2O$ ($\ell$)

      d      $HC\ell$ (aq)

      e      $NH_3$($\ell$)

      f      $NaC\ell$ (aq)

10      Identify the intermolecular forces between the molecules of the following substances.

      a      CO

      b      $H_2S$

      c      $CH_2CH_2$

      d      $CC\ell_4$

      e      $CH_4$

      f      $CH_3OH$

      g      $CH_3COOH$

**HOMEWORK QUESTIONS/ ACTIVITY**: Learners have to complete the homework activity. Additional homework: Oxford successful Physical Sciences grade 11 p 94 Activity 1.

**Recourses**: Diagrams to explain the different concepts, power point presentation, transparency, prescribed text books, CAPS-document (page 72).

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 8 | TOPIC | Physical state and density in terms of intermolecular forces. | Lesson | 3 |
|-------|----|---------|-------------------|------|---|-------|-----------------------------------------------------------------|--------|---|

| LESSON SUMMARY FOR:  DATE STARTED: | | DATE COMPLETED: | |
|-------------------------------------|--|------------------|--|

| LESSON OBJECTIVES | **At the end of the lesson learners should be able to:**<br>• Illustrate the proposition that intermolecular forces increase with increasing molecular size.<br>• Explain density of material in terms of the number of molecules in a unit volume, e.g. compare gases, liquids and solids |
|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

| TEACHING and LEARNING ACTIVITIES |
|----------------------------------|

1. **TEACHING METHOD/S USED IN THIS LESSON:**
Question and answer, explanation, practical experiment and demonstration.

2. **LESSON DEVELOPMENT**

2.1. **Introduction [10 min]**

Educator marks the homework given in lesson 2. Ensure that learners understand the difference between interatomic- and intermolecular forces as well as the different types of intermolecular forces.

**ANSWERS TO HOMEWORK ACTIVITY**

1. Covalent bonds are the sharing of one or more electron pairs between **atoms** in a molecule. Van der Waals forces are the forces that bond molecules in the liquid and solid phase.
2. Van der Waals forces increase in strength as the molecular mass of the molecules increase. $CH_4$ molecules are bonded with weaker forces than $C_7H_{16}$ molecules.
3. Dipole-dipole forces (interaction) are the forces between polar molecules in the liquid or solid phase. In molecules, where a highly electronegative atom is bonded to one or more H atoms, the intermolecular forces are stronger than dipole-dipole forces. These forces are called hydrogen bonds.
4.
   a. Sublimates – Iodine changes phase from a solid directly to a gas. $I_2(s) \rightarrow I(g)$
      Diatomic refers to elements that exist as molecules e.g. $N_2$; $O_2$ etc.
   b. $I_2(s)$ and $C\ell_2(g)$ are non-polar molecules.
   c. Induced-dipole Van der Waals forces.
   d. The $I_2(s)$ molecule has a molar mass of 253,8 g·mol$^{-1}$. $C\ell_2(g)$ has a molar mass of    71 g·mol$^{-1}$. Both substances have induced-induced dipole forces (London forces) between the molecules. The strength of the intermolecular forces increases as the molar mass of the molecules increase. London forces are strong enough to bond $I_2$ molecules in the solid phase, but not strong enough to bond the smaller $C\ell_2$ molecules in the solid phase.
5. Elements like N, O and F because they are highly electronegative.
6. Intermolecular forces.
7. The O-H bonds in the $H_2O$ molecule are very polar and the O atom takes on a significant negative charge. The proton of the H atom can get very close to the negative end of another $H_2O$ molecule. The electrostatic attraction between them is unusually strong. The    H atom becomes a bridge between the two electronegative atoms in the adjacent molecules.
8.
   a. Covalent bonds (Interatomic forces).
   b. $C_{12}H_{22}O_{11}$ is in the solid phase and $C_4H_{10}$ is in the gas phase.
   c. The molecules in both substances are bonded with weak London forces. The London forces between the bigger sugar molecules are stronger than in the smaller butane molecules.

9.
  a.  London forces or induced-dipole-induced-dipole forces.
  b.  Hydrogen bonds
  c.  Hydrogen bonds and dipole-dipole forces.
  d.  Dipole-dipole forces
  e.  Hydrogen bonds
  f.  Ionic bonds (Coulomb or electrostatic forces).
10.
  a.  Dipole-dipole forces
  b.  Dipole-dipole forces
  c.  London forces
  d.  London forces
  e.  London forces
  f.  Hydrogen bonds
  g.  Hydrogen bonds

**PRE-KNOWLEDGE**
A basic understanding of the following:
Interatomic- and intermolecular forces.
The kinetic particle model of matter.

**2.2.   Main Body   (Lesson presentation)  [20 min]**

- **The effect of molecular size on the strength of intermolecular forces**
  - ✓  The size of molecules (determined by atomic mass) plays an important role in the strength of intermolecular forces. Alkanes like methane ($CH_4$) and octane ($C_8H_{18}$) consist of H-atoms and C-atoms, but methane is in the gaseous phase at room temperature, while octane is a liquid. Both these molecules are non-polar and bonded with similar intermolecular forces, but the bonds in octane (molar mass: 114 g·mol$^{-1}$) are stronger than in methane (molar mass: 16 g·mol$^{-1}$).
  - ✓  The following elements and molecules can also be used as examples to explain the influence of atomic and molecular size on the strength of intermolecular forces: He(g), $O_2$(g), $C_8H_{18}(\ell)$ (petrol) and $C_{23}H_{48}$(s) (wax).

- **Density**

  *Ice, liquid water and water vapour*

  - ✓  The common statements that mercury is "heavier" than water or that iron is "heavier" than aluminium are actually not correct. It is not the mass of the substances that is compared, but the mass per unit volume, which is known as the **density**.
  - ✓  The density of a substance is independent of the amount and size of the sample and can therefore be used as an aid to distinguish one pure substance from another. Stronger intermolecular forces will result in substances having greater densities.
  - ✓  According to the kinetic molecular theory, particles in a gas are far apart with no regular motion. Particles in a liquid are close together with no regular arrangement. Particles in a solid are close together, usually in a regular pattern.
  - ✓  It implies that the number of particles per unit volume will decrease from the solid to the liquid state. (Refer to diagram).
  - ✓  The density of a substance **increases** as it changes from the gas to the liquid and solid state, because the intermolecular forces **increase** as substances changes



Solid          Liquid          Gas

from the gas to the solid state.

✓ Note: The density of most substances known, decreases as the temperature rises. However, the density of water increases as the temperature is raised from 0 °C to 4 °C. (Refer to the lesson: **Macroscopic properties of the three phases of water related to their microscopic structure**)

### LEARNER ACTIVITY(20 min)

#### EXPERIMENT 1– GROUP ACTIVITY

$$density = \frac{mass}{volume}$$

**Apparatus and chemicals:**

- Tall glass or beaker
- Syrup; glycerine; water coloured red with food colouring; olive oil or light cooking oil; surgical spirits coloured with blue food colouring.

**Method**

- Carefully fill the glass with the different liquids – starting with syrup, then glycerin, water, olive oil and surgical spirits.
- Wait for each layer to settle en dribble the next layer slowly down the inside of the glass so that the previous layer is not disturbed.

**Answer the following questions**

1  Draw a labelled diagram to show your observations.
2  Refer to the intermolecular forces in the substances to explain why the liquids float on each other.

#### EXPERIMENT 2 (Demonstration)

**Apparatus and chemicals:**

- Test tubes
- Water
- Xylene or carbon disulphide ($CS_2$)
- Ethanol ($CH_3CH_2OH$)
- Potassium permanganate ($KMnO_4(s)$); Iodine ($I_2(s)$);
- Add a few $KMnO_4$ crystals to the test tubes 1 and 4, and a few $I_2(s)$ crystals to test tubes 2 and 5.

**Method**

- Add 3 – 5 $cm^3$ of water and xylene (or $CS_2$) to test tubes 1 and 2.
- Add 3 -5 $cm^3$ of water and ethanol to test tube 3.
- Add 3 -5 $cm^3$ of ethanol to test tube 4 and 5.
- Add a few $KMnO_4$ crystals to the test tubes 1 and 4, and a few $I_2(s)$ crystals to test tubes 2 and 5.

**Answer the following questions**

1  Classify the solvents and solutes used in the experiment as non-polar, polar and ionic.
2  Draw labeled diagrams of the two test tubes to show your observations.
3  Explain the difference in densities of water and xylene (or $CS_2$).
4  Refer to the bonds that are formed and explain how

  a   $KMnO_4(s)$ dissolves in water.
  b   $I_2(s)$ dissolves in xylene (or $CS_2$)

#### ANSWERS for PRACTICAL DEMONSTRATION.

1.   Water: polar
    Xylene: non-polar
    Ethanol: polar
    $KMnO_4(s)$: ionic
    $I_2(s)$: non-polar

2.

Xylene (Colourless) $\longrightarrow$

Xylene + $I_2$(s)
(Purple)

Water + $KMnO_4$(s) $\longrightarrow$
(Purple)

Water (Colourless)

- The test tube with water and ethanol forms a homogeneous mixture (3).
- $KMnO_4$(s) and $I_2$(s) are both soluble in ethanol. (4 and 5)

3. The organic solvent consists of non-polar molecules bonded with weak London forces. Water consists of highly polar molecules bonded with stronger hydrogen bonds. The fact that the forces are different in strength results in a heterogeneous mixture. The xylene molecules are further apart and therefore less dense.

4.
   a. $KMnO_4$(s) dissociates in water and form $K^+$(aq) and $MnO_4^-$(aq) The ions move in between the polar water molecules that are bonded with strong hydrogen bonds and dipole-dipole bonds. The different bonds are of the same strength – like dissolves like. Ion-dipole forces form between the ions and polar $H_2O$ molecules.
   b. $I_2$(s) molecules are non-polar and the molecules of the organic solvent are non-polar. Like dissolves like and induced-dipole-induced dipole or dispersion forces bond the molecules of the solute and the solvent.

## 2.3 Conclusion [10 min]

- Educator discusses the answers of the practical activity.
- Ensures that learners understand the concepts that have been discussed in the lesson
- Educator summarises important aspects of the lesson, reinforcing what needs to be remembered and recalled.

## HOMEWORK ACTIVITY

1 Define the term density.
2 Why are the solid and liquid states called the condensed states of matter?
3 Explain why a sample of $H_2$(g) is less dense than a sample of $O_2$(g) at the same temperature.
4 Why do boats float higher on salty sea water than fresh water?
5 Explain why sea birds are often covered with oil after it was spilled from ships.
6 Distinguish between the following concepts:

   a dissolve and melt.
   b homogeneous and heterogeneous mixture.
   c solute and solvent.
   d unsaturated and saturated solutions.
   e miscible and non-miscible liquids.

7 Give one example of each of the following:

   a a liquid-liquid solution.
   b a solid liquid solution.
   c a solid-solid solution.
   d a liquid in gas solution.

8    Why does oil not dissolve in water?

9    Explain how water dissolves a crystal of potassium chloride (KCℓ). How is it possible that this endothermic process is able to take place spontaneously?

**HOMEWORK QUESTIONS/ ACTIVITY** Learners have to complete the activity given above.

**Recourses:** Power point presentation, transparency; chemicals, apparatus, prescribed text books, CAPS-document (page 72).

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 8 Lesson 4 | TOPIC | Particle kinetic energy and temperature. |
|-------|----|---------|--------------------|----|--------------|--------|---------------------------------------------|

| LESSON SUMMARY FOR: DATE STARTED: | | DATE COMPLETED: | |
|------------------------------------|--|-----------------|--|

| LESSON OBJECTIVES | *At the end of the lesson learners should be able to:*<br>• *Explain the physical properties evaporation and vapour pressure in terms of intermolecular strength, average kinetic energy and temperature.*<br>• *Explain the relationship between the strength of intermolecular forces and melting points and boiling points of substances composed of small molecules.*<br>• *Contrast the melting points of substances composed of small molecules with those of large molecules where bonds must be broken for substances to melt.* |
|-------------------|--------------------------------------------------------------------------------------------------------------------|

| TEACHING and LEARNING ACTIVITIES |
|----------------------------------|

1. **TEACHING METHOD/S USED IN THIS LESSON:**
; **Question and answer, explanation, practical experiment and demonstration.**

2. **LESSON DEVELOPMENT**

2.1. **Introduction** **[10 min]**

Educator does baseline assessment while marking homework activity.

**ANSWERS TO HOMEWORK ACTIVITY**

1. Density is the mass per unit volume of a substance:
   Unit: $g \cdot cm^{-3}$

2. The intermolecular forces of attraction between molecules are stronger in the liquid and solid states and molecules are closer to each other – there are more molecules per unit volume.

3. $H_2$ and $O_2$ molecules are non-polar and bond with weak London forces. $H_2$ molecules have a molar mass of 2 $g \cdot mol^{-1}$ and $O_2$ molecules have a molar mass of 32 $g \cdot mol^{-1}$. The intermolecular forces increase with an increase in molar mass. $O_2$ molecules are attracted with stronger forces and are closer to each other. More molecules per unit volume imply a greater density.

4. Salty seawater is denser than fresh water. In the salty water, ion-dipole interaction between ions of the salts and the water molecules are stronger than the hydrogen bonds and dipole-dipole interactions between the water molecules in fresh water. (Ask learners to do research about the *Plimsoll line*).

5.  Birds have a gland near the base of their tails that produces oil. Using their beaks or bills, the birds spread this oil over their feathers. The oil coats the feathers so water really does run off a duck's back! Oil from oil spills can dissolve in the natural oil on the feathers of the bird, because the bonds between the molecules are of the same strength.
    *One reason oil spills are so dangerous for birds is that the oil destroys the feathers' waterproofing and warming abilities. It also weighs the birds down, preventing flight or swimming. When birds try to preen, they swallow the oil, which is <u>poisonous</u>.*

6.
    a.  A solid called the solute dissolves in a liquid (solvent). *Melting* refers to a phase change where a solid changes to a liquid.
    b.  Homogeneous: The substances in the mixture are all in one phase.
        Heterogeneous: The substances in the mixture are in different phases and it is easy to separate the mixture.
    c.  The solvent is the liquid in which a solid or another liquid (the solute) is dissolved.
    d.  Unsaturated: A solution in which more solute can be dissolved.
        Saturated: A solution in which no more solute can dissolve.
    e.  If the solute mixes completely with the solvent, the solution is miscible.
        If the solute does not mix completely with the solvent, the solution is non-miscible.

7.
    a.  Alcohol in water
    b.  Salt or sugar in water
    c.  Solder – tin in lead
    d.  water vapour in air

8.  Oil consists of non-polar molecules bonded with weak London or dispersion forces. Water consists of polar molecules bonded with strong dipole-dipole and hydrogen forces. If the intermolecular forces are of different strengths the substances are insoluble.

9.  $KC\ell(s) \rightarrow K^+(aq) + C\ell^-(aq)$ The process is called dissociation. The ions move in between the water molecules and form ion-dipole Van der Waals forces. This process can only take place because ionic bonds and hydrogen bonds are equally strong.

**PRE-KNOWLEDGE**
A basic understanding of the following:
Interatomic- and intermolecular forces.
The kinetic particle model of matter.

### 2.2. Main Body   (Lesson presentation)  [20 min]

- **Evaporation**
  - ✓ It is the conversion of liquid to vapour without the boiling point necessarily being reached and can be considered as a spontaneous process.

    - ✓ liquid → vapour

  - ✓ It is an **endothermic** process and can also be described as a cooling process.
  - ✓ Should you want to evaporate a liquid at a constant temperature, it is necessary to supply energy constantly to the system.

  - ✓ The average energy for molecules in a liquid depends only on temperature. The higher the temperature, the higher the average kinetic energy and the greater the relative number of molecules with high kinetic energy.

  - ✓ Molecules with enough kinetic energy to enable them to overcome the intermolecular forces holding them together may leave the liquid to form the vapour. As the more energetic molecules leave the liquid, the average kinetic energy of the remaining molecules in the liquid must also decrease.

  - ✓ The non-polar molecules in a liquid are bonded with London dispersion forces. The molecules need a small amount of energy to overcome the weak intermolecular forces and more of them will evaporate at a given temperature. In polar liquids the stronger dipole-dipole forces are not so easily broken. A smaller number of molecules can overcome the stronger forces at a given temperature and less of them will evaporate.
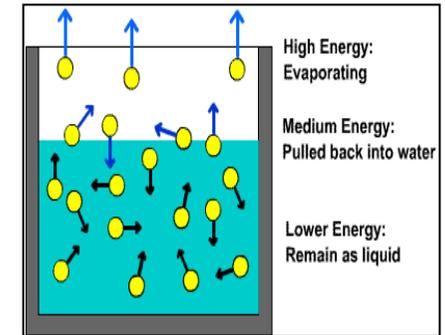
- **Vapour pressure**

  - ✓ If a sufficient amount of liquid is present in a closed system, it does not all evaporate. Instead equilibrium is established between the liquid and the vapour and a constant pressure is maintained in the container.
  - ✓ At first the amount of vapour increases, and the pressure that it exerts increases correspondingly. As the amount of vapour increases, the chance that a molecule in the vapour phase will collide with the surface of the liquid and return to the liquid phase also increases. This process is called **condensation.**
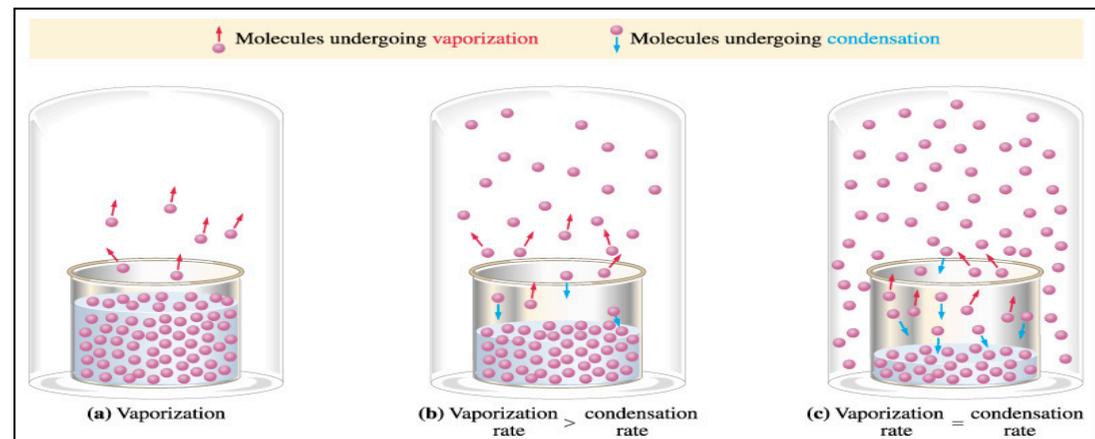
✓ A stage is eventually reached when the number of molecules which leave the liquid at a specific temperature is exactly equal to the number of particles which re-enter the liquid.
A *state of equilibrium* between the liquid and gaseous phases is then reached and is known as **phase equilibrium**.

✓ Since no *macroscopic* change in this system may be observed, it might appear that the evaporation of the liquid has stopped. However, the equilibrium is not *static* but *dynamic*.

✓ Evaporation and condensation continue to take place on a microscopic scale. This dynamic state of equilibrium may be represented as follows.

✓ Substances with weak intermolecular forces between the molecules have higher vapour pressures at a given temperature than substances with stronger intermolecular forces.

## LEARNER ACTIVITY [20 min]

### PRACTICAL DEMONSTRATION:

**Apparatus and chemicals:**

- Small glass beaker (50 cm$^3$)
- Medicine dropper
- Ether or any other volatile liquid
- Water
- Plastic straw (for drinking cooldrink)

**Method**

- Place a small droplet of water on a piece of hardboard.
- Fill the glass beaker with 25 cm$^3$ ether.
- Place the beaker with its content carefully on the droplet of water.
- Use the straw to blow over the liquid surface in order to speed up the evaporation process.

**Answer the following questions**

1   What happens to the droplet of water after a few minutes?
2   Explain your observation.
3   Give one practical application of spontaneous evaporation in daily life.

- **Melting and boiling points**

✓ The **melting point** of a solid is the temperature at which it changes <u>state</u> from <u>solid</u> to <u>liquid</u>. At the melting point the solid and liquid phase exists in equilibrium. The melting point of a solid depends on the strength of the forces that hold the particles (ions or molecules) in the crystal lattice together. Ionic solids have high melting points because the ions are bonded with strong electrostatic forces. Molecular solids like ice and sugar have lower melting points because less energy is needed to break the weaker intermolecular forces between the molecules.

✓ When the temperature of a liquid is raised to the point at which the vapour pressure is equal to the atmospheric pressure, bubbles of vapour form in the liquid and it is said to boil. A bubble of vapour can only form and expand in a liquid when the pressure in the bubble is sufficient to push the liquid away against the atmospheric pressure acting on the liquid.

✓ The **normal boiling point** of a liquid is defined as the temperature at which the vapour pressure is equal to 1 atmosphere (101,3 kPa). The temperature of the liquid cannot be raised above the boiling point. If more heat is supplied, bubbles are formed more rapidly and they also grow more rapidly.
At high altitudes, where the atmospheric pressure is lower, the boiling point of the liquid is correspondingly reduced.

- **Deviations in the normal trend of melting and boiling points**

  ✓ The melting and boiling points of atomic and molecular substances normally increase as the molecular mass (size) of the atoms and molecules increases. Temporary dipoles are more easily induced in the large particles than in smaller ones. This tendency is also noticeable in carbon halides, carbon hydrides and halogens.

  ✓ $NH_3$, $H_2O$ and HF show deviations from the expected properties (e.g. their particularly high melting and boiling points. All three substances contain hydrogen atoms bonded to highly electronegative elements (N = 3,0; O = 3,5 and F = 4,0). The hydrogen bond (discussed in lesson 2) is responsible the strong forces between the molecules mentioned here.
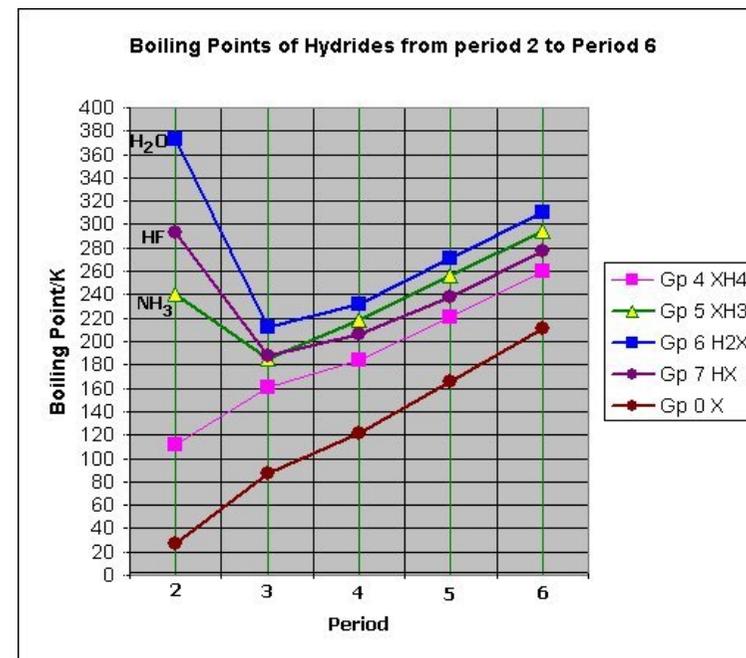
**Boiling Points of Hydrides from period 2 to Period 6**

Legend:
- Gp 4 XH4
- Gp 5 XH3
- Gp 6 H2X
- Gp 7 HX
- Gp 0 X

3. **Conclusion** [10 min]

Educator summarises important aspects of the lesson, reinforcing what needs to be remembered and recalled.

**HOMEWORK ACTIVITY**

1   Explain the difference between *boiling* and *evaporating*?
2   What intermolecular force(s) must be overcome to
    a   melt ice
    b   sublime solid $I_2$
    c   convert $NH_3(\ell)$ to $NH_3(g)$?
3   It requires more energy to allow a substance to evaporate than to let it melt? explain why.
4   Which one of each of the following pairs of compounds has the higher boiling point?

a      $O_2$ or $N_2$
b      $SO_2$ or $CO_2$
c      HF or HI
d      $SiH_4$ or $GeH_4$

5      Study the table of melting and boiling points of different molecular substances below:

| Substance | Formula | Formula mass | Melting point ($^0$C) | Boiling point ($^0$C) |
|---|---|---|---|---|
| Chlorine | $C\ell_2$ | 71 | -7 | +58 |
| Carbon dioxide | $CO_2$ | 54 | -79 | -79 |
| Oxygen | $O_2$ | 32 | -218 | -183 |
| Hydrogen | $H_2$ | 2 | -257 | -253 |

a      Name the type of bond found between the **atoms** in the **molecules** given in the table.
b      Give the relation observed between melting and boiling points and the formula masses of the substances.
c      *Explain* the tendency observed in (b).

6
a      What is a hydride?
b      Will the boiling points of the group IV hydrides, $CH_4$, $SiH_4$ and $GeH_4$, in this order increase or decrease. Explain your answer.

7      Hydrogen bonding causes deviations in the normal tendency of melting and boiling points of hydrides.
a      Use simple diagrams of water molecules to explain whether hydrogen bonds are interatomic- or intermolecular forces.
b      What is the discrepancy observed in the melting and boiling points of water?

**HOMEWORK QUESTIONS/ ACTIVITY** Learners have to complete the homework activity. Collect the labels of empty containers in which different machine- and motor oils are sold.

**Recourses** Power point presentation, transparency; chemicals, apparatus, prescribed text books, CAPS-document (page 72).

Name of Teacher_____      SIGN:_____      Date:_____

Name of HOD:_____      SIGN:_____      Date:_____

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 9 | TOPIC | Particle kinetic energy and temperature | Lesson | 1 |

| LESSON SUMMARY FOR: DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|
| **LESSON OBJECTIVES** | **At the end of the lesson learners should:** <br> • Be able to understand and explain the following concepts: surface tension, capillarity, viscosity. | | |

| TEACHING and LEARNING ACTIVITIES |
|---|

**1.    TEACHING METHOD/S USED IN THIS LESSON:**
Question and answer, explanation, experiment

**2.    LESSON DEVELOPMENT**

**2.1.    Introduction [10 min]**

Educator does baseline assessment while marking the homework activity.

**ANSWERS TO HOMEWORK ACTIVITY**

1.    A liquid boils when its vapour pressure is equal to the atmospheric pressure. Evaporation is a spontaneous process where molecules with more energy than the average kinetic energy of the liquid can overcome the surface tension and leave the liquid as a gas particle.

2.
   a.    Hydrogen bonds
   b.    London forces or dispersion forces or induced-dipole-dipole forces
   c.    Hydrogen bonds

3.    The difference in bond strength between the liquid and gas states is much greater than between the solid and liquid state (condensed states)..Molecules need more energy to change from the liquid to the gas phase than from the solid to the liquid phase.

4.
   a.    $O_2$ ($N_2$ is a smaller molecule – weaker London forces).
   b.    $SO_2$ ($SO_2$ is polar and bond with stronger dipole-dipole forces. $CO_2$ is non-polar)
   c.    HF (HF molecules bond with stronger hydrogen bonds)
   d.    $GeH_4$ (Bigger non polar molecules – bond with stronger London forces)

5.
   a.    Between atoms – covalent bonds; between molecules – weak London forces
   b.    The melting and boiling points increase as the molecular masses increase
   c.    As the molecular masses increase, the London forces between the molecules become stronger. More energy is needed to break the bonds in order to change the phase of the substance.

6.
   a.    Any molecule that consists of Hydrogen atom(s) bonded to atoms of other elements.
   b.    The boiling points will increase. The molecular mass of the given molecules increases and the London forces between the molecules become stronger. More energy is needed to break the bonds between $GeH_4$ molecules in order to obtain a vapour pressure that is equal to atmospheric pressure, than between $CH_4$
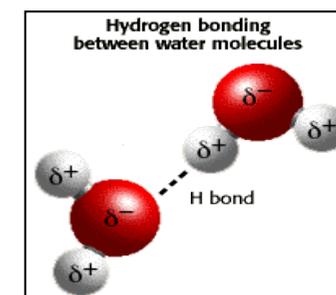
molecules.

7.
   a.  Intermolecular forces, because it is formed **between** water molecules.
   b.  Water is the smallest molecule of the hydrides in group VI. According to normal bond models, the boiling point of water should be lower than -62 $^0$C (the boiling point of H$_2$S). We all know that the boiling point of water is in fact much higher ≈100 $^0$C.

**PRE-KNOWLEDGE**
A basic understanding of the following:

- Intermolecular forces are responsible for different physical properties.

2.2.  <u>Main Body  (Lesson presentation)</u>  [20 min]

- **Surface tension**
   ✓  The surface of a liquid may be considered as an elastic film or skin. As a result of this surface phenomenon, it is possible for insects to walk on the surface of a liquid.

   ✓  The curved surfaces (menisci) of liquids, most noticeable in narrow tubes, and the fact that a water drop is always spherical, are properties which are linked to surface tension.
   ✓  **Surface tension** can be defined as the resistance that a liquid offers to a force which tries to increase its surface area.

   ✓  Consider molecule B within the liquid and molecule A on the surface of the liquid. Molecule B is surrounded by similar molecules and is strongly attracted in all directions by equal forces of **cohesion**. Molecule A, on the surface, experiences only sideways and downward cohesion forces.

      Molecule B in the liquid experiences a zero net (resultant) force, while molecule A on the surface experiences a net **downward** force.
   ✓  Forces between molecules of the same substance are called **cohesion forces** and forces between two different substances are called **adhesive forces**.
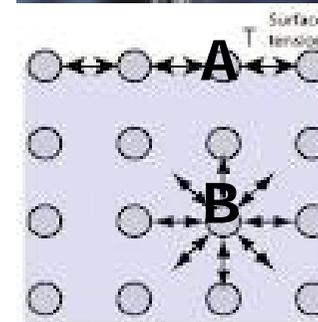
- **Capillarity**
   ✓  Surface tension is also responsible for the phenomenon of **capillarity**, the rising and sinking of liquids in narrow tubes. When a narrow tube is pressed into water, the water rises up the tube and forms a **concave** meniscus, while in the case of mercury the level in the tube drops and a **convex** meniscus is formed.
   ✓  This phenomenon can also be explained in terms of intermolecular forces. Because polar Si-O bonds are present on the surface of glass, polar H$_2$O-molecules are attracted to the glass (dipole-dipole interaction). These forces are strong enough to compete with the forces between the water molecules themselves.
   ✓  Thus, some water molecules can adhere to the walls while other water molecules are attracted to them and build a "bridge" into the liquid. The surface tension of the water (from cohesion forces) is great enough to pull the liquid up the tube, so the level of the water rises in the tube so as to decrease the area and form a concave meniscus.
   ✓  In the case of mercury, the cohesive forces are greater than the adhesive forces between the mercury and the glass, with the result that mercury molecules are pulled away from the glass surface. Mercury does not climb the walls of a glass






The meniscus of water (left) and mercury (right).

capillary and forms a convex or upward-curving meniscus.

- **Viscosity**

  ✓ When you turn over a glass full of water, it empties quickly. However, it takes much longer to empty a glass full of honey or olive oil. The resistance of liquids to flow is called **viscosity**. This property of liquids is also the direct result of intermolecular forces.

  ✓ Olive oil consists of long chains of carbon atoms and the molecules are therefore bonded with strong intermolecular forces.. Olive oil is about 70 times more viscose than ethanol, a small molecule with only two C-atoms and one O-atom.

  ✓ Honey (a concentrated aqueous solution of sugar molecules) is also a viscose liquid, even though the size of the molecules is relatively small. In this case the sugar molecules have numerous –OH groups that lead to strong hydrogen bonding between the molecules

## LEARNER ACTIVITY[25 minutes]

### PRACTICAL DEMONSTRATION: SURFACE TENSION

**Apparatus and chemicals:**

- 250 cm³ glass beaker
- Ethanol
- 20 mm wide strip of filter paper
- Razor blade or metal paper clip
- Shallow dish of water
- Four matches
- Dishwashing liquid
- Dropper

**Method A**

- Thoroughly wash the beaker and rinse with a small amount of ethanol.
- Fill the beaker with water to about 10 mm from the rim.
- Place the piece of metal on the filter paper and let it lie on the surface of the water until the wet paper begins to sink.
- Carefully remove the strip of paper.

**Method B**

- Fill the dish with clean water and allow settling so that the surface is completely smooth.
- Carefully float the matches on the surface of the water, arranged into a star-shape as shown.
- Using the dropper, add a drop of dishwashing liquid to the water in the centre of the dish.

**Answer the following questions**

1. Write down your observation for method A.
2. Explain the phenomenon of surface tension by referring to intermolecular forces.
3. What happens to the matches when the dishwashing liquid is added to the water?
4. Explain your observation.

## CLASSWORK ACTIVITY: VISCOSITY

**Method**

- Use the empty oil containers and make a summary of the information on the labels

**Answer the following questions**

1    Give the definition of viscosity.
2    What is SAE?
3    What is the difference between mono grade and multi grade oil?
4    What is the meaning of **15 W 40** and **SAE 30**?

## ANSWERS TO CLASWORK ACTIVITY

1.    Viscosity is the resistance of liquids to flow.
2.    Society of Automotive Engineering: The Society of Automotive Engineers is an international non-profit educational and scientific organization dedicated to advancing mobility technology. They develop technical information on all forms of self-propelled vehicles including aircraft and disseminate this information through many channels, including oil specifications
3.    Mono grade oil:
      Mono grade oils are designed to be used within a defined temperature range. The mono grade oils are classified by the thickness (or viscosity) of the oil. The intention is to ensure that the oil will cycle as required under specific operating conditions. In cold climates a thinner grade, e.g. SAE 30, is more likely to be required whilst in warmer climates a thicker grade e.g. SAE 100, is more likely to be selected. They can also be characterized by the presence of an additive package ("AD" or ashless dispersant oils) or the absence of such performance additives ("S" or "straight" oils).
      ⚜ Multi grade oil:
      Multi grade oils are designed to provide a more consistent viscosity across a wide range of temperatures. They are usually formulated around premium quality base stock (mineral and/or synthetic blend) enhanced with an additive package.
4.    15 W 40: This multi grade oil has the same thickness as an SAE 40 monograde at 100 $^0$C
      15 describe the low temperature fluidity of the oil.

      SAE 30 is used for mono grade oils: describe the fluidity of the oil at 100 $^0$C

## 2.3    Conclusion [5 min]

Educator discusses the answers of the classwork activity AND summarises important aspects of the lesson, reinforcing what needs to be remembered and recalled.

## HOMEWORK ACTIVITY

1    Explain the difference between cohesive and adhesive forces.

2    Name the forces that are responsible for the capillarity and surface phenomena of liquids.

3    Use diagrams to explain the difference in the menisci's of water and mercury.

4    What will the effect of an increase in temperature be on the surface tension of a liquid? Explain your answer.

5    Motor oils today are mainly blended by using base oils composed of hydrocarbons, thus organic compounds consisting entirely of carbon and hydrogen. How will the number of C-atoms in the molecule influence the viscosity of the oil?

6    Suppose that the forces of cohesion in liquid A are greater than those in liquid B. Explain how this fact will affect the following properties of the liquids:

      a    vapour pressure

| | | |
|---|---|---|
| b | boiling point | |
| c | viscosity | |
| d | surface tension | |

**HOMEWORK QUESTIONS/ ACTIVITY:** Learners have to complete the homework activity.

**Recourses** Power point presentation, transparency; chemicals, apparatus, prescribed text books, CAPS-document (page 72).

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**Reflection/Notes:**

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| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 9 | TOPIC | Intermolecular forces and the effects of intermolecular forces on evaporation, surface tension, solubility, boiling points and capillarity | Lesson | 2 |
|-------|----|---------|-------------------|------|---|-------|---|--------|---|

| LESSON SUMMARY FOR: DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|

| LESSON OBJECTIVES | At the end of the lesson learners should:<br>• Describe thermal expansion of a substance and how it is related to the motion of molecules in a substance composed of small molecules e.g. alcohol in a thermometer.<br>• Explain the difference between thermal conductivity in non-metals and metals. Be able to complete the experiment for formal assessment. |
|---|---|

## TEACHING and LEARNING ACTIVITIES

1. **TEACHING METHOD/S USED IN THIS LESSON:**
Question and answer, explanation, experiment

2. **LESSON DEVELOPMENT**

2.1. **Introduction** [10 min]

Educator do baseline assessment while marking the homework activity

**ANSWERS TO HOMEWORK ACTIVITY**

1. **Cohesive forces** are the forces between particles of the same kind. **Adhesive forces** are the forces that exist between the particles of different substances.
2. Cohesion and adhesion forces

3.
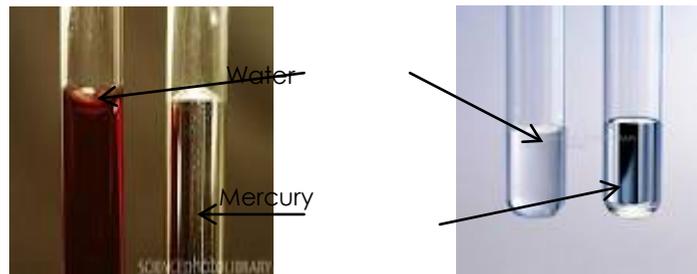


4. The surface tension will decrease. An increase in temperature results in an increase in energy. The bonds between the molecules become weaker.
5. An increase in the number of C atoms increases the mass of the molecules. This results in stronger intermolecular forces. The viscosity is increased.
6.
   a. The vapour pressure of liquid A will be lower than that of liquid B. Stronger cohesion forces implies that the molecules need more energy to break the surface tension. Fewer molecules will be able to evaporate at a given temperature.
   b. The boiling pint of liquid A will be higher than the boiling point of liquid B. A higher temperature is needed to evaporate enough molecules so that the vapour pressure = atmospheric pressure.
   c. The viscosity of liquid A will be greater than that of liquid B.
   d. The surface tension of liquid A will be greater than the surface tension of liquid B.

**PRE-KNOWLEDGE**

A basic understanding of the following:

- The relationship between average kinetic energy and temperature.
- Hydrogen bonds as an extreme case of dipole-dipole forces.

2.2.   Main Body   (Lesson presentation)   [25 min]

- **Kinetic energy of particles and temperature change**

  ✓ Heat is a form of energy. During the heating process, the particles of the substance absorb energy that allows them to vibrate in all directions and collide with each other. Energy that causes motion is called **kinetic energy**. All the particles do not gain the same amount of energy and they also transfer energy to other particles when they collide with each other.

  ✓ An increase in the temperature of gas particles increases the average kinetic energy of the particles and they will move faster  ($K = ½mv^2$). The average kinetic energy is directly proportional to the temperature of the particles.

- **Thermal expansion**

  ✓ The most easily observed examples of thermal expansion are size changes of materials as they are heated or cooled. Almost all materials (solids, liquids, and gases) expand when they are heated, and contract when they are cooled. Increased **temperature** increases the **frequency** and magnitude of the molecular **motion** of the material and produces more energetic collisions. Increasing the **energy** of the collisions forces the molecules further apart and causes the material to expand.

  ✓ Different materials expand or contract at different rates. In general, gases expand more than liquids, and liquids expand more than solids. Observation of thermal expansion in a solid object requires careful scrutiny. Several everyday examples are:

    ▪ The sag in outdoor electrical lines is much larger on hot summer days than it is on cold winter days.

    ▪ The rails for trains are installed during warm **weather** and have small gaps between the ends to allow for further expansion during very hot summer days.

    ▪ Because the metal expands more than glass a stuck metal lid on a glass container can be loosened by running hot water over the joint between the lid and the container.

  ✓ The manufacturing of mercury and alcohol thermometers is based upon the expansion difference between solids and liquids. Thermometer fabrication consists of capturing a small amount of liquid (mercury or alcohol) inside an empty tube made of glass or clear plastic.

  ✓ Because the liquid expands at a faster rate than the tube, it rises as the temperature increases and drops as the temperature decreases.

  ✓ The first step in producing a thermometer scale is to record the height of the liquid at two known temperatures (i.e. the **boiling** point and freezing point of water). The difference in fluid height between these points is divided into equal increments to indicate the temperature at heights between these extremes.

- **Thermal conductivity**

  ✓ **Heat transfer** by **conduction** involves transfer of energy within a material without any motion of the material as a whole. If one end of a metal rod is at a higher temperature, then energy will be transferred down the rod toward the colder end because the higher speed particles will collide with the slower ones with a net transfer of energy to the slower ones.



| Mercury thermometer | Alcohol thermometer |
| --- | --- |

metal ions
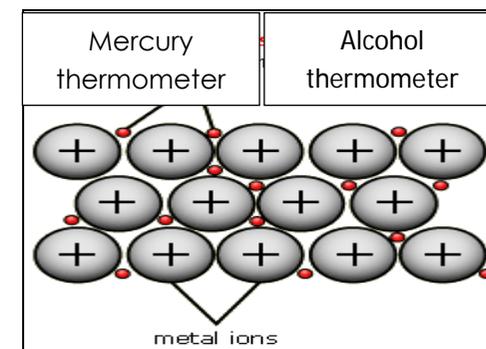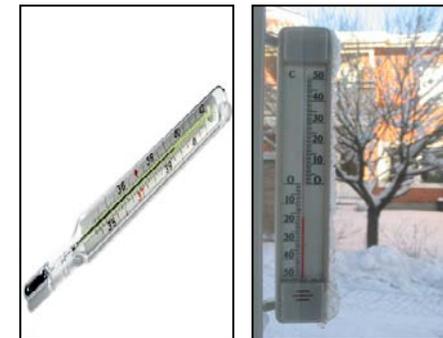
✓ Conduction of heat in metals can be explained by a model of the metal structure known as the "sea of electrons" model. A solid metal lattice consists of positive ions (kernels) that are held together by electrostatic forces of attraction of the "sea" of delocalized electrons. The electrons are free to move in the metal lattice and are able to conduct heat and electricity.

✓ Non-metals are made up of either small or giant molecules. Air is known as a heat insulator and consists of mainly $O_2$(g) and $N_2$(g) molecules. When small gas molecules at high temperatures collide with other molecules heat transfer takes place. Energy is transferred from molecules with high kinetic energy to molecules with lower kinetic energy. The intermolecular forces between the molecules are weak and the density is low. Relatively few collisions will occur and conduction of heat is weak.

✓ Graphite is an example of a giant molecule and conducts heat as vibration energy across the closely packed layers of the crystal lattice.
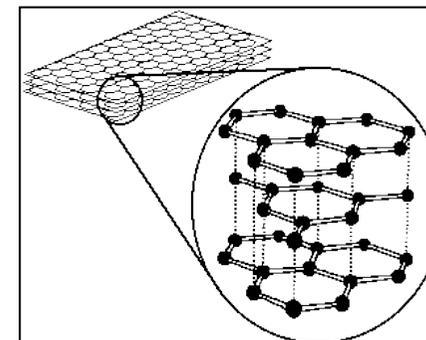
The crystal lattice of graphite

## LEARNER ACTIVITY [15]

### CLASSWORK ACTIVITY

1 Discuss the effect of an increase in temperature on the motion of molecules.
2 Explain how the temperature of a substance is related to the average kinetic energy of the particles of the substance.
3 Explain why fluorine and chlorine are gases, bromine a liquid and iodine a solid at room temperature.
4 Explain the change in density of the molecules of a substance during thermal expansion.
5 Discuss two applications of thermal expansion in our daily life.

### ANSWERS for the CLASSWORK ACTIVITY

1. Temperature is directly proportional to average kinetic energy of the particles. An increase in T increases K. $K = \frac{1}{2}mv^2$. The mass of the particles remains constant – motion increases.

2. $T \propto \bar{K}$ (Temperature is directly proportional to average kinetic energy of the particles).

3. The molar masses of the particles increase in the following order: $F_2 < Cl_2 < Br_2$. The London forces between the non-polar molecule increase with an increase in molar mass.
   At the same temperature, the forces between $F_2$ molecules are weaker than between $Cl_2$ molecules etc.

4. An increase in temperature decreases the bond strength between the molecules. The particles are further apart and the substance becomes less dense.

5. Thermometers work by using thermal expansion of a liquid to measure temperature; construction (bridges); it can also be used in loosening nuts and bolts; a hot-air balloon uses the thermal expansion of air to generate lift.

## 2. 3 Conclusion [10 min]

Educator discusses the answers of the classwork activity AND summarises important aspects of the lesson, reinforcing what needs to be remembered and recalled.

**HOMEWORK QUESTIONS/ ACTIVITY**: Learners prepare themselves to complete the prescribed experiment for formal assessment.
**Recourses:** Power point presentation, mercury and alcohol thermometers, prescribed text books, CAPS-document (page 74, 75).

Reflection/Notes:

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 9 | TOPIC | The chemistry of water | Lesson | 3 |
|-------|----|---------|------------------|------|---|-------|----------------------|--------|---|

| LESSON SUMMARY FOR:  DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|

| LESSON OBJECTIVES | **At the end of the lesson learners should:** <br> • Be able to describe the shape of the water molecule and its polar nature. <br> • Appreciate water's unique features due to hydrogen bonding in the solid, liquid and gaseous state. <br> • Indicate the number of $H_2O$ molecules in 1 litre of water. <br> • Understand the meaning of heat capacity and specific heat capacity of water. |
|---|---|

## TEACHING and LEARNING ACTIVITIES

1. **TEACHING METHOD/S USED IN THIS LESSON:**
Question and answer, explanation

2 **LESSON DEVELOPMENT**

2.1 **Introduction [5 min]**

Baseline assessment

• Educator asks questions determine the learner's understanding of intermolecular forces and its effect on physical properties if matter.

• Revise the principles of the VSEPR - model

**PRE-KNOWLEDGE**
A basic understanding of the following:

• Intermolecular forces are responsible for different physical properties.
• Hydrogen bonds as being an extreme case as dipole-dipole forces.
• Molecular geometry as predicted by the VSEPR - model.

2.2 **Main Body   (Lesson presentation)  [30 min]**

• **Introduction**

   ✓ Water ($H_2O$) is the most abundant compound on Earth's surface, covering about 70%.
   ✓ In nature, it exists in liquid, solid, and gaseous states.
   ✓ At room temperature, it is a tasteless and odourless liquid, nearly colourless with a hint of blue.
   ✓ Many substances dissolve in water and it is commonly referred to as the universal solvent.
   ✓ Because of this, water in nature is rarely pure and some of its properties may vary slightly from those of the pure substance. However, there are also many compounds that are essentially, if not completely, insoluble in water.
   ✓ Water is the only common substance found naturally in all three common states of matter and it is essential for all life on Earth. Water usually makes up 55% to 78% of the human body.

- **The shape of the water molecule and its polar nature.**
  - ✓ The VSEPR theory was discussed in unit 3. The shape of a water molecule, as predicted by the theory, is angular.
  - ✓ The oxygen atom bonds with covalent bonds to two hydrogen atoms. The molecule contains two lone pairs and to bond pairs of electrons resulting in an angular shape.
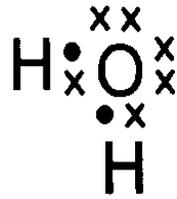


**Lewis-dot diagram for a water molecule**



  - ✓ The electronegativity difference between an O atom and a hydrogen atom is 1,4 (H = 2,1 and O = 3,5). The atoms in the molecule thus bond with polar covalent bonds. Because the electron charges of these polar covalent bonds are more concentrated around the oxygen atom, they are arranged asymmetrically in the molecule. The oxygen side (more electronegative atom) acquires a slightly negative charge ($\delta^-$) while the hydrogen side acquires a slightly positive charge ($\delta^+$).

  - ✓ Water molecules contain a net dipole moment and are considered as polar molecules.

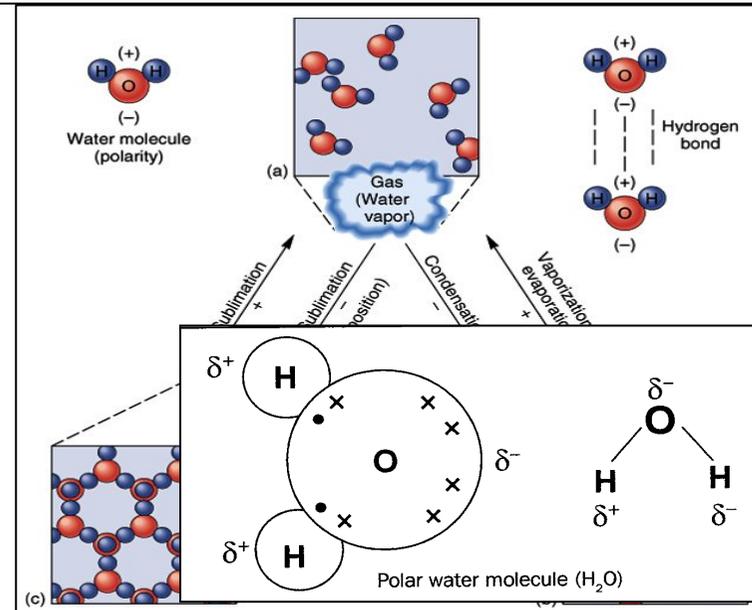**The three states of water and the phase changes between these states.**

- **Hydrogen bonding – the reason for the unusual features of water**

  **The structure of frozen water**

  - ✓ One reason for the unusual structure of frozen water is that each H-atom of a $H_2O$-molecule can form a hydrogen bond to a lone pair of electrons on the O-atom of an **adjacent** $H_2O$-molecule.

  - ✓ The O-atom has two lone pairs and can form two hydrogen bonds with hydrogen atoms from adjacent molecules. The result is a tetrahedral arrangement for the H-atoms around each O-atom involving two covalently bonded H-atoms and two hydrogen bonded H-atoms. The O-atoms are arranged at the corners of hexagonal rings.

  - ✓ Because of the regular arrangement of water molecules linked by hydrogen bonding, ice has an open-cage structure with lots of empty space.

  - ✓ This structure explains the fact that the density of ice is about 10 % less than the density of liquid water. Ice can therefore float on water.

- **The number of $H_2O$ – molecules per unit volume**

  - ✓ 1 litre of water has a mass of 1000 grams
  - ✓ The molar mass of water is 18 g·mol$^{-1}$.
  - ✓ The number of moles in 1 litre = $\dfrac{1000}{18}$ = 55,56 moles
  - ✓ One mole consist of 6,02 x 10$^{23}$ water molecules (Avogadro's number).
  - ✓ The number of water molecules in one litre = 55,56 x 6,02 x 10$^{23}$

- ✓ There is $3{,}34 \times 10^{25}$ water molecules in 1 litre water
- **Heat capacity of water**

  ✓ As has already being explained, hydrogen bonds are stronger than dipole-dipole forces. Although $H_2O(\ell)$ does not have the regular structure of ice, hydrogen bonding still occurs.

  ✓ The extent of hydrogen bonding decreases as the temperature increases. Disrupting hydrogen bonds requires a significant amount of energy and results in the high **heat capacity** of water. Heat capacity is the ratio of the heat energy absorbed by a substance to the substance's increase in temperature. As a result of the high heat capacity of water it can absorb a great amount of energy before the temperature of the water rises.

  ✓ The **specific heat capacity** of a substance is the energy needed to increase the temperature of 1 kg of the substance with 1 $^0$C.

**Hexagonal structures of ice**

## LEARNER ACTIVITY [15 minutes]

### CLASSWORK ACTIVITY

1 Answer the following questions about the water molecule:
   a What is the shape of the molecule?
   b Is a water molecule polar or non-polar?
   c Draw diagrams of two water molecules. Use the diagrams to explain the difference between interatomic and intermolecular forces.
2 The table below summarizes the melting and boiling points of group VI hydrides.

| Hydrides of group VI | Melting points ($^0$C) | Boiling points ($^0$C) |
|---|---|---|
| $H_2O$ | 0 | 100 |
| $H_2S$ | -85 | -61 |
| $H_2Se$ | -60 | -42 |
| $H_2Te$ | -49 | -2 |

   a How does the molecular size of the hydrides change from period 2 to period 5?
   b The melting and boiling point of water is relatively high compared to the other hydrides in group VI although water is the smallest of the hydride molecules. What is responsible for this discrepancy?
3 Frozen water is less dense than liquid water – ice floats on water. Explain this observation.
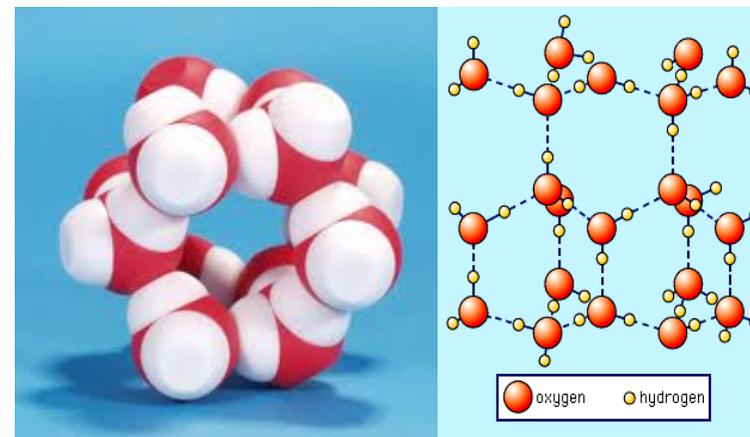
### ANSWERS for the CLASSWORK ACTIVITY

1.
    a.    Angular                              c.
    b.    Polar



covalent bonding between two atoms in a water molecule (*intramolecular forces*)

hydrogen bonds between two water molecules (*intermolecular forces*)

2.
    a.    The molecular sizes increase from period 2 to period 5.

    b.    Water molecules are bonded with strong hydrogen bonds. The molecules of the other hydrides in group VI are bonded with dipole-dipole Van der Waals forces. 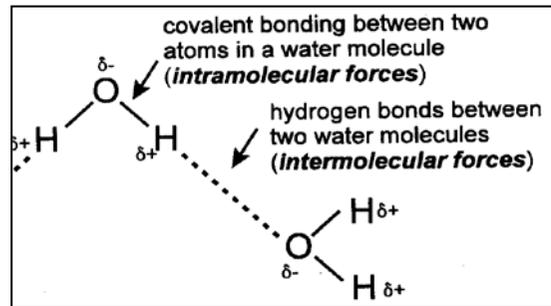Less energy is needed to break the bonds between these molecules, in order to obtain a vapour pressure that is equal to atmospheric pressure.

3.    All the bonds between molecules in the solid phase are hydrogen bonds. Because of the regular arrangement of the water molecules, ice has an open cage structure with open spaces between the molecules. Ice is less dense than water and floats on water.

**2. 3 Conclusion [10 min]**

Educator discusses the answers of the classwork activity AND summarises important aspects of the lesson, reinforcing what needs to be remembered and recalled.

**HOMEWORK QUESTIONS/ ACTIVITY** Learners can do selected questions from the revision exercise, page 113 – 115 From Oxford Successful Physical Sciences Grade 11.
**Recourses:** Power point presentation, transparency, prescribed text books, CAPS-document (page 74).

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 9 | TOPIC | Macroscopic properties of the three phases of water related to their microscopic structure | Lesson | 4 |
|-------|----|---------|-------------------|------|---|-------|------|--------|---|

| LESSON SUMMARY FOR: DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|
| **LESSON OBJECTIVES** | **At the end of the lesson learners should:** <br> • Be able to explain learners should be able to complete the recommended experiment for informal assessment. | | |

## TEACHING and LEARNING ACTIVITIES

**1. TEACHING METHOD/S USED IN THIS LESSON:**
Question and answer, explanation, experiment.

**2. LESSON DEVELOPMENT**

**Introduction [5 min]**

• Educator mark homework exercise.
• Baseline assessment is done.
• Educator asks questions to reinforce learners' understanding of the concepts: density, melting- and boiling point, solvent and solute.

**PRE-KNOWLEDGE**
A basic understanding of the following:
Intermolecular forces, polar and non-polar molecules, ionic compounds

**Main Body   (Lesson presentation)  [5 min]**

• If water is compared to other substances with molecules of the same size and structure, it is obvious that water has unique physical properties. The reason for these unusual characteristics has been discussed in lesson 7 (Refer to hydrogen bonding between water molecules).

• In this lesson some of the unique features will be investigated by the learners.


**LEARNER  ACTIVITY [40 minutes]**

**EXPERIMENT FOR INFORMAL ASSESSMENT**

**Refer to Oxford successful Physical Sciences grade 11, page 106 – 108**.

• Learners complete the three experiments in the laboratory.

• They record the observations for each experiment and use their observations to answer the following questions.

**QUESTIONS: INFORMAL ASSESSMENT**

1. Explain why the surface tension of water is greater than in most other substances.                                                   (3)

2. Distinguish between the term heat capacity and specific heat capacity.                                                   (4)

3.
   a.    How does the specific heat capacity of water compare to that of oil?     **(2)**
   b.    Explain the answer in 3 (a).     **(3)**
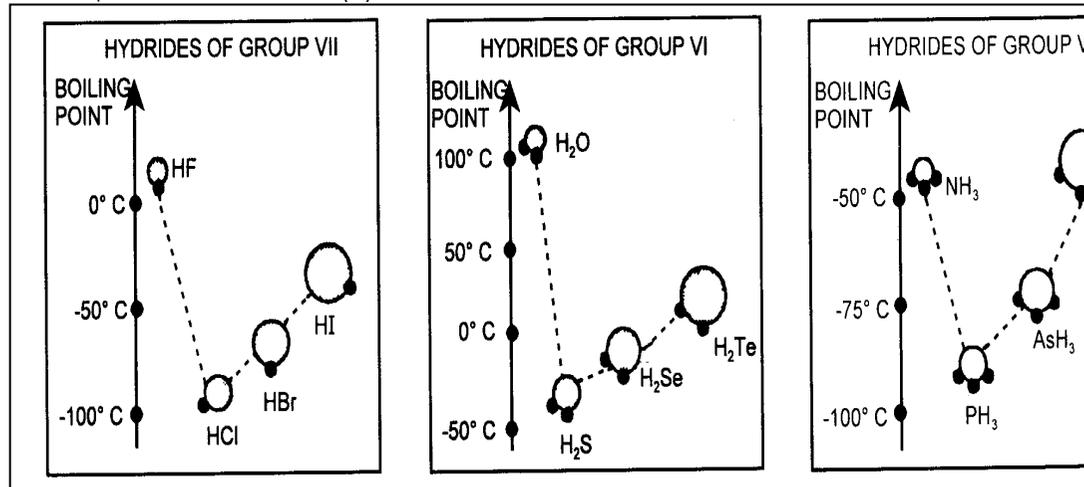
4.    The graphs below show the boiling points of the hydrides of groups V, VI and VII of the periodic table.



   a.   What relationship is there normally between the strength of intermolecular forces and the size of the molecule?     **(2)**
   b.   Are the hydrides mentioned in the question polar or non-polar?     **(2)**
   c.   What is the shape of a water molecule?     **(2)**
   d.   Explain any deviations from the normal trend in boiling points observed from the graphs.     **(3)**
   e.   The physical properties of water are significant for life on earth. Name three important physical properties of water.     **(3)**

5.    Explain why sodium chloride dissolves in water but iodine is insoluble in water.     **(6)**

**TOTAL [30]**

**ANSWER: INFORMAL ASSESSMENT**

1.    Surface tension can be defined as the resistance that a liquid offers to a force that tries to increase the surface tension. Molecules on the surface of water experience cohesion forces **downwards and sideways**, √ causing tension on the surface of the liquid. The strong **hydrogen bonds** √ between polar $H_2O$ molecules is responsible for the great surface tension of water. √     **(3)**

2.    Heat capacity is the amount of heat needed to raise the temperature of a substance with a given amount. √√ Specific heat capacity is the heat needed to raise the temperature of 1 kg of substance by 1 $^0C$. √√     **(4)**

3.
   a.    The specific heat capacity of water is much higher than that of oil. √√     **(2)**

4.    Water molecules are small molecules and are highly polar.√ The molecules are bonded strongly with hydrogen bonds. A great amount of energy is needed to increase the kinetic energy (temperature) of the molecules.√ The molecules in oil are bonded with weak Van der Waals forces.√

5.
   a.    As the size increases √ the strength of the intermolecular forces also increase. √     **(2)**

     b.     Polar √ √         **(2)**

     c.     Angular √ √         **(2)**

     d.     The substances with the smallest molecules in each group have the highest boiling points √ – the normal bonding model predicts that they should have the lowest boiling points. √  Hydrogen bonds between water are responsible for this deviation in the normal trend in boiling points. √   **(3)**

     e.     Ice is less dense than water; water exists in all three phases on earth; water acts as a universal solvent.   **(3)**

**3.**The general rule for solubility is like dissolves like. √ The strong electrostatic forces  √ between the sodium and chloride ions can be compared with the hydrogen bods between water molecules √ √. $I_2$ – molecules are non-polar, √ bonded with weak London dispersion forces and are therefore insoluble in water. √

**[30]**

### 2.3  Conclusion [10 min]

Educator discusses the answers of the practical activity. Learners do self or peer assessment.

**HOMEWORK QUESTIONS/ ACTIVITY** Educator asks learners to do research about the important role of water in traditional cooling apparatus. Learners can be divided in groups of two or three learners. Let them use their own initiative to prepare a presentation. Learners have to present their research during lesson 10.

**Recourses:** Power point presentation, transparency; chemicals, apparatus, prescribed text books, CAPS-document (page 74, 75).

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**Reflection/Notes:**

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| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

         © Gauteng Department of Education (CAPS  version)

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 10 | TOPIC | Macroscopic properties of the three phases of water related to their microscopic structure | Lesson | 1 |
|---|---|---|---|---|---|---|---|---|---|

| LESSON SUMMARY FOR:  DATE STARTED: | | | DATE COMPLETED: | |
|---|---|---|---|---|
| **LESSON OBJECTIVES** | **At the end of the lesson learners should:** <br> • Be able to explain that hydrogen bonds formed by water molecules enable water to absorb heat from the sun. <br> • Understand that this phenomenon ensures that the earth has a moderate climate. <br> • Be able to explain why water has an unusually higher than expected boiling point when compared to other hydrides. <br> • Understand that a decrease in density when water freezes helps moderate the temperature of the earth and its climate. <br> • Understand why the density of ice is less than the density of the liquid and the importance of this phenomenon in preserving aquatic life. | | | |

## TEACHING and LEARNING ACTIVITIES

1.  **TEACHING METHOD/S USED IN THIS LESSON:**
Question and answer, explanation

2.  **LESSON DEVELOPMENT**

2.1.  <u>Introduction</u> **[10 min]**

Educator allows learners to write a short baseline test to reinforce important concepts.

**BESELINE TEST**

1   Draw a Lewis structure for a water molecule. Use the structure to explain the polarity of the molecule.                                   **(5)**

2   Explain why the intermolecular forces in water are considered to be stronger than in hydrogen sulphide ($H_2S$). Identify the intermolecular forces in the two substances.
**(5)**

**[10]**

**ANSWERS TO BASELINE TEST.**
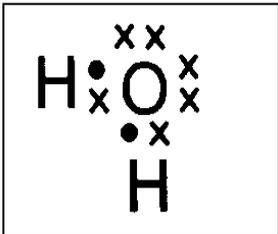
1      Water molecules are polar.√ The electronegativity difference of each O-H bond is 3,5 – 2,1 = 1,4.                          √√

2   √√ The molecule has an angular shape √ causing the one end of the molecule to be δ⁻ and the other end δ⁺. √
**(5)**

3    Intermolecular forces in $H_2O$ are hydrogen bonds. √√ Intermolecular forces in $H_2S$ are dipole-dipole interactions. √√ Hydrogen forces are stronger than normal dipole-dipole forces. √          (5)

[10]

**PRE-KNOWLEDGE**

**A basic understanding of the following:**

- The different physical properties of water related to strong hydrogen bonds.
- Heat capacity
- The greenhouse effect.

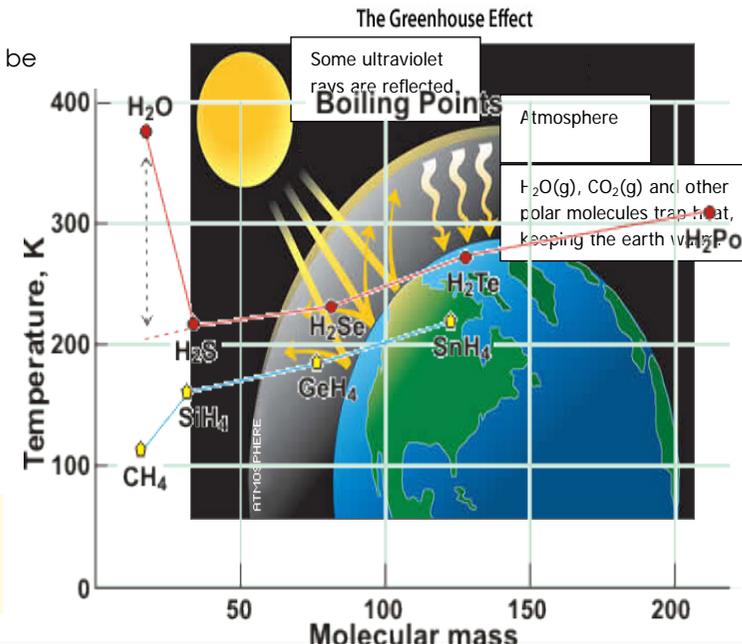**2.2.**   **Main Body   (Lesson presentation)  [30 min]**

- **Heat energy transferred by water and its effect on weather.**

  ✓   As has already being explained, hydrogen bonds are stronger than dipole-dipole forces.

  ✓   Although $H_2O(\ell)$ does not have the regular structure of ice, hydrogen bonding still occurs.

  ✓   The extent of hydrogen bonding **decreases** as the temperature **increases**.

  ✓   Disrupting hydrogen bonds requires a significant amount of energy and results in the high **heat capacity** of water.

  ✓   As a result of the high heat capacity of water, it can absorb a great amount of energy before the temperature of the water rises.

  ✓   The high heat capacity of water is, in large part, why oceans and lakes have such an enormous effect on weather.

  ✓   In autumn, when the temperature of the air is lower than the temperature of the ocean or lake, the water transfers energy as heat to the atmosphere, moderating the drop in air temperature.

  ✓   For each degree drop in temperature a great amount of energy is available to be transferred and the temperature of the water decreases very slowly.

  ✓   The temperature of oceans or lakes is normally higher than the average air temperature until late in autumn.

- **The greenhouse effect of water.**

  ✓   Earth's natural greenhouse effect makes life as we know it possible.

  ✓   Earth's gravity allows it to hold an atmosphere.

  ✓   Water vapour ($H_2O(g)$) and carbon dioxide ($CO_2(g)$) in the atmosphere provide a temperature buffer (greenhouse effect) which helps maintain a relatively steady surface temperature.

  ✓   The polarity of the covalent bonds in $H_2O$-molecules and the strong hydrogen bonds between the molecules that vibrates at the same frequency as infrared light are responsible for the fact that water absorbs sunlight.

  ✓   Water is the main absorber of the sunlight in the atmosphere and is responsible for about 70% of all atmospheric absorption of radiation, mainly in the infrared region where water shows strong absorption. It contributes significantly to the greenhouse effect ensuring a warm habitable planet.



The Greenhouse Effect

Some ultraviolet rays are reflected.

Atmosphere

$H_2O(g)$, $CO_2(g)$ and other polar molecules trap heat, keeping the earth warm.

Boiling Points

- ✓ The greenhouse gases, of which water accounts for most of the observed effect, allow Earth to warm by an average of $35^0C$. These gases are vital and life on Earth would be impossible without them.

- **The boiling point of water**
- ✓ We are used to the fact that water freezes at $0\ ^0C$ and boils at $100\ ^0C$.
- ✓ Intermolecular forces increases as the molecular size increases.
- ✓ Water is the smallest molecule of the hydrides in group VI, and the melting and boiling point of water is much higher than $H_2S$, $H_2Se$ and $H_2Te$. In fact, if we extrapolate the graph for boiling points, water would have a boiling point approximately $-100^0C$. That is about $200\ ^0C$ lower than the observed boiling point.

- ✓ The **hydrogen bonds** between highly polar water molecules are stronger than normal dipole-dipole forces and more energy is needed to break these bonds. Energy needed for molecules to evaporate, is called **heat of vaporization**. $40{,}7\ kJ\cdot mol^{-1}$ energy is needed for water molecules to evaporate – hence the higher than expected boiling point.

- **The relationship between changing density of water aquatic life and temperature**
- ✓ When ice melts at $0\ ^0C$, the regular structure imposed on the solid state by hydrogen bonding breaks down, and a relative large increase in density occurs. Surprisingly, as the temperature of liquid water is raised from $0\ ^0C$ to $4\ ^0C$, the density of the water **increases**. For almost all other substances known, density decreases as the temperature is raised.
- ✓ The hydrogen bonding model also explains this observation.
- ✓ At a temperature just above the melting point, some of the water molecules continue to cluster in ice-like arrangements and requires more space.
- ✓ Only about 15% of the bonds are broken when the ice melts. The volume contracts as the ice structures disappear and the density increases more.
- ✓ The density of water is a maximum at $4\ ^0C$. From this point the density declines with increasing temperature in the normal fashion.



©University of Kansas

Water freezes from the top down and protects the creatures underneath

- ✓ Because of the way the density of water changes as the temperature approaches the freezing point, lakes do not freeze solidly from the bottom up in the winter.
- ✓ As the lake water cools the density increases and the cooler water sinks while the warmer water rises.
- ✓ Oxygen-rich water moves to the bottom of the lake to restore the oxygen used during the summer and nutrients are brought to the top layers of the lake.
- ✓ As the temperature decreases more, the colder water stays on the top of the lake, because water cooler than $4\ ^0C$ is less dense than water at $4\ ^0C$. Ice can begin to form on the surface, floating there and protecting the water below and aquatic life from further heat loss.
- ✓ Remember that ice is a poor conductor of heat.

**LEARNER ACTIVITY** [15 MINUTES]

**CLASSWORK ACTIVITY**

1       The water just below the ice in a frozen lake is much colder than the water on the bottom of the lake.

   a       Why is this observation possible?

   b       Explain why this is important for the continued existence of aquatic life.

2       Explain how water in big lakes help to maintain moderate temperatures in autumn.

3       Greenhouse gases and the battle against global warming are certainly some of modern society's biggest problems. However, greenhouse gases are essential for life on earth. Why can we consider water vapour as a greenhouse gas?

4       Explain how the density of water changes as the temperature is increased from   $0\ ^0C$ to $25\ ^0C$.

5

   a       What is the shape of an ice crystal?

   b       Explain how ice crystals are formed?

**ANSWERS for the CLASSWORK ACTIVITY**

1.      In autumn when the temperature of the air is lower than the temperature of the ocean or lake, the water transfers energy as heat to the atmosphere, moderating the drop in air temperature. The temperature of the lake is normally higher than the average air temperature until late autumn.

2.      The polarity of the covalent bonds in the water molecules and the strong hydrogen bonds between the water molecules that vibrates with the same frequency as the infrared rays from the sun is responsible for the fact that water is the main absorber of sunlight. This ensures a warm habitable planet.

3.      When ice melts at $0\ ^0C$ the regular structure of the solid breaks down and a relative large **increase** in density occurs. (Most other substances show a decrease in density from $0 – 4\ ^0C$.) The reason is that some of the $H_2O$ molecules continue to cluster in ice-like arrangements that require more space. As the ice-like structures disappear, the density increases more. From $4\ ^0C$, where the density is a maximum, the density decreases in the normal manner.

4.

   a.      Ice crystals contain groups of six $H_2O$ molecules in a hexagonal structure.

   b.      Each H atom of a $H_2O$ molecule can form a hydrogen bond to a lone pair of electrons on the O atom of the adjacent $H_2O$ molecule. The O atoms are arranged at the corners of hexagonal rings.

**2.3  Conclusion** [5 min]

Educator discusses the answers of the classwork activity.

**HOMEWORK QUESTIONS/ ACTIVITY** Educator reminds learners of the research on traditional cooling systems. Presentations of the research must be done in the next lesson.

**Recourses:** Power point presentation, transparency; prescribed text books, CAPS-document (page 74, 75).

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 12 | TOPIC | Waves, sound and light: Geometrical optics - refraction. | Lesson | 1 |
|-------|----|---------|-------------------|------|----|-------|----------------------------------------------------------|--------|---|

| LESSON SUMMARY FOR: DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|

| LESSON OBJECTIVES | **At the end of the lesson learners should:**<br>• Have revised the concept of reflection<br>• Be able to state the law of reflection<br>• Define the speed of light as being constant when passing through a given medium and having a maximum value of $c = 3 \times 10^8$ m·s$^{-1}$ in a vacuum |
|---|---|

## TEACHING and LEARNING ACTIVITIES

1. **TEACHING METHODS USED IN THIS LESSON:**
Question and answer, explanation, demonstration

2. **LESSON DEVELOPMENT**

2.1. **Introduction [5 min]**

- Educator introduces the topic of geometrical optics as a method to describe the motion of light.
- Optics is the study of light and the interaction of light and matter.
- Briefly mention interesting characteristics of light e.g. why shadows are formed.
- Use pictures or diagrams to awake the learner's interest.

A basic understanding of the following:

- A pulse is a single disturbance in a medium.
- A wave is a number of consecutive pulses.
- Light waves can be classified as transverse waves.
- Light travels in straight lines – this is the reason for the formation of shadows.


28.105.3.1 Shadow game

2.2. **Main Body (Lesson presentation) [30 min]**

- In this lesson, Educator does revision of two concepts:

(a) **Reflection**

✓ When light rays (from a ray box) are shone onto a surface, the rays are reflected from the surface.

✓ Reflection of light makes it possible to see mirror images of ourselves.

✓ Educator can use a light ray from a ray box to explain the words: incident ray; refracted ray and normal.

✓ Learners should understand that a normal line is **constructed** perpendicular to the surface and at the point where the incident ray collides with the
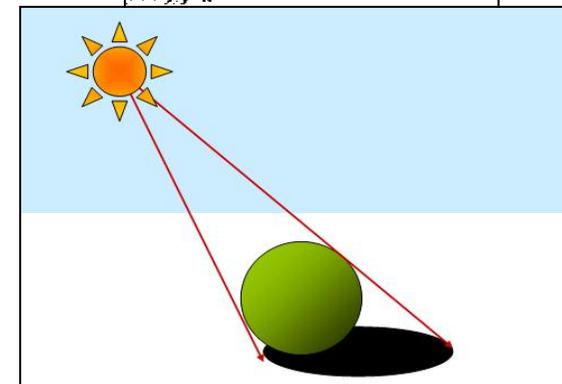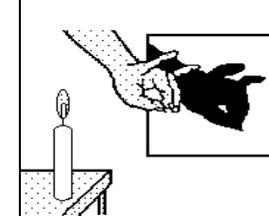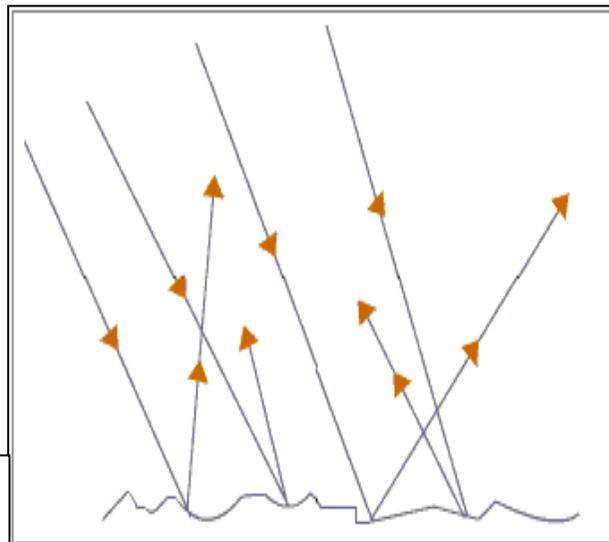
surface – refer to diagram. Angles are measured from the normal.

✓ The light is reflected (bounced off) from the surface, in such a way that the angle of reflection is always equal to the angle of incidence.

✓ The law of reflection states that for a light ray that is reflected off a surface the angle of incidence = angle of reflection.
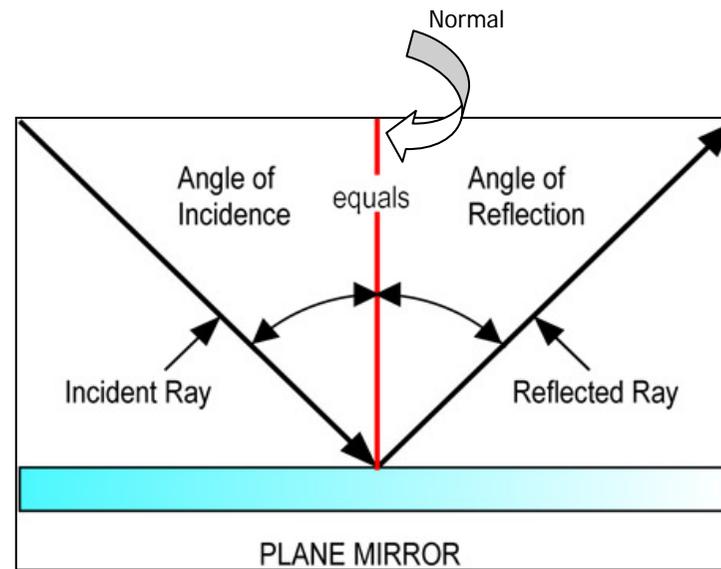


✓ Light rays can be reflected from a smooth or a rough surface.

✓ When light is reflected off a smooth surface such as a mirror, all of the rays are reflected at the same angle due to the smoothness of the surface and a clear image will be formed. This is called **specular reflection**.

✓ On a rough surface, the light rays are being reflected from parts of the surface that are at different angles to one another. The reflected rays are shining in different directions to one another and no clear image will be formed. This is called **diffuse reflection**.

Diffused reflection

✓ Although the law of reflection is always obeyed in both cases, we might not always be able to see the reflected rays.

**(b)** **Speed of light**

✓ Light waves are in the visible part of the electromagnetic spectrum.

✓ Light travels with a constant speed through a medium.

✓ Most other waves, like sound waves, need a medium through which it can be propagated. However, light waves can be propagated through a vacuum. . (Vacuum is a space that is empty of matter)

✓ When light travels through a vacuum, it has a speed of $3 \times 10^8$ m·s$^{-1}$.

✓ This is the maximum speed that light can have.

✓ The speed of light in air is slightly less – $2,998 \times 10^8$ m·s$^{-1}$.

✓ It is important that learners understand that the speed of light is different in different mediums.

✓ The density of the medium (optical density) determines the speed of the light ray.

**LEARNER ACTIVITY** **[15 min]**

**GROUPWORK:** Learners investigate the law of reflection

• Learners work in groups.

• Each group uses a light ray box, mirror, protractor, white paper and a pencil to prove that the angle of reflection is equal to the incident angle.

• They repeat the experiment for at least three different incident angles and redraw the constructions in their note books. All the constructions must be labeled.

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**2.3  Conclusion [10 min]**

- Educator controls the diagrams in the learner's books and discusses any misconceptions,

**HOMEWORK ACTIVITY**

Oxford Successful Physical Sciences grade 11: p 127 Activity 1

**Recourses:** Apparatus, power point presentation and transparencies; prescribed text books, CAPS-document (page 76).

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 12 | TOPIC | Waves, sound and light: Geometrical optics - refraction. | Lesson | 2 |
|---|---|---|---|---|---|---|---|---|---|

| LESSON SUMMARY FOR: DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|

| **LESSON OBJECTIVES** | **At the end of the lesson learners should:** <br> • Be able to define refraction <br> • Be able to define refractive index as $n = \frac{c}{v}$ <br> • Define optical density <br> • Know that the refracted index is related to optical density <br> • Explain that refraction is a change of wave speed in different media, while frequency remains constant |
|---|---|

## TEACHING and LEARNING ACTIVITIES

1. **TEACHING METHOD/S USED IN THIS LESSON:**
Question and answer, explanation

2. **LESSON DEVELOPMENT**

2.1. **Introduction [5 min]**

- Educator discusses the answers to homework questions. (Answers in Teacher's guide p 113)
- Ensure that learners understand the concept of reflection in order to minimize confusion when they start with refraction.

**A basic understanding of the following:**

- Frequency, wavelength and wave speed.
- The wave equation: v = fλ.
  - ✓ v is the speed of the wave in m·s$^{-1}$.
  - ✓ f is the frequency of the wave in Herz [Hz].
  - ✓ λ is the wavelength in meter [m].
- Learners should also understand that the equation is changed to c = fλ when light waves are discussed.
- As mentioned in lesson 1, the speed of light is constant in a specific medium.

2.2. **Main Body (Lesson presentation) [30 min]**

- **Refraction of light.**

  - ✓ When light moves from one medium into another with a different optical density, the ray changes direction. This phenomenon is observed because the speed of light changes from one medium to another.
  - ✓ The following diagrams can be used to relate everyday situations to the phenomenon called refraction.

The pencil in the water, looks bended because light rays reflected by the pencil, moves from water through air to reach the observer's eyes. The speed of the light changes as it enters into air.
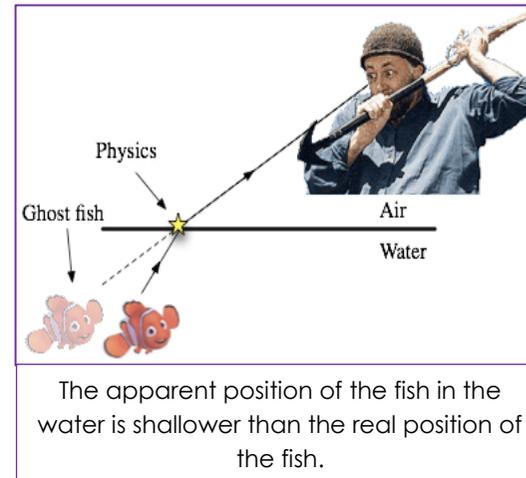


The apparent position of the fish in the water is shallower than the real position of the fish.



Dramatic effects of refraction

✓     The change in direction of waves because its speed changes as it moves from one optical medium to another, is called **refraction**.

✓ Each medium changes the speed of light by a different amount.

✓ The measure of the speed of light in a medium is called the **refractive index**.

- **Refractive index**

  ✓ The refracted index is linked to the **optical density** of the medium.

  ✓ Learners should not confuse optical density with the density of a substance which is the ratio $\frac{\text{mass}}{\text{volume}}$

  ✓ The more optical dense a substance is, the slower a wave will move through the material. A substance with a high optical density has a high refractive index, because it slows the light wave down more than a substance with a low optical density.

  ✓ As light enters a new medium and is refracted, the frequency of the waves remains **constant**.

  ✓ The speed and the wavelength are changed.

- **Calculating the refractive index**

  ✓ The following formula is used to calculate the refractive index: $n = \frac{c}{v}$

    where

    | |
    |---|
    | n = refractive index (the index is a ratio of two speeds, therefore no SI-units <br> c = speed of light in a vacuum: $3 \times 10^8$ m·s⁻¹ <br> v = the speed of light in the new medium: SI unit m·s⁻¹ |

- **Example**

  The speed of light in water is $2,25 \times 10^8$ m·s⁻¹. Calculate the refractive index of water.

  $n_{water} = \frac{c}{v} = \frac{3 \times 10^8}{2,25 \times 10^8} = 1,33$

- Because the speed of light is a maximum in a vacuum, the refractive index for other media relative to a vacuum is always greater than 1.

- The larger the refractive index, the slower light travels through the substance and the more it refracts the light.

**LEARNER ACTIVITY[15 min]**

**CLASSWORK ACTIVITY**

1. The speed of light in Perspex is $2,04 \times 10^8$ m·s⁻¹. Calculate the refractive index of Perspex.

2. A light wave with a frequency of $7,5 \times 10^{14}$ Hz enters glass that has a refractive index of 1,5. Calculate the following:

    (a) The speed of the light wave in glass.

    (b) The wavelength of the light wave in glass

    (c) The frequency of the light wave in glass.

3.    From the information given in the above questions, which substance has the greater optical density, Perspex or glass?

**ANSWERS for the CLASSWORK ACTIVITY**

1.    $n_{perspex} = \frac{c}{v} = \frac{3 \times 10^8}{2,04 \times 10^8} = 1,47$

2.

    (a)    $n_{glass} = \frac{c}{v}$    $v = \frac{c}{n_{glass}} = \frac{3 \times 10^8}{1,5} = 2 \times 10^8 \, m \cdot s^{-1}$

    (b)    From the wave equation $v = f\lambda$

        $\lambda = \frac{v}{f}$

        $\lambda = \frac{2 \times 10^8}{7,5 \times 10^{14}}$

        $\lambda = 2,67 \times 10^{-7} \, m$

    (c)    The frequency of the light does not change. $f = 7,5 \times 10^{14} \, Hz$

3.    The refractive index of glass (1,5) is higher than the refractive index of Perspex (1,47). Glass has a greater optical density than Perspex.

## 2. 3  Conclusion [10 min]

• Educator marks class work activity.

**HOMEWORK ACTIVITY**

Oxford Successful Physical Sciences grade 11: p 129 Activity 1

**Recourses:** Apparatus, Scientific calculator, power point presentation and transparencies; prescribed text books, CAPS-document (page 76).

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 12 | TOPIC | Waves, sound and light: Geometrical optics - refraction. | Lesson | 3 |

| LESSON SUMMARY FOR: DATE STARTED: | | DATE COMPLETED: | |

| LESSON OBJECTIVES | At the end of the lesson learners should:<br>• Be able to define Normal<br>• Define angle of incidence<br>• Define angle of refraction<br>• Sketch ray diagrams to show the path of a light ray through different media |

## TEACHING and LEARNING ACTIVITIES

1. **TEACHING METHOD/S USED IN THIS LESSON:**
Question and answer, explanation, practical experiment

2. **LESSON DEVELOPMENT**

2.1. **Introduction [5 min]**

- Educator discusses the answers to homework questions. (Answers in Teacher's guide p 114)
- Allow learners to ask any questions that they may have about homework questions..

A basic understanding of the following:

- Refraction.
- Refractive index.
- Speed of waves, frequency and wavelength.
- How to use a protractor,
- How to draw perpendicular lines.

2.2. **Main Body   (Lesson presentation)  [15 min]**

- In this lesson, learners are going to investigate how a light ray is refracted as it passes through a transparent object.

- It is important that they understand the terminology that is used:

✓ The **normal** to the surface – A line that is constructed perpendicular to the surface of a new medium, where light enters the medium.

New medium

Normal

- ✓ The **incident ray** enters the new medium where the normal is constructed.
- ✓ The angle between the normal and the incident ray, is called the **angle of incidence**,

Incident ray

Normal

Angle of incidence
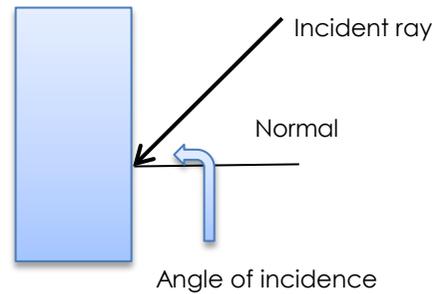
- ✓ he light ray that has entered the new medium is called the **refracted ray**.
- ✓ The angle that is formed between the refracted ray and the normal is called the angle of **refraction**.

Normal

Refracted ray

Angle of refraction
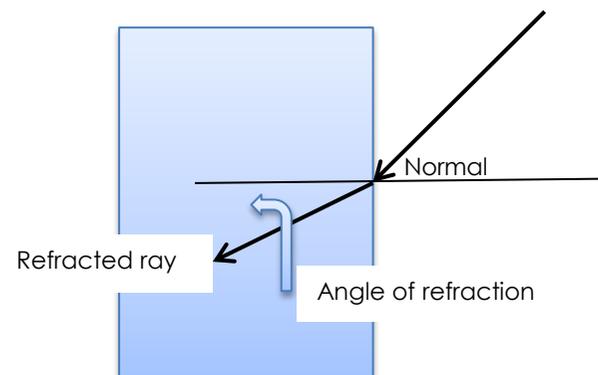
✓ The **emergent ray** comes out (emerges) from a transparent block.

✓ **Dispersion**: At certain angles the emergent ray from a triangular block splits up into the different colours of the spectrum.

The spectrum of white light is visible when a ray of white light is refracted through a 60⁰ prism.

- The following points must be highlighted.

  ✓ Refraction only occurs at a boundary where one medium meets another.

  ✓ Light is not refracted when it strikes the medium along the normal.

  ✓ Within a medium, the speed of light waves does not change and the light rays travel at a constant speed.

  ✓ When light rays **enter** a medium with a **higher** refractive index, it bends **towards** the normal.

  ✓ In the diagram, crests of waves are shown as they approach a boundary where waves slow down. Certain parts of the crests, that hit the boundary first, slow down before the rest of the crest.

  ✓ This changes the direction of the wave.

  ✓ The wavelength decreases and the waves bend towards the normal

  ✓ When light rays **enter** a medium with a **lower** refractive index, it bends **away** from the normal.

  ✓ The crests of the waves that hit the boundary first speed up and change direction.

  ✓ In this case the wavelength increases and the waves bend away from the normal.
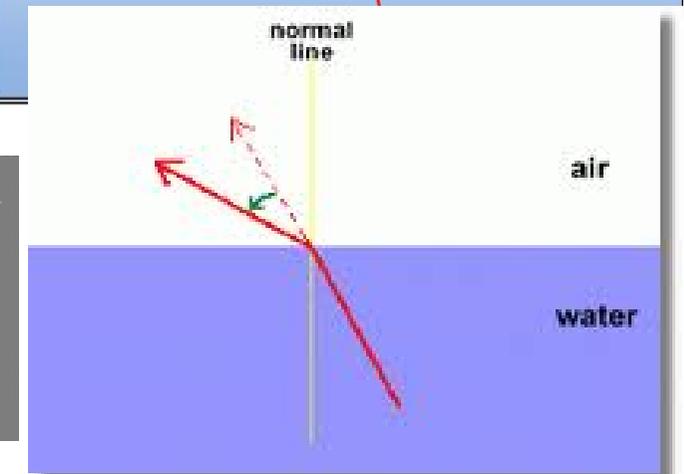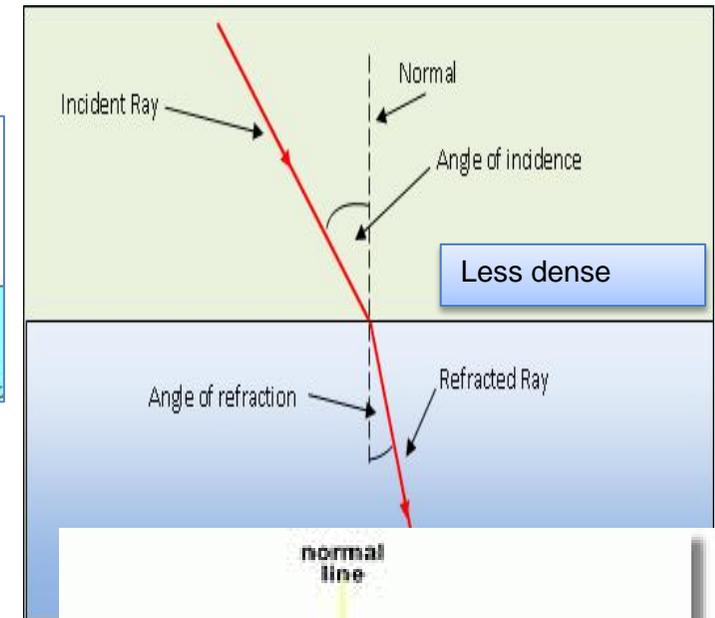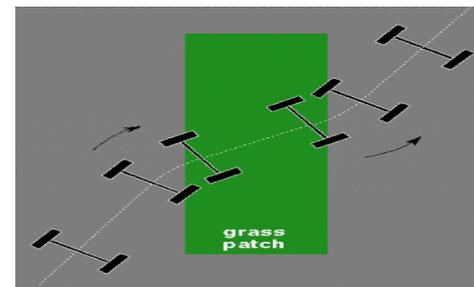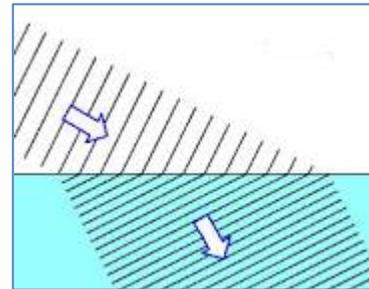
✓ The diagram shows how go-carts slow down as they move across a patch of lawn – this can be used as an analogy for the refraction of light rays.

✓ A ray that leaves a rectangular block, with parallel sides is in the same direction as the incident ray.

✓ The frequency of the light does not change.

**LEARNER ACTIVITY[25 min]**

**PRACTICAL ACTIVITY (Experiment)**

- Learners can work in small groups and investigate the propagation of light through transparent blocks.
- Do Experiment 1, page 130, Oxford Successful Physical sciences

**ANSWERS for the CLASSWORK ACTIVITY**

Page 130, Oxford Successful Physical sciences(Teacher's Guide)

**2.3 Conclusion [15 min]**

- Educator discusses the results of the experiment with learners.
- It is important that ray diagrams are neatly drawn and that all angles are measured accurately.

**HOMEWORK ACTIVITY**

Oxford Successful Physical Sciences grade 11: p 133 Activity 2

**Recourses:** Appropriate apparatus, power point presentations or transparencies; prescribed text books, CAPS-document (page 76).

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 12 | TOPIC | Waves, sound and light: Geometrical optics – Snell's Law | Lesson | 4 |
|-------|----|---------|-------------------|------|----|-------|---------------------------------------------------------|--------|---|

| LESSON SUMMARY FOR:  DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|

| LESSON OBJECTIVES | **At the end of the lesson learners should:**<br>• Be able to state the relationship between the angles of incidence and refraction and the refractive indexes of the medium when light passes from one medium into another (Snell's Law) |
|---|---|

## TEACHING and LEARNING ACTIVITIES

**1.    TEACHING METHOD/S USED IN THIS LESSON:**
Question and answer, explanation.

**2.    LESSON DEVELOPMENT**

**2.1.    Introduction [5 min]**

- Educator discusses the answers to homework questions. (Answers in Teacher's guide p 115)
- Discuss questions that learners may have.

A basic understanding of the following:

- Refraction.
- Refractive index.
- Incident and refractive rays.
- Incident and refractive angles.
- Speed of waves, frequency and wavelength.
- Trigonometry
- How to use a scientific calculator.

**2.2.    Main Body   (Lesson presentation)  [25 min]**

- Learners, offering Maths Literacy as a subject may find the Trigonometry in this lesson somewhat challenging.
- Educator should take much care when explaining the topiicc

- ✓    Use the diagram in explanations.
- ✓    Scientists have found a way of predicting the angle of refraction.
- ✓    In the diagram, the refractive index for the incident medium is $n_i$ and for the refractive medium is $n_r$.
- ✓    The angle that the incident ray makes with the normal is $\theta_I$ and the angle that the refracted ray makes with the normal is $\theta_r$.
- ✓    Snell's law states that the ratio of the sine's of the angles of incidence and refraction is equivalent to the ratio of phase velocities in the two media, or equivalent to the reciprocal of the ratio of the indices of refraction:

$$\frac{\sin\theta_I}{\sin\theta_r} = \frac{n_r}{n_i} = \frac{v_i}{v_r}$$
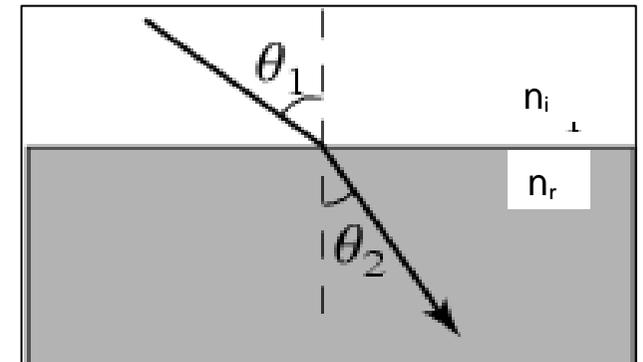
- ✓ From the equation above, it follows that that the sizes of the angles of incidence and refraction are related to the speed of light through the medium.
- ✓ Sin θ and therefore the angle θ, is greater in a medium in which the speed of light is faster.

- **Snell's Law** states that for light passing from an incident medium into a refracted medium: $n_i \sin θ_i = n_r \sin θ_r$

> $n_i$ is the refractive index for the incident medium
> $n_r$ is the refractive index for the refractive medium
> $θ_I$ is the angle of incidence
> $θ_r$ is the angle of refraction

- ✓ From $\frac{\sin θ_I}{\sin θ_r} = \frac{n_r}{n_i}$ it follows that the ratio $\frac{\sin θ_I}{\sin θ_r}$ for two media is constant and independent of the angle of incidence.
- ✓ If the incident light is in a vacuum (air) which has a refracted index of 1. the equation becomes:
- ✓ $\frac{\sin θ_I}{\sin θ_r} = n_r$

Learners should be familiar with their calculators. Explain to them how to convert sin θ to an angle with different calculators.

- **Example 1**

During an investigation by a group of grade 11 learners a ray of light from a laser is shone through a rectangular block of plastic.
They measured the angle of incidence = $30^0$ and the angle of refraction = $20^0$. Calculate the refractive index of the block.

**Solution**

$\frac{\sin θ_I}{\sin θ_r} = n_r$

$\frac{\sin 30}{\sin 20} = n_r$

$n_r = 1,46$

- **Example 2**

Light is shining from air into water at an angle of $45^0$ relative to the normal. Calculate the angle of refraction in water.                     ($n_{air}$ = 1; $n_{wate}$ = 1,33)

**Solution**

Air is the incident medium and water is the refracted medium.

Use Snell's Law:  $n_i \sin θ_i = n_r \sin θ_r$

$\sin θ_r = \frac{n_i \sin θ_i}{n_r} = \frac{(1) \sin 45^0}{1,33}$

$\sin\theta_r = 0,53$

$\theta = 32,11$

**LEARNER ACTIVITY[15 min]**

**CLASSWORK ACTIVITY (The activity can be used for informal assessment).**

1. Complete the ray diagrams below to show the path of light as the ray enters the new medium. (6)
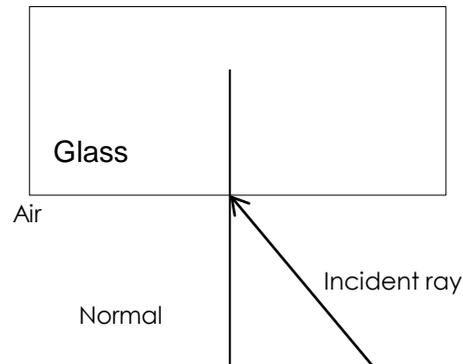
(a)                                                          (b)
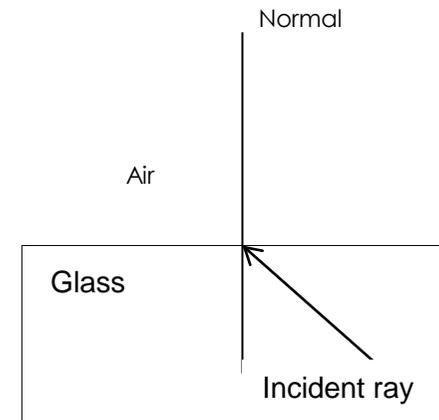


2. Light is shining from air into Perspex at an angle of $53^0$ with the normal. ($n_{air} = 1$; $n_{Perspex} = 1,47$) Calculate the angle of refraction of Perspex. (3)

3. Light that is shining from air into water has an angle of refraction in water of $23^0$. Calculate the angle of incidence in air. (4)

4. Light is shining from glass into air at an angle of $35^0$ with the normal. ($n_{air} = 1$; $n_{water} = 1,33$)

(a) Calculate the angle of refraction in air. (3)

(b) Water has a greater optical density than air. If this piece of glass is placed in water instead of air, and the angle of incidence is kept the same as before, would the angle of refraction in water be greater than, smaller than or equal to the angle of refraction in air? Explain your answer. (4)

**Total marks = 20**

**ANSWERS for the CLASSWORK ACTIVITY**

1.

(a)                                          (b)



Glass

Incident ray
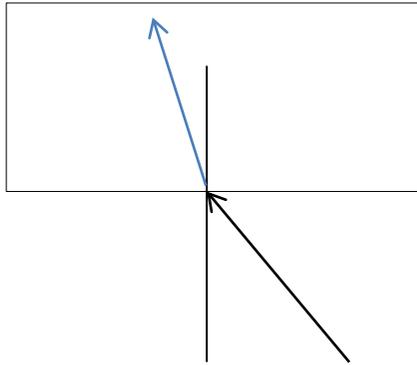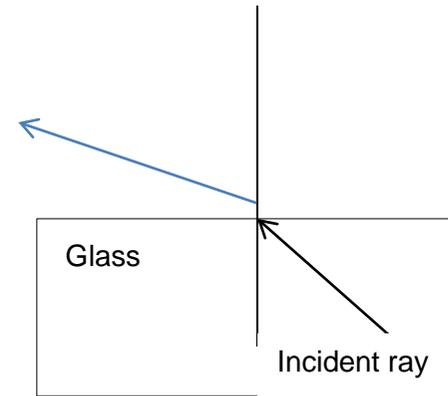
Allocate marks as follows:  (1) for showing refracted

(1)  for the ray is refracted towards/away from the normal

1.  for arrow-head on the ray                                                          (6)

2.  From Snell's Law:
$n_i \sin \theta_i = n_r \sin\theta_r$ √

$\sin\theta_r = \dfrac{n_i \sin \theta_i}{n_r} = \dfrac{(1) \sin 53^0}{1,47}$ √

$\theta_r = 32,9^0$ √                                                                  (3)

3.  $n_i \sin \theta_i = n_r \sin\theta_r$ √

$\sin\theta_i = \dfrac{n_r \sin \theta_r}{n_i} = \dfrac{1,33 \sin 23^0}{1}$ √

$\theta_i = 31,3^0$ √                                                                  (3)

4.

(a)  $n_i \sin \theta_i = n_r \sin\theta_r$ √

$\sin\theta_r = \dfrac{n_i \sin \theta_i}{n_r} = \dfrac{(1,52) \sin 35^0}{1}$ √

$\theta_r = 60,79^0$ √                                                                 (3)

(b)  Water has a greater optical density than air. √The denominator in the equation in (a) will increase√, so that $\sin\theta$ will decrease. The angle $\theta$ will also decrease.√
The angle of refraction in water will be smaller than in air.√                    (4)

(20)

## 2.3 Conclusion [15 min]

- Educator marks classwork activity - use peer or self assessment.
- Discuss learner's problems and try to limit misconceptions.

## HOMEWORK ACTIVITY

Oxford Successful Physical Sciences grade 11: p 137 Activity 2, Question 1,2

**Recourses:** Appropriate apparatus, Scientific calculator, power point presentations or transparencies; prescribed text books, CAPS-document (page 77).

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 13 | TOPIC | Waves, sound and light: Geometrical optics - refraction. | Lesson | 1 |
|---|---|---|---|---|---|---|---|---|---|

| LESSON SUMMARY FOR:  DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|

| **LESSON OBJECTIVES** | **At the end of the lesson learners should:**<br>• Be able to apply Snell's law to problems involving light rays passing from one medium to another.<br>• Draw ray diagrams showing the path of light when it travels from a medium with a higher refractive index to one of lower refractive index and vice versa |
|---|---|

## TEACHING and LEARNING ACTIVITIES

1. **TEACHING METHOD/S USED IN THIS LESSON:**
Question and answer, explanation

2. **LESSON DEVELOPMENT**

2.1. **Introduction [5 min]**

• Educator discusses the answers to homework questions. (Answers in Teacher's guide p 118)
• Allow learners to ask any questions that they may have about homework questions.

A basic understanding of the following:
• Snell's Law
• Optical density
• Refractive index
• Normal

2.2. **Main Body   (Lesson presentation)  [15 min]**

• This lesson focuses on learner's ability to use Snell's law to solve problems and to draw different ray diagrams.
• Educator can revise the content of the previous lesson and then allow learner's to do the classwork activity.

**LEARNER ACTIVITY[25 min]**

**CLASSWORK ACTIVITY**

1. Which ONE of the following ray diagrams explains why a bowl with water seems shallower than what it really is?

A

B

C

D
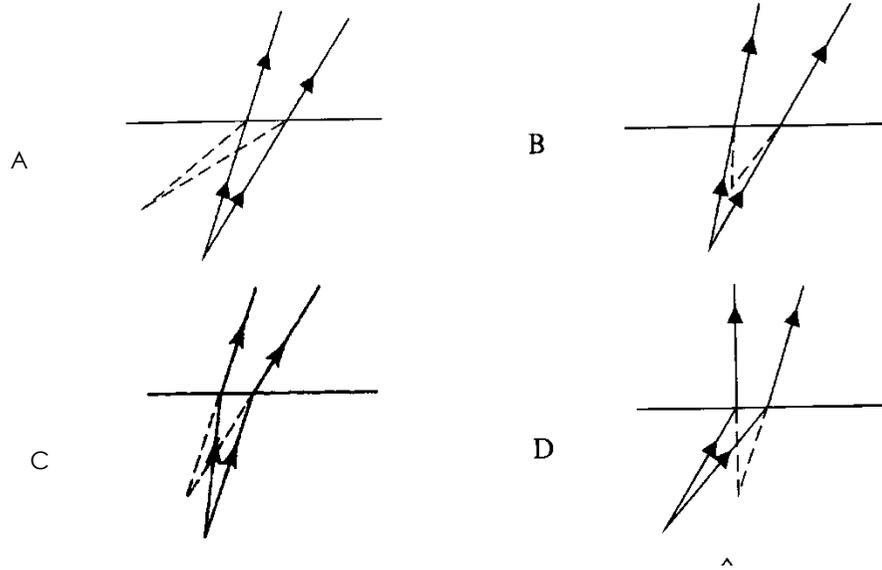
2. Seabirds instinctively know that the best way to catch fish is to dive directly from above towards the fish. Use a diagram to explain this observation.

3. Redraw the following diagram and complete the path of the ray as it moves from air to glass.

Air

Glass

4.  In the diagram below, a light ray is shown as it moves from air into water. Which of the three rays is the most likely one as the ray emerges into the air again? Explain your answer.

5.  In the diagram below, a light ray is shown as it moves from water into air. Which of the three rays is the most likely one as the ray emerges into the water again? Explain your answer.

6.  Allow learners to work through Oxford Successful Physical Sciences grade 11: p 137 Activity 2 Questions 3 and 4.

**ANSWERS for the CLASSWORK ACTIVITY**

1. C  Light moves from a more dense to a lese dense medium and is refracted away from the normal. The dotted lines show the apparent position in the water.

2. Although the fish appears shallower, the apparent position is directly above the real position. The bird will have a greater chance in catching the fish than when it dives at an angle.

3.

Air

Glass
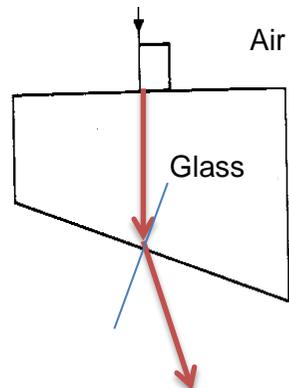
4. It is most likely to be **a**. The light ray moves from a less dense to a more dense optical medium and is bent towards the normal. As it emerges into air again it is bent away from the normal.

5. It is most likely to be **c**. The light ray moves from a more dense to a less dense optical medium and is bent away from the normal. As it emerges into water again it is bent towards the normal.

6. Answers are found in the Teacher's Guide ofOxford Successful Physical Sciences grade 11: p 118

**2.3 Conclusion [15 min]**

- Educator discusses the answers of the classwork activity.

**HOMEWORK ACTIVITY**

1. Fill in the missing words in the following sentences:
   (a) The law of reflection states that the angle of _____ is equal to the angle of _____. _____ (2)
   (b) A line that is constructed at right angles to a surface is called the _____ to the surface. (1)
   (c) The angle between the incident ray and the normal is called the angle of _____ (1)
   (d) The angle between the _____ ray and the normal is called the angle of refraction. (1)
   (e) The measure of the speed of light in a medium is called the _____ index of the medium. (1)
   (f) A light ray that moves from a medium with a low optical density to a medium with a higher optical density are bent _____ the normal. (1)

2. A light wave has a wavelength of 6 x 10$^{-7}$ m and a speed of 3 x 10$^8$ m·s$^{-1}$ in air. When the wave enters diamond its speed changes to 1,25 x 10$^8$ m·s$^{-1}$. Find the following:
   (a) The refractive index of diamond. (3)
   (b) The frequency of the light wave in diamond. (3)
   (c) The wavelength of the wave in diamond. (3)
3. Peter, Mpho, Ivan and Linda are in a room with a mirror, as shown in the diagram. There is a wall between Peter and Mpho. Answer the following questions. Explain each answer.



Peter          Wall          Mpho          Ivan          Linda
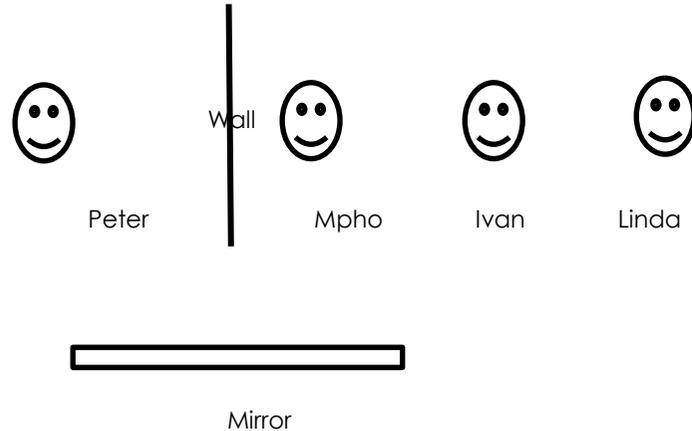
Mirror

   (a) Whose reflection will Mpho see in the mirror? (2)
   (b) Will Ivan be able to see his own reflection? (2)
   (c) Whose reflection will Linda see? (3)
   (d) Will Peter be able to see Mpho's reflection? (2)
4. The speed of light in Perspex is 2,03 x 10$^8$ m·s$^{-1}$.
   (a) Calculate the refractive index of Perspex. (3)
   (b) Light is shining from air into the Perspex with an angle of incidence of 30$^0$. Calculate the angle of refraction. (3)

**TOTAL: 30**

**Answers to homework activity**
1.
   (a) Incidence; reflection √√
   (b) Normal √
   (c) Incidence.√
   (d) Refracted √
   (e) Refractive √
   (f) Towards √                    (7)
2.
   (a) n $_{diamond}$ = $\frac{c}{v}$ √ = $\frac{3 \times 10^8}{1,25 \times 10^8}$ √ = 2,4 √    (3)
   (b) f = $\frac{c}{\lambda}$ √ = $\frac{3 \times 10^8}{6 \times 10^7}$ √ = 5 x 10$^{14}$ Hz √    (3)
   (c) v = fλ
       λ = $\frac{v}{f}$ √ = $\frac{1,25 \times 10^8}{5 \times 10^{14}}$ √ = 2,5 x 10$^{-7}$ m √    (3)

3.

(a) Mpho will see his own reflection as well as that of Ivan.√ The angle of incidence is always equal to the angle of reflection no rays coming from Linda will reach Mpho. Rays coming from Peter will be blocked by the wall.√ (2)

(b) Ivan will not see his own reflection √because he is not standing directly in front of the mirror. √ (2)

(c) Linda will see Peter's reflection,√ because rays from Peter will be reflected by the mirror and reach her eyes. The wall will not block these rays.√ (2)

(d) No,√ rays from Mpho will be blocked by the wall before they reach the mirror at the right place to be reflected to Peter. √ (2)

4.

(a) $n_{Perspex} = \frac{c}{v}$ √$= \frac{3 \times 10^8}{2,03 \times 10^{14}} =$√ $1,48$ √ (3)

(b) $n_i \sin\theta_i = n_r \sin\theta_r$ √

$\sin\theta_r = \frac{n_i \sin\theta_i}{n_r} = \frac{(1)\sin 30^0}{1,48}$ √ $= \theta_r = 19,7^0$ √ (3) (30)

**Recourses:** Appropriate apparatus, power point presentations or transparencies; prescribed text books, CAPS-document (page 76).

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 13 | TOPIC | Waves, sound and light: Geometrical optics – Snell's Law | Lesson | 2 |
|-------|----|---------|-------------------|------|----|-------|------|--------|---|

| LESSON SUMMARY FOR: DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|

| **LESSON OBJECTIVES** | **At the end of the lesson learners should:**<br>• Be able to verify Snell's Law of refraction for an unknown medium.<br>• Be able to determine the refractive index of an unknown medium.<br>• After completing these lessons, learners should be able to do the prescribe project as explained on p 12 of the CAPS document. |
|---|---|

## TEACHING and LEARNING ACTIVITIES

1.   **TEACHING METHOD/S USED IN THIS LESSON:**

**Question and answer, explanation, experiment (project).**

Educator can choose one of the following topics for prescribed formal assessment: Chemistry: exothermic and endothermic reactions or Physics: Snell's Law. Learners have to complete a project on one of the topics. Please refer to page 145 of the CAPS document for information on projects.

This lesson focuses on Snell's Law

2.   **LESSON DEVELOPMENT**

2.1.   <u>Introduction</u> [10 min]

- Educator discusses the answers to homework questions.
- Ensure that learners know how to manipulate the formula and understand how to use the calculator for trigonometric functions.
- They must also be able to identify the incident and refracted media.

**Answers to homework activity**
1.
    (a)   Incidence; reflection √√
    (b)   Normal √
    (c)   Incidence. √
    (d)   Refracted √
    (e)   Refractive √
    (f)   Towards √

(7)

2.

(a) $n_{diamond} = \frac{c}{v}$ √$= \frac{3 \times 10^8}{1,25 \times 10^8}$ √$= 2,4$ √ (3)

(b) $f = \frac{c}{\lambda}$ √ $= \frac{3 \times 10^8}{6 \times 10^7}$ √$= 5 \times 10^{14}$ Hz √ (3)

(c) $v = f\lambda$

$\lambda = \frac{v}{f}$ √$= \frac{1,25 \times 10^8}{5 \times 10^{14}}$ √ $= 2,5 \times 10^{-7}$ m √ (3)

3.

(a) Mpho will see his own reflection as well as that of Ivan.√ The angle of incidence is always equal to the angle of reflection no rays coming from Linda will reach Mpho. Rays coming from Peter will be blocked by the wall.√ (2)

(b) Ivan will not see his own reflection √because he is not standing directly in front of the mirror. √ (2)

(c) Linda will see Peter's reflection,√ because rays from Peter will be reflected by the mirror and reach her eyes. The wall will not block these rays.√ (2)

(d) No,√ rays from Mpho will be blocked by the wall before they reach the mirror at the right place to be reflected to Peter. √ (2)

4.

(a) $n_{Perspex} = \frac{c}{v}$ √$= \frac{3 \times 10^8}{2,03 \times 10^{14}}$ =√ $1,48$ √ (3)

(b) $n_i \sin\theta_I = n_r \sin\theta_r$ √

$\sin\theta_r = \frac{n_i \sin\theta_i}{n_r}$ $= \frac{(1) \sin 30^0}{1,48}$ √ $= \theta_r = 19,7^0$ √ (3)　　　　(30)

**A basic understanding of the following:**

- Snell's Law
- How to use a protractor and scientific calculator.

**2.2. Main Body   Learner activity[45 min]**

- Educator can decide on the format of the project. Learners can present their results and findings in the form of a poster, or they can follow the scientific method to test a hypothesis. Refer to page 10 and 11 of Oxford successful Physical science (Learner book) and page 116 – 118 (Teacher's guide).

- Explains to learners that they have to design an experiment to:

  ✓ Verify Snell's Law
  ✓ Determine the refractive index of an unknown solid transparent material by using Snell's law.

- Learners are divided into small groups.

- Each group needs the following:

  ✓ a rectangular block made of transparent material
  ✓ a 0-360⁰ protractor
  ✓ a ray box

    ✓    A4 paper

    ✓    pencil and ruler

- **Procedure**

    ✓    Mark the position of the rectangular block on the A4 paper by drawing a line around the block.

    ✓    Position the ray box so that a light ray shines at an angle onto one of the surfaces of the block.

    ✓    Use the pencil to mark the position of the incident ray.

    ✓    Make a mark at the position where the refracted ray exits the block

    ✓    Remove the block and use the ruler to draw in the incident and refracted rays on the piece of paper.

    ✓    Construct the normal to the surface at the positionwhere the incident ray strikes the surface.

    ✓    Use the protractor to measure the angle of incidence and the angle of refraction. Angles must be measured relative to the normal.

    ✓    Repeat the last six steps for at least two other angles of incidence.
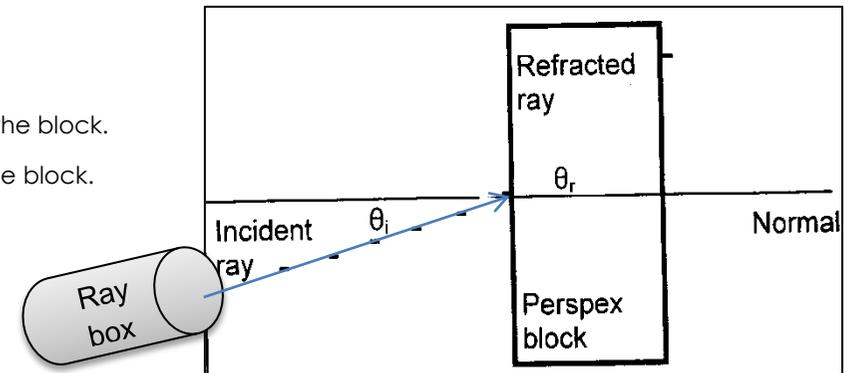
**2.3  Conclusion  [5 min]**

- Educator allows learners to ask questions about their results and findings.

**HOMEWORK ACTIVITY**

Learners have to prepare themselves for the write-up. This will be done during the next lesson under controlled circumstances.

**Recourses:** Appropriate apparatus, Scientific calculator, prescribed text books, CAPS-document (page 12, 77 and 145).

      © Gauteng Department of Education (CAPS version)

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 13 | TOPIC | Waves, sound and light: Geometrical optics – Snell's Law | Lesson | 3 |

| LESSON SUMMARY FOR:  DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|
| LESSON OBJECTIVES | At the end of the lesson learners should:<br>• Be able to submit the prescribed project for formal assessment | | |

## TEACHING and LEARNING ACTIVITIES

1.    **TEACHING METHOD/S USED IN THIS LESSON:**

Question and answer, explanation, experiment (project).

2.    **LESSON DEVELOPMENT**

2.1.   **Introduction** [5 min]

- Educator answers learner's questions on project and clears any misunderstanding.
- Educator explains the procedure for completing the write-up.
  - ✓ Each group submits their A4 page with the ray diagram for assessment.
  - ✓ Each learner does his own individual write-up.

2.2.   **Main Body   Learner activity[50 min]**

- The following rubric may be used to mark the ray diagram:

| Criteria | Marks |
|---|---|
| Neat diagram | 1 |
| Accurate diagram | 1 |
| Rays are clearly labelled | 3 |
| Position of block clearly shown | 1 |
| Incident rays are clearly shown | 3 |
| Refracted rays are clearly shown | 3 |
| Normal line is correctly constructed | 2 |
| Angles of incidence are correctly measured from the normal | 3 |
| Angles of refraction are clearly measured from the normal | 3 |
| **TOTAL MARKS** | **20** |

- Possible rubric for marking individual write-ups.

| Criteria | | Performance Levels | | | |
|---|---|---|---|---|---|
| | | 0 | 1-3 | 4-5 | Final score |
| **Plan an investigation** | **Investigative question** | Little evidence of performance | Average | Good-excellent | |
| | **Hypothesis** | Little evidence of performance | Average | Good-excellent | |
| | **Independent variable(s)** | Little evidence of performance | Name all possible variables | | |
| | **Dependant variable** | Little evidence of performance | Name all possible variables | | |
| | **Controlled variable(s)** | Little evidence of performance | Name all possible variables | | |
| **Conduct an investigation** | **Apparatus** | Little evidence of performance | Good-excellent | | |
| | **Method** | Little evidence of performance | Average Consider some safety precautions in | Good-excellent, Consider all safety precautions | |
| | **Observation** | Little evidence of performance | Makes some observations | Good-excellent | |
| | **Results** | Little evidence of performance | Some results are correct Headings and labels incomplete/incorrect | Good-excellent , Table with headings and correct SI units | |

| Criteria | Performance Levels | | | |
|---|---|---|---|---|
| | | **0** | **1-3** | **4-5** | **Final Score** |
| **Interpret Data** | **Data** | Little evidence of performance | Average, Use graphs Show calculations, but work is incorrect, Not based on scientific principles | Good-excellent, Appropriate graphs, calculations are accurate , Scientifically correct interpretation | |
| | **Conclusion** | Little evidence of performance | Average | Conclusion is logic and derived from interpretation | |
| **Problem solving skills** | **Hypothesis** | Little evidence of performance | Average | Good-excellent | |
| | **Method** | Little evidence of performance | Average | Good-excellent | |
| | **Safety measures** | Little evidence of performance | Good-excellent | | |
| **Communicate data** | | Little evidence of performance | Neat, Uses underlined and appropriate headings. | Outstanding, All headings are underlined, Graphs and diagrams are very neat | |
| | | | | Total: | /65 |

**TOTAL MARK /85**

**2.3  Conclusion [5 min]**

- Learners hand in their projects.

**HOMEWORK ACTIVITY**

Learners do revision on the work done from lesson 1 to 5.

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Reflection/Notes:

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| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 13 | TOPIC | Waves, sound and light: Geometrical optics – Critical angles and total internal reflection | Lesson | 4(1) |
|---|---|---|---|---|---|---|---|---|---|

| LESSON SUMMARY FOR: DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|

| LESSON OBJECTIVES | **At the end of the lesson learners should:**<br>• Be able to use Snell's Law to calculate the critical angle at the surface between a given pair of media |
|---|---|

## TEACHING AND LEARNING ACTIVITIES

1. **TEACHING METHODS USED IN THIS LESSON:**
Question and answer, explanation

2. **LESSON DEVELOPMENT**

2.1. **Introduction** [5 min]

- Educator discusses the learner's reports on the experiment done in the previous lesson.

- Allow learners to ask questions and solve problems that may have encountered.

**PRE-KNOWLEDGE**
A basic understanding of the following:

- Snell's Law
- Refractive index
- Critical angle
- Optical density

2.2. **Main Body** **(Lesson presentation)** [25 min]

- In this lesson learners will discover how to calculate the critical angle.

- Highlight the fact that this phenomenon is only observed when light travels from a medium with a higher refractive index to one with a lower refractive index.



- In the diagram on the left hand side, the refracted ray forms an angle of $90^0$ with the normal. We know that the incident angle is now called the critical angle.

- Snell's Law states that:
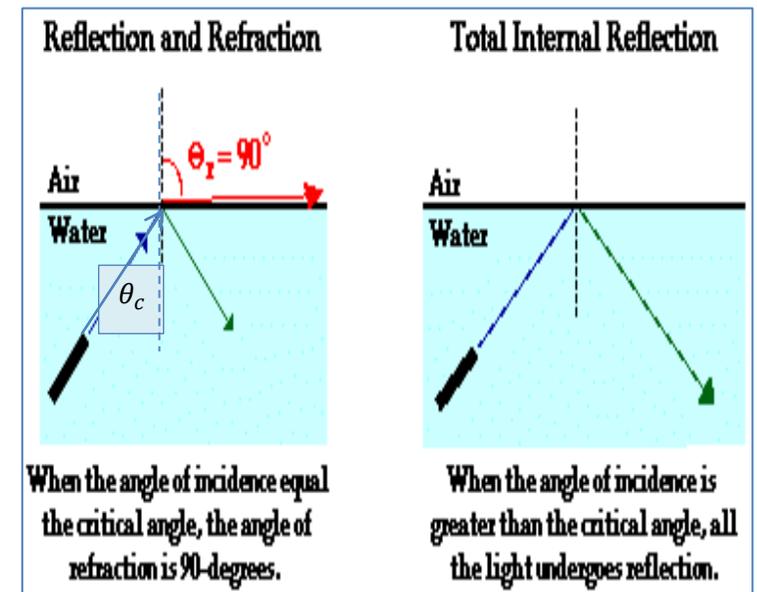
$n_{air} \sin \theta_{air} = n_{water} \sin \theta_{water}$

$n_{air} \sin 90^0 = n_{water} \sin \theta_{water}$ but $\sin 90^0 = 1$ and the critical angle $\theta_c = \theta_{water}$

$\therefore \sin \theta_c = \dfrac{n_{air}}{n_{water}}$

- The critical angle can be expressed by the equation:

$$\boxed{\sin \theta_c = \dfrac{n_r}{n_i}}$$

where $n_i$ is the refractive index for the incident medium

$n_r$ is the refractive index for the refractive medium

$\theta_c$ is the critical angle

- **Example**

If light is shining from Perspex into air at an angle of $50^0$ with the normal, will it be totally internally reflected?

($n_{air} = 1$ and $n_{Perspex} = 1,47$)

We have to determine the critical angle for light shining from Perspex into air:

$\sin \theta_c = \dfrac{n_r}{n_i} = \dfrac{1}{1,47}$

$\theta_c = 42,9^0$  Since the angle of incidence is greater than the critical angle, the light will be totally internally reflected.


**LEARNER ACTIVITY[20 min]**

**CLASSWORK ACTIVITY**

1. Calculate the critical angle for light shining from water into air ($n_{air} = 1$ and $n_{water} = 1,35$)

2. The critical angle for light that shines from an unknown medium into air is $42^0$. Calculate the refractive index of the medium.

3. If light strikes the boundary between diamond and air at an angle of incidence of $20^0$ from inside the diamond, will it be totally internally reflected? ($n_{air} = 1$ and $n_{diamond} = 2,4$)

4. Is it possible to find a critical angle for light shining from a medium with a lower refractive index to a medium with a higher refractive index? Explain your answer.

**ANSWERS for the CLASSWORK ACTIVITY**

1.  $\sin \theta_c = \frac{n_r}{n_i} = \frac{1}{1,33}$

    $\theta_c = 48,8^0$

2.  $n_i = \frac{n_r}{\sin\theta_c} = \frac{1}{\sin 42^0}$

    $n_i = 1,49$

3.  $\sin \theta_c = \frac{n_r}{n_i} = \frac{1}{2,4}$

    $\theta_c = 24,6^0$

    The angle of incidence is $20^0$ and is smaller than the critical angle. The light will not be totally internally refracted.

4.  When light shines from a less dense to a more dense medium it will only be refracted. We will never find an angle of refraction of $90^0$, because the light is refracted towards the normal.

## 2.3  Conclusion [10 min]

• Educator marks classwork activity.

**HOMEWORK ACTIVITY**

Oxford Successful Physical Sciences grade 11: p 139 Activity 2.

Learners have to find information on optic fibers and how it is used in endoscopes and telecommunication systems.

**Recourses:** Appropriate apparatus, scientific calculator, power point presentations or transparencies; prescribed text books, CAPS-document (page 77).

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 13 | TOPIC | Waves, sound and light: Geometrical optics – Critical angles and total internal reflection | Lesson | 4 |
|---|---|---|---|---|---|---|---|---|---|

| LESSON SUMMARY FOR:  DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|

| LESSON OBJECTIVES | **At the end of the lesson learners should:**<br>• Be able to explain the concept critical angle<br>• Be able to list the conditions required for total internal reflection. |
|---|---|

## TEACHING and LEARNING ACTIVITIES

1. **TEACHING METHODS USED IN THIS LESSON:**
Question and answer, explanation, practical experiment

2. **LESSON DEVELOPMENT**

2.1. **Introduction [5 min]**

- Educator introduces the lesson with a demonstration. Shows that light that travels from a denser to a less dense medium can be reflected by the surface of the medium instead of being refracted.

**PRE-KNOWLEDGE**
A basic understanding of the following:

- Refractive index
- Optical density

2.2. **Main Body   (Lesson presentation)  [15 min]**

- In this lesson learners will investigate light rays that move towards a medium with a lower refractive index (from a denser to a less dense medium).

- If the angle of incidence is increased sufficiently, it is possible that the refracted ray shines along the surface of the medium.

- This angle of incidence (i) which results in an angle of $90^0$ refraction (r), when light travels towards the medium with lower optical density, is called the **critical angle**. ($\theta_c$)

- When the angle of incidence is greater than the critical angle, there is no ray emerging into air, and we have **total internal reflection** inside the block.

- It means that the total amount of incident light at the boundary between two media is reflected and none is refracted.

- The following conditions are needed for total internal reflection to take place:

  ✓ Light must be in the medium that has a higher optical density and must be approaching the medium that has a lower optical density.

  ✓ The angle of incidence must be bigger than the critical angle ($\theta_i > \theta_c$).

- Two incident rays are indicated in the adjacent diagram: The **red ray** forms a 90⁰ angle of refraction and forms an incident angle that is called the **critical angle**.

  The **black ray** forms an incident angle that is smaller than the critical angle. The ray will only be refracted away from the normal.

  For any angle bigger than the critical angle, total internal reflection will take place. (See the **blue ray**).

  **Note that the incident angle and angle of reflection is always equal and obey the Law of reflection.**
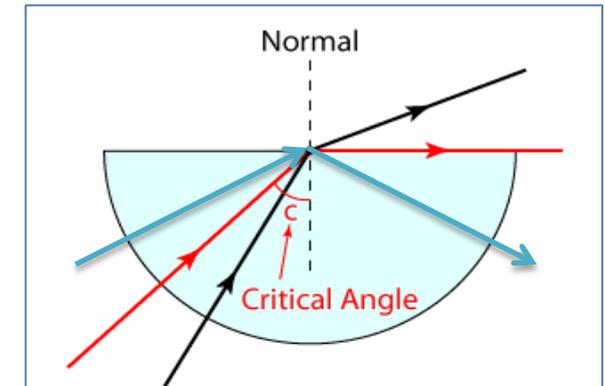


- The accompanying diagram shows how the direction of the refracted ray changes with a change in the size of the incident angle, until no light is refracted any more.

**LEARNER ACTIVITY** **[35 min]**

**PRACTICAL ACTIVITY (Recommended experiment for informal assessment)**
- Learners can work in small groups to determine the critical angle of a triangular glass block.
- Do Experiment 1, page 138, Oxford Successful Physical sciences Grade 11.

**ANSWERS for the PRACTICAL ACTIVITY**

Page 120, Oxford Successful Physical sciences(Teacher's Guide)

**2.3 Conclusion [5 min]**

- Educator discusses the results of the experiment with learners.

### HOMEWORK ACTIVITY

Learners have to write a report of the experiment for informal assessment.

They also have to find information on optic fibers and how it is used in endoscopes and telecommunication systems. (The information will be used in the final lesson on refraction).

**Recourses:** Appropriate apparatus, power point presentations or transparencies; prescribed text books, CAPS-document (page 77).

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**Reflection/Notes:**

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| Name of Teacher: | | HOD: | |
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| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 13 | TOPIC | Waves, sound and light: Geometrical optics – Critical angles and total internal reflection | Lesson | 5 |
|-------|----|---------|-------------------|------|----|-------|-------------------------------------------------------------------------------------------|--------|---|

| LESSON SUMMARY FOR: DATE STARTED: | | DATE COMPLETED: | |
|-----------------------------------|--|------------------|--|
| **LESSON OBJECTIVES** | **At the end of the lesson learners should:** <br> • Explain the use of optical fibres in endoscopes and telecommunications. | | |

## TEACHING and LEARNING ACTIVITIES

1. **TEACHING METHODS USED IN THIS LESSON:**
Question and answer, explanation, discussion

2. **LESSON DEVELOPMENT**

2.1. **Introduction [5 min]**

- Educator discusses the homework activity. . (Answers in Teacher's guide p 120 and 120)

- Allow learners to ask questions in order to minimize miss conception.

**PRE-KNOWLEDGE**
A basic understanding of the following:

- Snell's Law
- Refractive index
- Critical angle
- Optical density

2.2. **Main Body   (Lesson presentation)  [35 min]**

- In this lesson some of the applications of total internal resistance will be discussed.

- The focus is on optical fibres in endoscopes and telecommunication systems, but if time allows learners may find it interesting if more examples are mentioned.

- An optic fibre is made of glass which can be bent to suit the shape that is needed.

- The light is totally internally reflected inside the optic fibre.

- In this way light can be transmitted from one place to another without any loss in strength of the light, since none of the light is absorbed or refracted at the edges.

- An **endoscope** is an instrument that is used by doctors to examine what is happening in parts of the body that can not be seen by the human eye alone.

- The tube of the endoscope is made up of two bundles of narrow optic fibres.
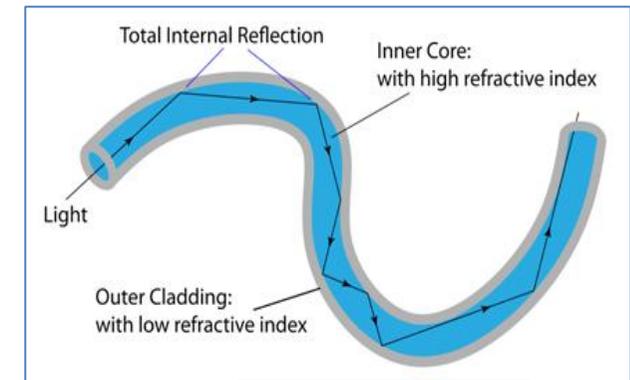


Optic fibres

- The one bundle sends a ray of light to the part of the body that is being examined. The other bundle carries light that forms the image from the body part back to the eyepiece.

- Here the image is magnified (enlarged) so that it can be seen clearly.

- The bundle of fibres is held together in a flexible probe that can be inserted into the body, for example, the person's mouth.



**The endoscope**
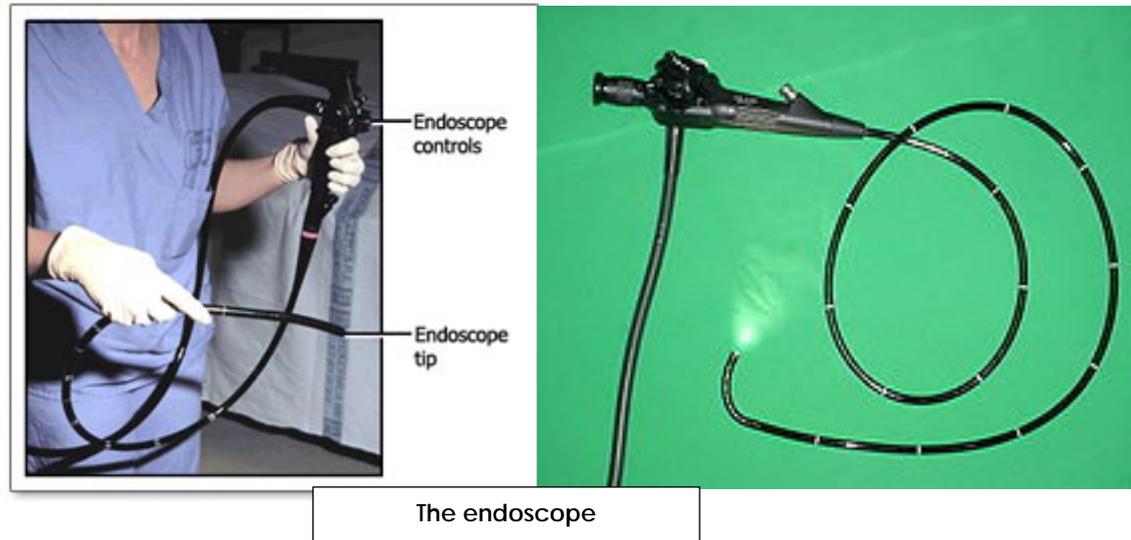
- Optical fibres are also used instead of wires in modern telecommunications.

- These fibres are thinner than human hair and can be bent without disrupting the message.

- There is very little dispersion and loss of light in the process. As a result they need very low amounts of light energy for sending messages.

- Optical fibres also allow much greater amount of electronic information to flow through them than the old copper wires which were used in the past. This increased bandwidth has allowed for much greater internet speeds.

- Optic fibres also cut out electrical interference which would disrupt signals.

- Different examples of optical fibres used in telecommunication systems are shown below.

**LEARNER ACTIVITY**[15 min]

DISCUSSION

- Allow learners to discuss the information that they collected about optic fibres.
- Mention the fact that total internal reflection has many other applications e.g. in binoculars and perisc

Periscope

Light Ray

Eye

Binoculars
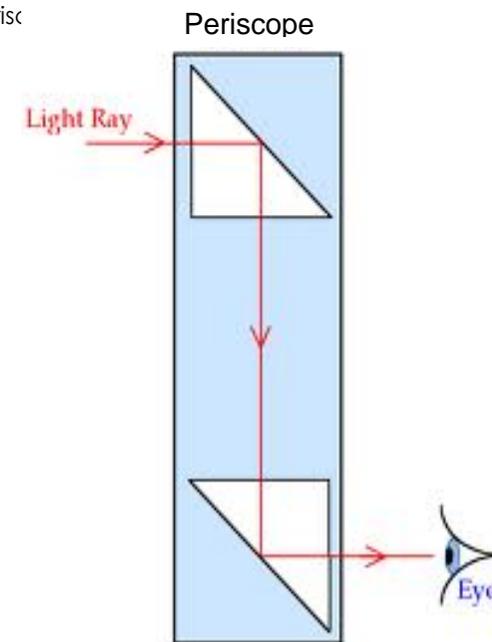
2.3  **Conclusion [5 min]**

- Educator summarises the most important facts about optic fibres in endoscopes end telecommunications.

**HOMEWORK ACTIVITY**

Oxford Successful Physical Sciences grade 11: p 141 Activity 1

**Recourses:** Power point presentations or transparencies; prescribed text books, CAPS-document (page 77).

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**Reflection/Notes:**

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| Name of Teacher: | | HOD: | |
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| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 14 | TOPIC | Diffraction | Lesson | 1 |
|-------|----|---------|-------------------|------|----|-------|-------------|--------|---|

| LESSON SUMMARY FOR:  DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|

| LESSON OBJECTIVES | At the end of this lesson learners should know:<br>• The meaning of diffraction.<br>The following results will be the outcome of this lesson:<br>• Learners must be able to define a wavefront as an imaginary line that connects waves that are in phase.<br>• Learners must be able to define diffraction as the ability of a wave to spread out in wavefronts as they pass through a small aperture or around a sharp edge.<br>• Learners must be able to state Huygen's Principle. |
|---|---|

| TEACHER ACTIVITIES | LEARNER ACTIVITIES | TIMING | RESOURCES NEEDED |
|---|---|---|---|
| **1.    TEACHING METHODS USED IN THIS LESSON**<br>Question and answer, Explanation<br>**2.    LESSON DEVELOPMENT:**<br>**2.1 Introduction**<br>• Introduce the lesson with the baseline questions<br>Pre-knowledge<br>• Frequency, waves, period, wavelength<br>**BASELINE ASSESSMENT**<br>• Baseline questions<br>▪ What is meant by the term frequency?<br>▪ Define period.<br>▪ Define wavelength.<br>**2.2 Main Body (Lesson presentation)**<br>• Lesson starts with the educator asking the learners the baseline questions.<br>• Educator and learners discuss the following answers of the baseline assessment<br>▪ Frequency: number of cycles or complete waves formed in one second.<br>▪ Period: time it takes for one complete wave to form.<br>▪ Wavelength: distance between any two consecutive points in phase.<br>• Educator explain and discuss with learners the following:<br>Diffraction patterns | 1.    Learners answer the baseline questions.<br>2.    Learners take notes from the board.<br>3.    Learners write the classwork.<br>**CLASSWORK**<br>1.    One word/term<br>a)    The phenomenon observed when a wave bends around the edges of an obstacle.<br>b)    The imaginary line joining points in phase on a wave.<br>c)    The principle which states that each point on a wave front acts as a source of secondary wavelets.<br>2.    Define diffraction.<br>3.    State Huygen's principle.<br>4.    Which situation will show | 5 min<br><br>30 min<br><br><br>15 min | Chalkboard for notes, discussions and classwork |

- Diffraction is the bending of the waves that pass the edge of an obstacle or the bending of waves as they go through a gap.
- This phenomenon is only found in waves and therefore any phenomenon that shows diffraction is a wave.
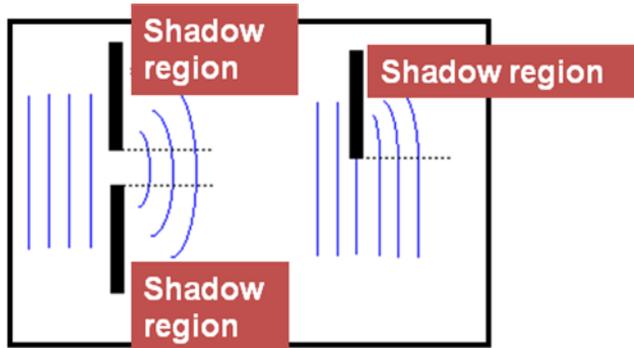


- The wavelength and size of the gap influences the amount of diffraction.
- The smaller the width of the gap, the greater the diffraction i.e.
- Diffraction patterns
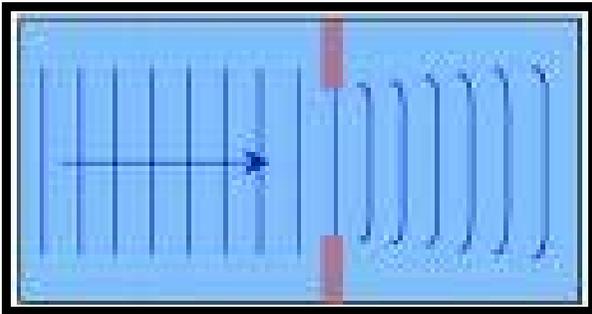


greater diffraction and why?

a) A wavelength of 3 cm or a wave of wavelength going through the same narrow gap or

b) The same wave passing through a gap of 5 cm or 7 cm.

**SOLUTIONS**

1.

a) **Diffraction**

b) **Wavefront**

c) **Huygen's Principle**

1. **Diffraction is the bending of the waves that pass the edge of an obstacle or the bending of waves as they go through a gap.**

2. **Huygen's principle states that every point on a wavefront is a source of a small wavelet that spreads out and sends out a secondary circular wavelet.**

3.

a) **The wave of wavelength 5 cm will show greater diffraction as it has a longer wavelength. The longer the wavelength, the greater the diffraction.**

b) **The smaller gap, 5 cm, will**

| | show greater diffraction. The smaller the gap, the greater the diffraction. | | |
|---|---|---|---|

- The wavelength and size of the gap influences the amount of diffraction.
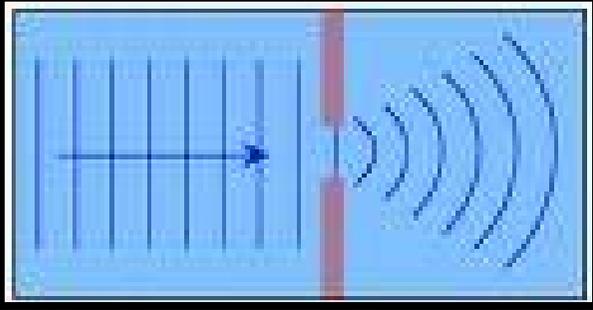- The smaller the width of the gap, the greater the diffraction i.e. **diffraction is inversely proportional to the width.**
- The longer the wavelength of the wave, the greater the amount of diffraction i.e. diffraction is directly proportional to wavelength.
- The maximum amount of diffraction occurs when circular waves are produced after the waves pass through the gap and the wavelength is equal to the width of the gap.
- The speed of the waves, however, does not change when the wave diffracts.
- To explain why diffraction takes place, Huygen's Principle is used.
- It states that every point on a wave front is a source of a small wavelet that spreads out and sends out a secondary circular wavelet.

## Huygens explains diffraction

Small circular wavelets are produced
by each point on the wavefront

Wavefronts
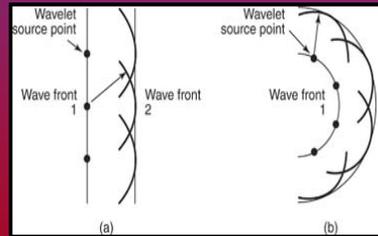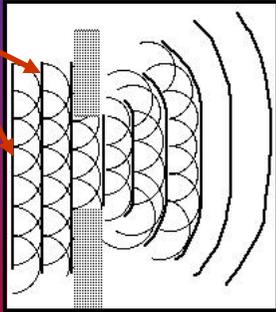
- The small wavefronts that spread out from each point on a wave front form a new wave front on the envelope of these secondary wave fronts.
- When straight wavefronts pass the edge of a boundary they continue in the forward direction.
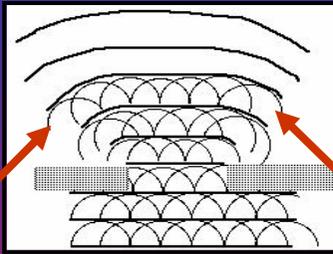
•The wavelets starting at the edge of the shadow region are able to spread out into the shadow region because there are no other wavefronts to interfere destructively and cancel the sideways contribution.

**2.3 Conclusion**

- Ask learners about the main aspects of the lesson.
- Give learners classwork.

Reflection/note

| Name of Teacher: | | HOD: | |
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| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 14 | TOPIC | **Diffraction** | Lesson | 2 |
|---|---|---|---|---|---|---|---|---|---|

| LESSON SUMMARY FOR:  DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|
| **LESSON OBJECTIVES** | At the end of this lesson learners should know: <br> • The meaning of interference <br> The following results will be the outcome of this lesson: <br> • Learners must be able to define interference as when two waves pass through the same region of space at the same time, resulting in superposition of waves. <br> • Learners must be able to explain the concepts of constructive and destructive interference. <br> • Learners must be able to predict areas of constructive and destructive interference from a diagram source material. <br> • Learners must be able to investigate the interference of waves on the surface of water from two coherent sources, vibrating in phase. <br> • Learners must be able to draw an interference pattern marking nodal lines and noting positions of maximum interference. | | |

| TEACHER ACTIVITIES | LEARNER ACTIVITIES | TIMING | RESOURCES NEEDED |
|---|---|---|---|
| **1.   TEACHING METHODS USED IN THIS LESSON** <br> Question and answer, Explanation <br> **2.   LESSON DEVELOPMENT:** <br> **2.1 <u>Introduction</u>** <br> • Introduce the lesson with the baseline questions <br> Pre-knowledge <br> • Interference, amplitude, wavelength, points in phase, standing waves <br> **BASELINE ASSESSMENT** <br> • Baseline questions <br> ▪ Define the following terms: <br> o Points in phase <br> o Wavelength <br> o Amplitude <br> o Transverse wave <br> o Constructive interference <br> o Destructive interference <br> **2.2 <u>Main Body (Lesson presentation)</u>** <br> • Lesson starts with the educator asking the learners the baseline questions. | 1.   Learners answer the baseline questions. <br> 2.   Learners take notes from the board. <br> 3.   Learners write the classwork. <br> **CLASSWORK** <br> 1.   Define the term interference. <br> 2.   State the principle of superposition. <br> 3.   What happens when <br> a)   a crest meets a crest <br> b)   a crest meets a trough <br> c)   a trough meets a trough <br> 4.   Define the following terms: <br> a)   Nodal lines <br> b)   Antinodal lines | 10 min <br><br><br> 30 min <br><br><br> 10 min | Chalkboard for notes, discussions and classwork |

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- Educator and learners discuss the following answers of the baseline assessment
- Points in phase: the particles of the medium through which the waves move are in phase when they move simultaneously in the same direction and with the same speed.
- Wavelength: distance between any two consecutive points in phase.
- Amplitude: maximum displacements of the particles from the rest position.
- Transverse wave: a transverse wave is formed when the particles of the medium move perpendicular to the direction of propagation of the wave.
- Constructive interference: when a crest meets a crest or trough meets trough in the same medium, their amplitudes are added together to form a bigger crest or trough.
- Destructive interference: when a crest meets a trough, their amplitudes are subtracted.
- Educator explain and discuss with learners the following

**Interference and superposition**

- Interference occurs when pulses or waves cross each in the same space.
- The displacements of the waves combine to form a new shape.
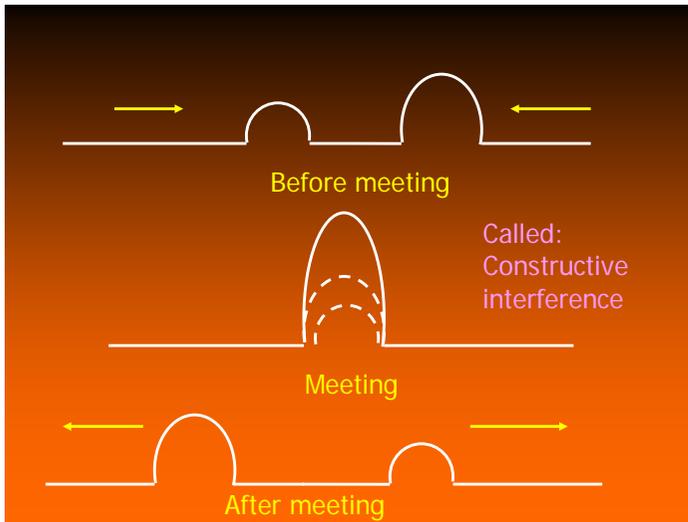


- The **Principle of Superposition** is used to determine the size of the displacement.
- It states that when wave pulses cross, the combined displacement is equal to the algebraic sum of their displacements.

5. $S_1$ and $S_2$ are two coherent point sources which are used to generate wavefronts to produce an interference pattern.

a) What is meant by coherent sources?

b) If the distance between $S_1$ and $S_2$ is decreased, what is the effect on the nodal lines?

**SOLUTION**

1. Interference occurs when pulses or waves cross each other in the same space.

2. Principle of superposition: when wave pulses cross, the combined displacement is equal to the algebraic sum of their displacements.

3.
a) Constructive interference
b) Destructive interference
c) Constructive interference

4.
a) Nodal lines are lines of zero disturbances caused by destructive interference.
b) Antinodal lines are lines of maximum disturbance caused by constructive interference.

- Standing waves are an example of interference.
- **Nodes** in a standing wave are points of **destructive interference** i.e. points of zero displacement.
- **Antinode**s are points of **constructive interference** i.e. points of maximum displacement.
- All of the above illustrate interference in one dimension.

**Interference in two dimensions**

- Interference in 2D is best illustrated using water waves.
- When two circular waves are set up and these cross each other, interference takes place.
- Patterns consisting of paths of zero disturbances, called nodal lines, are seen interspersed with paths of maximum disturbance.



Peak   Trough

Destructive interference

Constructive interference

Nodal lines are lines of zero disturbance caused by destructive interference.
 (crest & trough)

Antinodal lines are lines of greater disturbance caused by constructive interference.
2 crests or 2 troughs

-
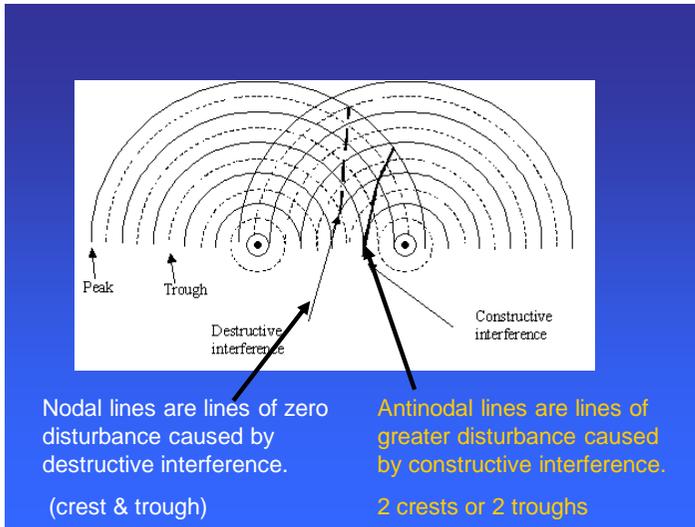
**2.3 Conclusion**

- Ask learners about the main aspects of the lesson.
- Give learners classwork.

5.

a) Coherent sources are sources that are in phase (same frequency)

b) The nodal lines in the pattern decrease.

Reflection/note

| Name of Teacher: | | HOD: | |
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| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 14 | TOPIC | Diffraction | Lesson | 3 |
|-------|----|---------|--------------------|------|----|-------|-------------|--------|---|

| LESSON SUMMARY FOR:  DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|

| LESSON OBJECTIVES | At the end of this lesson learners should know:<br>• The diffraction patterns<br>The following results will be the outcome of this lesson:<br>• Learners must be able to sketch the diffraction pattern for a single slit.<br><br>• Learners must be able to use $\sin\theta = \dfrac{m\lambda}{w}$<br><br>for a slit of width **w** to calculate the position(angle from the horizontal) of the dark bands in a single slit diffraction pattern. |
|---|---|

| TEACHER ACTIVITIES | LEARNER ACTIVITIES | TIMING | RESOURCES NEEDED |
|---|---|---|---|
| **1.   TEACHING METHODS USED IN THIS LESSON**<br>Question and answer, Explanation<br>**2.  LESSON DEVELOPMENT:**<br>**2.1 Introduction**<br>• Introduce the lesson with the baseline questions<br>Pre-knowledge<br>• Diffraction, interference<br>**BASELINE ASSESSMENT**<br>• Baseline questions<br>▪ Define diffraction<br>▪ Define constructive interference<br>▪ Define destructive interference<br>**2.2 Main Body (Lesson presentation)**<br>• Lesson starts with the educator asking the learners the baseline questions.<br>• Educator and learners discuss the following answers of the baseline assessment<br>• Diffraction is the bending of waves around the edges of an obstacle or opening.<br>• Constructive interference occurs when two pulses or waves meet crest to crest or trough to trough. | 1.   Learners answer the baseline questions.<br>2.   Learners take notes from the board.<br>3.   Learners write the classwork.<br>**CLASSWORK**<br>1.   Red light is shone through a single slit onto a screen forming a diffraction pattern. Blue light is then shone through the same slit. Compare the angle of the first dark band in the red diffraction pattern compared to the position in the blue diffraction pattern. The wavelength of the red light is 700 nm, while that of the blue light is 450 nm. The width of the slit is 8 x 10$^{-6}$. | 10 min<br><br>30 min<br><br>15 min | Chalkboard for notes, discussions and classwork |

- ▪ Destructive interference occurs when two pulses or waves meet peak to trough.
- • Educator explain and discuss with learners the following
- • Diffraction of Light and Sound
- • Sound waves are longer than light waves and therefore diffract more and are able to go around corners.
- • Example: sound can be heard around corners.
- • Light waves are short and do not refract much.
- • That is why we are unable to see around corners.
- • Nevertheless, if the gap is small enough, light does diffract.
- • For example: if one looks at a light bulb through a stretched piece of cloth, the light source looks bigger than when you look at it without the cloth.
- • Single slit diffraction of light
- • When light passes through a single narrow slit, the pattern similar to the one shown below is seen
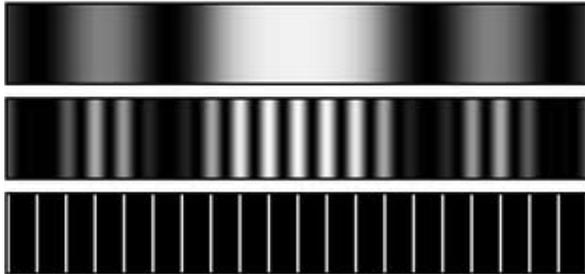


- • When monochromatic light is used, a broad, glowing, central light band is seen flanked by darker lines.
- • If a narrower slit is used, the central band is narrower, as a great amount of diffraction is produced.
- • When the light is passed through the single slit, diffraction takes place at the edges of the slit and according to Huygen's Principle the edges of the slit act as point sources sending out circular waves which interfere with each other.

2. Find the position of the first dark band (first minimum) formed on the screen when blue light of wavelength 460 nm and is passed through a slit with a width of 6 μm.

3. Determine the position of the first dark band formed on the screen, when red light of 690 nm is used instead of blue light.

4. How can you distinguish between a single-slit diffraction pattern and a double slit interference pattern?

5. Monochromatic light with a wavelength of 520 nm falls perpendicular onto a single slit, of width 0,5 mm. A diffraction pattern is seen on the screen.

**SOLUTIONS**

1.

Red: $\sin \theta = (m\lambda)/w$

$= \dfrac{(1)(700 \times 10^{-9})}{8 \times 10^{-9}}$

$\therefore \theta = 5^0$

Blue: $\sin \theta = (m\lambda)/w$

$= \dfrac{(1)(450 \times 10^{-9})}{8 \times 10^{-6}}$

$\therefore \theta = 3,2^0$

## Single slit diffraction and interference
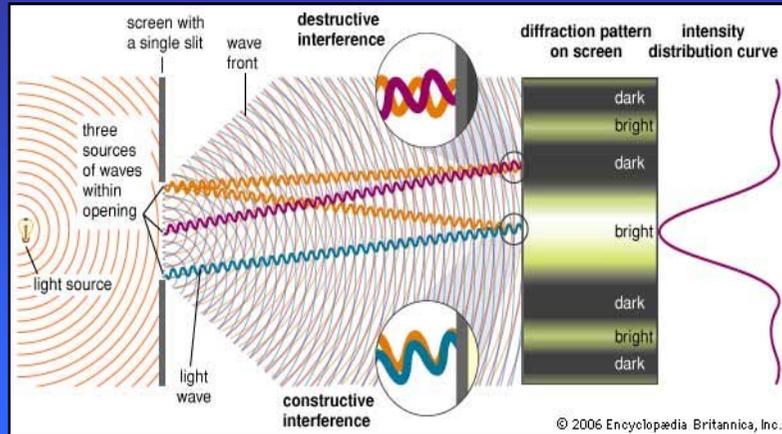


- 
- Slit diffraction pattern can be calculated by using the equation

$$\sin\theta = \frac{m\lambda}{w}$$

where a: width of the slit

λ: wavelength of the light
m: the number of dark bands from the centre.

### 2.3 Conclusion

- Ask learners about the main aspects of the lesson.
- Give learners classwork.

2.  $\sin\theta = (m\lambda)/w$

$\sin\theta = \dfrac{(1)(460 \times 10^{-9})}{6 \times 10^{-6}}$

$\therefore \theta = 4{,}39^{0}$

3.  $\sin\theta = (m\lambda)/w$

$\sin\theta = \dfrac{(1)(690 \times 10^{-9})}{6 \times 10^{-6}}$

$\therefore \theta = 6{,}6^{0}$

4.  Single- slit diffraction: one broad central band with bands next to it getting narrower and getting fainter.

    Double –slit diffraction: the bands are all the same thickness and the same brightness.

5.  $\sin\theta = (m\lambda)/a$

$\sin\theta = \dfrac{(3)(520 \times 10^{-9})}{0{,}5 \times 10^{-3}}$

$\therefore \theta = 0{,}179^{0}$

Reflection/note

| Name of Teacher: | | HOD: | |
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| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 14 | TOPIC | **Diffraction** | Lesson | 4 |
|-------|----|---------|-------------------|------|----|-------|-----------------|--------|---|

| LESSON SUMMARY FOR: DATE STARTED: | | DATE COMPLETED: | |
|-----------------------------------|--|-----------------|--|
| **LESSON OBJECTIVES** | At the end of this lesson learners should know:<br>• The meaning of diffraction and interference.<br>The following results will be the outcome of this lesson:<br>• Learners must be able to apply knowledge on 2D and 3D wave fronts. | | |

| TEACHER ACTIVITIES | LEARNER ACTIVITIES | TIMING | RESOURCES NEEDED |
|--------------------|--------------------|--------|------------------|
| **1. TEACHING METHODS USED IN THIS LESSON**<br>Question and answer, Explanation<br>**2. LESSON DEVELOPMENT:**<br>**2.1 Introduction**<br>• Introduce the lesson with the baseline questions<br>Pre-knowledge<br>• Diffraction, interference<br>**BASELINE ASSESSMENT**<br>• Baseline questions<br>▪ Define interference.<br>▪ State Huygen's Principle.<br>**2.2 Main Body (Lesson presentation)**<br>• Lesson starts with the educator asking the learners the baseline questions.<br>• Educator and learners discuss the following answers of the baseline assessment<br>▪ Diffraction is the bending of the waves that pass the edge of an obstacle or the bending of waves as they go through a gap.<br>▪ Huygen's principle states that every point on a wave front is a source of a small wavelet that spreads out and sends out a secondary circular wavelet.<br>• Educator give learners the following Consolidation Exercise on 2D and 3D wave fronts<br>• Consolidation Exercise<br>**QUESTION 1**<br>Huygen's principle is used to explain the wave phenomena, interference and diffraction. | 1. Learners answer the baseline questions.<br>2. Learners write the consolidation exercise.<br>3. Learners and educator discuss the consolidation exercise.<br>**SOLUTIONS( CONSOLIDATION EXERCISE)**<br>**QUESTION 1**<br>1.1 Each point on the wavefront acts a source of spherical secondary waves or wavelets travelling away from source.<br>1.2 Each point on the initial plane wavefront entering the slit acts as a source of secondary wavelets. The wavelets propagate in all directions beyond the slit causing the wave to spread into regions beyond those in line with the slit. | 5 min<br><br>30 min<br><br>15 min | Chalkboard for notes, discussions and classwork |

1.1  State Huygen's principle.

1.2  Use Huygen's principle to explain the diffraction of water waves in a ripple tank as they pass through a narrow opening in a barrier.

1.3  A single slit of unknown width is illuminated with red light of wavelength 650 nm. Calculate the width of the slit for which the first dark band will appear at $15^0$.

## QUESTION 2

Light of a single frequency pass through a single slit. The first minimum is observed at point P on a screen, as shown in the diagram below. Point O is the midpoint of the central bright band. The distance OP is 2,5 cm and the slit width is 3,2 x 10-5 m.
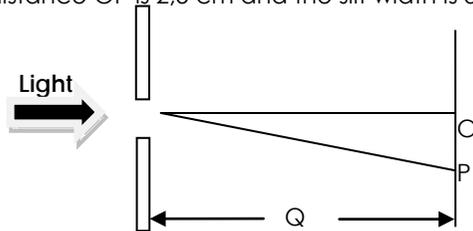


2.1. What can be deduced about the nature of light from this observation?

2.2. Explain how the minimum is formed at point P.

2.3. If the wavelength of the incident light is 600 nm, calculate the distance Q between the screen and the slit.

2.4. The original slit is now replaced by a second slit of different width, while the distance Q and the wavelength of the incident light remain the same. Distance OP changes to 4 cm.

2.4.1. How does the slit width of the second slit compare to that of the first slit? Only write down GREATER THAN, SMALLER THAN or EQUAL TO.

2.4.2. Explain your answer to QUESTION 2.4.1 without performing a calculation.

## QUESTION 3

Learners perform an experiment with monochromatic light. They pass the light through a single slit. The distance between the screen and the slit is kept constant. The diagram below represents the pattern observed during the experiment

---

1.3

$$\sin \theta = \frac{m\lambda}{a}$$

$\sin 15^0 = (1)(650 \times 10^{-9})/a$

$\therefore a = 2,7 \times 10^{-6}$ m

## QUESTION 2

2.1 Wave nature

2.2 Wavefronts from the slit arrive at point P out of phase and interfere destructively.

2.3

$$\sin \theta = \frac{m\lambda}{a}$$

$\sin \theta = (1)(600 \times 10^{-9})/3,2 \times 10^{-5}$

$\theta = 1,07^0$

$\tan 1,07 = (2,5 \times 10^{-2})/Q$

$\therefore Q = 1,34$ m

2.4.1 Smaller than

2.4.2 If  OP increases:

$\sin\theta$ = increases because $\sin\theta$ is inversely proportional to a.

## QUESTION 3

3.1  The ability of a wave to bend/spread out as they pass through a small aperture/around a sharp edge.

---

**KEY**

 Dark band
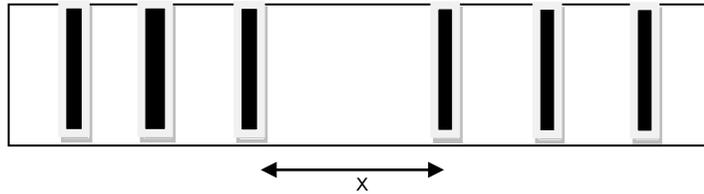
The slit has a width of 0,02 mm and the SECOND dark band is formed on the screen at an angle of $3^0$ from the centre of the slit.

3.1 Define the term diffraction.

3.2 Calculate the wavelength of this light.

3.3 The light is either green or red. Given that yellow light has a wavelength of 577 nm, which colour is used. Give a reason for your answer.

3.4 Using the same light as in QUESTION 3.2, write down TWO experimental changes that can be made to decrease the distance x in the diagram above.

3.5 Describe the pattern that will be observed if the single slit is now replaced with a double slit.

- Educator and learner discuss the solutions of the consolidation exercise.

**2.3 Conclusion**

- Ask learners about the main aspects of the lesson.

- Give learners classwork.

3.2  $\sin \theta = (m\lambda)/a$

$\sin 3^0 = (2)\lambda/0,02 \times 10^{-3}$

$\therefore \lambda = 5,23 \times 10^{-7}$ m

3.3 Green. It has a shorter wavelength than yellow light.

3.4 Increase the slit width. Decrease the distance between the screen and the slit.

3.5 A central band of alternate bright and dark bands of equal width.

**Reflection/note**

| Name of Teacher: | | HOD: | |
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| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 15 | TOPIC | Motion of particles: Kinetic Theory of Gases: Time: 60 mins | Lesson | 1 |
|-------|----|---------|--------------------|------|----|-------|-----------------------------------------------------------|--------|---|

| LESSON SUMMARY FOR:  DATE STARTED: | | DATE COMPLETED: | |
|------------------------------------|--|-----------------|--|
| **LESSON OBJECTIVES** | The following results will be the outcomes of this lesson:<br>At the end of the lesson, the learners must be able to:<br>• Describe the motion of individual molecules.<br>• Describe and explain the collision of molecules with each other and the walls of the container.<br>• Describe and explain the idea of average speeds in the context of gas molecules.<br>• Explain the temperature of a gas in terms of the average kinetic energy of the molecules of the gas.<br>• Explain the pressure exerted by a gas in terms of molecules with the walls of the container.<br>• Use the kinetic theory to explain gas laws.<br>• Describe an ideal gas in terms of the motion of molecules. | | |

| TEACHER ACTIVITIES | LEARNER ACTIVITIES | TIMING | RESOURCES NEEDED |
|--------------------|--------------------|--------|------------------|
| **1. Teaching Methods:**<br>Explanation, Observation, Demonstration, Question and answer.<br><br>**2. Lesson Development**<br>**2.1 Introduction:**<br>**2.1.1 Pre-knowledge required for the lesson:**<br>2.1.1.1 Knowledge about the relationship between temperature and kinetic energy of molecules.<br>2.1.1.2 Understanding of three phases of matter and how the particles behave in each phase.<br>2.1.1.3 Knowledge about dependent and independent variables.<br>**2.2 BASELINE ASSESSMENT:** The educator will write the questions on the board or design a worksheet.<br><u>Questions for baseline assessment</u><br>(i) Give 3 phases of matter and explain how particles of each phase behave.<br>     Use $H_2O$ as an example.<br>(ii) Describe the relationship between temperature and kinetic energy of molecules. | 1. Learners complete the worksheet on baseline assessment.<br><br>Learners interact with the teacher during the discussion while the teacher is explaining the concept. Learners answer the questions in class.<br><br>2. Homework:<br>Questions from the Grade 11 Physical sciences textbook. | Baseline Assessment: 15 min<br><br>Explaining the kinetic theory of gases and thermal properties: 25 min<br><br>Answering questions from the textbook:15 min<br><br>Conclusion: 5 min<br><br>Homework: 30 min | • Chalk and Chalkboard<br>• Physical Science Gr 11 study guide/textbook<br>• Balloon<br>• Bicycle tube and bicycle pump. |

<u>Solutions for baseline Assessment</u>

The three phases of matter are gases, liquids and solids. **Gases (steam):** They have no
definite volume and shape. fill the entire volume of the container. Molecules are
always in motion. **Liquids (Liquid water):** Have a definite volume and take the
shape of the container. Particles are able to move. **Solids (eg Ice):** Have a
definite shape and volume. Molecules are vibrating fixed positions. Solids are rigid
and are not compressible.

Kinetic energy of molecules increases with an increase in temperature. The higher the
temperature, the higher the kinetic energy will be and the molecules will move at
the faster speed.

**2.2   Main Body (Lesson presentation):**

a)   Start the lesson by inflating the balloon to generate the interest in the lesson. Use
the inflated balloon to ask questions such as: "What makes the balloon to be
inflated?"

b)   Describe the properties of the three phases of matter (gas, liquid and solid).Explain
the behaviour of particles in each phase by **focussing more on gases**. Combine
this with the **kinetic theory of matter on gases**.

**NB**: The educator must prepare a summary of notes on this part for the learners.

<u>Example of the Notes on Kinetic Theory of Gases.</u>

(i) Gases are made up of smaller particles in comparison to spaces between them.
This makes gases to be compressible.

(ii) The gas particles are always in motion. They have kinetic energy.

(iii) During their movement, the particles collide elastically with each other and against
the walls of the container.

NB: Elastically means kinetic energy/speed remains constant.

(i)During collision, the gas molecules exert a pressure on the walls of the container. For
an example, in the inflated balloon, car tyre or bicycle tyre. **Pressure is force per unit
area** $(P = \dfrac{F}{A})$.

(ii) The speed/kinetic energy of the molecules depends on the temperature. The higher the temperature the faster the molecules.

c) Explain the relationship between temperature and the kinetic energy of molecules. $E_k = \frac{1}{2}mv^2$

The educator must explain that when the temperature of the gas molecules rises, the gas molecules will move faster. The kinetic energy increases with an increase in temperature. Temperature is a measure of kinetic energy.
**NB**: The educator must ensure that this concept lays a good foundation for the understanding of collision theory (grade 12 Rates of reactions).

d) Give learners questions that involve kinetic theory of gases and thermal properties of gases. The questions should be taken from the grade 11 Physical Sciences Textbook.

**2.3  Conclusion (for the lesson):**
- Revise the key concepts in the kinetic theory of gases and thermal properties of gases.
- Explain to the learners that there are 3 variables that influence the behaviour of gases, i.e. temperature, volume and pressure. Explain to the learners that the relationship between these variables will be learnt in gas laws.

**Reflection/Notes:**
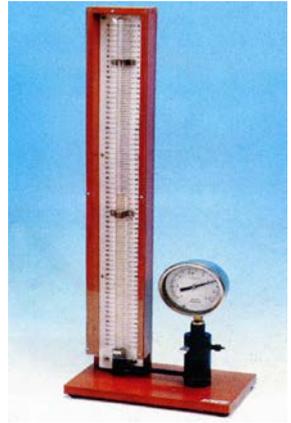
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| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 15 | TOPIC | Gases: Boyle's Law:  Time: 60 minutes | Lesson | 2 |

| LESSON SUMMARY FOR:  DATE STARTED: | | DATE COMPLETED: | |

| LESSON OBJECTIVES | The following results will be the outcomes of this lesson. The learners must be able to:<br>• state Boyle's Law.<br>• Determine and describe the relationship between volume and pressure for a fixed amount of gas at constant temperature.<br>• Identify the dependant, independent and controlled variables in the Boyle's law investigation.<br><br>• Plot the graph of Volume versus Pressure as well as the graph of volume versus $\dfrac{1}{p}$ . |

| TEACHER ACTIVITIES | LEARNER ACTIVITIES | TIMING | RESOURCES NEEDED |
|---|---|---|---|
| **1. Teaching Methods:**<br>Explanation, Demonstration, Question and answer.<br><br>**2. Lesson Development**<br>**2.1 Introduction:**<br>**2.1.1 Pre-knowledge required for the lesson:**<br>2.1.1.1 Knowledge of plotting graphs on a Cartesian plane (with x and y axes).<br>2.1.1.2 Knowledge of direct and inverse proportion.<br>2.1.1.3 Knowledge of using formulas and substituting into a formula.<br><br>**2.2 Main Body (Lesson presentation):**<br>• Explain to the learners that the lesson is about LO 1 where the relationship between volume and pressure is investigated.<br>• NB: The educator should explain the requirements for **the investigative question and hypothesis.**<br>NB: HYPOTHESIS IS THE ANSWER TO THE INVESTIGATIVE QUESTION. IT MUST INCLUDE THE DEPENDENT AND INDEPENDANT VARIABLES MENTIONED IN THE INVESTIGATIVE QUESTION.<br>• First, provide them with the following data: | 1. Learners complete the worksheet on baseline assessment.<br>2. Learners answer the questions using the data given.<br>3. Learners plot the graph of pressure v/s volume, using the data given.<br>4. Homework:<br>• Calculations on the formula $p_1V_1 = p_2V_2$ from the study guide/textbook. | Introduction: 5 min<br><br>Answering the questions and Plotting graph: 45 min<br><br>Conclusion: 10 min<br><br>Homework: 30 min | • Chalk and Chalkboard<br>• Physical Science Gr 11 study guide/textbook<br>• Calculator<br>• Boyle's Law apparatus with bicycle pump.<br><br> |

| Volume (cm³) | Pressure(kPa) | 1/p (kPa⁻¹) |
|---|---|---|
| 10 | 300 | $3 \times 10^{-3}$ |
| 15 | 200 | $5 \times 10^{-3}$ |
| 20 | 150 | |
| 25 | 120 | |
| 30 | 100 | |
| 35 | 86 | |
| 42 | 72 | |
| 50 | 60 | |
| 60 | 50 | |

**Ask the learners to use the data above and answer the following questions:**

a)   Give the **investigative question** for the Boyle's Law investigation.

b)   Write down the **hypothesis** for the Boyle's law investigation.

c)   Write down the dependent, independent and controlled variables.

d)   Write down the possible apparatus for this investigation.

e)   Write down the method followed in getting the above data. Use diagrams.

f)   For analysis of the results given, plot a graph of volume versus pressure as well as the graph of Volume versus 1/p.

g)   By using the graph, determine the relationship between volume and pressure.

h)   Write down a possible conclusion.


**Solutions**

a)   What is the relationship between volume and pressure?

b)   Volume is inversely proportional to pressure.

c)   Dependent Variable: Volume

    Independent Variable: pressure

    Controlled Variables: amount of gas  and temperature.

d)   Apparatus: Boyle's Law apparatus with the bicycle pump.

e) See the grade 11 Physical Science textbook.

f) Guide the learners when plotting the graph of volume v/s pressure.

   (Analysis of results)

**The graph of volume v/s pressure**
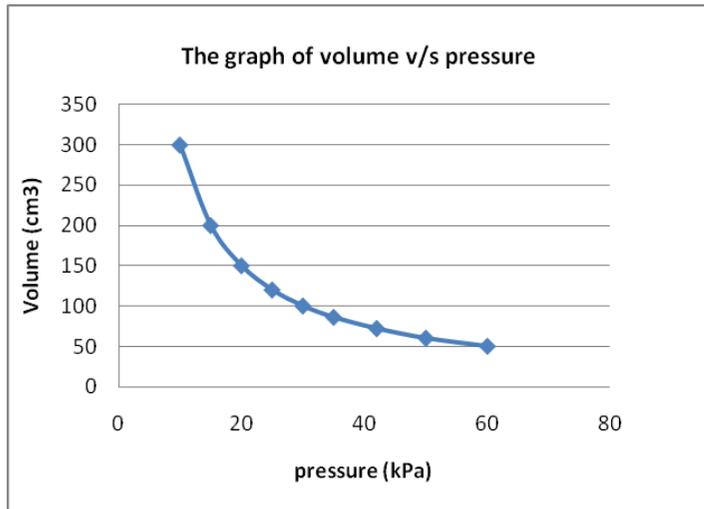


The graph of V versus 1/p



$$\frac{1}{p}$$
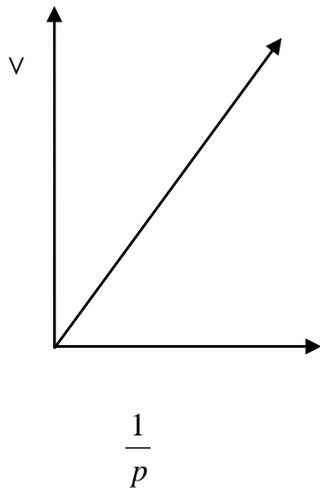
g) Volume is inversely proportional to pressure. As pressure increases, volume decreases.

h) The volume of an enclosed gas is inversely proportional to its pressure, provided that the temperature remains constant.

**2.3 Conclusion:**

| | | | |
|---|---|---|---|
| • Revise the relationship between pressure and volume with the help of the learners.<br>• State the definition of Boyle's Law: **The volume of an enclosed gas is inversely proportional to its pressure, provided that the temperature remains constant.**<br>• Derive the formula for calculations: $p_1V_1 = p_2V_2$.<br>From the data given: $P_1V_1 = k = 3000$ and $p_2V_2 = k = 3000$, Therefore $p_1V_1 = p_2V_2$ | | | |

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
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| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 15 | TOPIC | Charles' Law<br>Time: 60 minutes | Lesson | 3 |
|-------|----|---------|-------------------|------|----|-------|----------------------------------|--------|---|

| LESSON SUMMARY FOR:  DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|

| LESSON OBJECTIVES | The following results will be the outcomes of this lesson. The learners must be able to:<br>• describe the relationship between volume and temperature in Kelvins for a fixed amount of gas at constant pressure.<br>• state Charles' Law.<br>• convert temperature in Degrees Celsius ($^0C$) to Kelvin (K).<br>• take readings of temperature and pressure on Charles' Law apparatus.<br>• plot a graph of volume v/s temperature using the results obtained from the investigation.<br>• use the derived formula of $\dfrac{V_1}{T_1} = \dfrac{V_2}{T_2}$ to do the calculations. |
|---|---|

| TEACHER ACTIVITIES | LEARNER ACTIVITIES | TIMING | RESOURCES NEEDED |
|---|---|---|---|
| **1.   Teaching Methods:**<br>Explanation, Scientific, Observation, Demonstration, Question and answer.<br>**2.   Lesson Development**<br>**2.1  Introduction:**<br>**2.1.1.1 Pre-knowledge required for the lesson**<br>2.1.1.1 Knowledge about the relationship between temperature and kinetic energy of molecules.<br>2.1.1.2 Understanding of three phases of matter and how the particles behave in each phase.<br>2.1.1.3 Knowledge about dependent and independent variables.<br>2.1.1.4 Knowledge of inversely proportional and directly proportional.<br><br>**2.2  Main Body (Lesson presentation):**<br>• Explain to the learners that the lesson is about LO 1 where the relationship between volume and temperature in Kelvins is investigated.<br>• NB: The educator should explain the requirements for **the investigative question and hypothesis.**<br>NB: HYPOTHESIS IS THE ANSWER TO THE INVESTIGATIVE QUESTION. IT MUST INCLUDE THE DEPENDENT AND INDEPENDANT VARIABLES MENTIONED IN THE INVESTIGATIVE QUESTION.<br>• First, provide them with the following data: | 1.   Interact with the teacher by giving the answers during discussion.<br>2.   Learners answer the questions given using the data given.<br>3.   Learners plot the graph of Volume v/s temperature in both K & $^0C$, using the data collected.<br>4.   **Homework:**<br>• Calculations using the formula $\dfrac{V_1}{T_1} = \dfrac{V_2}{T_2}$ , from the Grade 11 Physical Sciences Study Guide/Text Book | Corrections: 10 min<br><br>Introduction of Charles' Law: 5 min<br><br>Answering questions: 35 min<br><br>Conclusion: 10 min<br><br>**Homework**: 30 min | • Chalk and Chalkboard<br>• Physical Science study guide/textbook<br>• Charles' Law apparatus.<br>• Calculator |

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| Temperature($^0$C) | Volume ($cm^3$) |
|---|---|
| 0 | 66 |
| 27 | 73 |
| 52 | 80 |
| 77 | 86 |
| 100 | 92 |

- Ask them to redraw the table of results and convert the temperature to Kelvins using the formula: (T= t + 273), where T is temperature in Kelvins and t is temperature in $^0$C.

**Ask the learners to use the data above and answer the following questions:**

a) Give the **investigative question** for the Charles' Law investigation.
b) Write down the **hypothesis** for the Charles' Law investigation
c) Write down the dependent, independent and controlled variables.
d) Write down the possible apparatus for this investigation.
e) Write down the method followed in getting the above data. Use diagrams.
f) For analysis of the results given, plot a graph of volume versus Temperature (in$^0$C) as well as the graph of Volume versus temperature (in Kelvins)
g) By using the graph, determine the relationship between volume and Temperature.
h) Write down a possible conclusion.

**Solutions**

a) What is the relationship between volume and temperature?
b) Volume is directly proportional to temperature.
c) Dependent Variable: Volume

   Independent Variable: temperature

   Controlled Variables: pressure and the amount of gas.
d) Apparatus: check the textbook.

e) See the grade 11 Physical Science textbook.

f) Guide the learners when plotting the graph of volume v/s pressure.

(Analysis of results)

- The graphs will look like the following:



Graph of Volume vs Temperature



Graph of Volume vs Temperature
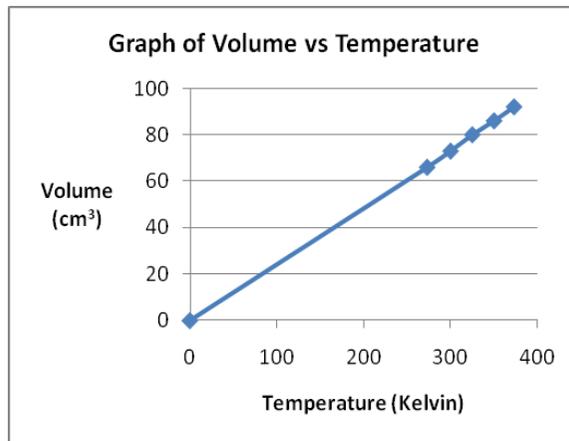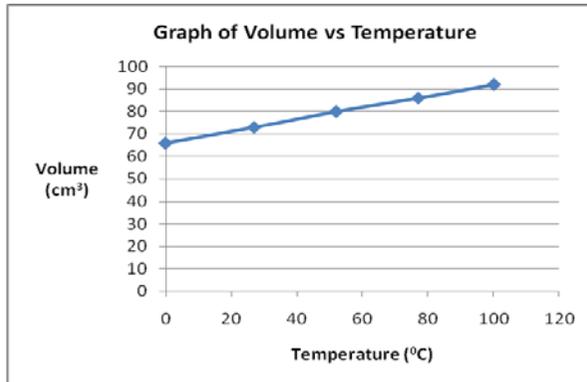
g) Volume is directly proportional to temperature. As temperature increases, volume increases.

h) The volume of an enclosed gas is directly proportional to its temperature, provided that the pressure remains constant.

| 3. **Conclusion for the lesson:** | | | |
|---|---|---|---|
| <br>• Give the relationship between volume and temperature with the help of the learners.<br>• Give the definition of Charles' Law: The volume of an enclosed gas is directly proportional to its Kevin Temperature, provided that the pressure remains constant.<br>• Explain STP [standard temperature (0 $^0$C or 273 K) and pressure (101,3 kPa)]<br><br>• Derive the formula for calculations: $\dfrac{V_1}{T_1} = \dfrac{V_2}{T_2}$<br><br>• Do one example in class using the formula: $\dfrac{V_1}{T_1} = \dfrac{V_2}{T_2}$<br><br>• A gas has a volume of 300 cm$^3$ at 100 $^0$C. Calculate the volume at standard temperature. (Don't forget to convert temperature to Kelvins) | | | |

**Reflection/Notes:**

<br><br><br><br><br><br><br><br><br><br>

| Name of Teacher: | | HOD: | |
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| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 15 | TOPIC | Gases: Gay-Lussac's Law<br>Time: 60 minutes | Lesson | 4 |

| LESSON SUMMARY FOR: DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|

| LESSON OBJECTIVES | The following results will be the outcomes of this lesson. The learners must be able to:<br>• describe the relationship between pressure and temperature for a fixed amount of gas at constant volume.<br>• state Gay-Lussac's Law.<br>• Describe Dependent Variables, Independent Variables and controlled variables in the Gay-Lussac's Law investigation.<br>• convert temperature in Degrees Celsius ($^0$C) to Kelvin (K).<br>• take readings of temperature and pressure using Gay-Lussac's Law apparatus.<br>• plot a graph of pressure v/s temperature using the results obtained from the investigation.<br><br>• use the derived formula of $\dfrac{p_1}{T_1} = \dfrac{p_2}{T_2}$ to do the calculation and apply the values of Standard Temperature and Pressure (STP). |
|---|---|

| TEACHER ACTIVITIES | LEARNER ACTIVITIES | TIMING | RESOURCES NEEDED |
|---|---|---|---|
| **1. Teaching Methods:**<br>Explanation, Scientific, Observation, Demonstration, Question and answer.<br><br>**2. Lesson Development**<br>**2.1 Introduction:**<br>**2.1.1 Pre-knowledge required for the lesson:**<br>2.1.1.1 Knowledge about the relationship between temperature and kinetic energy of molecules.<br>2.1.1.2 Understanding of three phases of matter and how the particles behave in each phase.<br>2.1.1.3 Knowledge about dependent and independent variables.<br>2.1.1.4 Knowledge of directly proportional and inversely proportional.<br><br>**2.2 Main Body (Lesson presentation):**<br>• Introduce the concept of Gay-Lussac's law by asking the **investigative question**:<br>What is the relationship between the pressure of an enclosed gas and temperature?<br><br>• Guide them when they answer the investigative question and help them understand that the answer to the investigative question is the **hypothesis** for the investigation.<br>(Answer: **Pressure of an enclosed gas is directly proportional to the Kelvin temperature**).<br>As temperature increases, pressure increases.<br><br>. | 1. Interact with the teacher by giving the answer to the investigative question (hypothesis) as well as the variables.<br><br>2. Learners collect the data by recording the readings they get for pressure and temperature from Gay-Lussac's Law apparatus.<br><br>3. Learners plot the graph of pressure v/s temperature in both K & $^0$C, using the data collected. | Corrections: 10 min<br><br>Introduction and giving variables: 10 min<br><br>Collecting Data and sketching the graphs: 25 min<br><br>Conclusion: 15 min<br><br>**Homework:** 30 min | • Chalk and Chalkboard<br>• Physical Science study guide/textbook<br>• Gay-Lussac's Law apparatus<br>• Calculator. |

- Explain to the learners that they are about to do an investigation on Gay-Lussac's Law, which looks at the relationship between pressure of an enclosed gas and temperature.
- Show them the Gay-Lussac's law apparatus.
- Ask the learners to give the following(in writing):
  - (i) Independent Variable (answer: Temperature: x-axis)
  - (ii) Dependent Variable (answer: Pressure: y-axis, depends on the change in temp)
  - (iii) Controlled variables (answer: volume, amount of gas/moles: kept constant)
- Ask them to sketch the apparatus (if necessary).

• Ask 2 learners to start using the apparatus by increasing temperature using the Bunsen burner and record the results in intervals up to the maximum temperature, including the whole class.
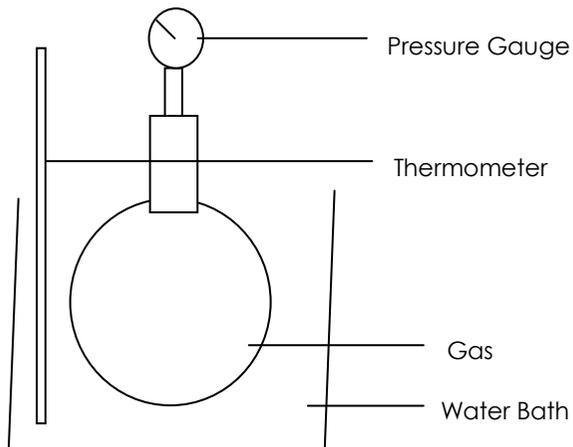


4. **Homework**:

- Calculations using the formula $\dfrac{p_1}{T_1} = \dfrac{p_2}{T_2}$, from the Grade 11 Physical Sciences Study Guide/Text Book

**If the school does not have the apparatus, just give the learners the following data:**

| Temperature(⁰C) | Pressure (kPa) |
|---|---|
| -273 | 0 |
| 20 | 100 |
| 30 | 103 |
| 40 | 107 |
| 50 | 110 |
| 60 | 114 |
| 70 | 117 |

- Guide the learners when plotting the graph of pressure v/s Temperature (in ⁰C).
- Ask them to redraw the table of results and convert the temperature to Kelvins using the formula: (T= t + 273), where T is temperature in Kelvins and t is temperature in ⁰C.

      (Analysis of results)

- The graphs will look like the following graphs:

**The Graph of Pressure vs Temperature**

**Graph of Pressure vs Temperature**

Pressure (kPa) — values 0, 20, 40, 60, 80, 100, 120, 140

Temperature (Kelvin) — values 0, 100, 200, 300, 400
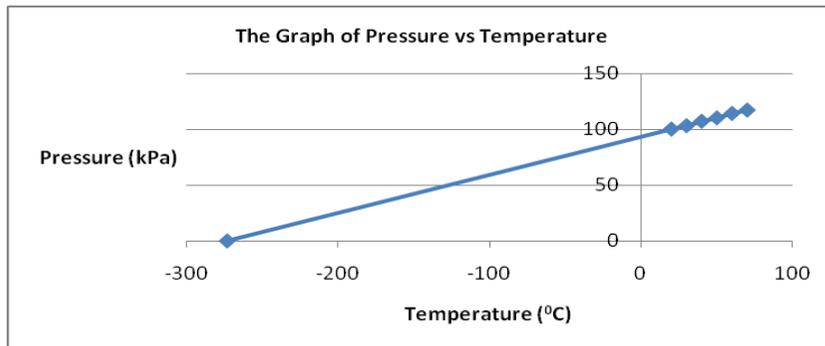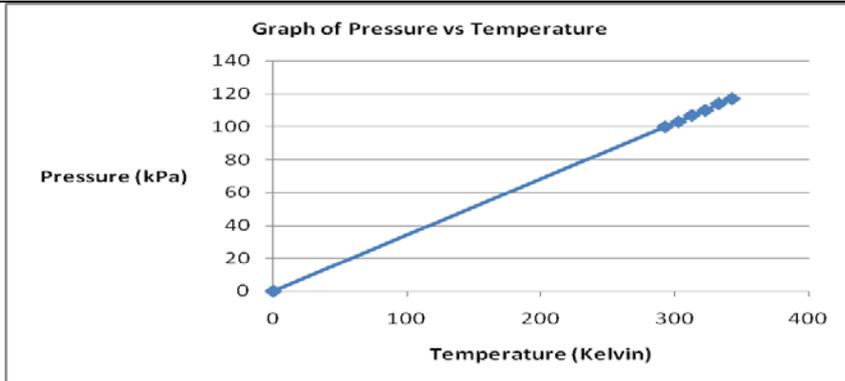
3. **Conclusion:**
- Give the relationship between pressure and temperature with the help of the learners.
- Give the definition of Gay-Lussac's Law: The pressure of an enclosed gas is directly proportional to its Kevin Temperature, provided that the volume remains constant.
- Explain STP [standard temperature (0 $^0$C or 273 K) and pressure (101,3 kPa)]

- Derive the formula for calculations: $\dfrac{p_1}{T_1} = \dfrac{p_2}{T_2}$

- Do one example in class using the formula: $\dfrac{p_1}{T_1} = \dfrac{p_2}{T_2}$

A certain volume of gas exerts a pressure of 130 kPa at 5 $^0$C. Calculate its temperature at the pressure of 300 kPa.

**Reflection/Notes:**

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| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 16 | TOPIC | Combined Gas Equation: Time: 60 minutes | Lesson | 1 |

| LESSON SUMMARY FOR:  DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|
| **LESSON OBJECTIVES** | The following results will be the outcomes of this lesson. The learners must be able to:<br>• describe the relationship between pressure, volume and temperature in Kelvins for a fixed amount of gas.<br>• convert temperature in Degrees Celsius ($^0C$) to Kelvin (K).<br>• use the derived formula of $\dfrac{p_1V_1}{T_1} = \dfrac{p_2V_2}{T_2}$ to do the calculations. | | |

| TEACHER ACTIVITIES | LEARNER ACTIVITIES | TIMING | RESOURCES NEEDED |
|---|---|---|---|
| **1.    Teaching Methods:**<br><br>Explanation, Scientific, Observation, Demonstration, Question and answer.<br><br>**2.   Lesson Development**<br>**2.1  Introduction:**<br>**2.1.1.    Pre-knowledge required for the lesson:**<br>2.1.1.1 Knowledge about the relationship between temperature and kinetic energy of molecules.<br>2.1.12 Knowledge of Boyle's, Gay-Lussac's and Charles' Laws.<br>2.1.1.3 Knowledge about dependent and independent variables.<br>2.1.1.4   Knowledge of inversely proportional and directly proportional.<br>**2.1.2 Baseline Assessment:**<br>(The educator will design a worksheet/transparency or write questions on the board to assess learners' prior knowledge)<br>**Questions For the Baseline Assessment**<br>a)   Define (i) Boyle's, (ii) Gay-Lussac's and (iii)  Charles' Laws.<br><br>b)   Convert the following temperatures into Kelvin temperatures:<br><br>(i) 200 $^0C$, (ii) 173 $^0C$ (iii) 0 $^0C$ (iv) -273 $^0C$<br><br>c)   The pressure of a gas is increased from 50 kPa to 125 kPa. If the original volume of the gas was 300 $cm^3$, calculate the new volume of the gas after the increase in pressure, provided that the temperature remains constant.<br>d)   A gas syringe contains a helium gas with the pressure of 30 kPa at the temperature of 15 $^0C$. Calculate the temperature of the gas (in Kelvins)  at the pressure of 60 kPa.<br><br><br><br>**2.2  Main Body (Lesson presentation):** | 1.   Learners complete the worksheet on baseline assessment.<br><br>2.   Interact with the teacher by giving the answers to the questions asked in class.<br><br>3.   Learners attempt the examples used in class before the teacher does them.<br><br>4.   **Homework**:<br><br>• Calculations using the all the formulas of gas laws learned so far  , from the Grade 11 Physical Sciences Study Guide/Text Book | Corrections: 10 minutes<br><br>Baseline Assessment:<br><br>20 min<br><br>Class Examples:  20 min | • Chalk and Chalkboard<br>• Physical Science study guide/textbook<br>• Calculator |

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a) Start the lesson by using the examples that will require the use of the following equation: $\dfrac{p_1 V_1}{T_1} = \dfrac{p_2 V_2}{T_2}$ .

b) **Use the following examples:**

(i) The pressure of a fixed volume of gas is 200 kPa and the temperature is 27 $^0$C. If the temperature is now decreased to 10 $^0$C, calculate the pressure.

(ii) The volume of a gas is 253 cm$^3$ at a pressure of 110 kPa and a temperature of 18 $^0$C. Calculate the volume of the gas at STP

**2.3 Conclusion:**

- Revise the definitions of (i) Boyle's, (ii) Gay-Lussac's and (iii) Charles' Laws.
- Revise different formulas used in gas laws so far.
- Revise the investigative question and hypothesis for each gas law.
- Revise the dependent, independent and controlled variables in each gas law.

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Conclusion: 10 min

**Homework:** 30 min

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**Reflection/Notes:**

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| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 16 | TOPIC | General Gas Equation and Ideal Gas Law: Time: 60 mins | Lesson | 2&3 |

| LESSON SUMMARY FOR: DATE STARTED: | | DATE COMPLETED: | |

| LESSON OBJECTIVES | The following results will be the outcomes of this lesson. The learners must be able to:<br>• convert any given unit of each quantity into SI unit required for the equation $pV = nRT$.<br>   E.g. Convert $dm^3$ to $m^3$, $cm^3$ to $m^3$, kPa to Pa and $^0C$ to Kelvin<br>• calculate the number of moles or mass using the formula: $n = \dfrac{m}{M}$.<br>• use a calculator when dealing with the values in scientific notation.<br>• define an ideal gas.<br>• explain and describe the conditions when the real gases behave as ideal gases.<br>• explain and describe the conditions when the real gases behave as non-ideal gases. |

| TEACHER ACTIVITIES | LEARNER ACTIVITIES | TIMING | RESOURCES NEEDED |
|---|---|---|---|
| **1.  Teaching Methods:**<br>Explanation, Scientific, Observation, Demonstration, Question and answer.<br><br>**2.  Lesson Development**<br>**2.1 Introduction:**<br>**2.1.1.  Pre-knowledge required for the lesson:**<br>2.1.1.1  Converting units.<br>2.1.1.2  Calculating the molar mass (M) of molecules.<br>2.1.1.3  Calculating the number of moles and mass using the formula: $n = \dfrac{m}{M}$<br>2.1.1.4  Knowledge of using a calculator with values in scientific notation<br><br>**2.2  Baseline Assessment:** (The educator will design a worksheet/transparency or write questions on the board to assess learners' prior knowledge)<br>Questions For the Baseline Assessment<br>1.  Convert the following values of volume to $m^3$:<br>1.1  50 $cm^3$<br>1.2  80 $dm^3$<br>1.3  75 $mm^3$<br>**2.3 Calculate the number of moles for the following:**<br>5g of oxygen gas<br>1.4  8g of nitrogen gas | 1.  Learners complete the worksheet on baseline assessment.<br>2.  Interact with the teacher by giving the answers to the questions asked in class.<br><br>3.  Learners attempt the examples used in class before the teacher does them.<br><br>4.  **Homework**:<br>• Calculations using the formula $pV = nRT$ from the Grade 11 Physical Sciences Study Guide/Text Book | Corrections: 10 min<br><br>Baseline Assessment: 15 min<br><br>Class Examples:  20 min<br><br>Explanation about ideal gases: 10 min<br><br>Conclusion: 5 Min<br><br>**Homework**: 30 min | • Chalk and Chalkboard<br>• Physical Science study guide/textbook<br>• Periodic Table<br>• Calculator |

**2.4 Main Body (Lesson presentation):**

a)  Start the lesson with deriving the formula $pV = nRT$ .

b)  Do the examples in class that will use the formula $pV = nRT$ , with the help of the learners. Do examples such as the following:

1.  A quantity of oxygen is collected in a 280 cm³ flask. The pressure of this gas at 25 $^0$C is 115 kPa.

1.1 Calculate the number of moles of the gas in the flask.(use $pV = nRT$ )

1.2 Calculate the mass of oxygen gas in the flask. (use

$$n = \frac{m}{M})$$

(c)  Define ideal gases: Gases which obey all the gas laws.

(d)  Describe the principles/properties of an ideal gas.

(i) All gas molecules are identical.

(ii) They occupy no volume

(iii) All collisions between the gas molecules are perfectly elastic.

(iv)The particles of an ideal gas exert no force on each other. Etc.

(e)  Explain and describe the conditions when the real gases behave as **ideal gases**.

i.e. High temperature and low pressure.

(f)  Explain and describe the conditions when the real gases behave as **non-ideal gases**. i.e. Low temperature and high pressure.

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
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| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 17 | TOPIC | Quantitative aspects of chemical change: Molecular and formula masses | Lesson | 1 |
|-------|----|---------|-----------------|------|----|-------|------------------------------------------------|--------|---|

| LESSON SUMMARY FOR:  DATE STARTED: | | DATE COMPLETED: | |
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| LESSON OBJECTIVES | **At the end of the lesson learners should be able to:**<br>• Determine the empirical formula for a given substance from percentage composition.<br>• Determine the number of moles of water of crystallization in salts. |
|---|---|

## TEACHING and LEARNING ACTIVITIES

**1.  TEACHING METHOD/S USED IN THIS LESSON:**
Question and answer, Explanation, Experiment
**2.  LESSON DEVELOPMENT**
**2.1  Introduction [5 min]**

• Educator explains that the symbol and formula of a compound is important in quantitative calculations.

• A chemist sometimes has to determine the formula by using the masses of the atoms in the compound or the percentage mass of each element in the compound.

**PRE-KNOWLEDGE**
A basic understanding of the following:

• Atomic mass, molecular mass and formula mass.

• The Avogadro constant: the number of units represented by one mole of a substance – $6,02 \times 10^{23}$

• Meaning of the concept percentage.

**BASELINE ASSESSMENT[15 min]**

•  Educator mark homework activity.

•  Allow time for learners to ask questions and clear any misconceptions.


**2.2.  Main Body   (Lesson presentation)  [15 min]**

• Educator explains the difference between empirical and molecular formulae.

• The **empirical formula** of a substance indicates the simplest whole number ration of the atoms in the compound.

• **Molecular formula** indicates the real number of atoms in the compound - note

• Educator uses the following (or any other) example to explain the method.

When mercury reacts with chlorine it is discovered that the compound contains 73,9% mercury (Hg atoms) and 26,1% chlorine (Cl atoms) determine the empirical formula of the compound.

**Answer  (Use the steps below as a guideline)**

(a)    If the mass of the sample is 100 g, it contains 73,9 g Hg atoms and 26,1 g Cl atoms.

(b)    Convert the masses in (a) to mole

Hg: $n = \dfrac{m}{M} = \dfrac{73,9}{201}$ = 0,369 mole Hg atoms

Cl:  $n = \dfrac{m}{M} = \dfrac{26,1}{35,5}$ = 0,735 mole Cl atoms

(c)    Divide the smallest number of moles in the other mole numbers: $\dfrac{0.369}{0.369}$ = 1   and  $\dfrac{0,735}{0,369}$ = 2

(d)    The ratio between the atoms in the compound is: Hg:Cl = 1:2

(e)    Empirical formula = **HgCl₂**

•    The second part of this lesson is a practical activity. To save time the Educator can demonstrate this experiment

**Demonstration [20 min]**

•    You will need: hydrated copper(II)sulphate crystals, mass meter, small crucible, spatula, Bunsen burner and lighter, tripod stand and metal gauze.

•    Determine and note the mass of the crucible.

•    Add 4 spatulas of $CuSO_4 \cdot 5H_2O(s)$ to the crucible and determine and note the new mass.

•    Heat the crucible on the tripod stand until the crystal are white – all the water has evaporated,

•    Allow the crucible to cool down. Determine the mass of the crucible and anhydrous (without water) crystals. Note the mass.

•    Determine the mass of the water and the $CuSO_4$ crystals.

•    Calculate the empirical formula of the $CusO_4$ hydrate.

**CALCULATE THE EMPIRICAL FORMULA:**

•    Determine the number of moles of water: Use the formula  $n = \dfrac{m}{M}$

•    Determine the number of moles of $CuSO_4(s)$ Use the formula:  $n = \dfrac{m}{M}$

•    Determine the water-salt ration: $n(H_2O):n(CuSO_4) = \dfrac{n(H_2O)}{n(CuSO_4)}$   (The number of moles of water of crystallization) must be a whole number)

•    Write the correct empirical formula.

**3. Conclusion [5 min]**

•    Educator summarises important aspects of the lesson, reinforcing what needs to be remembered and recalled

**HOMEWORK QUESTIONS/**  Use Physical Science written by Volunteers – Siyavula, Ex 19.5 p 344   [30 min]
**Resources:**  Scientific calculator, worksheets, power point presentation, transparency; prescribed text book; CAPS-document (page 51)

Reflection/Notes:

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 18 | TOPIC | Concentration - TIME: 120 Minutes | LESSON | 2 |
|-------|----|---------|-------------------|------|----|-------|-----------------------------------|--------|---|

| LESSON SUMMARY FOR: DATE STARTED: | | DATE COMPLETED: | |
|-----------------------------------|--|------------------|--|

| LESSON OBJECTIVES | The following results will be the outcomes of this lesson: <br> At the end of the lesson, the learners must be able to: <br> • Distinguish between a solute, solvent and solution. <br><br> • Calculate the molar concentration of a substance using the formula $C = \dfrac{n}{V}$. <br><br> • Convert any given units of volume to dm$^3$. |
|-------------------|--|

| TEACHER ACTIVITIES | LEARNER ACTIVITIES | TIMING | RESOURCES NEEDED |
|--------------------|--------------------|--------|------------------|
| **1. Teaching Methods** <br> Explanation, Observation, Demonstration, Question and answer. <br><br> **2. Lesson Development** <br> **2.1 Introduction** <br> **2.1.1 Pre-knowledge required for the lesson** <br> 2.1.1.1 Knowledge of a periodic table(i.e. How to read a Molar Mass and Atomic Number on the periodic table) <br> 2.1.1.2 Knowledge of using formulas and substituting into a formula. <br> 2.1.1.3 Knowledge of using a calculator. <br> 2.1.1.4 Knowledge of homogeneous and heterogeneous mixtures. <br><br> **2.2 Main Body (Lesson presentation)** <br> a) The educator should introduce the lesson by explaining the meaning of a solute, solvent and solution. This can be done by preparing a solution with water(solvent) and Sodium hydroxide powder(solute). Sodium Hydroxide will dissolve in water and form a solution of NaOH$_{(aq)}$ <br> The above solution can be used in introducing the calculation of molar concentration. | . <br><br><br><br><br><br><br><br><br><br><br><br><br><br><br> Learners interact with the teacher during the discussion while the teacher is explaining the concept. | | • Chalk and Chalkboard <br> • Physical Science Gr 11 study guide/textbook |

| | |
|---|---|
| b) The educator should explain to the learners that the molar concentration of a solution can be calculated by using the formula of $C = \dfrac{n}{V}$, **where C is concentration in mol.dm$^{-3}$, n is number of moles in moles, and V is volume in dm$^{-3}$.** | Learners attempt the examples on their own before the educator gives the solutions. |
| c) The educator should give the learners the following examples to do in class:<br>　1) The solution of sodium hydroxide was prepared by dissolving 60 g of sodium hydroxide in 800 cm³. Calculate the molar concentration of the solution in mol.dm³.<br>　2) Calculate the mass of potassium hydroxide which needs to be weighed when preparing a solution of 2 mol.dm$^{-3}$ with a volume of 900 cm³ of water. | |
| **Solution**<br>1. Data: m=60 g<br>　V=800 cm³=0,8 dm³.<br>　C=?<br><br>$C = \dfrac{n}{V}$　　　$n = \dfrac{m}{M} = \dfrac{60}{23+16+1} = \dfrac{60}{40} = 1,5 \; mol$<br><br>$\therefore = \dfrac{1,5}{0,8}$<br><br>$C = 1,88 \, mol \cdot dm^{-3}$<br><br>2. Data: m=?<br>　C=2 mol.dm$^{-3}$<br>　V=900 cm³= 0,9 dm³ | Learners answer the questions in class. |

| | | | | |
|---|---|---|---|---|
| $C = \dfrac{n}{V}$ $\therefore 2 = \dfrac{n}{0,9}$ $n = 2 \times 0,9$ $n = 1,8 \ mol$ | $n = \dfrac{m}{M}$ $1,8 = \dfrac{m}{(39 + 16 + 1)}$ $1,8 = \dfrac{m}{56}$ $m = 1,8 \times 56$ $\therefore m = 100,8 \ g$ | 1. <u>Homework:</u> Questions from the Grade 11 Physical sciences textbook. | | |

**Conclusion**

Summarise the whole lesson and emphasize the important concepts.

**Reflection/note**

| **Name of Teacher:** | | **HOD:** | |
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| **Date:** | | **Date:** | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 17 | TOPIC | Stoichiometry - TIME: 60 Minutes | LESSON | 3 |
|-------|----|---------|-------------------|------|----|-------|----------------------------------|--------|---|

| LESSON SUMMARY FOR: DATE STARTED: | | DATE COMPLETED: | |
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| LESSON OBJECTIVES | The following results will be the outcomes of this lesson:<br>At the end of the lesson, the learners must be able to:<br>• Perform stoichiometric calculations using balanced equations.<br>• Determine a limiting reagent in a chemical reaction.<br>• Convert any given units to required units. |
|---|---|

| TEACHER ACTIVITIES | LEARNER ACTIVITIES | TIMING | RESOURCES NEEDED |
|---|---|---|---|
| **1.    Teaching Methods**<br>Explanation, Observation, Demonstration, Question and answer.<br><br>**2.   Lesson Development**<br>**2.1  Introduction**<br>**2.1.1 Pre-knowledge required for the lesson**<br>2.1.1.1 Knowledge of a periodic table(i.e. How to read a Molar Mass and Atomic Number on the periodic table)<br>2.1.1.2  Knowledge of using formulas and substituting into a formula.<br>2.1.1.3 Knowledge of using a calculator.<br>2.1.1.4   Knowledge of ratios.<br><br>**2.2  Main Body (Lesson presentation)**<br>a)   The educator should introduce the lesson by explaining what stoichiometric calculations are all about and the steps to be followed when dealing with stoichiometric calculations.<br>(i)  Stoichiometric calculations are calculations whereby number of  moles, mass and volume of reactants and products of a chemical reaction are calculated.<br>(ii)  These calculations can be done by using a balanced chemical reaction.<br>(iii)  Steps to be followed when doing stoichiometric calculations:<br>Step 1: Make sure the equation is balanced.<br>Step 2: Write down the molar ratio of the species present.<br>Step 3: Calculate the number of moles using the given information. | .<br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br><br>Learners interact with the teacher during the discussion while the teacher is explaining the concept.<br><br>Learners attempt the examples on their own before the educator gives the solutions. | | • Chalk and Chalkboard<br>• Physical Science Gr 11 study guide/textbook |

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$$n = \frac{m}{M}; \qquad n = cV; \qquad n = \frac{V}{V_m} \qquad\qquad V_m = 22{,}4 dm^3 \cdot mol^{-1}$$
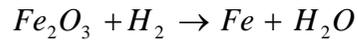
$$at\ STP$$

Step 4: Check for limiting reagents.
Step 5: From the mole ratios in the equation, find the moles of the required substance.
b) The educator should give the learners the examples to be done in class.
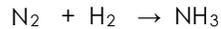
Examples:
1. Consider the following equation:
$$Fe_2O_3 + H_2 \rightarrow Fe + H_2O$$
1.1 Balance the equation.
1.2 How many moles of $H_2$ are required to react with 50 g of $Fe_2O_3$?
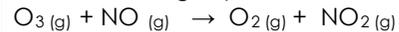1.3     Determine the mass of Fe produced from 50g of $Fe_2O_3$.

2. Consider the following equation:
    $N_2$  + $H_2$  → $NH_3$
2.1 Balance the equation.
2.2 If 11,2 dm³ of hydrogen gas is placed in the reaction vessel at STP with excess nitrogen gas, determine the volume of ammonia that forms.

3. The following equation indicates the reaction between ozone and nitrogen monoxide:
$O_{3(g)}$ + $NO_{(g)}$  → $O_{2(g)}$ + $NO_{2(g)}$
In this reaction, 0,74 g of $O_3$ reacts with 0,67 g of NO.
3.1 Calculate the number of moles of $O_3$ and of NO present at the start of the reaction.
3.2 Identify the limiting reagent in the reaction and justify your answer.
3.3 Calculate the mass of $NO_2$ produced from the reaction.

Answers

1.

1.1. **Balanced equation:**

$$Fe_2O_3 + 3H_2 \rightarrow 2Fe + 3H_2O$$
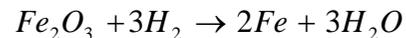
$$Ratio \quad 1 \quad : 3 \quad : \ 2 \ : \quad 3$$

1.2. **Number of moles of $H_2$.**

$$n_{(Fe_2O_3)} = \frac{m}{M} = \frac{50}{(56 \times 2) + (16 \times 3)} = \frac{50}{160} = 0{,}3125\ mol$$

$$\therefore n_{H_2} = 3 \times 0{,}3125 = 0{,}9375\ mol \ \text{(because the ratio is } 1:3)$$

Learners answer the questions in

class.

1.   Homework:

Questions from the Grade 11

Physical sciences textbook.

1.3. $\therefore n_{Fe} = 2 \times 0,3125 = 0,625 \, mol$ (because the ratio is $1:2$)

$$\therefore n_{Fe} = \frac{m_{Fe}}{M_{Fe}}$$

$$0,625 = \frac{m_{Fe}}{56} \qquad \qquad \therefore m_{Fe} = 56 \times 0,625 = 35 \, g$$

2.1. **Balanced equation** for the Haber Process: $N_2 + 3H_2 \rightarrow 2NH_3$.

2.2. **Volume of ammonia that forms**.

$$\therefore n_{H_2} = \frac{V}{V_m} = \frac{11,2}{22.4} = 0,5 \, mol$$

$$n_{NH_3} = \frac{2 \times 0,5}{3} = 0,33 \, mol$$

$$\therefore n_{NH_3} = \frac{V}{V_m}$$

$$0,33 = \frac{V}{22,4} \qquad \therefore V_{NH_3} = 0,33 \times 22,4 = 7,47 \, dm^3$$

3.1.

$$\therefore n_{Ozone} = \frac{m}{M} \qquad \qquad n_{NO} = \frac{m}{M}$$

$$= \frac{0,74}{48} \qquad \qquad = \frac{0,67}{30}$$

$$= 0,0154 \, mol \qquad \qquad = 0,0223 \, mol$$

3.2. Ozone $(O_3)$ is a limiting reagent.

3.3. Mass of $NO_2$ produced.

$\therefore n_{NO_2} = 0,0154 \; mol$ (because the ratio is $1:1$)

$$n = \frac{m}{M}$$

$$0,0154 = \frac{m_{NO_2}}{14 + (16 \times 2)}$$

$$0,0154 = \frac{m_{NO_2}}{46}$$

$\therefore m_{NO_2} = 0,7084 \; g$

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**Reflection/note**

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| Name of Teacher: | | HOD: | |
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| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 17 | TOPIC | Quantitative Aspects of Chemical Change - TIME:120 Minutes | LESSON | 4 |
|---|---|---|---|---|---|---|---|---|---|

| LESSON SUMMARY FOR:  DATE STARTED: | | DATE COMPLETED: | |
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| LESSON OBJECTIVES | The following results will be the outcomes of this lesson: <br> At the end of the lesson, the learners must be able to: <br> • Describe the mole as the SI unit for amount of substance. <br> • Calculate the molar mass of a substance given its formula. <br> • Determine the percentage composition for different substances using their molar masses. <br> • Calculate the mass and number of moles of a substance using the formulae: $n = \dfrac{m}{M}$;  $n = \dfrac{V}{V_m}$  and  $n = \dfrac{N}{N_A}$ . <br> • Describe the relationship between the mole and Avogadro's number. <br> • Conceptualise the magnitude of Avogadro's number. |
|---|---|

| TEACHER ACTIVITIES | LEARNER ACTIVITIES | TIMING | RESOURCES NEEDED |
|---|---|---|---|
| **1.  Teaching Methods** <br> Explanation, Observation, Demonstration, Question and answer. <br><br> **2.  Lesson Development** <br> **2.1 Introduction** <br> 2.1.1 Pre-knowledge required for the lesson <br> 2.1.1.1 Knowledge of a periodic table(i.e. How to read a Molar Mass and Atomic Number on the periodic table) <br> 2.1.1.2  Knowledge of using formulas and substituting into a formula. <br> 2.1.1.3   Knowledge of using a calculator. <br><br> **2.2 Main Body (Lesson presentation)** <br> **LESSON 1: Molar Mass Calculations** <br> a)  The educator should introduce the lesson by giving definitions of the key concepts in the lesson. <br> i) **Mole:** is the SI unit of the quantity of matter. | . <br><br><br><br><br><br><br><br><br><br><br><br><br> Learners interact with the teacher during the discussion while the teacher is explaining the concept. | | • Chalk and Chalkboard <br> • Physical Science Gr 11 study guide/textbook |

ii) **Avogadro's Number**: is the number of particles in one mole of a substance. The number of particles in 1 mole = $6{,}022 \times 10^{23}$.

   [The educator can relate this to a dozen. 1 dozen=12 units]

iii) **Molar mass**: is the mass of one mole of a substance. Its unit is g.mol$^{-1}$.

   Molar masses for different elements can be found on the periodic table.

b)   The educator should show the learners how to use the periodic table to find molar mass of a substance. Give the learners examples to do in class to calculate the molar mass for different substances. Examples that can be used:

Calculate the molar mass for each of the following:
(i)        Ca
(ii)       $MgCl_2$
(iii)      $H_2SO_4$
(iv)      $Ca(NO_3)_2$

Solutions
(i)        $40 \, \text{g} \cdot \text{mol}^{-1}$
(ii)                                                                 (iii)

$$= 24 + (35{,}5 \times 2) \qquad\qquad = (1 \times 2) + 32 + (16 \times 4)$$

$$= 24 + 71 \qquad\qquad\qquad\quad = 2 + 32 + 64$$

$$= 95 \, \text{g} \cdot \text{mol}^{-1} \qquad\qquad = 98 \, \text{g} \cdot \text{mol}^{-1}$$

(iV)
$$= 40 + (2 \times 14) + (2 \times 16 \times 3)$$

$$= 40 + 28 + 96$$

$$= 164 \, \text{g} \cdot \text{mol}^{-1}$$

c)   The educator should explain the "concept of water of crystallization" as follows:
In some ionic crystals, water is trapped in between the ions. The water trapped in between the molecules is called water of crystallization. The mass of the water must be included in the formula of molar mass when calculating the molar mass.

Examples including water of crystallization:

Learners attempt the examples on their own before the educator gives the solutions.

Learners answer the questions in class.

Calculate the molar mass for each of the following:

(i)        $CuSO_4 \cdot 5H_2O$

(ii)       $BaCl_2 \cdot 2H_2O$

Solutions:

(i)
$$= 63,5 + 32 + (16 \times 4) + (5 \times 1 \times 2) + (5 \times 16)$$
$$= 63,5 + 32 + 64 + 10 + 80$$
$$= 249,5 \text{ g} \cdot \text{mol}^{-1}$$

(ii)
$$= 138 + (35,5 \times 2) + (2 \times 1 \times 2) + (2 \times 16)$$
$$= 138 + 71 + 4 + 32$$
$$= 245 \text{ g} \cdot \text{mol}^{-1}$$

d) The educator should explain how to calculate the percentage composition in a substance by using the molar masses. The examples that can be used are:

Determine the percentage composition for each of the following substances:

(i)        $MgCl_2$

   Step 1: Calculate the molar mass for the $MgCl_2$ molecule = 95 g.mol$^{-1}$
   Step 2: Calculate the % for each substance in a molecule.

$$\% \text{ for Mg} = \frac{24}{95} \times 100 = 25,26\%$$

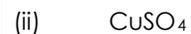$$\% \text{ for Cl} = \frac{35,5 \times 2}{95} \times 100 = 74,74\%$$

(ii)       $CuSO_4$

  Step 1: Calculate the molar mass for the $CuSO_4$ molecule = 159,5 g.mol$^{-1}$
  Step 2: Calculate the % for each substance in a molecule.

$$\text{\% for Cu} = \frac{63,5}{159,5} \times 100 = 39,81 \text{ \%}$$

$$\text{\% for S} = \frac{32}{159,5} \times 100 = 20,06\text{\%}$$

$$\text{\% for O} = \frac{16 \times 4}{159,5} = 40,13\text{\%}$$

**LESSON 2: Number of moles Calculations**
a) The educator should provide the learners with formulas that can be used to calculate the number of moles of a substance.

The formulae that can be used are:

(i) $n = \frac{m}{M}$ where n is the number of moles

    m is the mass in grams(g)

    M is the molar mass in $g. \, mol^{-1}$

(ii) $n = \frac{V}{V_m}$ where n is the number of moles

    V is the volume of a gas in $dm^3$

    V is the molar volume in $dm^3. \, mol^{-1}$

  At STP, the molar volume of a gas is 22,4 $dm^3 mol^{-1}$

(iii) $n = \frac{N}{N_A}$ where n is the number of moles

    N is the number of particles
    $N_A$ is the number of particles in one mole of a substance

b) The educator should give the learners the examples to do in class on their own when calculating the number of moles. Examples:

1. Given 80 g of NaOH.
1.1 Calculate the number of moles of 80 g of NaOH.

1.2  Calculate the number of NaOH particles in 80 g of NaOH.

2.  Given 0,05 kg of $CaCO_3$.Calculate:
2.1  the number of moles of 0,05 kg of $CaCO_3$.
2.2  the number $CaCO_3$ particles in 0,05 kg of $CaCO_3$.
2.3  the number of oxygen atoms in 0,05 kg of $CaCO_3$.
3  Given 11,2 $dm^3$ of nitrogen gas at STP. Calculate:
3.1  The number of moles of 11,2 $dm^3$ of nitrogen gas at STP.
3.2  The number of $N_{2(g)}$ molecules at STP.
3.3  The number of nitrogen(N) atoms at STP.

**Solutions**

1) **For NaOH**
1.1. Molar mass for NaOH = 23 + 16 + 1 = 40 g.mol⁻¹

$$\therefore \ n = \frac{m}{M} = \frac{80}{40} = 2 \, mol$$

1.2.
$$\therefore N = n \times N_A$$
$$= 2 \times 6,022 \times 10^{23} = 12,044 \times 10^{23} \ \text{NaOH particles}$$

2) **For $CaCO_3$**
2.1. Convert 0,05 kg to grams=50g
     Molar mass of $CaCO_3$= 40+12+(16×3)
                    =40+12+48= 100 g.mol⁻¹

$$\therefore \ n = \frac{m}{M} = \frac{50}{100} = 0,5 \, mol$$

3.4
$$\therefore N = n \times N_A$$
$$= 0,5 \times 6,022 \times 10^{23} = 3,011 \times 10^{23} \ \text{CaCO}_3 \ \text{particles}$$

2.3) The number of oxygen atoms in 50g of $CaCO_3$ = 3×3,011×10²³= 9,033 ×10²³ atoms

3) For nitrogen gas ($N_{2(g)}$)

3.1. $$\therefore n = \frac{V}{V_m} = \frac{11,2}{22,4} = 0,5 \, mol$$

1.  Homework:

Questions from the Grade 11

Physical sciences textbook.

| | | | |
|---|---|---|---|
| 3.2.<br><br>$\therefore N = n \times N_A$<br><br>$= 0,5 \times 6,022 \times 10^{23} = 3,011 \times 10^{23}$  $N_{2(g)}$  particles<br><br><br>3.3) The number of nitrogen atoms $= 2 \times 3,011 \times 10^{23} = 6,022 \times 10^{23}$ atoms<br><br><br>**2.3** <u>Conclusion</u><br><br>**Summarize the above lessons by explaining the relationship between n, m and M.** | | | |

Reflection/note

| **Name of Teacher** | | **HOD:** | |
|---|---|---|---|
| **Sign:** | | **Sign:** | |
| **Date:** | | **Date:** | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 18 | TOPIC | Quantitative aspects of chemical change: Basic stoichiometric calculations | Lesson | 1 |
|-------|----|---------|-------------------|------|----|-------|-------------------------------------------------------------------------------|--------|---|

| LESSON SUMMARY FOR: DATE STARTED: | | DATE COMPLETED: | |
|-----------------------------------|--|-----------------|--|

| LESSON OBJECTIVES | **At the end of the lesson learners should be able to:** <br> • Calculations based on concentration, mass, moles, molar mass and volume |
|-------------------|----------------------------------------------------------------------------------------------------------------------------------------|

## TEACHING and LEARNING ACTIVITIES

1. **TEACHING METHOD/S USED IN THIS LESSON:**
Question and answer, explanation.

2. **LESSON DEVELOPMENT**

2.1. **Introduction [5 min]**

• Educator explains the meaning of stoichiometry: it involves the calculation of the quantities of reactants and products in chemical reactions.

• Stoichiometry means to measure elements)

**PRE-KNOWLEDGE**
A basic understanding of the following:

• Molar concept

• Avogadro's number

• Balancing of equations for chemical reactions

**BASELINE ASSESSMENT [5 min]**

• Educator revises .the meaning of coefficients (numbers written before formulae of substances in a chemical reaction).

• Ask learners to write the reaction between hydrogen gas and nitrogen gas to form ammonia as a balanced chemical equation.

$3H_2(g) + N_2(g) \rightarrow 2NH_3(g)$
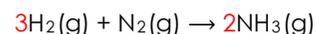
• Ask learners to explain the LAW of CONSERVATION of MASS by using the equation:

Total mass od reactants: $3(2(1)) + 2(14) = 34$ g

Total mass of products: $2(14 + 3(1)) = 34$ g

Matter can change form but can not be created or destroyed.

• Learners have to understand that the atoms are also conserved during the reaction.
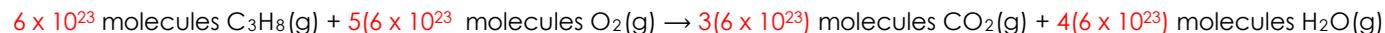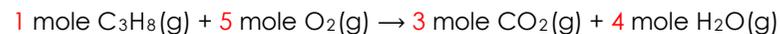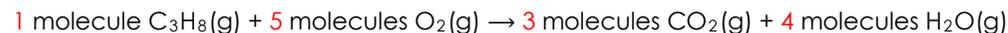
2.2 **Main Body (Lesson presentation) [40 min]**

• Educator explains the meaning of mole ratios in balanced chemical reactions.

• Use the following example in the explanation: Propane burns in oxygen to form carbon(IV)oxide and water.

- ➤ Balanced chemical equation: $1C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$
- ➤ Stoichiometric ratios: $1 : 5 : 3 : 4$
- ➤ Possible meaning of ratios:

  1 molecule $C_3H_8(g)$ + 5 molecules $O_2(g) \rightarrow$ 3 molecules $CO_2(g)$ + 4 molecules $H_2O(g)$

  1 mole $C_3H_8(g)$ + 5 mole $O_2(g) \rightarrow$ 3 mole $CO_2(g)$ + 4 mole $H_2O(g)$

  $6 \times 10^{23}$ molecules $C_3H_8(g)$ + $5(6 \times 10^{23}$ molecules $O_2(g) \rightarrow 3(6 \times 10^{23})$ molecules $CO_2(g)$ + $4(6 \times 10^{23})$ molecules $H_2O(g)$

  44 g $C_3H_8(g)$ + 160 g $O_2(g) \rightarrow$ 132 g $CO_2(g)$ + 72 g molecules $H_2O(g)$

- ➤ Learners have to understand that the stoichiometric ratio has to be maintained in all reactions regardless of the amount of reactants.
- ➤ 0,5 mole $C_3H_8(g)$ + 2,5 mole $O_2(g) \rightarrow$ 1,5 mole $CO_2(g)$ + 2 mole $H_2O(g)$   (Divide the smallest ratio into the others to obtain:      $1 : 5 : 3 : 4$
- • **Example 1:** Potassium chlorate decomposes into oxygen and potassium chloride.
- A.    Calculate the mass of oxygen formed if 14,7 g of potassium chlorate is heated.
  - ➤ **Write the balanced chemical equation:**

    $2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$
  - ➤ **Determine the molar masses of the substances involved in the question:**

    $M(KClO_3) = 39 + 35,5 + 3(16) = 122,5$ g·mol$^{-1}$

    $M(O_2) = 2(16) = 32$ g·mol$^{-1}$
  - ➤ **Convert all the given quantities (mass, volume or number of particles) to mole**

    $n(KClO_3)$  $n = \frac{m}{M} = \frac{14,7}{122,5} = 0,12$ mol $KClO_3(s)$ is used in the reaction.
  - ➤ **Use the stoichiometric ratio:**

| $KClO_{3=}$ | $O_2$ |
|:---:|:---:|
| 2 | 3 |
| 0,12 | x |

$2x = (3)(0,12)$

$x = 0,18$ mole $O_2(g)$ is produced.

  - ➤ **Convert mole to gram**

$n = \frac{m}{M}$

$m = nM$

$m = (0,18)(32)$

m = 5,76 g $O_2$(g) is produced.

•     Educator discusses an example of mass-volume calculations:

A. 50 $dm^3$ of oxygen is produced at STP. Determine the mass of $KClO_3$(s) needed to complete the reaction.

➢     **Write the balanced chemical equation:**

    2$KClO_3$(s) → 2KCl(s) + 3$O_2$(g)

➢     **Determine the molar masses of the substances involved in the question:**

    M($KClO_3$) = 39 + 35,5 + 3(16) = 122,5 g·$mol^{-1}$

    M($O_2$) = 2(16) = 32 g·$mol^{-1}$

➢     **Convert all the given quantities (mass, volume or number of particles) to mole**

➢     $n = \frac{V}{V_0} = \frac{50}{22,4}$ = 2,23 mole $O_2$(g) is produced

➢

| $KClO_{3=}$ | $O_2$ |
|:---:|:---:|
| 2 | 3 |
| x | 2,23 |

    3x = (2)(2,23)

    x = 1,53 mole $KClO_3$(s) is needed

➢     **Convert mole to gram**

    $n = \frac{m}{M}$

$$m = nM$$

    m = (1,53)(122,5)

    m = 187,43 g $KClO_3$(s) is needed

**3.**     **Conclusion [10 min]**

•     Educator summarises important aspects of the lesson, reinforcing what needs to be remembered and recalled

**HOMEWORK QUESTIONS/ ACTIVITY** Use Physical Science written by Volunteers – Siyavula, Ex 19.7 p 354   [30 min]
**Resources:** Worksheets, power point presentation (if available) chalk- or white board, prescribed text book; CAPS-document (page 52).

**Reflection/Notes:**

| Name of Teacher | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 18 | TOPIC | Quantitative aspects of chemical change:  Basic stoichiometric calculations – Time: 60 min | Lesson | 2 |
|---|---|---|---|---|---|---|---|---|---|

| LESSON SUMMARY FOR:  DATE STARTED: | | | DATE COMPLETED: | |
|---|---|---|---|---|
| **LESSON OBJECTIVES** | **At the end of the lesson learners should be able to:** <br> • Calculations based on concentration, mass, moles, molar mass and volume | | | |

## TEACHING and LEARNING ACTIVITIES

**1.  TEACHING METHOD/S USED IN THIS LESSON:**
Question and answer, explanation.
Classwork activity to practice different applications of stoichiometric calculations.
**2.   LESSON DEVELOPMENT**
**2.1  Introduction [5 min]**

- Educator explains that the number of moles of a certain compound per unit volume is considered as the concentration.

**PRE-KNOWLEDGE**
A basic understanding of the following:

- Stoichiometric principles

- The molar concept.

**BASELINE ASSESSMENT[5 min]**

- Educator Mark homework activity and discuss difficulties that learners have encountered

**2.2.   Main Body   (Lesson presentation)  [40 min]**

Lesson 14 and 15 both covers stoichiometric calculations. In lesson 15 more advanced examples will be discussed.

- Educator explains the fact that there are limiting reactants in most chemical reactions. It implies that one of the reactants is in excess and that a certain amount of this substance will not be used up.

- Leaners have to understand that all the given quantities have to be converted to mole before the limiting reactant can be determined.

**Example 1**: Hydrogen reacts with nitrogen to form ammonia gas. 100 $cm^3$ of hydrogen gas is mixed with 100 $cm^3$ of nitrogen gas

(a)     Write a balanced chemical equation for the reaction

(b)     Determine which of the gases is in excess.

(c)     Calculate the total volume of all the gases in the container after the reaction has reached completion.

(d)     Calculate the mass of ammonia that can be produced during the reaction.

**Answers**

(a)     $1N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$

(b) Convert the given volumes to mole.

$n = \dfrac{V}{V_0} = \dfrac{100}{22,4} = 4,46$ mole

The reaction is started with 4,46 mole of $N_2(g)$ and 4,46 mole $H_2(g)$

Consider the stoichiometric ratios to find the limiting reactant.

Table 1

| $N_2$ | $H_2$ |
|-------|-------|
| 1 | 3 |
| 4,46 | x |

**OR**

Table 2

| $N_2$ | $H_2$ |
|-------|-------|
| 1 | 3 |
| x | 4,46 |

- The answer for x, in the first table is (3)(4,46) = 13,38 mole $H_2(g)$. Only 4,46 mole $H_2(g)$ is available. This indicates that $H_2(g)$ is the limiting reactant and that $N_2(g)$ is in excess.
- In table 2: 3x = 4,46
  x = 1,49 mole $N_2(g)$ reacts.

$N_2(g)$ is in excess

(c)

| $N_2$ | $H_2$ | $NH_3$ |
|-------|-------|--------|
| 1 | 3 | 2 |
| 1,49 | 4,46 | 2,97 |

Mole $N_2(g)$ that does not react = 4,46 – 1,49 = 2,97 mole $N_2(g)$ in excess

Mole $NH_3(g)$ formed = 2,97

There is (2,97 + 2,97) = 5,94 mole of $N_2(g)$ and $NH_3(g)$ in the container when all the $H_2(g)$ has been used up.

Convert to volume: $n = \dfrac{V}{V_0}$

$V = nV_0 = (5,94)(22,4) = 133,06$ cm³

(d) From (c) 2,97 mole of $NH_3(g)$ is formed.

Convert mole to gram: $M(NH_3) = 17$ g·mol⁻¹

$$n = \frac{m}{M}$$

m = nM

m = (2,97)(17)

m = 50,49 g NH$_3$(g) is formed

**Example 2**

Aluminium and oxygen reacts according to the following equation:2Al(s) + 3O$_2$(g) → 2Al$_2$O$_3$(s). There is 3 mole aluminium and 2 mole oxygen on a container and it is allowed to react.

(a)     Determine the number of moles of aluminium that is in excess.
(b)     Calculate the mass of aluminium oxide formed during the reaction.

**Answers**

(a)     Table 1

| Al | O$_2$ |
|----|----|
| 2 | 3 |
| 3 | x |

Table 2

| Al | O$_2$ |
|----|----|
| 2 | 3 |
| x | 2 |

- Table 1: 2x = 9
  x = 4,5 mole O$_2$(g) is needed to react with 3 mole Al(s) Only 2 mole is available.

- Table 1: 3x = 4

  x = 1,33 mole Al(s) is needed to react with 2 mole of O$_2$(g).

- Both these calculations prove that Al(s) is in excess.

3mole – 1,33 mole = 1,67 mole of aluminium is in excess.

(b)

| Al | O$_2$ | Al$_2$O$_3$ |
|----|----|----|
| 2 | 3 | 2 |
| 1,33 | 2 | 1,33 |

Convert 1,33 mole Al$_2$O$_3$(s) to mass:  M(Al$_2$O$_3$) = 2(27) + 3(16) = 102 g·mol$^{-1}$

$$n = \frac{m}{M}$$

$$m = nM$$

$$m = (1{,}33)(102)$$

m = 135,66 g $Al_2O_3$ (s) is formed during the reaction.

### 3. Conclusion [10 min]

- Educator summarises important aspects of the lesson, reinforcing what needs to be remembered and recalled

**HOMEWORK QUESTIONS/ ACTIVITY** Use Physical Science written by Volunteers – Siyavula, End of chapter exercise (choose from question   1 -14  [30 min]
**Resources:** Worksheets, power point presentation (if available) chalk- or white board, prescribed text book; CAPS-document (page 52).

**Reflection/Notes:**

| Name of Teacher | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 18 | TOPIC | Quantitative aspects of chemical change: Basic stoichiometric calculations - Time: 60 min | Lesson | 3 |
|-------|-----|---------|-------------------|------|-----|-------|---------|--------|---|

| LESSON SUMMARY FOR: DATE STARTED: | | DATE COMPLETED: | |
|-----------------------------------|---|-----------------|---|
| **LESSON OBJECTIVES** | **At the end of the lesson learners should be able to:** <br> • Determine the theoretical yield of a product in a chemical reaction when the reaction is started with a known mass of reactant. | | |

| TEACHING and LEARNING ACTIVITIES |
|----------------------------------|

**1. TEACHING METHOD/S USED IN THIS LESSON:**
Question and answer, explanation, class work activity

**2. LESSON DEVELOPMENT**

**2.1 Introduction [5 min]**

- Educator explains that the amount of product that is formed during chemical reactions is normally less than the **theoretical yield**. It means that not all the reactants are converted to products. In grade 10, learners will determine the theoretical yield of a product when if the reaction is started with a known mass of reactant.

**PRE-KNOWLEDGE**
A basic understanding of the following:

- Balancing of equations

- Stoichiometric ratios

- The molar concept

**BASELINE ASSESSMENT[5 min]**

- Educator asks a few general questions determine learner's level of understanding of the molar concept and balancing of equations and stoichiometric ratios.

**2.2. Main Body (Lesson presentation) [15 min]**

- Educator can use an example to explain to learners how to calculate the theoretical yield of products in a chemical reaction.

➢ In an investigation to determine the amount of iron that can be recovered from iron ore, you start the reaction with 150 g of $Fe_2O_3$. Assume that all the $Fe_2O_3$ will react during the process ($Fe_2O_3$ is the limiting reactant) Determine the theoretical yield of Fe.

➢ The unbalance chemical equation for the reaction, is:

$Fe_2O_3(s) + CO(g) \rightarrow Fe(s) + CO_2(g)$

➢ Allow learners to balance the equation:

$Fe_2O_3(s) + 3CO(g) \rightarrow 2Fe(s) + 3CO_2(g)$

➢ Convert 150 g $Fe_2O_3$ to mole: $n = \frac{m}{M} = \frac{150}{160} = 0,94$ mole $Fe_2O_3$ formula units.

➢ Determine the stoichiometric ratio, by using the coefficients in the balanced equation.

| $Fe_2O_3$ | $O_2$ |
|---|---|
| 1 mole | 2 mole |
| 0,94 mole | x mole |

x = (2)(0,94) = 1,88 mole

1,88 mole Fe atoms is obtained from 0,94 mole $Fe_2O_3$

➢ Convert 1,88 mole Fe atoms to mass in gram.

$n = \frac{m}{M}$

$m = n \cdot M = (1,88)(56) = 105,25$ g Fe atoms

**LEARNER ACTIVITY [20 min]**
**CLASS WORK (Peer assessment)**

• Learners do a class work assignment to practice the concept of theoretical yield.

1. Methanol ($CH_3OH(\ell)$) can be decomposed to form hydrogen gas and carbon(II)oxide. During a decomposition reaction, 125 g of methanol is decomposed.

    (a) Write the formula for carbon(II)oxide and give the general name of the compound.

    (b) Write a balanced chemical reaction for the above mentioned decomposition reaction.

    (c) Determine the theoretical yield of $H_2(g)$

2. When calcium carbonate is heated, it decomposes into calcium oxide and carbon(IV)oxide gas. During such a reaction Megan heated 50 g of calcium carbonate and captures the gas in a syringe.

    (a) Write the formula for carbon(IV)oxide and give the household name of the compound.

    (b) Write a balanced chemical equation for the reaction described above.

    (c) Determine the volume of carbon(IV)oxide produced during the reaction at STP..

    (d) Determine the theoretical yield of carbon(IV)oxide.

**ANSWERS TO CLASSWORK ACTIVITY**

1.

(a) CO(g) – Carbon monoxide

(b) $CH_3OH(\ell) \rightarrow 2H_2(g) + CO(g)$
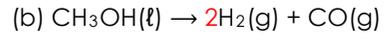
(c) $M(CH_3OH) = 12 + 3(1) + 16 + 1 = 32$ g·mol$^{-1}$

$n = \frac{m}{M} = \frac{125}{32} = 3,91$ mole $CH_3OH$-molecules

| CH$_3$OH | H$_2$(g) |
|---|---|
| 1 mole | 2 mole |
| 3,91 mole | x mole |

$x = 7,82$ mole $H_2$

$n = \frac{m}{M}$

$m = n \cdot M = (7,82)(2) = 15,64$ g $H_2$ molecules.


2.

(a) $CO_2(g)$ carbon dioxide

(b) $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$
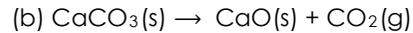
(c) $n = \frac{m}{M} = \frac{50}{100} = 0,5$ mole $CaCO_3$ formula units

(d)   $n = \frac{V}{V_0}$

(e) $V = n \cdot V_0 = (0,5)(22,4) = 11,2$ dm$^3$ $CO_2(g)$ molecules

(f) $n = \frac{m}{M}$

$m = n \cdot M = (0,5)(44) = 22$ g $CO_2(g)$ molecules.

3. **Conclusion [15 min]**

• Learners mark the class work activity.
• Educator summarises important aspects of the lesson, reinforcing what needs to be remembered and recalled

**HOMEWORK QUESTIONS/ ACTIVITY** Use Physical Science written by Volunteers – Siyavula, End of the chapter exercise p 355 16,17 [20 min]
**Resources:** Worksheets, power point presentation (if available) chalk- or white board, prescribed text books; CAPS-document (page 52).

Reflection/Notes:

| Name of Teacher | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 18 Lesson 4 | TOPIC | Chemical Change: *More complex Stoichiometric calculations.* |
|-------|----|---------|-------------------|------|-------------|-------|---------------------------------------------------------------|

**LESSON SUMMARY FOR: DATE STARTED:** | | **DATE COMPLETED:**

| LESSON OBJECTIVES | *At the end of the lesson learners should:*<br>• *Be able to determine the percentage CaCO$_3$ in an impure sample of sea shells (purity or percentage composition)* |
|-------------------|------------------------------------------------------------------------|

## TEACHING and LEARNING ACTIVITIES

1. **TEACHING METHOD/S USED IN THIS LESSON:**
; **Question and answer, explanation, experiment**

2. **LESSON DEVELOPMENT**

2.1. **Introduction [5 min]**

A variety of seashells

- Educator discusses the fact that seashells are the hard outer protective layer of marine organisms, animals without backbones commonly known as invertebrates.

- Seashells mainly consist of calcium carbonate (CaCO$_3$).

- Calcium carbonate also gives hardness and strength to rocks and eggshells.

**PRE-KNOWLEDGE**
**A basic understanding of the following:**

- Stoichiometric calculations.
- The meaning of percentage composition.
- The difference between actual and theoretical yield.

2.2. **Main Body   (Lesson presentation)  [10 min]**

- Calcium carbonate reacts with hydrochloric acid to form calcium chloride, carbon(IV)oxide and water.
- The balanced chemical equation for the reaction is:
  $CaCO_3(s) + 2HC\ell(aq) \rightarrow CaC\ell_2(aq) + CO_2(g) + H_2O(\ell)$
- The salt $CaC\ell_2$ is soluble in water.
- $CO_2(g)$ turns clear lime water milky.
- The percentage $CaCO_3(s)$ in a sample of seashells $= \frac{Mass\ CaCO_3}{Mass\ of\ shells}$ x 100

**LEARNER ACTIVITY[35 min]**

**GROUPWORK:** Learners determine the percentage calcium carbonate in a sample of sea shells.

- Learners can work in small groups or individually.
- Do Experiment 1, page 188, *Oxford Successful Physical sciences Grade 11 (Learner guide).*
- Educator must explain the dangers of substances like hydrochloric acid before the learners attempt the experiment.
- Repeat the experiment with different samples of shells.
- Use the results to calculate the % $CaCO_3$ in each sample.
- Answer the following question as part of the experiment:

> Calcium carbonate, which is found in bird eggshells and seashells, reacts with hydrochloric acid according to the following equation:
>
> $$CaCO_3(s) + HC\ell(aq) \rightarrow CaCl_2(aq) + H_2O(\ell) + CO_2(g)$$
>
> This reaction can be used to determine the mass percentage of $CaCO_3$ in an impure sample of sea shells. During an investigation, Shane allows a 50 g sample of shells to react with excess hydrochloric acid. He captures the carbon dioxide gas at **STP**.
>
> a    Determine the mass of the $CO_2(g)$ if it is assumed that the sample is 100 % pure $CaCO_3(s)$.
> b    The volume of $CO_2(g)$ collected is 9,5 $dm^3$. Calculate the percentage $CaCO_3$.

**Answer:**

a.  $n = \frac{m}{M} = \frac{50}{100} = 0,5$ mol of $CaCO_3(s)$ reacts

Ration: $CaCO_3:CO_2 = 1:1$

Shane can collect 0,5 mol $CO_2(g)$

m = nM

m = (0,5)(44)

m = 22 g $CO_2$ can be collected  (*Theoretical yield*)

b.  Convert 9,5 $dm^3$ to mol

$n = \frac{V}{V_0} = \frac{9,5}{22,4}$ 0,42 mol

$m = nM$

$m = (0,42)(44)$

$m = 18,48$ g $CaCO_3$ is really collected (*Actual yield*)

$Percentage\ yield = \frac{actual\ yield}{theoretical\ yield} \times \frac{100}{1}$

$= \frac{18,48}{22} \times \frac{100}{1}$

$= 84\ \%$

3. **<u>Conclusion</u> [10 min]**

- Educator allows learners to ask questions about the experiment.

**HOMEWORK ACTIVITY**

Learners have to complete the write-up for the experiment.( Refer to *Oxford Successful Physical Sciences p 160 (Teacher's guide).*

**Recourses:** Appropriate chemicals and apparatus for experiment, power point presentations or transparencies; prescribed text books, CAPS-document (page 82).

Name of Teacher_____     SIGN:_____          Date:_____

Name of HOD:_____     SIGN:_____          Date:_____

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 19 | TOPIC | Chemical Change: More complex Stoichiometric calculations: Informal experiment | Lesson | 1 |
|-------|----|---------|-------------------|------|----|-------|-----------------------------------------------------------------------------------|--------|---|

| LESSON SUMMARY FOR: DATE STARTED: | | DATE COMPLETED: | |
|-----------------------------------|--|-----------------|--|

| LESSON OBJECTIVES | **At the end of the lesson learners should:** <br> • Be able to determine the mass of $PbO_2$ prepared from a certain mass of $Pb(NO_3)$. <br> • Be able to complete the recommended experiment for informal assessment. |
|-------------------|---|

## TEACHING and LEARNING ACTIVITIES

**1. TEACHING METHOD/S USED IN THIS LESSON:**
Question and answer, explanation, experiment.

**2. LESSON DEVELOPMENT**

**2.1 Introduction [5 min]**

• Educator explains the aim of the experime

✓ Learners will prepare lead(IV)oxide from lead(II)nitrate. (Note that Stock-notation is used)
✓ The mass of the lead(IV)oxide precipitate will be determined.
✓ Determine the percentage yield of the lead(IV)oxide.

**PRE-KNOWLEDGE**
A basic understanding of the following:

• Stoichiometric calculations.
• Stock-notation

$PbO_2$

**2.2 Main Body   (Lesson presentation)  [10 min]**

• Before learners do this experiment, it is important that Educator informs them of the following:

✓ Do not inhale any of the gases.
✓ Being a strong oxidant, lead dioxide is a poison when ingested.
✓ The associated symptoms include abdominal pain and spasms, nausea, vomiting and headache.
✓ Acute poisoning can lead to muscle weakness, metallic taste, loss of appetite, insomnia, dizziness, with shock, coma and death in extreme cases.
✓ The poisoning also results in high lead levels in blood and urine.
✓ Contact with skin or eyes results in local irritation and pain.
✓ Avoid skin contact. In case of skin contact, flush with large quantities of water.

• Warning signs that can be used on containers or in laboratories that contains dangerous chemicals.

- Wear gloves when handling the chemicals.
- All apparatus must be handled with great care – beakers can be very hot.

**LEARNER ACTIVITY [40 min]**

**EXPERIMENT**

- Do the experiment on page 184 Oxford Successful Physical Sciences grade 11 (Learner book).

- Educator demonstrates the experiment and learners record the data.

**2.3 Conclusion [5 min]**

- Educator discusses the results of the experiment.

**HOMEWORK ACTIVITY**

Learners complete the worksheet given on page on page 156 of Oxford Successful Physical Sciences (Teacher's guide)

**Recourses:** Apparatus and chemicals for experiment, power point presentations or transparencies; prescribed text books, CAPS-document (page 82).

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 19 | TOPIC | Chemical Change: Volume relationships in gaseous reactions | Lesson | 2 |

| LESSON SUMMARY FOR: DATE STARTED: | | DATE COMPLETED: | |

| LESSON OBJECTIVES | At the end of the lesson learners should:<br>• Do stoichiometric calculations with explosions as reactions during which a great many molecules are produced in the gas phase so that there is a massive increase in volume<br>• e.g. ammonium nitrate in mining. |

## TEACHING and LEARNING ACTIVITIES

**1. TEACHING METHOD/S USED IN THIS LESSON:**
Question and answer, explanation

**2. LESSON DEVELOPMENT**

**2.1 Introduction [5 min]**

• Educator explains that stoichiometric calculations can also be applied to gaseous reactions.

• In these exothermic reactions a great amount of energy is released to the environment.
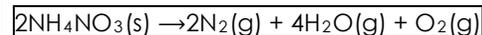
**PRE-KNOWLEDGE**
A basic understanding of the following:

• Stoichiometric calculations.

**2.2 Main Body (Lesson presentation) [10 min]**

• The chemical compound **ammonium nitrate**, the nitrate of ammonia with the chemical formula $NH_4NO_3$, is a white crystalline solid at room temperature and standard pressure.

Warning sign for explosives

An exothermic reaction

• It is commonly used in agriculture as a high-nitrogen fertilizer, and it has also been used as an oxidizing agent in explosives, including improvised explosive devices.
• Heating or any ignition source may cause violent combustion or explosion.
• Ammonium nitrate reacts with combustible and reducing materials as it is a strong oxidant. It is widely used in fertilizers and explosives.
• The explosives used in breaking up rock in mining is called ammonium nitrate fuel oil (ANFO or AN/FO).
• Ammonium nitrates are also used to modify the detonation rate of other explosives.
• Example will be ammonia dynamites (Nitro-glycerine).
• The gases that form in all these reactions move rapidly outwards and push the particles of the surrounding material apart into much smaller pieces.
• The thermal decomposition reaction of ammonium nitrate can be represented by the following chemical reaction:

$2NH_4NO_3(s) \longrightarrow 2N_2(g) + 4H_2O(g) + O_2(g)$

- Learners should understand that Avogadro's hypothesis is applicable on all gaseous reactions.

- Avogadro's hypothesis: The volume of gas at a given temperature and pressure is directly proportional to the amount of gas in moles:

V∝n at constant T and p


Ammonium nitrate




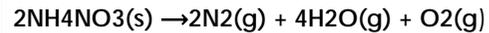Nitro-glycerine explosion

**LEARNER ACTIVITY**[35 min]

**CLASSWORK ACTIVITY**

Ammonium nitrate is a salt produced from the reaction between ammonia and nitric acid. The salt can be decomposed in an exothermic reaction to produce a great amount of gas molecules. The balanced chemical reaction for this process, is:

**$2NH_4NO_3(s) \rightarrow 2N_2(g) + 4H_2O(g) + O_2(g)$**

360 g of $NH_4NO_3$ is allowed to decompose at STD. Calculate the mass of water vapour that can be produced in the reaction.

A volume of 2000 cm3 of $N_2(g)$ is needed. Calculate the mass (in gram) of ammonium nitrate that must be decomposed at 25 0C and a pressure of 150 kPa to produce this amount of $N_2(g)$.

Calculate the volume of each of the gases produced during thermal decomposition of $NH_4NO_3$ (s) if the mass of the salt is 0,75 kg.

Determine the mass of water produced from the decomposition of 25.09 of solid ammonium nitrate.

Name two uses of ammonium nitrate

**ANSWERS TO CLASSWORK ACTIVITY**

Convert 360 g $NH_4NO_3$ to mol

n=360/80 = 4,5 mol $NH_4NO_3$(s)

$NH_4NO_3$ : $H_2O$ = 1 : 2

= 4,5 : 9

m = nM

m = (9)(18)

m = 162 g $H_2O$ can be produced.


pV = nRT

n=pV/RT = $((150× 〖10〗^{(3)}) (2000× 〖10〗^{(-6)}))/((8,31)(298))$ = 0,12 mol $N_2(g)$ is needed

$NH_4NO_3$ : $N_2$ = 1 : 1

= 0,12 : 0,12

m = nM

m = (0,12)(80)

m = 9,6 g $NH_4NO_3$(s) is needed

n=m/M = 750/80 = 9,375 mol $NH_4NO_3$

$NH_4NO_3 : N_2 : H_2O : O_2 = 2 : 2 : 4 : 1$

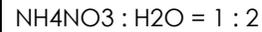$\qquad = 9,375 : 9,375 : 18,75 : 4,6875$

$V(N_2) = nV_0 = (9,375)(22,4) = 210 \ dm^3$

$V(H_2O) = nV_0 = (18,75)(22,4) = 420 \ dm^3$

$V(O_2) = nV_0 = (4,6875)(22,4) = 105 \ dm^3$

$n = m/M = 25,09/80 \ 0,314$ mol $NH_4NO_3$ is decomposed

$NH_4NO_3 : H_2O = 1 : 2$

$\qquad = 0,314 : 0,628$ mol $H_2O$ is produced

$\qquad m = nM$

$\qquad m = (0,628)(18)$

$\qquad m = 11,304 \ g \ H_2O(g)$ is produced


It can be used as fertilizer.

It is used as an explosive.

**2.3  Conclusion** [10 min]

Educator discusses the answers of the classwork activity

HOMEWORK ACTIVITY

Oxford Successful Physical Sciences p 197 Activity 1 Question 4 (Learner book)

Recourses: Power point presentations or transparencies; prescribed text books, CAPS-document (page 83).

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |

| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 19 | TOPIC | Chemical Change: Volume relationships in gaseous reactions | Lesson | 3 |
|-------|-----|---------|-------------------|------|-----|-------|------------------------------------------------------------|--------|---|

| LESSON SUMMARY FOR:  DATE STARTED: | | DATE COMPLETED: | |
|---|---|---|---|

| LESSON OBJECTIVES | At the end of the lesson learners should:<br>• Do stoichiometric calculations with explosions as reactions during which a great many molecules are produced in the gas phase so that there is a massive increase in volume<br>• e.g. petrol in a car cylinder |
|---|---|

### TEACHING and LEARNING ACTIVITIES

**1.  TEACHING METHOD/S USED IN THIS LESSON:**
Question and answer, explanation

**2.  LESSON DEVELOPMENT**

**2.1  Introduction [10 min]**

• Educator marks homework p 168  Oxford Successful Physical Sciences Grade 11 (Teacher's Guide)

• Educator briefly discusses the history of the petrol engine:

✓ Nikolaus August Otto as a young man was a traveling salesman for a grocery concern.

✓ In his travels he encountered the internal combustion engine.

✓ He invented the Otto, one of the first engines to use a spark plug, which is a device that produces a small electric spark to ignite the fuel charge.

**PRE-KNOWLEDGE**

A basic understanding of the following:

- Stoichiometric calculations.
- Exothermic reactions

**2.2.** **Main Body   (Lesson presentation)  [15 min]**

- Octanes are a family of hydrocarbons that are typical components of gasoline.
- They are colourless liquids that boil around 125 °C (260 °F).
- One member of the octane family, isooctane is used as a reference standard to benchmark the tendency of gasoline, petrol, or benzene fuels to resist self-igniting.
- Self-ignition leads to inefficiencies (or even engine damage) if it occurs during compression prior to the desired position of the piston in the cylinder as appropriate for valve and ignition timing.
- The problem of premature ignition is referred to as pre-ignition and also as engine knock, which is a sound that is made when the fuel ignites too early in the compression stroke.
- Severe knock causes severe engine damage, such as broken connecting rods, melted pistons, melted or broken valves and other components. The **octane rating** is a measure of how likely a gasoline or liquid petroleum fuel is to self-ignite. The higher the number, the less likely an engine is to pre-ignite and suffer damage.
- The following chemical reaction represents the **complete** combustion of octane.

  $2C_8H_{18}(\ell) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(g) + $ energy

- Combustion reactions are exothermic and release a great amount of energy.
- The $CO_2(g)$, that is one of the products in the reaction, contributes to the greenhouse effect.
- If Internet excess is available, Educator can expose learners to the many interesting websites that cover this topic.



The higher the number, the less likely an engine is to pre-ignite and suffer damage.

**LEARNER ACTIVITY[20 min]**

**CLASSWORK ACTIVITY**

1. Octane is burnt in excess oxygen to form carbon (IV) oxide and water vapour. Energy is released in this combustion reaction and it can be considered as an exothermic reaction.

a. Give the formulae for carbon(IV)oxide and water vapour.
b. Give one important application of the combustion reaction of octane.
c. The balanced chemical reaction for the combustion process, is:

$2C_8H_{18}(\ell) + 25O_2(g) \rightarrow 16CO_2(g) + 18H_2O(g)$
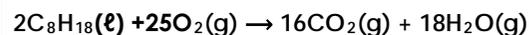
Calculate the mass of carbon dioxide that is formed when 400 g of octane is burned in excess oxygen.

d. 20 dm³ $CO_2(g)$ is formed during combustion of octane in air at STP. Determine the mass of the reactant combusted.
e. Discuss the negative impact of $CO_2(g)$ on the environment.

**ANSWERS TO CLASSWORK ACTIVITY**

1.

a. $CO_2$

b. It is used as a fuel in vehicles.

c. $n = \frac{m}{M} = \frac{400}{114}$ 3,51 mol $C_8H_{18}$

$C_8H_{18} : CO_2 = 1 : 8$

3,51 : 28,08 mol $CO_2$

m = nM

m = (28,08)(44)

m = 1235,52 g $CO_2$(g) is formed.

d. $n = \frac{V}{V_0} = \frac{20}{22,4} = 0,89$ mol $CO_2$ is formed

$C_8H_{18} : CO_2 = 1 : 8$

0,11 : 0,89 (0,11 mol $C_8H_{18}$ is needed to form 0,89 mol $CO_2$(g)

m = nM

m = (0,11)(114)

m = 12,54 g $C_8H_{18}$(ℓ) is needed to form 20 dm³ of $CO_2$(g)

e. It is a greenhouse gas. It traps infra-red rays from the sun and increases the temperature of the Earth.

**2.3 Conclusion [10 min]**

• Educator discusses the answers of the classwork activity

**HOMEWORK ACTIVITY**

Oxford Successful Physical Sciences Grade 11 p 197 Activity 1 Question 3 (Learner book)

**Recourses:** Power point presentations or transparencies; prescribed text books, CAPS-document (page 83).

**Reflection/Notes:**

| | | | |
|---|---|---|---|
| **Name of Teacher:** | | **HOD:** | |
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| GRADE | 11 | SUBJECT | Physical Sciences | WEEK | 19 | TOPIC | Chemical Change: Volume relationships in gaseous reactions | Lesson | 4 |
|-------|----|---------|--------------------|------|----|-------|------------------------------------------------------------|--------|---|

| LESSON SUMMARY FOR: DATE STARTED: | | DATE COMPLETED: | |
|-----------------------------------|--|------------------|--|

| LESSON OBJECTIVES | At the end of the lesson learners should:<br>• Be able to do as application the functioning of airbags.<br>• Be able to use the Sodium azide reaction: $2NaN_3(s) \rightarrow 2Na(s) + 3N_2(g)$   (Reaction must be given  when used in calculations.) |
|-------------------|---|

## TEACHING and LEARNING ACTIVITIES

1.    **TEACHING METHOD/S USED IN THIS LESSON:**
Question and answer, explanation

2.    **LESSON DEVELOPMENT**

2.1.    **Introduction  [10 min]**

• Educator marks homework p 168  Oxford Successful Physical Sciences Grade 11 (Teacher's Guide)
• Educator discusses the reason why modern cars are equipped with airbags in terms of physics principles.

  ✓    During an accident, an airbag increases the time it takes to bring a passenger to a stationary position.
  ✓    From the formula $a = \frac{\Delta v}{\Delta t}$ it follows that if the time is increased, the acceleration of the body is decrease.
  ✓    As a result the force on the body will decrease and will prevent injury.

• In this lesson learners will learn more about the chemistry of airbags and how to do stoichiometric calculations.

**PRE-KNOWLEDGE**
A basic understanding of the following:

• Stoichiometric calculations.
• Exothermic reactions

2.2.    **Main Body   (Lesson presentation)  [20 min]**

• Airbags are an ingenious invention.

• The use of an airbag can protect your head, neck and chest areas.

• Normally, they emerge out of the steering wheel or from the dashboard, within a few milliseconds of the collision. When your head hits the airbag, the airbag starts deflating slowly, allowing you to get out of the car.

• In some cars, when the speed exceeds 200-300 mph, airbags deploy automatically, even in the absence of a collision

• Often airbags may prove inadequate, if you aren't wearing a seat-belt. Due to the increasing number of accidents, governments of many countries have made the use of seat-belts mandatory, which is said to have effectively reduced the number of injuries due to vehicle accidents. However, the latest designs in airbags can protect the person, even if he's not wearing a seat-belt.

- How does an airbag work?

  ✓ When the crash sensor in the car detects a collision, it sends a signal to the control module which deploys the airbag.

  ✓ An airbag installed in the dashboard or in the steering wheel will only be deployed, if there is a front-end collision, such as in the case of a head-on collision or within 30 degrees from any side from the core of the car.

  ✓ The same rule applies to airbags installed at the sides of the car. The airbag is deployed when the car is hit at a certain angle. The ones on the left won't deploy, if the collision is on the right side and vice versa.

  ✓ The control module or the airbag brain is a small computer that receives data of the crash from different sensors, and then decides which airbag is to be deployed. It is unable to deploy an airbag, if it receives only one pulse. It would need two or more pulses from the sensors to do so.

  ✓ The second pulse comes from the arming sensor that is located inside the car, which senses a sudden decrease in speed.

  ✓ When the control module is certain about a severe crash, it signals the squib inflators, also known as the igniter, which is an electrical device that has a thin bridge wire.

  ✓ As the current flows through the wire, it overheats, and ignites the airbag propellant which is made of sodium azide.

  ✓ Sodium azide is a fast-burning fuel that produces large amounts of nitrogen gas, which goes through filters and fills the nylon airbags.

  ✓ After your head hits the nitrogen-filled bag, the bag deflates by releasing the gas through tiny holes. The cloud of smoke that fills the vehicle is actually talcum powder or corn-starch. The powder prevents the bag from sticking to itself, while it's folded inside.

  ✓ The nitrogen gas that is released from the tiny holes is absolutely harmless (nitrogen actually constitutes 78% of the air that we inhale).

  ✓ One just needs to open the doors or windows for the gas and powder to escape.

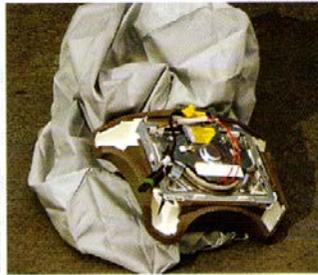These interesting facts are taken from an article by Stephen Rampur.
Read more at Buzzle: http://www.buzzle.com/articles/how-do-airbags-work.html
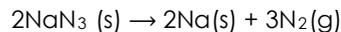


The green solid (propellant) detonates and

Driver-side airbags inflate with 35-70 $\ell$ of $N_2(g)$. Passenger air

The bag deflates within 0,2 s. The gas escapes through the holes in the

✓      As mentioned above, in many types of airbags, the explosion of sodium azide generates nitrogen gas.

$2NaN_3\ (s) \rightarrow 2Na(s) + 3N_2(g)$

✓      The final volume of the bag will depend on the amount of nitrogen gas generated.

✓      The relationship between volume and the amount of gas was first noted by Amadeo Avogadro in 1811.

**LEARNER ACTIVITY[20 min]**

**CLASSWORK ACTIVITY**

1. Most modern cars are equipped with airbags. The following reaction allows a gas to be produced to fill the airbag.

**$2NaN_3(s) \rightarrow 2Na(s) + 3N_2(g)$**

a. Calculate the mass of $N_2$ needed to inflate a sample airbag to a volume of 65 dm³ at 25 °C and 99,3 kPa. Assume that the temperature remains constant.

b. Explain why nitrogen can/cannot be referred to as an ideal gas.

c. Criticise the following statement: "Nitrogen gas can be considered as a greenhouse gas and will impact negatively on the environment."

**ANSWERS TO CLASSWORK ACTIVITY**

1.

a.  $pV = nRT$

$n = \dfrac{pV}{RT} = \dfrac{(99,3\times10^3)\ (65\times10^{-3})}{(8,31)(298)} = 2,61$ mol $N_2(g)$ is needed.

$m = nM$

$m = (2,61)(28)$

$m = 73,08$ g $N_2(g)$ is needed

b.  Nitrogen deviates from ideal gas behaviour.

• Nitrogen molecules are big and occupy volume – it is assumed that ideal gas molecules do not have volume.

• There is London forces between the molecules that are effective when the pressure is high and the temperature is low – it is assumed that there are no forces between ideal gas particles.

c.  The statement is false – $N_2$ molecules are non-polar and contain non-polar covalent bonds. These bonds do not vibrate at the same frequency as infra-red rays and cannot trap these rays.

**2.3  Conclusion [10 min]**

• Educator discusses the answers of the classwork activity

**HOMEWORK ACTIVITY**

Oxford Successful Physical Sciences p 197 Activity 1 Question 3  (Learner book)

**Recourses:** Power point presentations or transparencies; prescribed text books, CAPS-document (page 83).

**Reflection/Notes:**

| Name of Teacher: | | HOD: | |
|---|---|---|---|
| Sign: | | Sign: | |
| Date: | | Date: | |