A-Level Physics
Question and Answers 2020/2021

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* = topics that contain interactive resources, multiple choice questions or audio files. To interact with this content, please go to www.s-cool.co.uk/biology.

Topics that only contain interactive questions

These topics only contain interactive questions such as animations, multiple choice or audio files. To interact with this content, please go to www.s-cool.co.uk/Physics.

- Alternating Currents
- Atomic Structure
- Magnetic Fields

A Comparison of Electric and Gravitational Fields (Questions) *

1. The graphs in Fig. 1.1 show the variation with seperation r of (i) the electrostatic force F_E and (ii) the gravitational force F_G between two points.

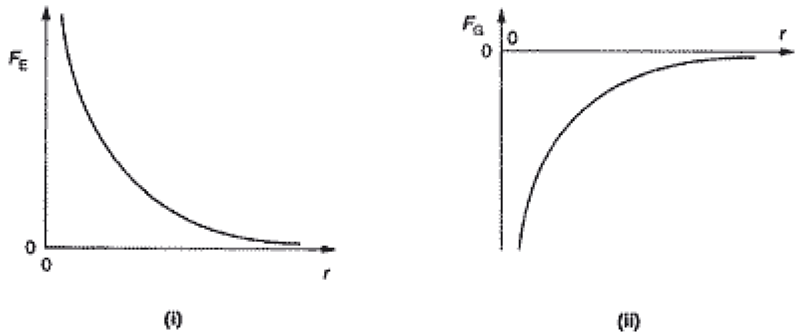


Fig. 1.1

a) State the relation between

i) F_E and r

ii) F_G and r.

(2 Marks)

b) Why is F_E positive, whereas F_G is negative?

(1 Mark)

c) The range of values or r represented by each graph is the same. State with a reason whether the F_E and $F_G$scales cover the same range of values.

(2 Marks)

(Marks available: 5)

2. A hydrogen atom appears to behave like a proton orbited by an electron with an orbit radius of 0.50 x 10^{-10} m.

Given that - ekectronic charge = 1.6 x 10^{-19} C.

electron mass = 9.1 x 10^{-31} kg

proton mass = 1.7 x 10^{-27} kg

$$\text{Electric field constant} = \frac{1}{4\pi\varepsilon_o} = 9.0 \times 10^{9}\ Nm^{2}\ C^{-2}$$

and Gravitational Field Constant = G = 6.7×10^{-11} N m^2 kg^{-2}

Calculate:

a) the electric fild at a distance of 0.5×10^{-10} m from a proton.

(2 Marks)

b) the electrical force on an electron at that distance from a proton.

(2 Marks)

c) the Gravitational Field at a distance of 0.5×10^{-10} m from a proton.

(2 Marks)

d) the gravitational force on an electron at that distance from a proton.

(2 Marks)

e) the ratio of the electrical force to the gravitational force on an electron.

(1 Mark)

(Marks available: 9)

A Comparison of Electric and Gravitational Fields (Answers)

Answer outline and marking scheme for question:

1. **a) i)** F_E proportional to $1/r^2$ or $F_E = Q^2/(4ðå\ _0r^2)$ or in words

   ii) F_G proportional to (-) $1/r^2$ or F_G = (-) m^2G/r^2) or in words

   (2 Marks)

   b) Eletrostatic forces (between protons) always repulsive gravitational forces always attractive

   (1 Mark)

   c) (at equal seperations) magnitude of F_E >> magnitude of F_G so F_E scale has bigger range of values than F_G

   (2 Marks)

   (Marks available: 5)

2. **a)**

$$\text{Electric field} = \frac{1}{4\pi\varepsilon_o} \cdot \frac{Q}{r^2} \text{ (1 Mark) } = \frac{9.0 \times 10^9 \times 1.6 \times 10^{-19}}{(0.5 \times 10^{-10})^2}$$

3. = 5.76×10^{11} NC^{-1}(1 Mark)
4. **(2 Marks)**
5. **b)** Electric Force = eE = $1.6 \times 10^{-19} \times 5.76 \times 10^{11}$ (1 Mark)
6. = 9.22×10^{-8} N (1 Mark)
7. **(2 Marks)**
8. **c)**

$$\text{Gravitational field} = \frac{GM}{r^2} = \frac{6.7 \times 10^{-11} \times 1.7 \times 10^{-27}}{(0.5 \times 10^{-10})^2}$$

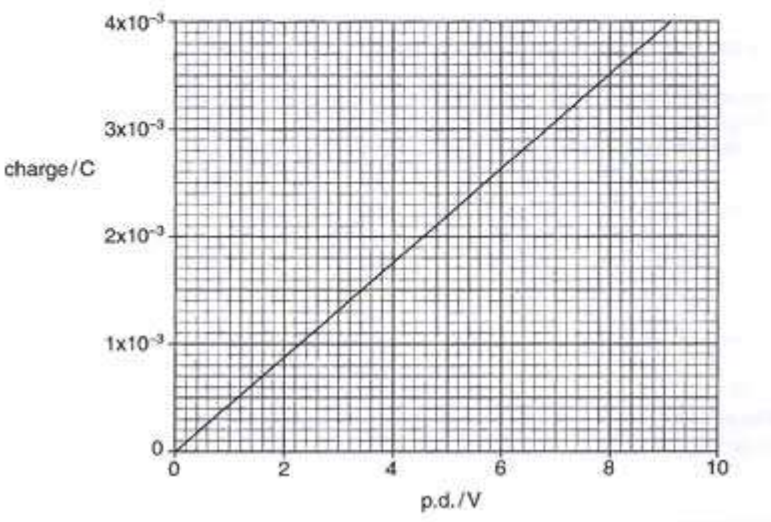
9. = 4.56×10^{-17} N kg^{-1} (1 Mark)
10. **(2 Marks)**
11. **d)** Gravitational force = mass x gravitational field = $9.1 \times 10^{-27} \times 4.56 \times 10^{-17}$ (1 Mark)
12. = 4.15×10^{-47} N (1 Mark)
13. **(2 Marks)**
14. **e)**

$$\frac{\text{Electrical force}}{\text{Gravitational force}} = \frac{9.22 \times 10^{-8}}{4.5 \times 10^{-47}} = 2.2 \times 10^{39} \text{ (1 Mark)}$$

15. **(1 Mark)**
16. **(Marks available: 9)**
17. **(Maximum = 14 Marks)**

Capacitors (Questions) *

1. The graph shows how the chanreg of a capacitor varies with the p.d. across the capacitor.



Use the graph to find

a) the energy stored by the capacitor when charged to a potential difference of 8 V

energy stored = ... J

(2 Marks)

b) the capacitance of the capacitor

capacitance = ... F

(2 Marks)

(Marks available: 4)

2. Fig. 7.1 shows a circuit diagram of a capacitor discharging through a resistor.

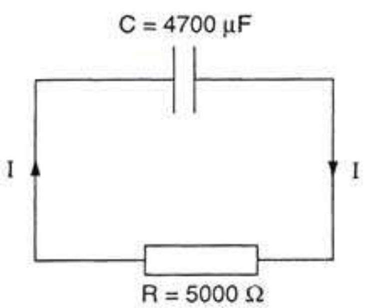


Fig. 7.1

A simple mathematical model of the discharge of the capacitor is shown in Fig. 7.2. It is assumed that the current / is constant over each small time interval, Δt, The process is repeated as shown.

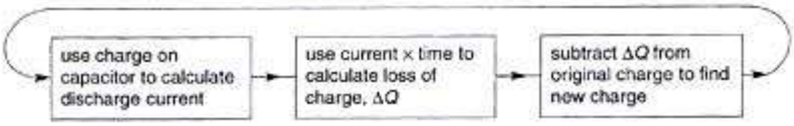


Fig. 7.2

Complete the table for the discharge of the 4700μF capacitor. The small time interval used is Δt = 2.0 s.

Q	$I = \frac{V}{R} = \frac{Q}{RC}$	$\Delta Q = I\Delta t$	$Q_{new} = Q - \Delta Q$
5.64×10^{-2}C			5.16×10^{-2}C
5.16×10^{-2}C			

(3 Marks)

(Marks available: 3)

3. In the circuit in Fig. 6.1, the capacitor is charged to a potential difference of 6.0 V.

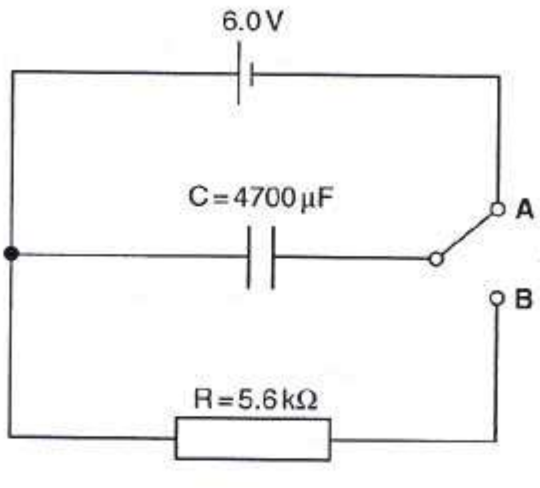


Fig. 6.1

When the switch is moved from A to B , the capacitor discharges through the resistor.

a) Show that the initial value of the discharge current is about 1 mA.

(2 Marks)

b) The time constant RC of the discharge circuit is about 26 s.

Calculate the current in the discharge circuit after the switch has been closed for a time equal to RC.

current = ... mA

(2 Marks)

(Marks available: 4)

Capacitors (Answers)

Answer outline and marking scheme for question:

a. **a)** Sum of the currents = zero (at junction)OR

sum of the currents in = sum of currents out (at junction)

b) Area under graoh (equiv to ½ QV) = ½ x 3.5 x 10^{-3} x 8 (1 Mark)

= 0.014 J (1 Mark)

(2 Marks)

c) Grad = 3 x 10^{-3} / 6.8 (for example) (1 Mark) = 4.4 x 10^{-4} F (1 Mark)

(2 Marks)

(Marks available: 4)

b. First line of table : 2.4 x 10^{-3}, 4.8 x 10^{-3} (1 Mark)

Second line of table : 2.2 x 10^{-3}, 4.4 x 10^{-3} (1 Mark)

4.7 x 10^{-2}

(3 Marks)

(Marks available: 3)

c. **a)** I = V/R = 6/ 5.6 x 10^{3} (1 Mark) = 1.1 x 10^{-3} A = (about) 1 mA (1 Mark)

(2 Marks)

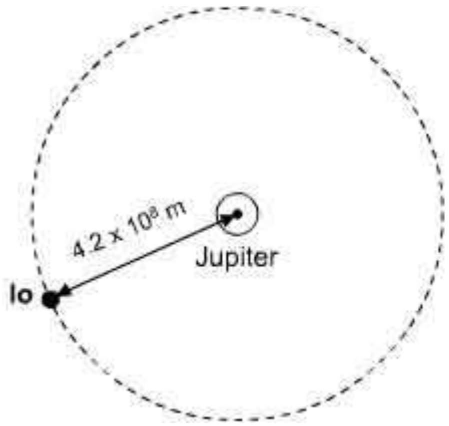
b) I = 1.1 x 10^{-3} x e^{-1} = 1.1 x 10^{-3} x 0.37 (1 Mark) = 0.4 mA (1 Mark) (accept rule of thumb third, answers using 1 mA and answers using decay equation)

(2 Marks)

(Marks available: 4)

Circular Motion (Questions)

1. This question is about the planet Jupiter and one of the moons that orbits it, called Io.



Io orbits Jupiter at a speed, v of 1.7×10^4 m s^{-1} at an orbital radius, *r*, of 4.2×10^8m.

a) Show that Io takes approximately 43 hours to orbit Jupiter once.

(2 Marks)

b) Io is held in its orbit by a centripetal force, $F = -\frac{mv^2}{r}$, where *m* is the mass of Io. This force is the gravitational attraction between Io and Jupiter.

i) Show that $M = \frac{v^2 r}{G}$ where M is the mass of Jupiter.

ii) Show that the mass of Jupiter is about 2.0×10^{27} kg.

(4 Marks)

c) Show that the gravitational potential at the top of Jupiter's atmosphere, 7.1×10^7 m from the centre of the planet, is about -2×10^9 Jkg^{-1}.

Assume that Jupiter is a sphere.

(2 Marks)

d) In July 1994, comet Shoemaker-Levy 9 crashed into Jupiter causing dramatic heating of the planet's atmosphere. During the approach to the planet, the comet broke up. One piece that struck the planet had a mass of about 4×10^{12}kg.

This fragment crossed the orbit of Io heading directly towards Jupiter with a velocity of 10 km s^{-1}.

i) Show that kinetic energy of the fragment at that moment is 2×10^{20} J.

(1 Mark)

ii) Explain why the fragment will enter the atmosphere of Jupiter with a velocity greater than 10km s^{-1}.

(2 Marks)

(Marks available: 11)

2. **a)** A cyclist goes round a circular track, of radius 10 m, at a constant speed of 8.0 m s^{-1}.

What is the acceleration of the cyclist and what is its direction?

(3 Marks)

b) What is the resultant force on the cycle and the rider if together they have a mass of 90 kg?

(2 Marks)

(Marks available: 5)

Circular Motion (Answers)

Answer outline and marking scheme for question:

1. **a)** Time = 2ð r/1.7 x 10^4

= 155230s

= 43.1 hours

(2 Marks)

b) i) -GMm/r^2

= -mv^2/r

So: Gm/r^2 = v^2/r

Therefore M = v^2r/G

ii) M = (1.7 x 10^4)^2 x 4.2 x 10^8/ 6.67 x 10^{-11}

= 1.82 x 10^{27} kg

(4 Marks)

c) Vg = -GM/r = -6.67 x 10^{-11} x 1.9 x 10^{27}/7.1 x 10^7

= - 1.79 x 10^9 K kg^{-1}

(2 Marks)

d) i) ½ mv^2 = ½ x 4 x 10^{12} x 10000^2 = 2 x 10^{20} J

(1 Mark)

ii) The fragment will have gained kinetic energy (1 Mark) as it lost gravitational potential energy during the approach to the planet (1 Mark).

(Or force argument: Attracted by gravity (1 Mark) causes it to accelerate (1 Mark)

(2 Marks)

(Marks available: 11)

2. **a)**

$$a = \frac{v^2}{r} = \frac{8^2}{10} = 6.4 \text{ m s}^{-2}$$

Direction: towards the centre of the track.

(3 Marks)

b) F = ma (1 Mark) = 90 x 6.4 = 576 N (1 Mark)

(2 Marks)

(Marks available: 5)

Current, Charge and Voltage (Questions)

1. Fig. 1.1 shows an electrical circuit.

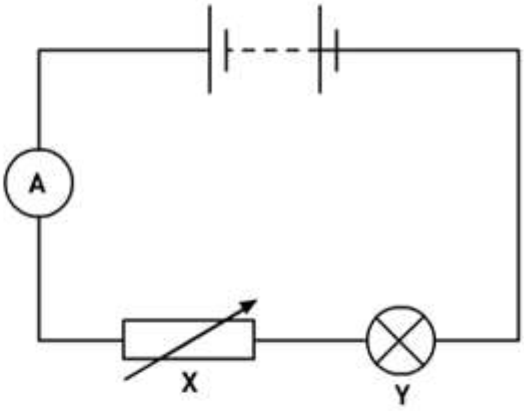


Fig. 1.1

a) Name the component marked X.

(1 Mark)

b) Suggest one reason why component X may be useful in the electrical circuit.

(1 Mark)

c) On Fig. 1.1 indicate the direction of flow of electrons.

(1 Mark)

d) State the energy changes taking place in the component Y.

(1 Mark)

(Marks available: 4)

2. The current I through a wire id given by the expression I = nAve.

a) Explain the meaning of n.

(1 Mark)

b) Calculate the value of n for a semiconductor in which I = 3.6 mA, v = 80 m s^{-1} and A = 8.2 x 10^{-6} m^2.

n = ... m^{-3}

(2 Marks)

c) The value of n for copper is about 109 times greater than that for the semiconductor. Briefly explain why in terms of band theory.

(2 Marks)

(Marks available: 5)

3. Fig. 4.1 shows an electrical circuit.

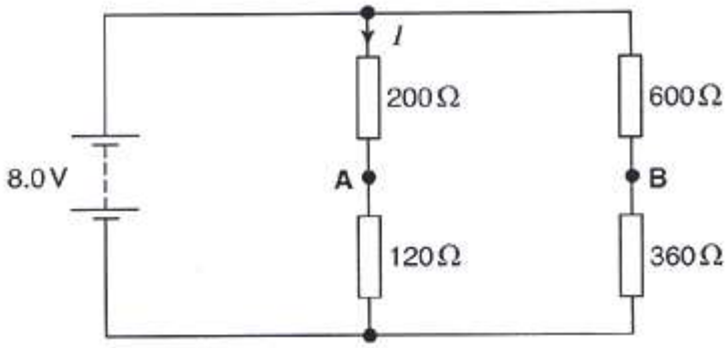


Fig. 4.1

The battery has negligible internal resistance.

a) Show that the current I is 25 mA.

(2 Marks)

b) Calculate the potential difference (p.d.) across the resistor of resistance 120Ω.

p.d. = ... V

(1 Mark)

c) Explain why a voltmeter connected between points A and B will read 0 V.

(2 Marks)

(Marks available: 5)

(Marks available: 14)

Current, Charge and Voltage (Answers)

Answer outline and marking scheme for question:

1. **a)** Variable resistor / rheostat

   (1 Mark)

   b) To change (allow 'control') current/ ammter reading / resistance (of the circuit) / brightness (of lamp) / p.d. (across) lamp / X

   (1 Mark)

   c) Clockwise

   (1 Mark)

   d) Electrical to heat / light

   (1 Mark)

   (Marks available: 4)

2. **a)** n is the number of free electrons / charge carriers per unit volume / m^3

   (1 Mark)

   b) n = I/Ave

   $= 0.0036/(8.2 \times 10^{-6} \times 80 \times 1.6 \times 10^{-19}) = 3.4 \times 10^{19}\ m^{-3}$

   (2 Marks)

   c) In a metal the conduction band (of energy levels) is oermanently occupied by electrons, so many are available for conduction; In a semiconductor electrons must be promoted from the valence to the conduction band by thermal energy and few are available at normal temperatures.

   (2 Marks)

   (Marks available: 5)

3. **a)** $R = R_1 + R_2$ / R = 200 + 120 / R = 320

   $$\text{current} = \frac{8.0}{320}$$

   current = 2.5×10^{-2} (A)

(2 Marks)

$$V = \frac{120}{120 + 200} \times 8.0$$

b) v = 25 x 10^{-3} x 120 /

v = 3.0 (V)

(1 Mark)

c) p.d. across the 60 (Ω) resistor = p.d. across the 120 (Ω) resistor / There is no current between A and B / in the voltmeter (Allow 'A & B have same voltage' - BOD)

The p.d.calculated across 360 Ω resistor is shown to be 3.0 V / The ratio of the resistances of the resistors is shown to be the same.

(2 Marks)

(Marks available: 5)

Deformation of Solids (Questions)

1. The images A and B show two different kinds of fracture.

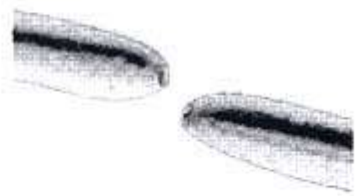


image A


image B

State the two kinds of fracture, for each suggesting a material that fractures in this way.

A shows ....fracture,

a possible materials is ....

B shows .... fracture,

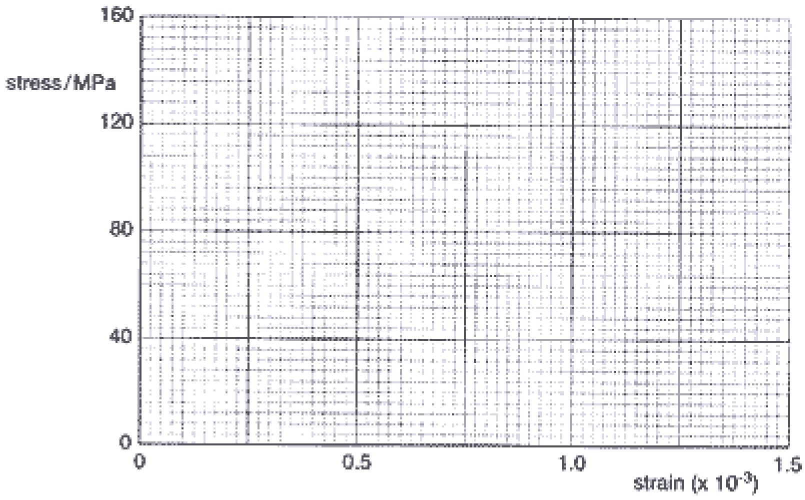
a possible material is ....

(4 Marks)

2. A metal wire is suspended from a fixed point. Increasing weights are added to the lower end of wire. The stress and strain in the wire are as follows.

stress/MPa	0	20	40	60	80	100	120	140
strain ($\times 10^{-3}$)	0	0.162	0.302	0.488	0.624	0.804	1.04	1.42

a) On the axis below, plot the points and draw the graph of stress against strain.



(2 Marks)

b) Use the graph **(i)** to calculate the Young modulus of the maetrial of the wire.

Young modulus = ... Pa

(3 Marks)

(Marks available: 5)

Deformation of Solids (Answers)

Answer outline and marking scheme for question:

1. **A:** ductile / plastic fracture AW

   e.g. metals / copper / plastics / pvc (all correct)

   B: brittle / clean fracture AWv

   e.g. glass / cermaic / named alloy / (cast) iron (all correct)

   (4 Marks)

2. **a)** All points plotted correctly;

   Correct graph shown: straight section through origin and curve.

   (2 Marks)

   b) Use of point on straight line / gradient of straight line used;

   Correct data from graph;

   Young modulus between 1.2×101^{1} Pa and 1.3×10^{11} Pa

   (3 Marks)

   (Marks available: 5)

Diffraction (Questions)

1. **a)** Explain the meaning of the term diffraction.

(2 Marks)

b) i) Describe how transverse water waves with a plane wavefront may be produced in a ripple tank.

(2 Marks)

ii) State how the wavelength of the waves could be shortened.

(1 Mark)

c) Fig.5.1 shows plane water waves in a ripple tank approaching a narrow gap, the size of which is approximately the same as the wavelength of the waves.

i) On Fig. 5.1, draw the pattern of the wavefronts emerging from the gap.

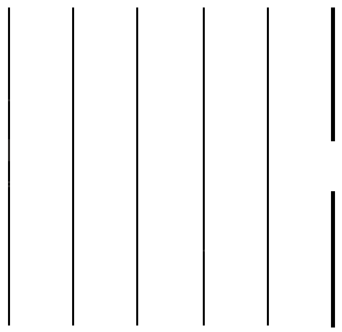


Fig. 5.1

(2 Marks)

ii) Describe how the pattern of wavefronts emerging from the gap would change if the size of the gap were significantly increased.

(2 Marks)

iii) State why, under normal circumstances, light seems to travel in a straight line and does not appear to be diffracted.

(1 Mark)

(Marks available: 10)

2. A single slit is illuminated by a monochromatic (single colour) light source. A screne is placed 5.0 m away from this slit and two very narrow, parallel slits, 0.5 mm apart, are placed half way between the single slit and the screen. Interference fringes are visible on the screen and 10 fringe spaces measure 20 mm on the screen.

   a) What is the wavelength of the light?

   (3 Marks)

   b) What happens if you use double slits with half the spacing between them?

   (1 Mark)

   c) What happens if you cover one of the double slits?

   (2 Marks)

   (Marks available: 6)

Diffraction (Answers)

Answer outline and marking scheme for question:

1. **a)** the spreading out of the wavefront/waves

{do not allow 'the spreading out of light/sound' or 'bending of waves'}

when they pass through a gap (OR pass an obstacle)

(2 Marks)

b) i) a straight strip (OR bar OR ruler)

is vibrated vertically OR up and down (in the water)

(2 Marks)

ii) increase the frequency (of the waves/wave source)

OR use a shallower depth of water

(1 Mark)

c) i) semicircular wavefronts drawn

no change in λ : i.e. approx. same λ before & after gap

(2 Marks)

ii) less diffraction occurs

wavefronts only slightly curved at edges (OR shown in a diagram)

{full marks may be scored from a valid diagram}

(2 Marks)

iii) Wavelength of light much smaller than most gaps

(1 Mark)

(Marks available: 10)

2. **a)**

$$\lambda = \frac{ax}{D}$$ (1 Mark)

where,

λ = wavelength

a = double slit spacing = 0.5 m m

x = fringe spacing = $^{20}/_{10}$ = 2.0 mm

D = double slit to screen distance = 2.5 m

$$\text{So, } \lambda = \frac{0.5 \times 10^{-3} \times 2.0 \times 10^{-3}}{2.5} = 4.0 \times 10^{-7} \text{ m}$$ (1 Mark)

(1 Mark)

(3 Marks)

b) If a is halved and D and λ remain the same, the fringe spacing (x) must be doubled.

(1 Mark)

c) The fringes disappear (1 Mark) and you can see a single slit pattern. This is a bright central line with parallel, fainter lines visible on each side.

(2 Marks)

(Marks available: 6)

Electric Fields and Forces (Questions)

1. Fig. 4.1 shows two large parallel insulated capacitor plates, seperated by an air gap of 4.0×10^{-3} m. The capacitance of the arrangement is 200 pF. The plates are connected by a switch to a 2000 V d.d. power supply. The switch is closed and then opened.

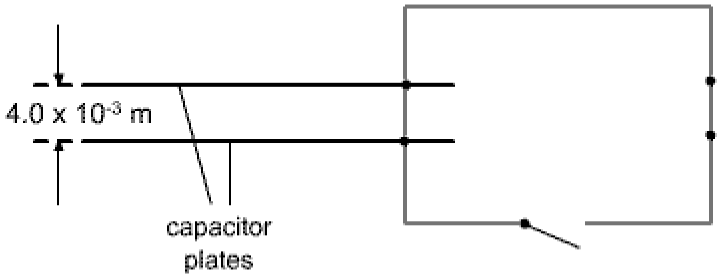


Fig.4.1

Calculate

a) the magnitude of the electric field strength between the plates givinga suitable unit ofr your answer.

electric field strength = ... unit ......

(2 Marks)

b) the magnitude in μC of the charge on each plate

charge = ... μC

(3 Marks)

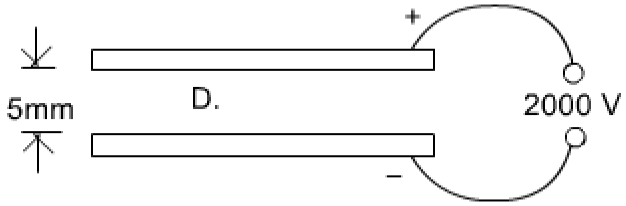
c) the energy stored in μJ stored in the capacitor.

energy = ... μJ

(3 Marks)

(Marks available: 8)#

2. The diagram shows a pair of flat, wide metal plates. They are parallel and connected to a constant 2000 V supply.



a) What is the electric field (E) between the plates?

(2 Marks)

b) A drop of oil (D), between the plates carries a change of 10 electrons (each 1.6×10^{-19} C).

What is the force on the drop?

(2 Marks)

c) If the drop moves a distance of 2.5 mm towards the positive plate, how much electrical energy is transferred?

(2 Marks)

(Marks available: 6)

Electric Fields and Forces (Answers)

Answer outline and marking scheme for question:

1. **a)** $E = v/d = 2000/4 \times 10^{-3} = 5 \times 10^5$; $N\ C^{-1}/\ V\ m^{-1}$

(2 Marks)

b) $Q = CV$; $= 200 \times 10^{-12} \times 2000l = 4 \times 10^{-7} = 0.40$ (μC)

taking p as 1^{0-9} -1 mark / corect conversion of any answer to μC gets final mark

(3 Marks)

c) $W = ½ CV^2$ ecf possible $= ½ QV$;

$= 0.5 \times 200 \times 10^{-12} \times 4 \times 10^6$; $= 400$ (μJ)

(3 Marks)

(Marks available: 8)

2. **a)**

$$E = \frac{V}{d} = \frac{2000}{5 \times 10^{-3}}$$ (1 Mark) = 400 kV m^{-1} (or kJC^{-1}) (1 Mark)

(2 Marks)

b) $F = qE$ (1 Mark) $= 10 \times 1.6 \times 10^{-19} \times 400 \times 10^3$

$F = 6.4 \times 10^{-13}$ N (1 Mark)

(2 Marks)

c) $W = Fd$ (1 Mark) $= 6.4 \times 10^{-13} \times 2.5 \times 10^{-3}$

$W = 1.6 \times 10^{-15}$J(1 Mark)

(2 Marks)

(Marks available: 6)

Electric Potential (Questions) *

1. Fig. 5.1 shows electric equipotential lines between a charged sphere and an earthed plate.

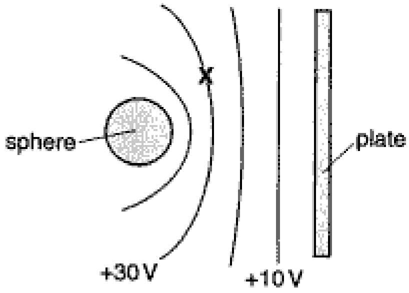


Fig. 5.1

a) On Fig. 5.1, draw an arroe to show the direction of the electric filed at the point labelled X.

(2 Marks)

b) Here is a list of potentials

+50 V

0 V

-10 V

-50 V

The potential of the sphere is +50 V.

State the best value for the potential of the plate.

(1 Mark)

(Marks available: 3)

2. This question is about the ground state energy of a hydrogen atom.

A hydrogen atom in its ground state has an energy of -2.2×10^{-18} J. The most probable seperation between electron and proton is 5.3×10^{-11} m in this state.

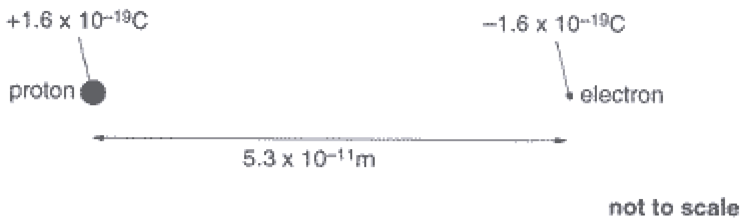


Fig. 12.1

a) The electron has electrical potential energy.

Show that the electrical potential is about +27 V at a distance of 5.3×10^{-11} m from the proton.

$e = 1.6 \times 10^{-19}$ C, $k = 1/4\pi\varepsilon_0 = 9.0 \times 10^9$ N m^2 C^{-2}

(2 Marks)

b) Show that the potential energy of the electron is about -4.3×10^{-18}J at this distance from the proton.

(2 Marks)

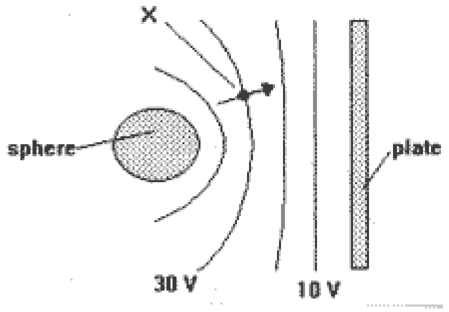
(Marks available: 4)

Electric Potential (Answers)

Answer outline and marking scheme for question:

1. **a)** at right angles to euipotential through the point (by eye) pointing away from sphere

   ACCEPT curved field lines which have the correct direction at X



(2 Marks)

b) 0 V

(1 Mark)

(Marks available: 3)

2. **a)** V = kQ/r

   $V = 9.0 \times 10^{9} \times 1.6 \times 10^{-19} / 5.3 \times 10^{-11} = 27.2$ V

(2 Marks)

b) Ep = QV

$Ep = -1.6 \times 10^{-19} \times 27.2 = -4.35 \times 10^{-18}$ J

(2 Marks)

(Marks available: 4)

Electromagnetic Induction (Questions) *

1. The magnetic flux linkage of a coil wire increases steadily by 90 mWb in a time of 450 μs.

   a) Show that the rate of change of magnetic flux linkage is 200 Wb s^{-1}.

   (2 Marks)

   b) State the emf induced across the coil by the rate of change og magnetic flux linkage.

   emf = ... V

   (1 Mark)

   (Marks available: 3)

2. The wing span of an Airbus A300 is 44.8 m.

   a) What area is swept out per second when the plane is in level flight at 250 m s^{-1}?

   (2 Marks)

   b) If the vertical component of the Earth's magnetic field is 50 μT, what potential difference is induced between the tips of the Airbus wings?

   (2 Marks)

   (Marks available: 4)

Electromagnetic Induction (Answers)

Answer outline and marking scheme for question:

1. **a)** 90 mWb = 90 x 10^{-3} Wb, 450 μs = 450 x 10^{-6} s

   90 x 10^{-3}/450 x 10^{-6} (= 200 Wb s^{-1})

   (2 Marks)

   b) 200 V

   (1 Mark)

   (Marks available: 3)

2. **a)** Area per second = wing span x speed (1 Mark)

   = 44.8 x 250

   = 1.12 x 10^4 m^2 s^{-1} (1 Mark)

   (2 Marks)

   b) Magnetic flux = B x A

   = 50 x 10^{-6} x 1.12 x 104 wb (1 Mark)

   emf = $\frac{d\Phi}{dt}$ = 0.56 volts (1 Mark)

   (2 Marks)

   (Marks available: 4)

Electromagnetic Waves (Questions)

1. Jon measures the focal length f of a convex lens. He repeats the measurement several times. The mean value of the measurement is 0.125 m. The range over which the measurements vary due to experimental uncertainty is ± 0.005 m.

   Jon correctly records the final result with the equation

   f = 0.125 ± 0.005 m.

   a) The minimum value for f indicated by this equation is 0.120 m.

   Write down the maximum value for f indicated by this equation.

   maximum value for f = ... m

   (1 Mark)

   b) Jon calculates the power P of the lens using the relationship

   $$P = \frac{1}{f}$$

   For the mean vvalue f = 0.125 m P = 8.00 D.

   Calculate the maximum value of the power corresponding to the minimum value of the focal length 0.120 m. Consider sensible significant figures.

   maximum power = ... D

   (1 Mark)

   c) Complete the equation below to indicate the range of values within which the power can be expected to lie.

   P = 8.0 ± .... D

   (1 Mark)

   (Marks available: 3)

2.

Name	Wavelength
γ -rays	< 10^{-10} m
x -rays	< 10^{-9} m
ultra-violet	7 x 10^{-7} to 10^{-9} m
Visible Light	4 x 10^{-7} - 7 x 10^{-7} m
Infra-red	7 x 10^{-7} - 10^{-3} m
Microwave	10^{-3} - 10^{-1} m
Radiowaves	> 10^{-1} m

a) γ -rays and x -rays can have similar wavelength. How are they different?

(2 Marks)

b) Ultra-violet is much more likely to cause the release of photo-electrons from a metal than visible light. Explain why this is so.

(2 Marks)

c) Visble light is diffracted when it passes through a slit less than a millimetre wide. Microwaves can be diffracted by a slit a few centimetres wide. Why?

(2 Marks)

d) Electromangetic waves may be plane-polarised. What does this prove about the waves?

(1 Mark)

(Marks available: 7)

Electromagnetic Waves (Answers)

Answer outline and marking scheme for question:

1. **a)** 0.13 (0) m

   (1 Mark)

   b) 8.33 / 8.3

   (1 Mark)

   c) ± 0.3 / 0.4 D ecf on (b)

   (1 Mark)

   (Marks available: 3)

2. **a)** γ -rays are emitted by the **nuclei** of some radioactive atoms as they lose energy (1 Mark). X-rays are emitted by**electrons** as they slow down and lose kinetic energy.(1 Mark)

   (2 Marks)

   b) Ultra Violet has a **shorter wavelength** and **higher frequency** than visible light. (1 Mark)

   Because the energy carried by a photon E = hf, the **u-v photon carries more energy** and so can release electrons from a metal more easily. (1 Mark)

   (2 Marks)

   c) Microwaves havve much larger wavelength (1 Mark) than visible light so are diffracted by longer objects. (1 Mark)

   (2 Marks)

   d) To be polarised, a wavemust be a transverse wave. So Electromagnetic waves are transverse waves.

   (1 Mark)

   (Marks available: 7)

Equations of Motion (Questions)

1. Fig. 1.1 shows a long rope that is tied at one end to a high support. A woman swings forwards and backwards across a pool using the other end of the rope.

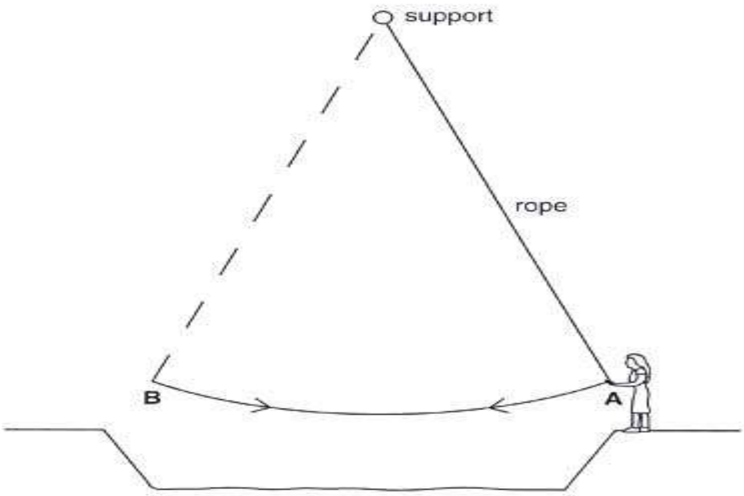


Fig. 1.1

Fig. 1.2 shows the variation with time *t* of the displacement *x*, of the woman from **A** to **B** and back to **A**.

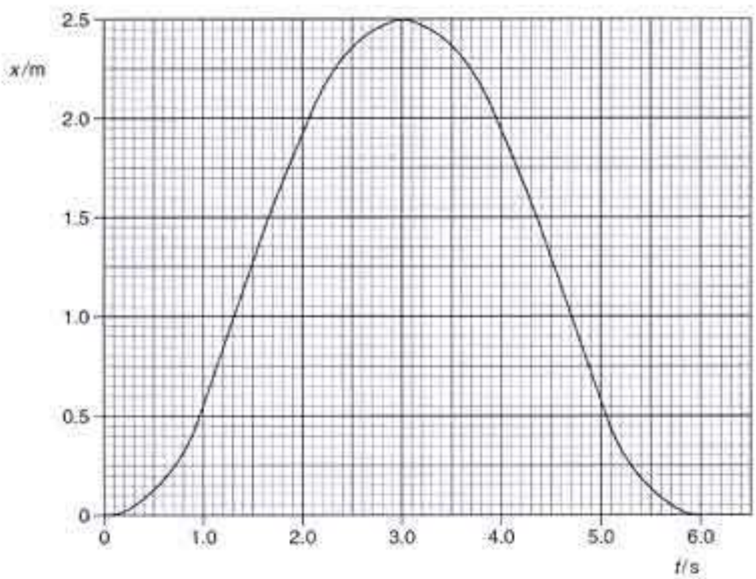


Fig. 1.2

a) State what the gradient of the graph represents and explain why the graph shows both negative and positive gradients.

(2 Marks)

b) Mark on Fig. 1.2 with a corss

- a position where the speed of the woman is zero (label this cross Z)
- a position where the speed of the woman is a maximum (label this cross M)

(2 Marks)

c) Use Fig. 1.2 to calculate the maximum positive spee of the woman. Show on the Fig. 1.2 how you determined your answer.

Maximum speed = ... m s^{1}-

(3 Marks)

(Marks available: 7)

2. Fig. 3.1 shows the path of a golf ball from the time it ends contact with a golf club, point C, until it hits the ground at G. Assume that there is no air resistance.

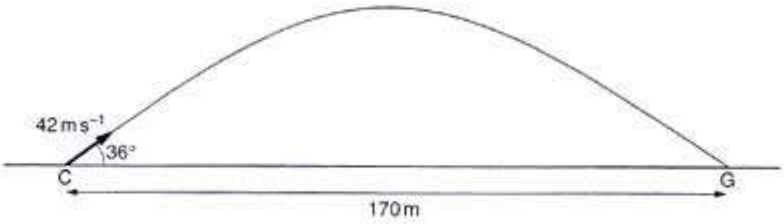


Fig. 3.1

The ball leaves the club with a velcotiy 42 m s^{-1} at an angle of 36° to the horizontal.

a) Show that the horizontal component of the velocity is 34 m s^{-1}

(1 Mark)

b) The distance C to G is 170m. Sow that the time taken for the ball to travel from C to G is 5.0s.

(1 Mark)

c) Calculate

i) the initial vertical component of the velocity

vertical velocity component = ... m s^{-1}

(2 Marks)

ii) the maximum height reached.

maximum height = ... m

(3 Marks)

d) The ball has a mass of 50g. Calculate the kinetic energy of the ball at maximum height.

kinetic energy = ... J

(3 Marks)

e) ON Fig. 3.1 sketch the path of the golf ball if air resistance is assumed not to be negligible.

(2 Marks)

f) Explain the shape of your sketch

(1 Mark)

(Marks available: 13)

3. An aircraft of total mass 1.5×10^5 kg accelerates, at maximum thrust from the engines, from rest along a runwau for 25s before reaching the required speed to take-off of 65m s^{-1}.

Assume that the acceleration of the aircraft is constant.

Calculate

a) the acceleration of the aircraft

acceleration = ... m s^{-2}

(3 Marks)

b) the force acting on the aircraft to produce this acceleration

force = ... N

(2 Marks)

c) the distance travelled by the aircraft in this time.

distance = ... m

(2 Marks)

(Marks available: 7)

Equations of Motion (Answers)

Answer outline and marking scheme for question:

1. **a)** velocity

travels in two oposite directions or equivalent words / increasing and decreasing displacement

(2 Marks)

b) Z any peak or trough / A / B / 0 / 3.0 / 6.0s

M any point where gradient is a maximum (1.0 - 1.6 or 4.4 - 5.0 s)

If M and Z are given on Fig. 1.1 then max 1

(2 Marks)

c) tangent to curve drawn

values given correct from graph

answers correct for maximum in range of 1.3 to 1.5

(3 Marks)

(Marks available: 7)

2. **a)** V_x = 42 cos36

= 34 (m s^{-1})

(1 Mark)

b) time = 170 / 34

= 5 (s)

(1 Mark)

c) i) V_y = V sin36 / cos54

= 24.7 (25 allowed)

(2 Marks)

ii) $v^2 = u^2 + 2as$ / $s = ut + ½ at^2$ / $S = [(u + v)/2]t$

$0 = (24.7)^2 - 2 \times 9.81 \times s$ ecf from c) (i)

s = 3.(1) (m) allow 31 to 32 as answer depends on sig figs and equation used.

(3 Marks)

d) k.e = ½ m v^2

$= 0.5 \times 50 \times 10^{-3} \times (34)^2$

= 28.9 (J)

(3 Marks)

e) i) height less

range less

(2 Marks)

ii) force acting against the motion and this effect on the acceleration / ball does not work against air resistance / k.e. reduced due to air resistance / velocity is reduced by air resistance

(1 Mark)

(Marks available: 13)

3. **a)** acceleration = (v-u) / t

= (65 - 0) / 25

= 2.6 (m s^{-2})

(3 Marks)

b) force = ma

= 150000 x 2.6

= 390000 (N) / 3.9×10^5

(2 Marks)

c) distance = (u+v) t / 2

= (0 + 65) x 25 / 2

= 813 (m) (allow 810)

(2 Marks)

(Marks available: 7)

Forces (Questions) *

1. This question is about driving poles into the ground.

Fig. 8.1 shows a 220 kg mass held in position 5.0 m above the top of a rigid, cylindrical pole. The lower end of the vertical pole is resting on the ground.

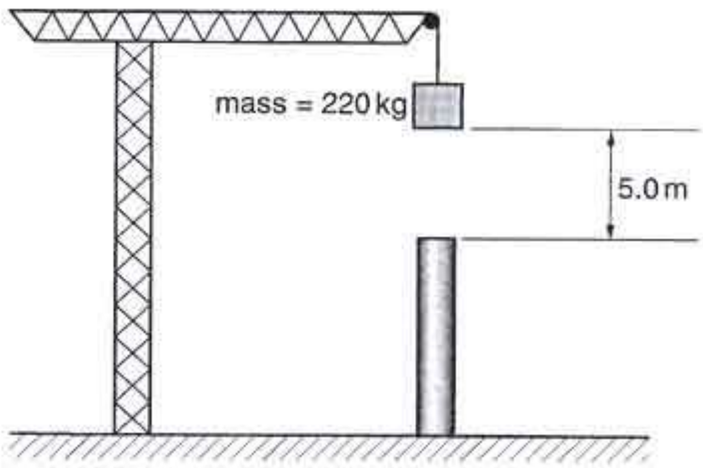


Fig. 8.1

When released, the mass drops freely from the rest under gravity and strikes the top of the pole.

a) Describe the energy taking place from the moment the mass falls until it strikes the top of the pole.

(2 Marks)

b) Show that the speed of the mass is about 10 m s^{-1} when it strikes the top of the pole.

g = 9.8 N kg^{-1}

(2 Marks)

c) In bringing the moving mass to reat on top of the vertical pole, the pole is pushed down into the ground. The depth of penetration of the pole into the ground is 0.4m.

Show that the average force exerted by the pole on the mass is about 27 kN.

(2 Marks)

(Marks available: 6)

2. A boat of mass m = 2000 kg is moving with velocity u = 6.0 m s^{-1} towards a dock. The boat is stopped by a constant braking force F = 300 N.

   Complete the following table in order to calculate the time, *t*, and the distance, *d*, the boat takes to stop.

Starting from force = mass x acceleration and the appropriate equation of motion show that Ft = mu.	Starting from force = mass x acceleration and the appropriate equation of motion show that Fd = ½mu^2
Calculate the boat's initial momentum. momentum = ... N s	Calculate the boat's initial kinetic energy kinetic energy = ... N s
Calculate the time the boat takes to stop time = ... s	Calculate the distance the boat takes to stop. distance = ... m

(8 Marks)

Forces (Answers)

Answer outline and marking scheme for question:

1. **a)** gravitational potential energy to kinetic energy (and internal energy in air)

(2 Marks)

b) v = √(2 x 9.8 x 5) (1 Mark) = 9.9 m s^{-1} (1 Mark) (explicit)

(2 Marks)

c) ½ mv^2 ≈ F x 0.4 (1 Mark) F ≈ x 27 500 N (1 Mark)

or

a ≈ $(10)^2$/(2 x 0.4) = 125 m s^{-2} F ≈220a = 27 500 N

or

mgh = F x 0.4 F = 26 950 N

(2 Marks)

(Marks available: 6)

2.

F = ma	$v^2 = u^2 + 2ad$
v = 0 (1 Mark)	a = (-) u^2/2d (1 Mark)
F = (-) m u / t (1 Mark)	F = m u^2/2d (1 Mark)
Hence Ft = mv (0 Marks)	Hence Fd = ½ mv^2
mv = 2000 kg x 6 m s^{-1}	½ mv2 = ½ x 2000 x 6^2
= 12 000 N s (1 Mark)	= 36 000 N m OR J (1 Mark)
12 000 Ns / 300 N	36 000 N m / 300 N
= 40 s (1 Mark)	=120 m (1 Mark)

(8 Marks)

Forces in Magnetic Fields (Questions)

1. Fig. 7.1 shows the magnetic field between the two pole pieces of a large U-shaped magnet, with the north pole vertically above the south pole. When the strength of a magnetic field is measured along the lineAB, it is found to vary as shown in Fig. 7.2.

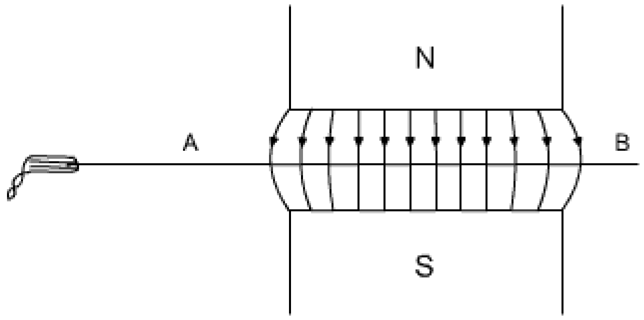


Fig. 7.1

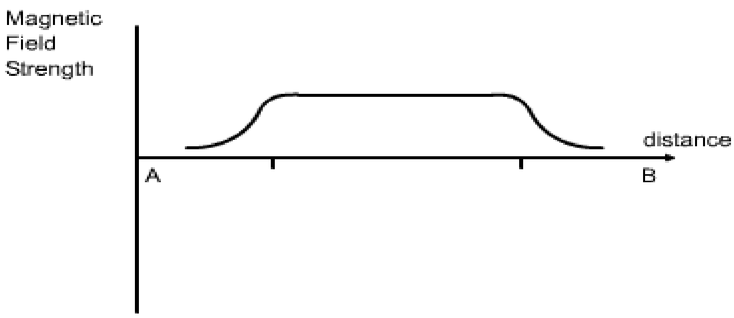


Fig. 7.2.

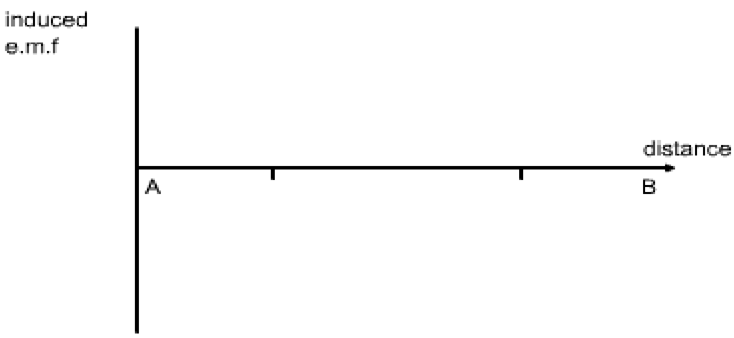


Fig. 7.3

a) Describe in words how the magnetic flux linkage in a coil changes as the coil in Fig. 7.1 moves from A to B.

(3 marks)

b) State Faraday's law of electromagnetic induction.

(2 marks)

c) Draw, on the axes provide in Fig. 7.3, a graph to show how the e.m.f .induced in the coil varies as the coil moves from A to B.

(4 marks)

(Marks available: 9)

2. A diagram of a loudspeaker is shown in Fig. 6.1.

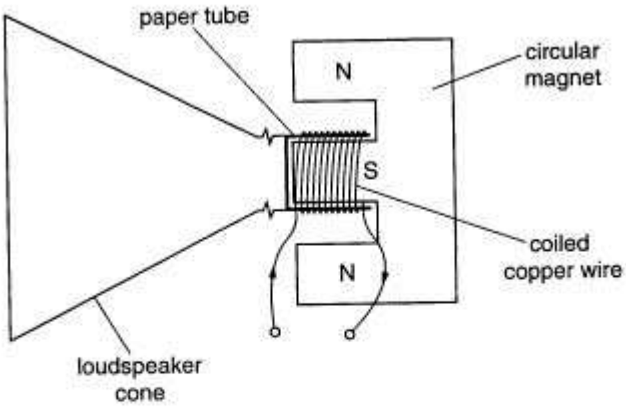


Fig. 6.1

The thin copper wire is wound onto a paper tube that surrounds the south pole of the circular magnet. The copper coil has 250 turns and has a mean radius of 1.5 cm. The magnet provides a field of magnetic flux density 3.6×10^{-2} T at right angles to the wire.

a) Show that the length of the copper wire in the magnetic field is about 24 m.

(2 marks)

b) Calculate the magnitude of the force acting on the copper wire due to the magnetic field when carrying a constant current of 48 mQ.

force = ... N

(3 marks)

(Marks available: 5)

3. **a)** Fig. 6.1 shows the magnetic field pattern for a current-carrying conductor placed between the poles of a permanent magnet.

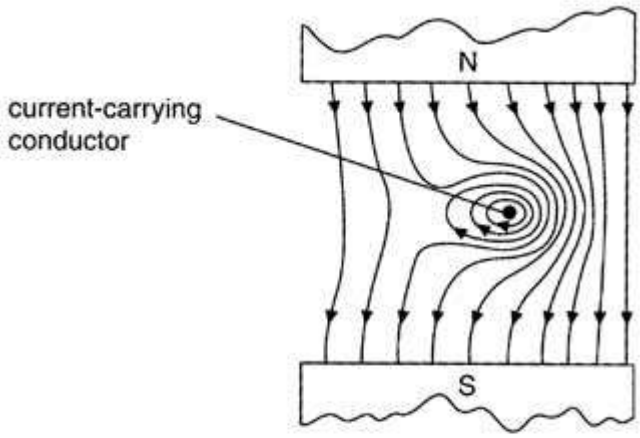


Fig. 6.1

i) State the direction of the current in the conductor.

(1 mark)

ii) On Fig. 6.1, mark with a cross (X) a point between the poles of the magnet where the magnetic field is weakest.

(1 mark)

b) Like the Earth, the planet Jupiter has its own magnetic field.

A small Spacecraft orbuting Jupiter records a tiny force of 3.0 x 10-6 N experienced on a 2.7 m long conductor. The conductor carries a current of 200 mA and is at right angles to the magnetic field.

Determine the magnitude flux density B at the position of the spacecraft.

B = ... unit ....

(3 marks)

(Marks available: 5)

Forces in Magnetic Fields (Answers)

Answer outline and marking scheme for question:

1. **a)** increases to a constant value then decreases

   (3 marks)

   b) induced e.m.f proportional to rate of change of flux linkage

   (2 marks)

   c) pulses of reasonable shape in opposite directions

   (4 marks)

   (Marks available: 9)

2. **a)** length = 2pr (x N)

   length = 2p x 0.015 x 250

   length = 23.57 (m) $^{\sim}$ 24 (m) (9.4 x 10^{-2} (m) scores 1/2)

   (2 marks)

   b) F = BIL

   F = 3.6 x 10^{-2} x 48 x 10^{-3} x 24 (-1 for 10^{n} error)

   F = 4.147.. x $10^{-2\sim}$ 4.1 x 10^{-2} (N) (F $^{\sim}$ 4.1 x 10^{-2} (N) if length 23.57 m is used)

   (Allow ecf from a)(i) but -1 mark for not using given value of 24 m)

   (3 marks)

   (Marks available: 5)

3. **a) i)** Into (plane of) paper.

   (1 mark)

   ii) Correct region to the left of the conductor

   (1 mark)

   b) F = BIL (Allow any subject)

$B = 3.0 \times 10^{-6} / (0.2 \times 0.027)$

$B = 5.56 \times 10^{-4} \sim 5.6 \times 10^{-4}$

unit: tesla / T / $NA^{-1}m^{-1}$ / Wb m^{-2}

(3 marks)

(Marks available: 5)

Gravitational Fields and Forces (Questions)

1. This question is about gravitational fields. You may assume that all the mass of the Earth, or the Moon, can be considered as a point mass at its centre.

   a) It is possible to find the mass of a planet by measuring the gravitational field strength at the surface of the planet and knowing its radius.

   i) Define gravitational field strength, g.

   (1 Mark)

   ii) Write down an expression for g at the surface of a planet in terms of its mass M and radius R

   (1 Mark)

   iii) Show that the mass of the Earth is 6.0 x 1024 kg.

   radius of the Earth = 6400 km

   (1 Mark)

   b) Use the data below to show the value of g at the Moon's surface is about 1.7 N kg-1.

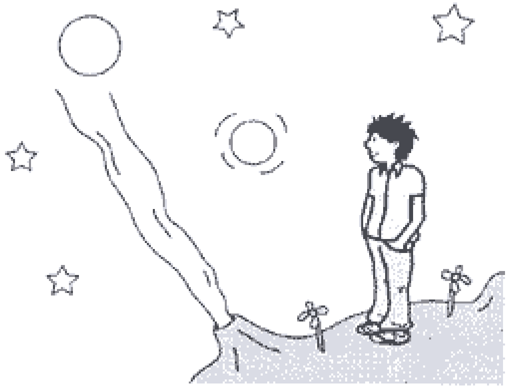
   mass of Earth = 8.1 x mass of Moon

   radius of Earth = 3.7 x radius of Moon

   (2 Marks)

   (Marks available: 5)

2. This question is about the gravitational fields of asteroids and moons in the Solar System. In a children's story, the Little Prince travels from asteroid to asteroid.



a) One such asteroid is roughly 500 m in radius and has density 5000 kg m^{-3}. Show that its mass is about 3 x 10^{12}kg.

(2 Marks)

b) The Little Prince has a mass of 50 kg. Show that he weighs about 0.04 N on this asteroid.

G = 6.7 x 10^{-11} Nm^2kg^{-2}

(3 Marks)

(Marks available: 5)

Gravitational Fields and Forces (Answers)

Answer outline and marking scheme for question:

1. **a) i)** (Gravitational) force on/per unit mass (at that point)

   (1 Mark)

   ii) $g = (-)\ GM/R^2$ accept lower case m and r in formula

   (1 Mark)

   iii) $g = 9.8 = 6.67 \times 10^{-11}\ M/(6.4 \times 10^6)^2$ giving $M = 6.0 \times 10^{24}$(kg)

   (1 Mark)

   b) $g_m = M_m/M_e.R_e^2/R_m^2.g_e$ or gR^2/M = constant or AW;

   $g_m = 3.7^2/81 \times 9.8 = 1.66$ (N kg^{-1})

   (2 Marks)

   (Marks available: 5)

2. **a)** $V = (4/3)\pi\ r^3 = (4/3)\ \pi \times (500\ m)^3 = 5.2 \times 10^8 m^3$ (1 MArk)

   Mass = $\rho V = 5000 \times 5.2 \times 10^8 = 2.6 \times 10^{12}$kg (1 Mark)

   (2 Marks)

   b) $F = GMm/r^2$ (1 Mark)

   $= 6.7 \times 10^{-11}\ N\ m^2\ kg^{-2} \times 2.6 \times 10^{12}\ kg \times 50kg/\ (500m)^2$

   = 0.035 N - 0.04 N (1 Mark) s (1 Mark) e

   (3 Marks)

   (Marks available: 5)

Gravitational Potential Energy (Questions) *

1. This question is about gravitational field and potential near the Earth.

The gravitational potential V_{grav} due to the mass of an approximately spherical body is given by the expression.

$$V_{grav} = \frac{-GM}{R}$$

where

M is the mass of the body

R is the distance from the centre of the body.

a) Show that the gravitational potential at the Earth's equator is about -6.25×10^7 J kg^{-1}.

mass of Earth = 5.98×10^{24} kg

radius of Earth at the Equator = 6.38×10^6 m

radius of Earth at the poles = 6.36×10^6 m

gravitational constant G = 6.67×10^{-11} N m^2 kg^{-2}.

(2 Marks)

b) Show that the magnitude of the gravitational potential at one of the poles is about 1.003 times the magnitude at the equator.

(2 Marks)

c) Explain why gravitational potential is always negative.

(2 Marks)

(Marks available: 6 Marks)

2. **a)** The Moon's gravitational field at its surface id 1.70 Nkg^{-1} and its mean radius is 1.74×10^6 m. Calculate the mass of the Moon?

(3 Marks)

b) A rocket reaches a height of 100 m on the Earth. Ignoring the effect of air resistance on Earth, and assuming it operates in the same way as the Moon, caluculate the height that it would reach on the Moon.

Assume the Earth's gravitational field = 9.81 Nkg^{-1} and the Gravitational constant (G) = $6.67 \times 10^{-11} m^3 kg^{-1} s^{-2}$.

(3 Marks)

(Marks available: 6)

Gravitational Potential Energy (Answers)

Answer outline and marking scheme for question:

1. **a)** V_{grav}= -6.67 x 10^{-11} x 5.98 x 10^{24}/ 6.38 x 10^{6} (1 Mark) = -6.252 x 10^{7} (1 Mark) J kg^{-1}

Own value needed.

(2 Marks)

b) Calulating V_{grav} = -6.27 x 10^{7} (1 Mark) J kg^{-1} using this to give ratio 6.27/6.25 = 1.003(2) (1 Mark)

Own value needed.

OR: explanation leading to 6.38/6.36 = 1.0031 (1 Mark)

(2 Marks)

c) Gravity is always attractive (AW) (1 Mark) hence it always takes energy/work to seperate gravitationally bound masses. At infinity the energy 'stored' is zero therefore an object in a field will be in a potential well. (1 Mark) (AW)

(2 Marks)

(Marks available: 6)

2. **a)**

$$mg_m = \frac{GmM}{r^2} \quad \text{(1 Mark)}$$

$$\text{So, } M = \frac{g_m.r^2}{G} = \frac{1.70 \times (1.74 \times 10^6)^2}{6.67 \times 10^{-11}} \quad \text{(1 Mark)}$$

M = 7.72 x 10^{22} kg (1 Mark)

(3 Marks)

b) Potential Energy at max height is the same on the Earth and the Moon, so

$Mg_mh_m = mg_E h_E$ (1 Mark)

(where M= mass of rocket, g is gravitational field strength and h is height reached on Moon (m) and Eart (E))

c)

$$\text{So, } h_m = \frac{g_E h_E}{G_m} = \frac{9.81 \times 100}{1.70} \text{ (1 Mark)}$$

Height on Moon = hm = 577 m (1 Mark)

(3 Marks)

(Marks available: 6)

Kinetic Theory (Questions) *

1. A gas cylinder with a volume of 0.1 m^3 contains Helium at a temperature of 300 K. The pressure of the helium is 1.1 x 10^5 Pa. Calculate:-

   a) The mass of helium in the cylinder

   (4 Marks)

   b) The r.m.s. speed of the helium atoms.

   (3 Marks)

   (Marks available: 7)

2. A cylinder contans 0.005 m^3 of a gas at 20°C and at constant pressure of 100 K Pa. The gas is heated and it pushes back a piston at the end of the cylinder by 20 mm and increases its volume. The pressure of the gas remains unchanged.

   a) What force does the gas exert at the piston of its area is 1.5 x 10^{-2} m^2.

   (2 Marks)

   b) How much work is done by the gas as it expands.

   (3 Marks)

   c) What is the final temperature after the gas has expanded? (The mass of gas and its pressure do not change).

   (3 Marks)

   (Marks available: 8)

Kinetic Theory (Answers)

Answer outline and marking scheme for question:

1. **a)**

$pV = nRT$ so, $n = \frac{pV}{RT}$ moles (1 Mark)

and $n = \frac{1.1 \times 10^5 \times 0.1}{8.31 \times 300} = 4.41$ moles (1 Mark)

But 1 mole of helium has a mass of 4 g (1 Mark)
Therefore mass of helium = 4.41 x 4 g
= $\underline{17.6 \text{ g or } 1.76 \times 10^{-2} \text{ kg}}$ (1 Mark)

(4 Marks)

b)

$p = \frac{1}{3} \rho <c^2>$, So, $<c^2> = \frac{3p}{\rho} = \frac{3p}{m/v}$

So $<c^2> = \frac{3pV}{m}$ (1 Mark) and rms speed = $\sqrt{\frac{3pV}{m}}$

$\therefore$ rms speed = $\sqrt{\frac{3 \times 1.1 \times 10^5 \times 0.1}{1.76 \times 10^{-2}}}$ (1 Mark)

= $\underline{1.37 \times 10^3 \text{ m s}^{-1} \text{ OR } 1.37 \text{ km s}^{-1}}$ (1 Mark)

(3 Marks)

(Marks available: 6)

2. **a)** F = p x A (1 Mark) = 100 x 10^3 x 1.5 x 10^{-2}

= 1.5 x 10^3 N OR 1.5 kN (1 Mark)

(2 Marks)

b) W = pΔV (1 Mark) ; ΔV = A Δx = 1.5 x 10^{-2} x 2 x 10^{-2}

ΔV = 3 x 10^{-4} m ^{3} (1 Mark)

So, W = 100 x 10^3 x 3 x 10^{-4}

W = 30J (1 Mark)

(3 Marks)

c)

p is constant, So $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ (1 Mark)

T_1 = 293 K, V_1 = 0.005 m^3, V2 = 0.0053 m^3

So $T_2 = \frac{V_2}{V_1} \times T_1 = \frac{0.0053}{0.005} \times 290$ (1 Mark)

T_2 = 310.6 K OR 37.6°C (1 Mark)

(3 Marks)

(Marks available: 8)

Kirchoff's Laws and Potential Dividers (Questions) *

1. **a)** Kirchhoff's first law is based on the conservation of an electrical quantity. State the law and the quantity conserved.

(2 Marks)

Fig 4.1 shows a potential divider circuit. The battery has negligible internal resistance and the voltmeter has very high resistance.

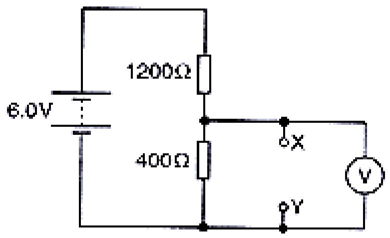


Fig. 4.1

i) Show that the voltmeter reading is 1.5V.

(2 Marks)

b) An electric device rated at 1.5V, 0.1A is connected between the terminals X and Y. The device has constant resistance. The voltmeter reading drops to a very low value and the device fails to operate, even though the device itself is not faulty.

i) Calculate the total resistance of the device and the 400 Ω resistor in parallel.

Resistance =......................................Ω

(3 Marks)

ii) Calculate the p.d. across the device when it is connected between X and Y.

p.d. =.......................................V

(2 Marks)

iii) Why does the device fail to operate?

(2 Marks)

2. **a)** State Kirchoff's first law.

(2 Marks)

b) Fig. 3.1 shows part of an electrical circuit.

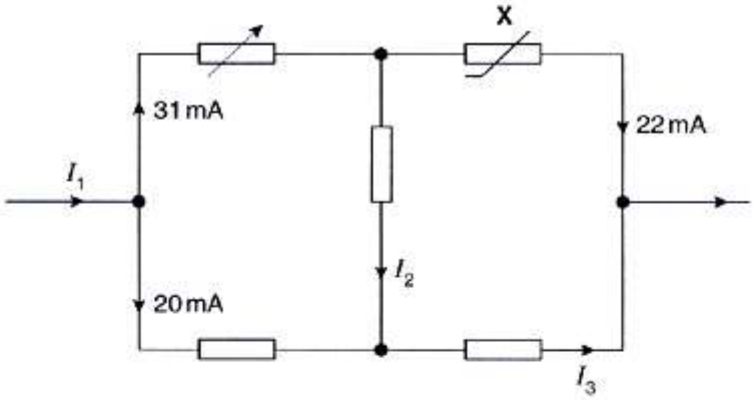


Fig. 3.1

i) Name the component marked X.

(1 Mark)

ii) Determine the magnitude of the currents I_1, I_2, and I_3 .

I_1 = ... mA

I_2 = ... mA

I_3 = ... mA

(3 Marks)

3. Fig. 4.1 shows a simple design for a 'movement' sensor used in an earthquake region. The supply has negligible internal resistance.

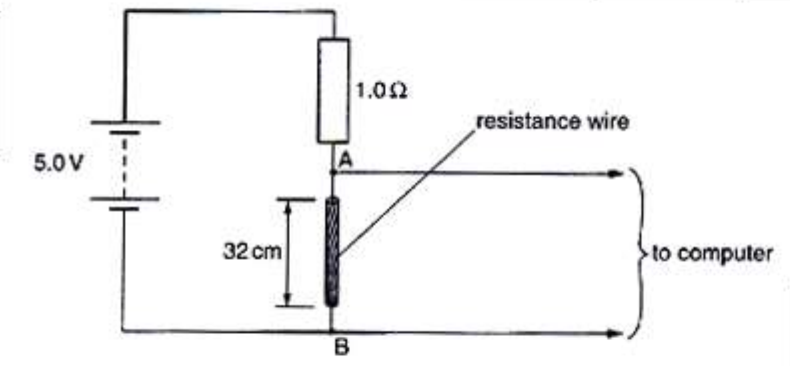


Fig. 4.1

A resistance wire is stretched between two rigid steel plates, not shown in the diagram. During an earthquake, ground movement changes the seperation between the plates and so the length of wire changes.

The wire has a radius of 0.62 mm and length 32 cm. It is made of a material of resistivity 6.8×10^{-6} Ωm.

a) Show that the resistance of the wire is 1.8 Ω.

(3 Marks)

b) Calculatethe potential difference (p.d.) between A and B.

p.d. = ... V

(3 Marks)

c) The length of the wire increases. State and explain the effect on the p.d. between A and B.

(2 Marks)

(Marks available: 25)

Kirchoff's Laws and Potential Dividers (Answers)

Answer outline and marking scheme for question:

1. **a)** Sum of the currents = zero (at junction)OR

sum of the currents in = sum of currents out (at junction)

(2 Marks)

i) $V = V_0 \times R_2 / (R_1 + R_2)$

V = 6.0 x 400 / (1200 + 400)

V = 1.5 (V)

{Answer of 4.5(V) scores 1/2)

OR

$R = V/I$ and $R = R_1 + R_2$

$I = 6.0 / 1600 = 3.75 \times 10^{-3}$(A)

$V = 3.75 \times 10^{-3} \times 400$

V = 1.5(V)

(2 Marks)

b) i) RD = 1.5 / 0.1 = 15Ω

$R = R_1R_2 / (R_1+R_2) / 1R_T= \Sigma 1/R_1$

R = 400 x 15 / (400 + 15) = 14.5 = 15Ω (possible e.c.f)

(3 Marks)

ii) V ≈ 6.0 x 15 / (1200 + 15)

V ≈ 0.07V

{answer of 5.93 scores 1/2}

OR

$I \approx 6.0 / 1200 + 15 \approx 4.98 \times 10^{-3}$ (A)

V ≈ 4.98 x 10^{-3} x 15 = 0.07 (V)

(2 Marks)

iii) Resistance of device is small(er) / current in device is small(er) / p.d. across device is small(er)

(2 Marks)

2. **a)** sum of current(s) into a point / junction = sum of current(s) out (from the point / junction) (-1 for ommission of 'point' or 'sum' in the statement of the law)

(Algebraic sum of current(s) at a point = 0)

(2 Marks)

b) i) Thermistor

(1 Mark)

ii) I_1 = 51 mA

I_2 = 9 mA

I_3 = 29 mA

(3 Marks)

3. **a)**

$$\rho = \frac{RA}{L}$$ (Any subject for equation) (Possible credit from (a))

$$A = \pi r^2 = \pi \times (0.62 \times 10^{-3})^2$$ (= 1.208×10^{-6} (m^2))

$$R = \frac{6.8 \times 10^{-6} \times 0.32}{\pi \times (0.62 \times 10^{-3})^2}$$

$$R = 1.8\ (\Omega)$$

(3 Marks)

b)

$$V = \frac{R_2}{R_1 + R_2} \times V_0$$

$$V = \frac{1.8}{2.8} \times 5.0$$

$$V \approx 3.2\ (V)$$

(1.8 (V) scores 2/3)

$V = IR$ and $R_T = R_1 + R_2$

$$I = 5.0 / 2.8 = 1.786 \approx 1.8\ (A)$$

$$V = 1.786 \times 1.8 \approx 3.2\ (V)$$

(Allow ECF from (b)(i) but −1 mark for not using given value of 1.8 Ω)

(3 Marks)

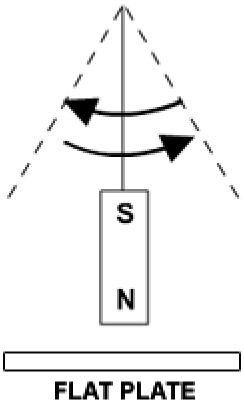
c) The p.d. increases because the resistance (of wire) increases (as it gets thinner / longer)

(2 Marks)

(Marks available: 25)

Lenz's Law (Questions)

1. A bar magnet is fixed on the end of a string to make a simple pendulum, as shown in the diagram.



a) If a flat sheet of copper is placed just below the swining magnet, what happens inside the copper?

(1 Mark)

b) What effect does this have on the swinging magnet and why does it have this effect?

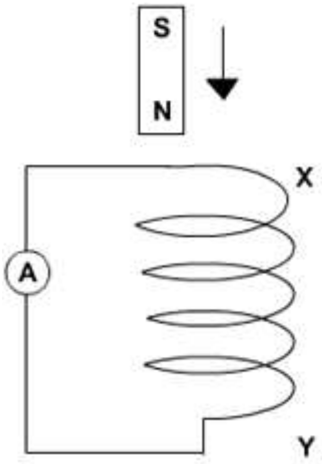
(2 Marks)

c) What happens if a glass plate is used instead of copper?

(2 Marks)

(Marks available: 5)

2. A magnet is dropped through a wire coil. As it goes through a current is generated in the coil which produces a magnetic field near the coil.



a) Which magnetic pole (N or S) is produced at X as the magnet goes into the top of the coil?

(1 Mark)

b) Explain your answer to a)?

(2 Marks)

c) Which magnetic pole (N or S) is produced at Y as the magnet leaves the bottom of the coil? Why?

(2 Marks)

(Marks available: 5)

Lenz's Law (Answers)

Answer outline and marking scheme for question:

1. **a)** An electric current is induced in the copper by the changing magnet field from the swinging magnet.

   (1 Mark)

   b) The magnet (or pendulum) decreases its swing, because the induced current is produced in the direction which opposes the change producing it. (1 Mark) Lenz's Law) (1 Mark)

   (2 Marks)

   c) Glass is an insulator (1 Mark) , so no (or negligible) current is produced in it and the pendulum is not affected by the presence of the glass. (1 Mark)

   (2 Marks)

   (Marks available: 5)

2. **a)** North Pole

   (1 Mark)

   b) By Lenz's Law the induced current must oppose the change which causes it (1 Mark) - so it must repel the magnet.(1 Mark)

   (2 Marks)

   c) North pole (N) (1 Mark) - to attract the South pole of the magnet as it moves away (1 Mark).

   (2 Marks)

   (Marks available: 5)

Matter and Antimatter (Questions)

1. The atomic bomb dropped on Hiroshima had an explosive energy of 8.4 x 10^{13}J. How many kilograms of mass must have been converted into energy in this explosion?

   (Marks available: 1)

2. Lawrence, the inventor of the cyclotron, produced an early model with a diameter of 25cm. It could accelerate protons up to an energy of 1 MeV.

   Calculate:

   a) The speed of the protons produced.

   b) The flux density of the magnetic field that would be required

   c) The frequency at which the p.d. across the Ds must change

   Mass of proton = 1.7 x 10^{-27}Kg

   Charge of proton = 1.6 x 10^{-27}C

   (Marks available: 3)

3. **a)** The following series of reactions occur inside the Sun.

   Write nuclear equations to represent these reactions.

   i) Two hydrogen-1 nuclei fuse to produce hydrogen-2 (deuterium) nucleus and a positron.

   (1 Mark)

   ii) The hydrogen-2 nucleus fuses with another hydrogen-1 nucleus to produce helium-3.

   (1 Mark)

   iii) Two helium-3 nuclei then fuse to give helium-4 two hyrdrogen-1 nuclei.

   (1 Mark)

   b) Use your answers to (i), (ii) and (iii) to deduce an equation which summarises the fusion of hydrogen-1 nuclei to forma helium-4 nucleus.

   (2 Marks)

(Marks available: 5)

Matter and Antimatter (Answers)

Answer outline and marking scheme for question: 3

a) i) $^{1}_{1}H + ^{1}_{1}H \rightarrow ^{2}_{1}H + ^{0}_{1}\beta$ (+v)

(1 Mark)

ii) $^{2}_{1}H + ^{1}_{1}H \rightarrow ^{3}_{2}He$

(1 Mark)

iii) $^{3}_{2}He + ^{3}_{2}He \rightarrow ^{4}_{2}He + 2^{1}_{1}H$

(1 Mark)

b) $^{3}_{2}He + ^{3}_{2}He \rightarrow ^{4}_{2}He + 2^{1}_{1}H$

$2^{2}_{1}H + 2^{1}_{1}H \rightarrow 2^{3}_{2}He$

$2^{1}_{1}H + 2^{1}_{1}H \rightarrow 2^{2}_{1}H + 2^{0}_{1}\beta$ (+2v) (allow β^{+} or $^{0}_{1}e$)

add:

$6^{1}_{1}H \rightarrow ^{4}_{2}He + 2^{0}_{1}\beta + 2^{1}_{1}H$

cancel two $^{1}_{1}H$'s:

$4^{1}_{1}H \rightarrow ^{4}_{2}He + 2^{0}_{1}\beta$ (+ 2V)

(2 Marks)

(Marks available: 5)

Moments, Couples and Equilibrium (Questions)

1. Fig. 2.1 shows a computer resting on a tabletop that is hunged at A.

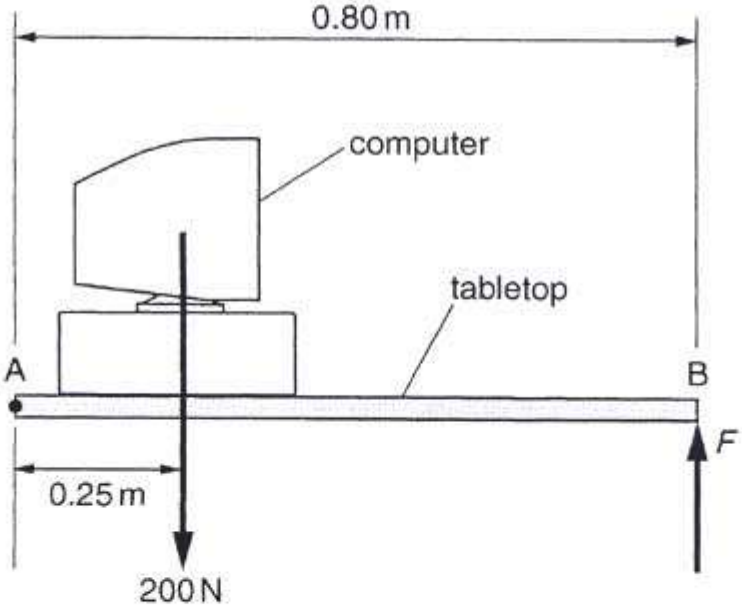


Fig. 2.1

The tabletop has a mass of 5.0kg and its centre of gravity is 0.40 m from the axis of the hinge at A. The computer has a weight of 200 N acting through a point 0.25m from the hinge at A. The tabletop is supported to maintain it in a horizontal position by a force of F acting vertically at B. The distance AB is 0.80 m.

a) Calculate the weight if the tabletop.

weight = ... N

(1 Mark)

b) On Fig. 2.1 draw and label an arrow to reprsent the weight W of the tabletop.

(1 Mark)

c) Apply the principle of momentd about the hinge at A to determine the vertical force F applied at B that is required to maintain the tabletop in equilibrium.

force = F .... N

(3 Marks)

d) The tabletop must experience a resultant force of zero in order to be in equilibrium. Explain how the forces acting on the tabletop fulfill this condition.

(2 Marks)

(Marks available: 7)

2. Fig. 4.1 shows the open bonnet of a car. The bonnet is held open at an angle of 60° to the horizontal by a vertical force V applied at one end of the bonnet (shown on the diagram). The bonnst is 0.90 m long, has a weight of 25 N and its centre of gravity G is 0.35 m from the hinge at O.

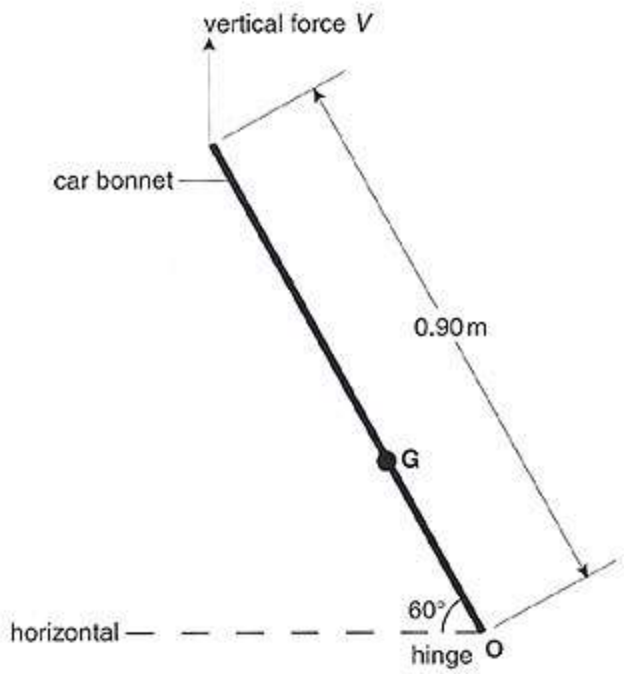


Fig. 4.1

a) On Fig. 4.1, draw and label the two forces other than V acting on the bonnet.

(2 Marks)

b) By taking moments about O, show that the vertical force V applied at the end of the bonnet is 9.7 N.

(2 Marks)

c) Calclate the magnitude of the force acting at the hinge O. Show your working.

force at hinge = ... N

(2 Marks)

(Marks available: 6)

Moments, Couples and Equilibrium (Answers)

Answer outline and marking scheme for question:

1. **a)** W = 5 x 9.81 = 49 N (allow g = 10)

   (1 Mark)

   b) arrow acting down (labelled W) drawn approximately halfway from A to B

   (1 Mark)

   c) any correct moment

   F x 0.8 = 200 x 0.25 + 49 x 0.4

   F = 87 N

   (3 Marks)

   d) upward force acts at the hinge

   So F and force at hinge equals weight of table and computer (allow one mark for the upward forces equal the downward forces)

   (2 Marks)

   (Marks available: 7)

2. **a)** W vertically down at G

   Force at O vetical

   (2 Marks)

   b) By taking moments about O, show that the vertical force V applied at the end of the bonnet is 9.7 N.V x 0.9 xcos60 = W x 0.35 x cos60

   V = (25 x 0.35) / 0.9

   = 9.7 (22) (N)

(2 Marks)

c) Total force is zero stated or implied / 25 - 9.7

force at hinge = 15.3 (N)

(or may take moments about G or V)

(2 Marks)

(Marks available: 6)

Momentum and Impulse (Questions)

Answer outline and marking scheme for question:

1. **a)** Äp = 280 x 55 - 280 x 0 (1 Mark) = 15 400 (1 Mark) kg ms^{-1} (1 Mark)

   (3 Marks)

   b) f = ma = 280 x (55/0.25) (1 Mark) = 61600 N (1 Mark)

   (2 Marks)

   c) argue from Newton 3 oe conservation of momentum leading to a force on the plane (1 Mark) this makes the plane move dow (1 Mark) (as plane is much more massive so acceleration/movement much less than that of the pilot). (Accept plane wont move because its on the ground for second mark).

   (2 Marks)

   (Marks available: 7)

2. **a)** 70 m s^{-1}

   (1 Mark)

   b) 70 x 0.11 = 7.7 (1 Mark) kg m s^{-1} (1 Mark) Ns e.c.f. from (a)

   (2 Marks)

   (Marks available: 3)

3. **a)** momentum = mv

   = $6.68 \times 10^{-27} \times 1.8 \times 10^{7} = 1.20 \times 10^{-19}$ N s

   (2 Marks)

   b) ke of á- particle = ½ mv^2

   = ½ $6.68 \times 10^{-27} \times (1.38 \times 10^{7})^2$

   = 6.36×10^{-13} J

   ke of helium nucleus = ½ mv^2 = ½ $6.68 \times 10^{-27} \times (1.15 \times 10^{7})^2$

   = 4.42×10^{-13} J

   (allow 2 sf on each answer)

(3 Marks)

c) i) so total ke after collision equal to ke of incident á- particle

total ke before collision = (6.36 + 4.42) x 10^{-13} = 1.08 x 10^{-12} J or other evidence of a calculation

(2 Marks)

ii) Collision is elastic

accept 'kinetic energy is conserved in this collision'

allow ecf from c) (i)

(1 Mark)

(Marks available: 8)

Nuclear Energy (Questions) *

1. Give 2 arguments for and against nuclear power.

   (Marks available: 4)

2. The mass defect of a carbon -12 nucleus is found to be -0.0989u.

   Calculate:

   a) The binding energy of the a carbon - 12 nucleus in joules

   b) The binding energy per nucleon in MeV

   Take:

   u to be 1.66056 x 10 -27 kg;

   c to be 3.0 x 10 8 ms-1;

   e to be 1.602 x 10 -19 C

   (Marks available: 4)

3. In a nuclear power station a controlled nuclear chain-reaction is used to produce energy. Control rods and a moderator are used to ensure that the nuclear reactions proceed at the correct rate.

   a) With the help of a sketch explain what a chain-reaction is

   b) What role does the moderator play in a nuclear reactor, why is it important and suggest a suitable material.

   (Marks available: 6)

4. Explain in terms of binding energy why very large nuclides undergo fission.

   (Marks available: 2)

Nuclear Energy (Answers)

Answer outline and marking scheme for question: 1

Advantages: Cheap energy production, conservation of fossil fuels, no harmful gas by-products, production of useful radioactive nuclides

(1 mark for each up to 2)

Disadvantages: Possibility of accidents (explosions, radioactive leaks), produces radioactive waste which is difficult to dispose of, high decommissioning costs

(1 mark for each up to 2)

(Marks available: 4)

Answer outline and marking scheme for question: 2

a) -1.478 x 10 -11 J

(2 marks)

b) 92.26 MeV

(2 marks)

(Marks available: 4)

Answer outline and marking scheme for question: 3

a) Neutron strikes nucleus causing it to split into fragments **(1 mark)** Neutrons are released **(1 mark)** Released neutrons cause further fissions **(1 mark)**

b) The moderator slows fast moving neutrons **(1 mark)** so that they have more chance of causing fission when they strike nuclei **(1 mark)** Suitable materials are graphite and water **(1 mark)**

(Marks available: 6)

Answer outline and marking scheme for question: 4

Iron nucleus has the lowest binding energy per nucleon. **(1 mark)** By breaking into smaller nuclei closer in size to the iron nucleus, large nuclei reduce their binding energy and hence become more stable. **(1 mark)**

Particle Classification and Interactions (Questions)

1. **a)** Write down the charges of the up, down and strange quarks.

   b) Show how a neutron and a proton carrying the correct charges can be formed from different combinations of 3 up and down quarks.

   (Marks available: 2)

2. How many up quarks does an alpha particle contain?

   (Marks available: 3)

3. Within the nucleus positive protons in are very close together. A student suggests that as a result no nuclei can be stable due to the electromagnetic repulsion between them. Suggest an interaction which could be responsible for holding the nucleus together, give its properties and explain your reasoning.

   (Marks available: 5)

4. The Rutherford scattering experiment is an example of the use of radioactive particles.

   a) What type of radiation was used in the experiment?

   b) What physical property caused the scattering?

   c) The particles in this experiment are unsuitable for probing the structure of the nucleus itself. Suggest a different particle that could be used stating the physical principle that causes the scattering in this case.

   d) Give another use of radioactive particles and state the source of radiation involved.

   (Marks available: 6)

Particle Classification and Interactions (Answers)

Answer outline and marking scheme for question: 1

a) up = +2/3e, down = -1/3e and strange = -1/3e

(1 mark)

b) proton has charge +1e so needs two up and one down quark (2/3+/2/3-1/3 = +1)

(1 mark)

(Marks available: 2)

Answer outline and marking scheme for question: 2

Alpha particle is made up of 2 protons and 2 neutrons

(1 mark)

Protons have 1 up quark and neutrons 2 up quarks

(1 mark)

So total up quarks = 5

(1 mark)

(Marks available: 3)

Answer outline and marking scheme for question: 3

Strong interaction

(1 mark)

Properties: Caused by the exchange of mesons

(1 mark)

Range = 10-15m

(1 mark)

Strong interaction is stronger than electromagnetic interaction

(1 mark)

over short ranges as found in the nucleus

(1 mark)

(Marks available: 5)

Answer outline and marking scheme for question: 4

a) Alpha radiation

b) Electrostatic repulsion

c) Electrons

(1 mark)

Diffraction

(1 mark)

d) e.g. radioactive dating

(1 mark)

carbon 14

(1 mark)

or medical tracing

(1 mark)

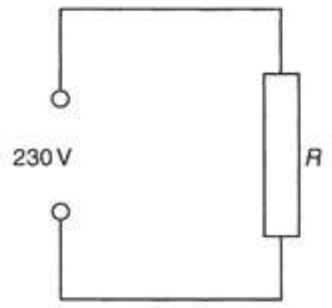
technetium 99m

(1 mark)

(Marks available: 6)

Power and Energy (Questions)

1. The heating element of an electric kettle operates at 230 V and has a power rating of 2.52 kW.



a) calculate the working resistance R of the heating element.

working resistance = ... Ω

(2 Marks)

b) A digital multimeter is used to measure the resistance of the heating element when it is cold. The value of the resistance measured by this method is considerably lower than the working resistance.

Suggest a reason for this.

(1 Mark)

(Marks available: 3)

2. Fig. 3.2 shows a negative temperature coefficient (NTC) thermistor connected to 24 V power supply of negligible internal resistance. The ammeter had negligible resistance.

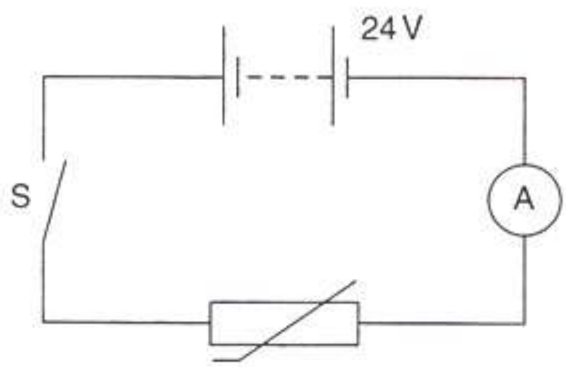


Fig. 3.2

a) When the switch S is closed, the ammeter reading is 28 mA. Calculate the power dissipated by the thermistor.

power = ... W

(3 Marks)

b) A few minutes after closing the switch, the current has increased to a constant value of 40 mA. Explain why the current increases.

(2 Marks)

(Marks available: 5)

3. A simple cell may be constructed by inserting into a fresh lemon two electrodes made from different metals. The juice of the lemon acts as an electrolyte (conducting liquid). Positive and negative ions within the lemon move towards the metal electrodes. Fig. 2.1 shows such a lemon-cell. It has an e.m.f. of 1.32 V and can provide enough electrical energy to activate a digital lock for many days.

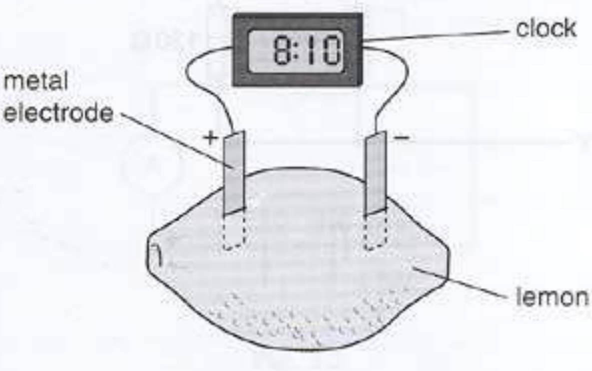


Fig. 2.1

a) On Fig. 2.1, indicate with an arrow the direction in which negative charge moves within the lemon.

(1 Mark)

b) The lemon-cell is capable of providing a steady current of 1.2 mA for eight days (6.9×10^5 x). Calculate

i) the charge passing through the clock during eight days

charge = ... C

(3 Marks)

ii) the power delivered by the lemon-cell

power = ... unit ....

(3 Marks)

(Total =7)

Power and Energy (Answers)

Answer outline and marking scheme for question:

1. **a)** Sum of the currents = zero (at junction)OR

   sum of the currents in = sumof currents out (at junction)

   b) R = V^2 / P / I = 10.96 A (1 Mark) m ; = 21.0 Ω (1 Mark) e

   (2 Marks)

   c) reference to element being colder and so lower resistance AW ora (NOT it is colder)

   (1 Mark)

   (Marks available: 3)

2. **a)** P = VI / I^2R / $\frac{V^2}{R}$

   P = 24 x 0.028

   power = 0.672 ≈ 0.67 (W) (-1 for 10^n error therefore 670 (W) scores 2/3)

   (3 Marks)

   b) (Thermistors) temperature increases (due to electrical heating) [AW] Resistance of thermisistor decreases.

   (2 Marks)

   (Marks available: 5)

3. **a)** Arrow (within the lemon) and towards the negative terminal

   (1 Mark)

   b) i) Δ Q = IΔ t (Allow other subject. Δ is not necessary)

   charge = $1.2 \times 10^{-3} \times 6.9 \times 10^5$

   charge = 828 ≈ 830 (C) (-1 for 10^n error tand -1 for t = 8 days)

   (3 Marks)

ii) P = VI

P = 1.32 x 1.2 x 10^{-3} (ECF for current from b(i))

P = 1.58 x 10^{-3} ≈1.6 x 10^{-3}

unit: W / Js^{-1} / VA

(3 Marks)

(Marks available: 7)

Power and Internal Energy (Questions)

1. The front of a lorry can be considered a flat vertical surface of area $8.0m^2$. The average pressure due to air resistance is 150 Pa when the lorry travels at a constant speed of 16 m s^{-1}. You may assume the air resistance force acts perpendicular to the front of the lorry. When the lorry travels at 16 m s^{-1}.

a) calculate the force due to the air resistance

force due to air resistance = ... N

(2 Marks)

b) calculate the power dissipated in overcoming the air resistance.

power = ... W

(3 Marks)

c) State and explain how the values of the quantities calculated above would change if the lorry increased its speed.

(3 Marks)

(Marks available: 8)

2. An electric motor drives a pulley which lifts a mass of 6kg at a constant speed of 3 m s^{-1} (g = 9.81 m s^{-2})

a) What force is needed to lift the mass?

(1 Mark)

b) What is the power output of the motor?

(2 Marks)

c) If the motor is 60% efficient, what is the power input from the electricty supply?

(2 Marks)

(Marks available: 5)

Power and Internal Energy (Answers)

Answer outline and marking scheme for question:

1. **a)** force = pressure x area / 150 x 8

= 1200 (N)

(2 Marks)

b)power = F x v

= 1200 x 16 ecf

= 19200 (W)

(3 Marks)

c) (force greater as) air resistance is greater explanation of why: correct quantification, air resistance proportional to v or v^2 or in terms of molecules harder collisions or increased rate of collision.

power greater as force is greater

power greater as velocity is greater

(3 Marks)

(Marks available: 8)

2. **a)** F = mg = 6 x 9.81 = 58.86 N

(1 Mark)

b)

$$\text{Power} = \frac{\text{Force x distance}}{\text{time}} = \text{Force x speed (1 Mark)}$$

= 58.86 x 3 = 176.58 W (1 Mark)

(2 Marks)

c)

60	Power output
——— =	———
100	Power input

So power input = Power output x $^{100}/_{60}$ (1 Mark)

= 176.58 x $^{100}/_{60}$

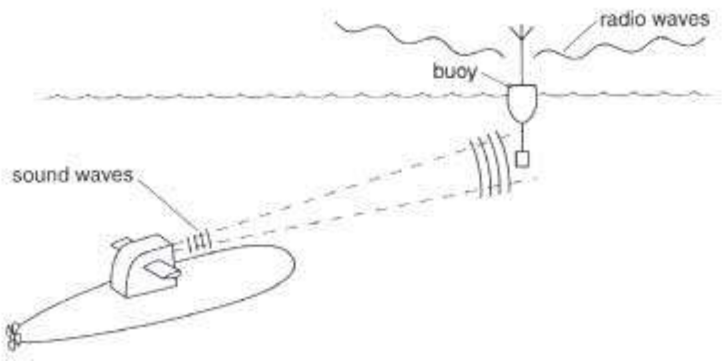
= 294.3 W (1 Mark)

(2 Marks)

(Marks available: 5)

Progressive Waves (Questions) *

1. Radio waves cannot be transmitted through water, but submarines can now transmit and receive e-mails, without having to surface.



An 'accoustic modem' on the submarine transmits sound waves through water, at a frequency of 8.0 kHz, The waves carry information at 2.4 kbit s^{-1} to a radio buoy. The information is relayed from the buoy to shore by radio waves. The buoy can also receive radio signals, and transmit the information as sound waves back to the submarine.

a) Show that the wavelength of the 8.0 kHz sound waves in sea water is about 0.2 m.

speed of sound n sea water = 1500 m s^{-1}

(3 Marks)

b) The sound waves travel 5.0 km from the submarine to the buoy.

Calculate the time taken for the sound waves to travel this distance.

time taken = ... s

(2 Marks)

(Marks available: 5)

2. This question is about a violin.

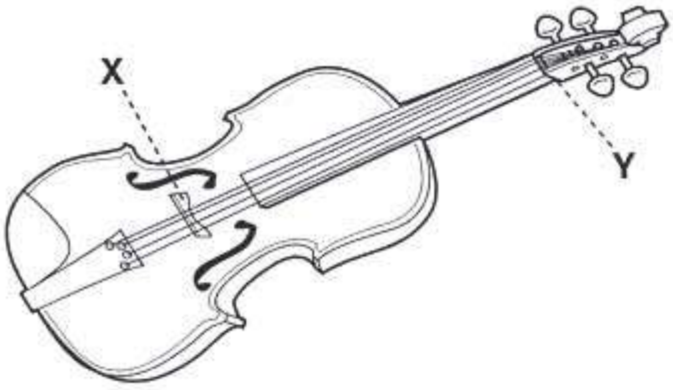


Fig. 8.1

Fig. 8.1 shows a violin with its four strings in place. Each string is in tension between the bridge X and the nut Y. At X and Y the mvoement of the strings is restricted.

Fig. 8.2 shows one of the four strings on the violin.

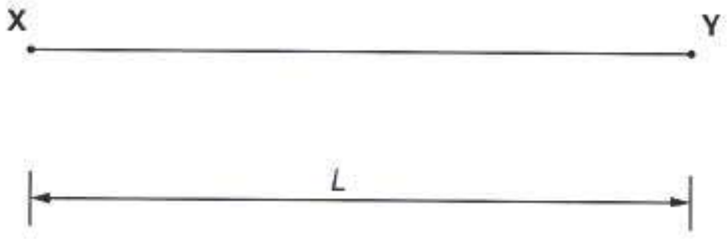


Fig. 8.2

a) Draw on Fig. 8.2 the lowest frequency standing wave that can be obtained on the string. Label the nodes and antinodes with the letters 'N' and 'A' respectively.

(2 Marks)

b) The length L of the string betweem X and Y is 0.40 m.

State the wavelength of the standing wave you have drawn.

wavelength = ... m

(1 Mark)

c) The frequency of the lowest frequency standing wave is 440 Hz.

Calculate the velocity v of the transverse waves on the string.

velocity = ... m s^{-1}.

(2 Marks)

(Marks available: 5)

3. Fig. 3.1 represents the screen of a cathode ray oscilloscope (c.r.o.).

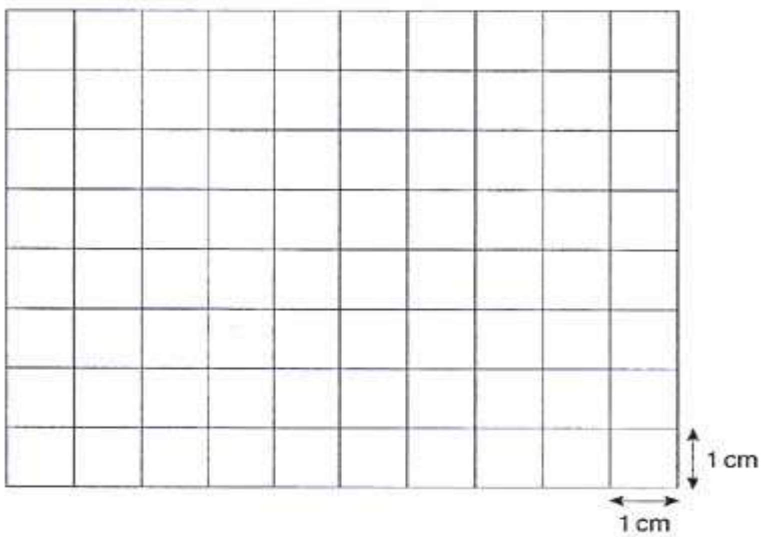


Fig. 3.1

The time-base setting is 0.50 ms cm^{-1} and the voltage (y-gain) setting is 2.0 mV cm^{-1}. A microphone connected to the c.r.o. detects a pure (sinusoidal) sound wave note of frequency 500 Hz.

a) Calculate the period of the note.

period = ... s

(1 Mark)

b) The amplitude of the signal from the microphone produced by the note is 6.0 mV.

Draw on Fig. 3.1 the trace produced on the c.r.o. screen when the mircophone detects the sound wave. Draw at least two full cycles of the wave on Fig. 3.1.

(3 Marks)

c) The speed of sound in air is 330 m s-1. Calculate the wavelength of the sound received by the microphone.

wavelength = ... m

(2 Marks)

(Marks available: 6)

Progressive Waves (Answers)

Answer outline and marking scheme for question:

1. **a)** $\lambda = v / f$; = 1500 / 8000 ; = 0.19 m

   ora v = 1600 m s^{-1} is about 1500 m s^{-1} full marks

   (3 Marks)

   b) t = s / v / = 5000 / 1500 ; = 3.3 s

   (2 Marks)

   (Marks available: 5)

2. **a)** One loop (1 Mark) nodes and antinodes labelled (1 Mark)

   (2 Marks)

   b) 0.8 (m) (1 MArk) ecf from a)(i)

   (1 Mark)

   c) = 440 x 0.8 (1 Mark) = 352 (m s^{-1}) (1 Mark) ecf from a)(ii)

   (2 Marks)

   (Marks available: 5)

3. **a)** period = 1/500 = 0.002s (or 2ms)

   (1 Mark)

   b) at least 2 full (sine) waves of constant period (+/- 2mm)

   of amplitude 3 cm (+/- 2mm in both directions)

   correct 'period' of 4 cm (+/- 2mm throughout)

   (3 Marks)

   c) correct substitution into $v = f \lambda$: e.g. $330 = 500 \lambda$

λ = 0.66 m {do not allow 0.6 but allow 0.7 }

(2 Marks)

(Marks available: 6)

Quantum Physics (Questions) *

1. **a)** In an experiment, an electrically insulated zinc plate is negatively charged. When exposed to a weak ultra-violet source, the plate starts to lose its negative charge.

   Explain this phenomenon in terms of the photoelectric effect. Suggest how increasing the intensity of the ultra-violet source would affect the experiment.

   (You will be awarded marks for the quality of written communication in your answer to this question.)

   b) A 1.0W laser produces red light of wavelength 6.3×10^{-7}m.

   Calculate

   i) the frequency of the radiation,

   frequency = ...unit..................

   ii) the energy of a photon of red light.

   energy =..J

   iii) Calculate the number of photons emitted per second by the laser.

   Number =...................................s^{-1}

   iv) State how, and explain why, the number of photons emitted per second would change if the 1.0mW laser produced blue light.

   (Marks available: 16)

2. Fig. 7.1 shows a photocell.

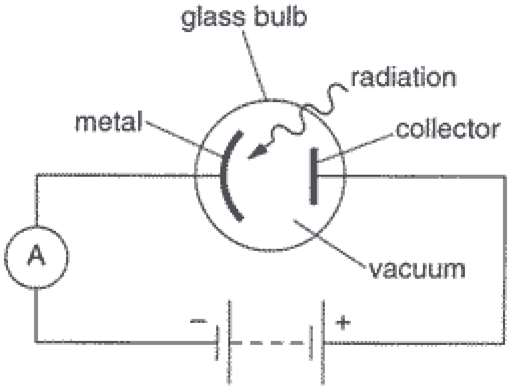


Fig. 7.1

When the metal surface is exposed to electromagnetic radiation, photoelctrons are ejected. The collector collects the photoelectrons and the sensitive ammeter indicates the presence of a tiny current.

a) For a certain frequency and intensity of radiation, the ammeter shows a current of 1.2×10^{-7} A. Calculate:

i) the charge reaching the collector in 5.0 s

charge = ... C

ii) the number of photoelectrons reaching the collector in 5.0 s.

number of electrons = ...

(3 Marks)

b) The work function energy of the metal is 3.5×10^{-19} J and the incident radiation has frequency 7.0×10^{14} Hz. Calculate the maximum kinetic energy of an ejected photoelectron.

energy = ... J

(3 Marks)

c) The intensity of the incident radiation is doubled but the wavelength is kept constant. State the effect this has on each of the following

i) the energy of each photon

(1 Mark)

ii) the maximum kinetic energy of each photoelectron

(1 Mark)

iii) the currrent in the photocell

(1 Mark)

(Marks available: 9)

Quantum Physics (Answers)

Answer outline and marking scheme for question: 1

a) Any <u>five</u> from:

- photons are involved / E=hf
- surface electrons are involved
- one to one exchange of energy between photon and electron
- electrons carry negative charge, therefore removal means resuction in (negative) charge (of plate)
- electron released when photon energy > workfunction (energy)
- electron emission related to threshold frequency
- energy conserved in the interaction (between photon and electron).
- Einstein's equation mentioned (hf = 1/2 mv^2 + ø)

(5 marks)

Any <u>two</u> from:

- More photons (in a given time)
- More electrons are removed (in a given time)
- The plate loses charge quicker.

(2 marks)

b) i) f = 3.0 x 10^8 / 6.3 x 10^{-7}

f = 4.7 (6) x 10^{14}

unit: hertz, Hz

(3 marks)

ii) E = hf

E = $6.63 \times 10^{-34} \times 4.76 \times 10^{14} = 3.1(6) \times 10^{-19}$ (J)

(2 marks)

iii) N = $1 \times 10^{-3} / 3.16 \times 10^{-19}$

N = $3.1(7) \times 10^{15}$ (s^{-1})

(2 marks)

iv) Energy of photon is greater / blue light has shorter wavelength

Reduced (rate) of photons / fewer photons (in a given time)

(2 marks)

(Marks available: 16)

Answer outline and marking scheme for question: 2

a) i) $\Delta Q = I \Delta t$ / $1.2 \times 10^{-7} \times 5$ (Any subject and no need for Δ notation)

charge = 6.0×10^{-7} (C) (Allow 6×10^{-7} (C))

ii)

number = $\dfrac{6.0 \times 10^{-7}}{1.6 \times 10^{-19}}$ $3.75 \times 10^{12} \approx 3.8 \times 10^{12}$ (Possible ECF)

(3 Marks)

b) E = hf / E = $6.63 \times 10^{-34} \times 7.0 \times 10^{14} = 4.64 \times 10^{-19} \approx 4.6 \times 10^{-19}$ (J)

$hf = \varphi + KE_{max}$ (Allow other subject for photoelectric equation)

$KE_{max} = (4.64 - 3.5) \times 10^{-19} = 1.14 \times 10^{-19} \approx 1.1 \times 10^{-19}$ (J)

(3 Marks)

c) i) Energy of photon is the same

ii) KE of electron is the same

iii) The current doubled (as there are twice as many photons)

(1 Mark)

(Marks available: 9)

Radioactive Decay Equations (Questions)

1. **a)** Define the bequerel.

   (1 mark)

   b) Write down an equation that relates the activity (A) of a source to the number of atoms it contains (N). Identify any new symbols you introduce.

   (1 mark)

   (Marks available: 2)

2. A sample of radioactive material contains 1 x 1018 atoms and its activity is measured as 9 x 1012 Bq. Calculate the decay constant for the sample.

   (Marks available: 2)

3. A piece of wood from an ancient spear has a mass of 1kg. An activity of 7.5 disintegrations per minute is recorded from it (assume due to be from the decay of the isotope carbon 14). A similar modern replica made from the same wood but with a mass of 2kg has an activity of 30 disintegrations per minute. If the half-life of carbon 14 is 5730 years calculate the age of the ancient spear.

   (Marks available: 2)

4. Cobalt 60 is used in many applications where gamma radiation is required. The half-life of cobalt 60 is 5.26 years. If a sample has an initial activity of 2 x 1015 Bq what will its activity be after 3 years?

   (Marks available: 2)

5. Living matter has an activity of 260 BqKg-1 due to carbon 14. If a sample of wood from a burial site has an activity of 155 Bq Kg-1 estimate the age of the site. Half-life of carbon 14 is 5730 years.

   (Marks available: 2)

6. Geiger counter placed 20cm from a point source of gamma radiation registers a count rate of 6000s-1. Calculate the count rate 1 metre away.

(Marks available: 2)

Radioactive Decay Equations (Answers)

Answer outline and marking scheme for question: 1

a) 1 Bq = 1 decay per second

(1 mark)

b) A = lN l is the decay constant

(1 mark)

(Marks available: 2)

Answer outline and marking scheme for question: 2

Use A = lN

(1 mark)

l = 1 x 105 per second

(1 mark)

(Marks available: 2)

Answer outline and marking scheme for question: 3

5730 years

Answer outline and marking scheme for question: 4

1.35 x 1015 Bq

Answer outline and marking scheme for question: 5

Around 4280 years

Answer outline and marking scheme for question: 6

1200 s-1

Radioactivity (Questions) *

1. **a)** What is ionising radiation?

   (1 mark)

   b) Why is ionising radiation dangerous to living tissue?

   (1 mark)

   c) Why is alpha radiation particularly dangerous if ingested?

   (1 mark)

   (Marks available: 3)

2. The radioactive nuclide, $^{239}_{92}U$, decays by alpha-particle emission. The newly formed nuclide X is also unstable and decays by a different radioactive emission to a third nuclide Y. Y then decays to become another isotope of uranium$^{234}_{92}U$.

   a) Explain the meaning of the term isotope.

   (1 mark)

   b) Write down suitable symbols in the form $^{239}_{92}U$ for

   an α-particle ....

   a β-particle.........................

   (2 marks)

   c) Show how $^{239}_{92}U$ can become the isotope $^{234}_{92}U$ after three decays.

   (3 marks)

   (Marks available: 6)

3. The equation shows a possible neutron-induced fission for a nucleus of plutonium-239.

$$^{239}_{94}Pu + ^{1}_{0}n \longrightarrow ^{100}_{42}Mo + ^{134}_{52}Te + \text{neutrons}$$

How many neutrons are emitted?

number of neutrons = ...

(1 mark)

Radioactivity (Answers)

Answer outline and marking scheme for question:

1. **a)** Radiation capable of ionising atoms.

   (1 mark)

   b) The charged particles/ions produced can interfere with biological processes.

   (1 mark)

   c) Alpha radiation is highly ionising if inside the body it can easily damage internal tissue.

   (1 mark)

   (Marks available: 3)

2. **a)** An element can exist in more than one form, having a different number of neutrons /can have different mass but same proton number / AW

   (1 mark)

   b) ${}^{4}_{2}He$ / ${}^{4}_{2}\alpha$; (-) ${}^{0}_{-1}e$ / ${}^{0}_{-1}\beta$

   (2 marks)

   c) ${}^{238}_{92}U \rightarrow {}^{234}_{92}U + {}^{4}_{2}\alpha + {}^{0}_{-1}\beta + {}^{0}_{-1}\beta$

   or ${}^{238}_{92}U \rightarrow {}^{234}_{90}X + {}^{4}_{2}\alpha$

   ${}^{234}_{90}X \rightarrow {}^{234}_{91}Y + {}^{0}_{-1}\beta$

   ${}^{234}_{91}Y \rightarrow {}^{234}_{92}U + {}^{0}_{-1}\beta$

   (3 marks)

   (Marks available: 6)

3. Six

   (1 mark)

Reflection, Refraction and Polarisation (Questions) *

1. **a)** Define the refractive index of a transparent medium.

b) Fig 1.1 shows a ray of light **X** emitted by point light source embedded in a glass block of refractive index 1.49. The angle of incidence of **X** at the glass/air surface is 30°.

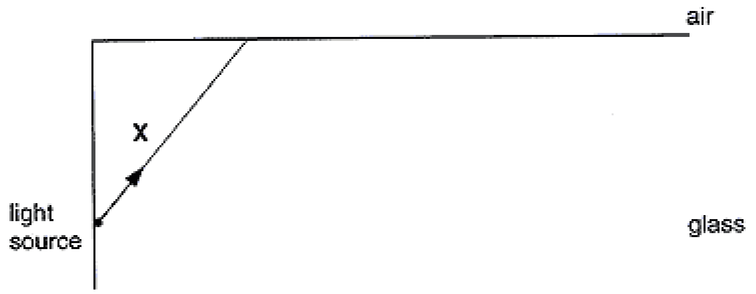


Fig. 1.1

i) Calculate the angle of refraction of **X**.

angle of refraction =________________________°

ii) Complete Fig. 1.1 to show what happens to the ray X after it is incident at the glass/air interface.

iii) Calculate the critical angle at the glass/air interface.

critical angle = ____________________°

iv) On Fig. 1.1 draw the complete path followed by another ray of light leaving the light source which reaches the glass/air interface at the critical angle (there is no need to measure the critical angle accurately but it should be labelled).

c) i) Calculate the speed of light in glass of refractive index 1.49.

speed =___________________ms^{-1}

ii) Calculate the minimum time taken for a light pulse to travel from end to end along a straight glass fibre of length 50.0km and refractive index 1.49.

time = __________________s

iii) Suggest a reason why the time taken might be slightly greater than that calculated in (ii).

(Marks available: 15)

2. A beam of light enters glass, of refractive index n = 1.5.

Calculate the speed of light in glass.

Speed of light in air = 3.0×10^8 m s^{-1}

speed = ... m s^{-1}

(2 Marks)

3. **a)** Calculate the refractive index for light passing from medium 1 to medium 2.

refractive index = ...

(2 Marks)

b) Determine the value of i that corresponds to an angle of refraction, in medium 2, of 35°.

i = ... °

(2 Marks)

(Marks available: 4)

Reflection, Refraction and Polarisation (Answers)

Answer outline and marking scheme for question:

1. **a)** Refractive Index = speed of light in air/speed of light in the medium

{Allow sin i / sin r if i and r are correctly identified e.g. on a sketch}

(1 mark)

b) i) ${}_gn_a$ =1/1.49

Correct substitution into n = sin i / sin r : sin r = 1.49 x sin 30

→ r = 48°

{If n=1.49 is used, allow 2 marks for r = 19.6 (or 19.9° i.e. 2 ecf marks)

(3 marks)

ii) REFRACTED RAY correctly drawn on Fig 1.1 (i.e. r>30°)

{allow ecf (error carried forward) from (i) for r = 19.6 °s i.e. for refracted ray bending towards the normal}

(Partially) reflected ray drawn at 30° (roughly judged by eye)

{**NB** *allow this mark if partially refected ray is showm either here or in (**iv**)*}

(2 marks)

iii) correct substitution into sin C = 1/n : sin C = 1/1.49 (1 mark)

→ C = 42°

(2 marks)

iv) Ray drawn to the right of X with C (or 42°) correctly **labelled** REFRACTED RAY along interface (1 mark)

{*ignore partially reflected ray unless mark in (b)(ii) was not gained*}

(2 marks)

c) i) recall of n = c_a/c_g OR c_g= (1/1.49) x 3.0 x 10^8

c_g= **2.01×10^8** (m/s)

(2 marks)

ii) time = dist./vel. OR t = (50 x 10^3)/(2.01 x 10^8) {allow ecf fro (i)}

= **2.49 x 10^{-4} s**

(2 marks)

iii) some light travels further because of Total Internal Reflection (WTTE)

(1 mark)

(Marks available: 15)

2. **a)** speed in glass = speed in vacuo / n (1 Mark) or numerical m ;

= 2 x 10^8 m s^{-1}(1 Mark)

(2 Marks)

b) recall of R.I = c_i /c_r OR 3.0 x 10^8 / 1.9 x 10^8

= 1.58 (R 1.6)

(2 Marks)

c) recall of R.I = sin i/sin r

sin i = sin 35° x 1.58 implies hence i = 65° (64.9 to 67)

(2 Marks)

(Marks available: 4)

Resistance (Questions)

1. Fig. 3.1 shows part of an electrical circuit.

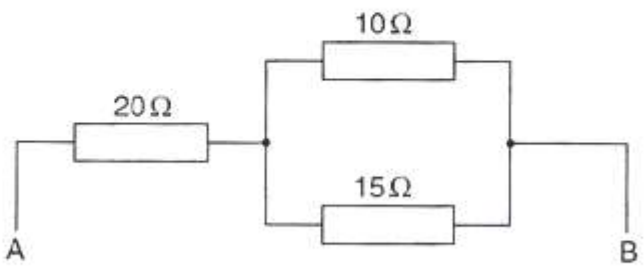


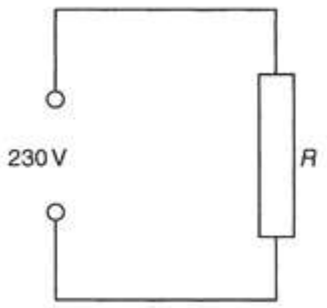
Fig. 3.1

Calculate the total resistance between A and B.

resistance = ... Ω

(Marks available: 3)

2. The heating element of an electric kettle operates at 230 V and has a power rating of 2.52 kW.



a) Calculate the working resistance R of the heating element.

working resistance = ... Ω

(2 Marks)

b) A digital multimeter is used to measure the resistance of the heating element when it is cold. The value of the resistance measured by this method is considerably lower than the working resistance.

Suggest a reason for this.

(1 Mark)

(Marks available: 3)

3. Calculate the total resistance between the points X and Y for the circuit shown in Fig. 3.1

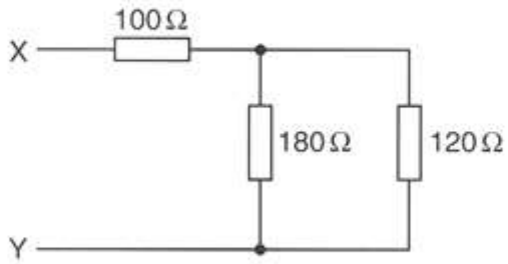


Fig. 3.1

resistance = ... Ω

(Marks available: 3)

Resistance (Answers)

Answer outline and marking scheme for question:

1. Sum of the currents = zero (at junction)OR

sum of the currents in = sum of currents out (at junction)

$$R = \frac{R_1 R_2}{R_1 + R_2} \quad \backslash \quad \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$R = \frac{10 \times 15}{10 + 15} = 6.0\ (\Omega)$$

resistance = 20 + 6 = 26 (Ω) (Possible ECF)

(3 Marks)

(Marks available: 3)

2. **a)** R = V^2 / P / I = 10.96 A (1 Mark) m ; = 21.0 Ω (1 Mark) e

(2 Marks)

b) reference to element being colder and so lower resistance AW ora (NOT it is colder)

(1 Mark)

(Marks available: 3)

$$R = \frac{R_1 R_2}{R_1 + R_2} \quad / \quad \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} \quad / \quad R = \frac{180 \times 120}{180 + 120} \quad / \quad \frac{1}{R} = \frac{1}{120} + \frac{1}{180}$$

R = 72 (Ω) (-1 for each error)

3. R_{XY} = 72 +100 = 172 (Ω) (Allow 170) (Possible ECF)

(3 Marks)

(Marks available: 3)

Simple Harmonic Motion and Damping (Questions) *

1. Fig. 2.1 shows an airtrack glider of mass 0.40 Kg held by two strecthed strings. When the glider is pulled 0.050 m to the left and released, it oscillates freely without friction.

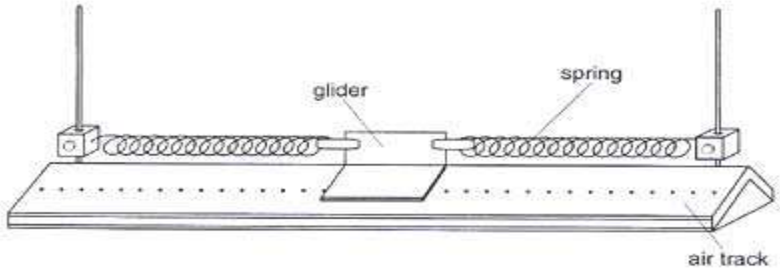


Fig. 2.1

Fig. 2.2 shows the variation of the elastic strain energy stored in the springs with the displacement x from the equilibrium posotion. Note that the strain energy is 70 mJ when the glider is not oscillating.

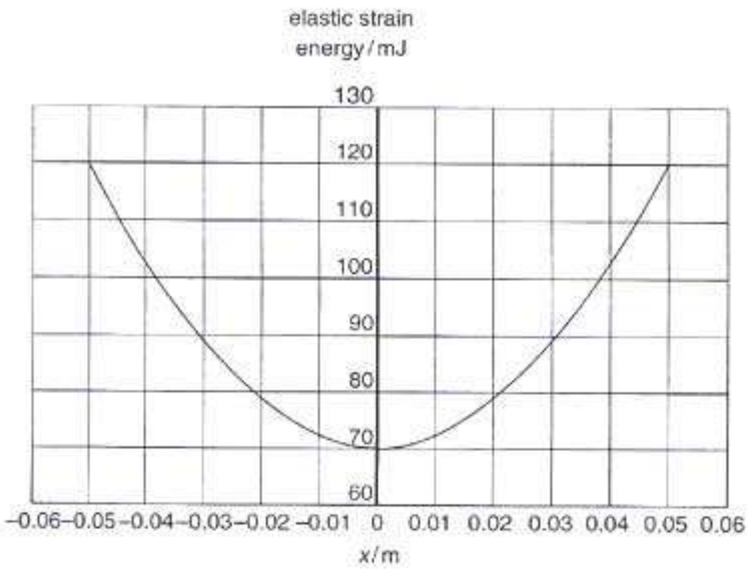


Fig. 2.2

a) Write down

i) the total energy stored in the system when oscillating .... mJ

(1 Mark)

ii) the maximum kinetic energy of the glider .... mJ

(2 Marks)

b) i) Show that the maximum speed of the glider is 0.50 ms-1.

(2 Marks)

ii) Use Fig. 2.2 or otherwaise to find the amplitude of oscillation required to halve the maximum speed of the glider. Show your reasoning.

amplitude = ... m

(2 Marks)

c) The equation of motion of the glider relating its acceleration a in m s $^{-2}$ to its displacement x in m is

a = -110 x

i) Use the equation to show that the period of ocsillation is 0.60 s.

(2 Marks)

ii) Use the data from (b)(i) and (c)(i) to sketh on Fig. 2.3 the velocity-time graph for the glider. It is released at x = 0.050 m at t = 0.

(3 Marks)

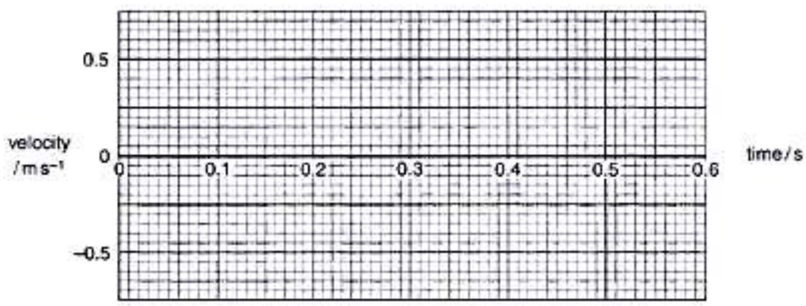


Fig. 2.3

(Marks available: 12)

2. The variation in depth of water in a harbour can be modelled as a simple harmonic oscillation.

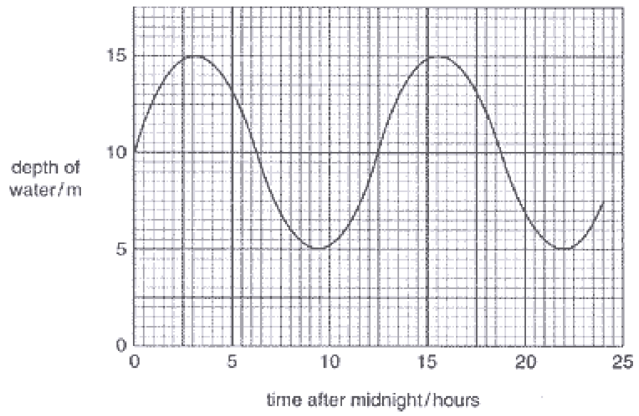


Fig. 7.1

Fig. 7.1 shows a graph produced fom the model. It shows the variation of depth of water in a harbour with time over the period of one day (24 hours).

a) Use the grpah to find

i) the maximum depth of the water in the harbour

maximum depth = ... m

(1 Mark)

ii) the amplitude A of the tidal motion

amplitude of motion = ... m

(1 Mark)

iii) the rate of change of deptg in metres per hour (m hr-1) at t = 6 hours where t = time after midnight in hours. Show your working.

rate of change in depth = ... m hr^{-1}

(3 Marks)

b) Use data from the graph to calculate the frequency f of the tidal motion in units of tides per hour

frequency = ... tides per hour

(3 Marks)

c) The equation for the depth of water d, in metres, in the harbour is

$d = 10 + A \sin(2\pi f t)$.

Use your answer to a)(ii) and this equation to show that the lowest depth of water is 5 m.

(2 Marks)

(Marks available: 10)

Simple Harmonic Motion and Damping (Answers)

Answer outline and marking scheme for question:

1. **a) i)** 120 (mJ)

(1 Mark)

ii) 120- 70 ; = 50(mJ) give 2 marks for correct answer without working

(2 Marks)

b) i) k.e. = ½ mv^2 = 50 x 10^{-3} = 0.2 V^2 (ecf from a(ii))

v^2 = 0.25 ; v = 0.5 (m s^{-1})

(2 Marks)

ii) reasoning, e.g. max energy = ½ mv^2 = ½ kA^2 so A proportional to V_m/AW;

or max ke - 12.5 mJ so total energy = 8.25 mJ, read x from graph;

giving A = 0.025 (m)

(2 Marks)

c) i) a = $4\pi^2 f^2 x$;

f^2 = 110/ $4\pi^2$ = 2.786 / f = 10.5 / 2π = 1.67 so f = 1/T = 0.6 (s)

(2 Marks)

ii) sinusoidal wave with correct period; correct amplitude correct phase accept A or -A at 0.15 s

(3 Marks)

(Marks available: 12)

2. **a) i)** Max depth = 15 m

(1 Mark)

ii) Amplitude = 5 m

(1 Mark)

iii) Gradient at t = 6 hours (1 Mark) correct reading from graph (1 Mark) answer worked to 3.0 m hr^{-1} (1 Mark) (answers in range 2.5 m hr^{-1} to 3.5 m hr^{-1})

(3 Marks)

b) time period from graph = 12.5 hrs (1 Mark) f = 1/T = 1/12.5 (1 Mark) = 0.050 hr^{-1} (1 Mark)

(3 Marks)

c) d = 10 + 5 sin (2πsin 0.080 * 9.5) (1 Mark) = 5.0 m (1 Mark) (allow ecf from a(ii) and b) or sin varies between +1 and -1 (1 Mark) so lowest value is 10-A (this allows incorrect value for A to ecf) (1 Mark)

(2 Marks)

(Marks available: 10)

Stress and Strain (Questions) *

1. **a)** Define

   i) stress

   ii) strain

   b) i) Distinguish between elastic and plastic behavior when materials are stretched.

   ii) Define elastic limit

   c) i) State the SI unit of the Young's modulus.

   unit =....................................

   ii) Describe, with the aid of a diagram, an experiment to determine the Young's modulus of steel in the form of a wire. Explain how to use your readings to obtain the Young's modulus. (You will be awarded marks for the quality of written communication in this part of the question.)

2. A wire of a length 1m and diameter of 0.4mm is hung from a ceiling. Find the extension caused in the wire, by attaching a weight of 100N, if the material of the wire has the Young's modulus (E) of 200×10^{11} Nm^{-2}.

   (Marks available: 2)

3. A kitchen freezer of total mass 300 kg (including contents) rests ona vinyl plastic floor covering.

   a) Calculate the weight of the freezer and its contents.

   $g = 9.8$ N kg^{-1}

   weight = ... N

   (1 Mark)

   b) The feet of the freezer have a total cross-sectional area of 8.0 x 10-4 m^2.

   The vinyl plastic floor covering has a compressive yield stress of 3.5 MPa.

   Show that the feet of the freezer can cause permanent damage to the vinyl plastic floor covering.

   (2 Marks)

   (Marks available: 3)

Stress and Strain (Answers)

Answer outline and marking scheme for question: 1

a) i) stress = force / (cross sectional) area

ii) strain = extension / (original) length

(2 marks)

b) i) elastic returns to its original length /shape when the force/load is removed

plastic does not regain its original length/size when the load is removed

(allow 1/2 if removal of load is not specified but remainder is clear)

(2 marks)

ii) force/stress/strain/extension beyond which the material does not return to its original length (when the load is removed)

(point beyond.... scores one only)

(2 marks)

c) i) unit: Pa / N m^{-2}

(1 mark)

ii) Any seven from:

- Appropriate arrangement drawn
- Measure length
- Apply force and measure the extension
- Take a series of readings
- Measure the diameter
- Graph of stress against strain OR force-extension graph
- Gradient for E **OR** E= stress/strain **OR** Gradient = $EA/_L$
- Point of detail e.g. second wire, micrometer used for diameter, Vernier for extension, very long wire

(7 mark)

(Marks available: 14)

Answer outline and marking scheme for question: 2

E= stress/strain.

i.e. stress/E = strain

Stress = force area =100/cross sectional area =100/(p/4)(8x10^{-4})^2 Pa = 1.99x10^8 Pa

Strain = 1.99x10^8/200x1011 = 0.995 x 10^{-3} m = 0.995mm

~1mm

Answer outline and marking scheme for question: 3

a) W = mg = 300 x 9.8 = 2490 N e

(1 Mark)

b) stress / pressure = W / A = 2490 / 8.0 x 10-4 (1 Mark) m ;

= 3.7 x 10^6 Pa (> yield stress) (1 Mark) e ; if ecf from a) gives lower than 3.5 MPa explicit comparison needed

(2 Marks)

(Marks available: 3)

Temperature and Thermal Properties (Questions) *

1. It has been suggested that drinking ice-cold water at 0°C can help weight loss because the body uses stored energy in the form of fat to warm the water up to body temperature of 37°C.

   0.5 kg of fat stores about 1.6×10^8 J of energy.

   a) Calculate the mass of ice-cold water that a person would need to drink in order to lose 0.5 kg of fat.

   Specific thermal capacity, c = 4200 J kg-1 K-1

   mass = ... kg

   (2 Marks)

   b) Give a reason why it is not sensible to drink ice-cold water in order to lose weight.

   (1 Mark)

   (Marks available: 3)

2. A can of drinking chocolate contains a chemical heating pack that releases 3.5×10^4 J of energy into drink when activated.

   Calculate the final temperature of the drink assuming no energy is lost to the can or surroundings.

   mass of drink = 0.21 kg

   specific thermal capacity of drink = 4200 J kg^{-1} K^{-1}

   initial temperature of drink = 20°C

   final temperature of drink = ... °C

   (Marks available: 3)

Temperature and Thermal Properties (Answers)

Answer outline and marking scheme for question:

1. **a)** M = Q/C.Δ θ = 1.6 x 10^8 / a 200 x 37 (1 Mark) = 1030 kg (1 Mark)

   (1000 kg to 2 sf is acceptable)

   (2 Marks)

   b) e.g. lower body temperature, you can't just do it (approx twenty times body mass), too much fluid absorbed.

   (1 Mark)

   (Marks available: 3)

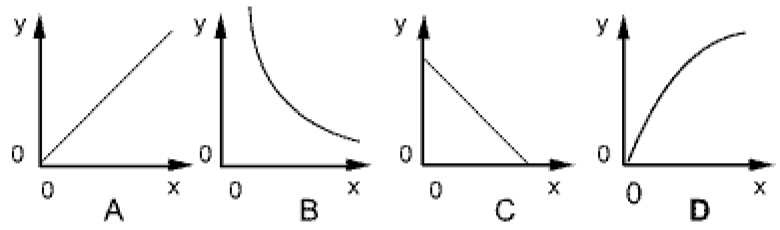
2. Δ θ = Q/ mc = 3.5 x 10^4 / 0.21 x 4200 (1 Mark) = 40°C (39.7°C) (1 Mark)

   Final temperature = 40 + 20 = 60°C (1 Mark) (59.7°C)

   (Marks available: 3)

Thermodynamics and Ideal Gases (Questions) *

1. Study the graphs **A, B, C, D**



a) Which graph shows the variation in **volume** (y) of a fixed mass of ideal gas at constant pressure with **absolute temperature** (x)?

answer ....

(1 Mark)

b) Which graph shows the variation in **pressure** (y) of a fixed mass of ideal gas at constant temperature with**volume** (x)?

answer ....

(1 Mark)

(Marks available: 2)

2. 4.0 g of helium contains one mole (6.0×10^{23} atoms). The helium is at a presure of 1.0×10^{5} Pa and at a temperature of 300 K.

a) Show that one mole of helium occupies a volume of about 0.025 m^3 under these conditions.

molar gad constant R = 8.3 J mol^{-1} K^{-1}

(2 Marks)

b) The gas is compressed to volume of 0.020 m^3. The temperature of the gas is kept constant.

Calculate the new pressure of the gas.

pressure = ... pA

(2 Marks)

(Marks available: 4)

3. Two students attempt the same experiment to find how air pressure varies with temperature. They heat identical sealed glass flasks of air, to be considered as an ideal gas, in an oil bath. The flasks are heated from 300 K to 400 K. The pressure in flask A rises from atmospheric presure, p_o, as expected, but the pressure in flask B remains at $p_o$because the rubber bung is defective and air leaks out of the flask.

a) Calculate the pressure in flask A at 400 K in terms of p_o.

pressure = ...

(2 Marks)

b) Calculate the fraction, f, of gas molecules in flask B compared to flask A at 400 K.

$$f = \frac{\text{number of gas molecule in B at 400 K}}{\text{number of gas molecule in A at 400 K}}$$

f = ...

(2 Marks)

(Marks available: 4)

Thermodynamics and Ideal Gases (Answers)

Answer outline and marking scheme for question: 1

a) answer ....A..................

(1 Mark)

b) answer ....B..................

(1 Mark)

(Marks available: 2)

Answer outline and marking scheme for question: 2

a) pV = nRT (1 Mark) -> V = nRT/p = 1 x 8.31 x 300 / 1.0 x 10^5 (1 Mark) = 0.0249 m^3

(can work backwards or use pV = nKt)

(2 Marks)

b) 1.0 X 10^5 X 0.025 = P_2 X 0.020 (1 Mark) p_2 = 1.3 x 10^5 Pa (1 Mark) (accept 1.25 x 10^5)

candidates can use their answers to 5 a) (ecf) (e.g. 1.2 x 10^5 if 0.0249 used).

(2 Marks)

(Marks available: 4)

Answer outline and marking scheme for question: 3

a) p/T = constant / AW; $p/p_o = T_1/T_o$ = 400/300 giving p = 1.33 p_o

(2 Marks)

b) use of n = pV/RT / n (proportional to) p / N (proportional to) p / f = $(N_B/N_A) = n_B/n_A = p_o/p$

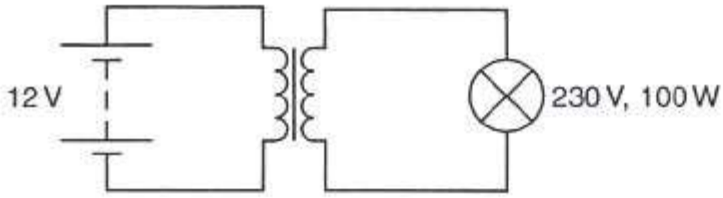
= ¾ or 0.75 ecf from c(i)

(2 Marks)

(Marks available: 4)

Transformers and Rectification (Questions)

1. A transformer cannot be used to run a 230 V, 100 W mains lamp directly from a 12 V car battery.



Which **one** of the following is the correct reason for this?

a) The internal resistance of the battery will not allow enough current in the primary coil.

b) Eddy currents in the iron core will heat up the iron core.

c) The current from the battery will produce a steady flux in the secondary coil.

answer...........

(1 Mark)

2. An alternating supply delivers a current of 0.025 A at 12 V to the primary coil of a transformer. A 20 Ω resistor is connected to the secondary coil.

a) The current in the secondary circuit is 0.110 A.

the power input

power input = ... W

(1 Mark)

the power output

power output = ... W

(2 Marks)

the efficiency

efficiency = ... %

(2 Marks)

b) The frequency of the supply is increased. The power input is kept constant. The current in the secondary coil falls to 0.105 A.

Calculate the new efficiency of the transformer.

efficiency = ... %

(2 Marks)

(Marks available: 7)

Transformers and Rectification (Answers)

Answer outline and marking scheme for question:

1. answer.....**C**.....

   C The current from the battery will produce a steady flux in the secondary coil.

   (1 Mark)

2. **a)** power input = 0.025 x 12 = 0.30 W

   (1 Mark)

   power output = I^2R

   = 0.110^2 x 20 = 0.242 W

   (2 Marks)

   efficiency = (output power / input power) x 100

   = 0.242 / 0.30 x 100 = 80.7 % (e.c.f)

   (2 Marks)

   b) New efficiency = (0.1052 x 20 / 0.03) x 100

   = 73.5 % (e.c.f)

   (2 Marks)

   (Marks available: 7)

Units, Quantities and Measurements (Questions) *

1. Here is a list of five units for physical quantites.

   kgm^{-3}

   Nm^{-2}

   Cs^{-1}

   Ω m

   Ws

   From the list

   a) write down the unit for electrical current ....

   b) write down the unit for mechanical stress ....

   (2 Marks)

   (Marks available: 2)

2. Here is a list of five units

   J

   N

   Jkg^{-2}

   Nkg^{-1}

   From the list write down the correct unit for

   a) the energy stored in a stretched spring ....

   b) centripetal force ....

   (Marks available: 2)

3. The acceleration, a, of a body in simple harmonic motion is given by:

   $a = -(2\pi f)^2 x$

   Where f if frequency of the oscillation and x is the displacement.

   Show that the right hand side of the equation has the units of acceleration.

   (Marks available: 2)

Units, Quantities and Measurements (Answers)

Answer outline and marking scheme for question: 1

a) Cs^{-1}

b) $N\ m^{-2}$

(2 Marks)

(Marks available: 2)

Answer outline and marking scheme for question: 2

a) the energy stored in a stretched spring ....J...

b) centripetal force ....N.......

(Marks available: 2)

Answer outline and marking scheme for question: 3

Unit of f^2 is s^{-2} (1 Mark) or f is s^{-1} (unit of x is m therefore)

combined unit is m s^{-2} (which is the uni of acceleration) (1 Marks)

(Marks available: 2 Marks)

Vectors and Scalars and Linear Motion (Questions) *

1. Fig. 1.1 shows a table of vector and scalar quantities.

speed, acceleration	
energy, power	
force, pressure	
velocity, displacement	

Fig. 1.1

In the blank spaces provided in Fig. 1.1, label the pair of quantities that are both vectors with a V and the pair that are both scalars with an S

(Marks available: 2)

2. **a)** Fig. 4.1 shows a car of mass 1200 kg, pulling a caravan of mass 400 kg along a horizontal road.

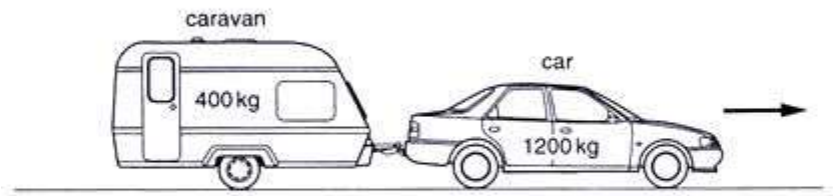


Fig. 4.1

Fig. 4.2 shows the variation with time t of the velocity v of the car as it accelerates from rest.

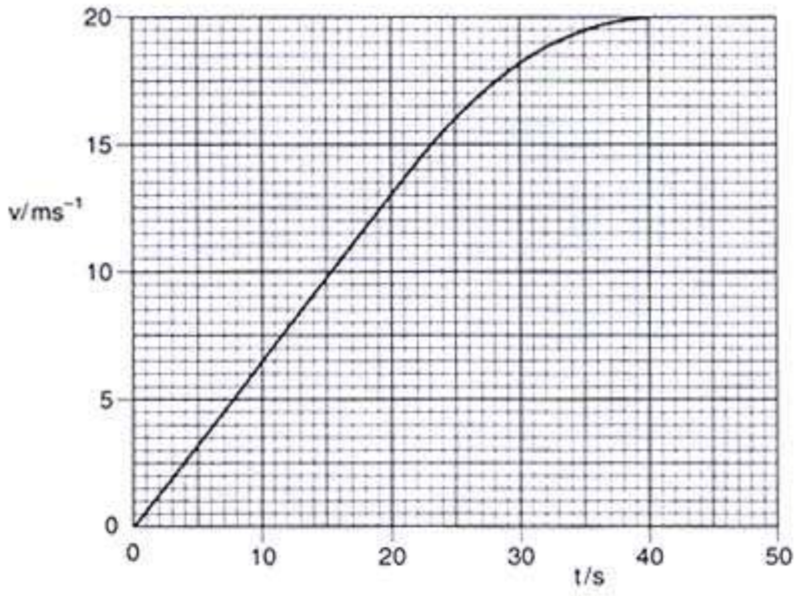


Fig. 4.2

Calculate, for the first 20s of the journey:

i) the acceleration of the car

acceleration = ... m s^{-1}

(2 Marks)

ii) the resultant force acting on the car

resultant force on the car = ... N

(2 Marks)

iii) the resultant force acting on the caravan

resultant force on the caravan = ... N

(2 Marks)

b) i) Use the graph in Fig. 4.2 to describe how the acceleration changes **after** the first 20 s of the journey.

(1 Mark)

ii) Suggest a possible reason for this change.

(1 Mark)

c) Fig. 2.1 shows a boy on a sledge travelling down a slope. The boy and sledge have a total mass of 60 kg and are travelling at a constant speed. The angle of the slope to the horizontal is 35°. All the forces acting on the boy and sledge are shown on Fig. 2.1 and in a force diagram in Fig. 2.2.

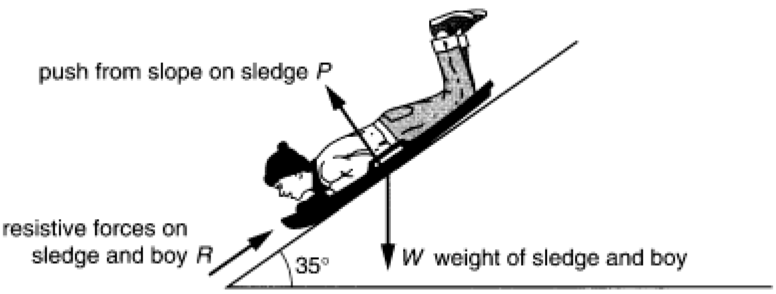


Fig. 2.1

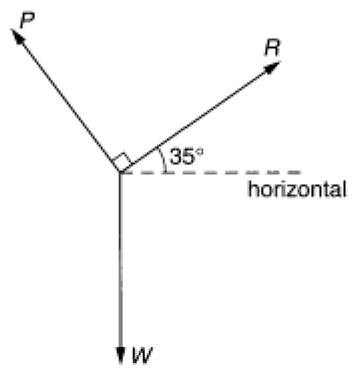


Fig. 2.2

i) Calculate the magnitude of W, the total weight of the boy and sledge.

weight W = ... N

(1 Mark)

ii) Determine the magnitude of the resistive force R. You may find it helpful to draw a vector triangle.

resistive force R = ... N

(4 Marks)

iii) Determine the component of the weight W that acts perpendicular to the slope.

component of W = ... N

(2 Marks)

iv) State and explain why the boy travelling at constant speed even though he is moving down a slope.

(2 Marks)

(Marks available: 17)

Vectors and Scalars and Linear Motion (Answers)

Answer outline and marking scheme for question: 1

speed, acceleration

energy, power S

force, pressure

velocity, displacement V

(Marks available: 2)

Answer outline and marking scheme for question: 2

a) i) Acceleration = **13 / 20** or gradient attempted

= 0.65 (m s^{-2}) ± 0.01

(2 Marks)

ii) force = ma / 1200 x 0.65 ecf (b)(i)

= 780 (N)

(2 Marks)

iii) force = 400 x 0.65 ecf (b)(i)

= 260 N

(2 Marks)

b) i) (gradient is less hence) acceleration is less / reaches terminal velocity

(1 Mark)

ii) resultant force is less / resistive forces are increasing / driver eases off the accelerator / climbing a hill

(1 Mark)

c) i) weight = 60 x 9.81 (9.8 allowed, 10 not allowed)

= 589 (N) (590 allowed)

(1 Mark)

ii) Point for correct shape triangle/link given between **R** and the component of the weight down the slope e.g. R = Wcos55

Point for scale given / working shown

Point for resistive force **R = 340** (N) (± 20 (N) for scale diagram)

(4 Marks)

iii) Component of **W = 589 cos 35**

= 482 (N) (480 allowed)

(or from triangle and = -P)

If the answers are reversed in b) and c) then -1 points

(2 Marks)

iv) Resultant force is zero (so no acceleration) / in equilibrium force up the slope equals force down the slope

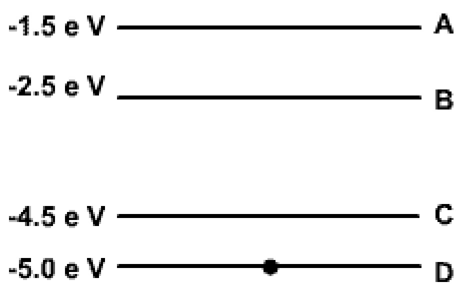
(restrictive force up slope = component of W down slope scores two)

(2 Marks)

(Marks available: 17)

Wave Particle Duality and Electron Energy Levels (Questions)

1. The diagram show part of the energy level diagram for an atom.



There are four energy levels, labelled **A, B, C** and **D**. The atom is initially in energy level **D**. An electron of energy 3.0 eV collides with the atom. This causes the atin to change energy.

a) i) If the collision raises the atom to energy level **B**, how much energy is the colliding electron left with?

energy = ... eV

(1 Mark)

ii) Which energy level (**A, B** or **C**) will the atom definitely **not** be in after the collision?

energy level = ...

(1 Mark)

(Marks available: 2)

2. The kinetic eneryg of the electron in a ground state hydrogen atom is $+2.2 \times 10^{-18}$ J.

a) Show that this suggests an electron momentum of 2.0×10^{-24} kg m s^{-1}.

me = 9.1×10^{-31} kg

(3 Marks)

b) Show that the de Broglie wavelength for an electron with this momentum is about 3×10^{-10} m.

h = 6.6×10^{-34} J s.

(2 Marks)

((Marks available: 5)

3. In 1924, Prince Louis de Broglie suggested that all moving particles demonstrate wave-like behaviour.

   a) State the de Broglie equation and define all the symbols.

   (2 Marks)

   b) Neutrons may be used to study the atomic structure of matter. Diffraction effects are noticeable when the de Broglie wavelength of the neutrons is comparable to the spacing between the atoms. This spacing is typically 2.6×10^{-10} m.

   i) Suggest why using neutrons may be preferable to using electrons when investigating matter.

   (1 Mark)

   ii) Calculate the speed v of a neutron having a de Broglie wavelength of 2.6×10^{-10} m. The mass of a neutron is 1.7×10^{-27} kg.

   v = ... m s^{-1}

   (3 Marks)

   (Marks available: 6)

Wave Particle Duality and Electron Energy Levels (Answers)

Answer outline and marking scheme for question:

1. **a)** 3.0 - 2.5 = 0.5 eV

   (1 Mark)

   b) A

   (1 Mark)

   (Marks available: 2)

2. **a)** p = mv

   $v = 2.0 \times 10^{-24} / 9.1 \times 10^{-31} = 2.2 \times 10^{6}$ m s^{-1}

   $Ek = 0.5mv^2 = 0.5 \times 9.1 \times 10^{-31} \times (2.2 \times 10^{6})^2$

   $(= 2.2 \times 10^{-18}$ J)

   (3 Marks)

   b) λ = h/p

   $\lambda = 6.6 \times 10^{-34} / 2.0 \times 10^{-24} = 3.3 \times 10^{-10}$ m

   (2 Marks)

   (Marks available: 5)

3. **a)**

   $$\lambda = \frac{h}{mv} \quad / \quad \lambda = \frac{h}{p}$$

   λ = wavelength, h = Planck constant,

   m = mass (of particle) and v = speed / velocity OR p = momentum

(2 Marks)

b) i) Neutrons have no charge / Neutrons experiences no electrical forces (ora)

(1 Mark)

ii) $2.6 \times 10^{-10} = 6.63 \times 10^{-34} / mv$ / $mv = 2.55 \times 10^{-24}$ ($kgms^{-1}$)

$v = 6.63 \times 10^{-34} / (2.6 \times 10^{-10} \times 1.7 \times 10^{-27})$ / $v = 2.55 \times 10^{-24} / 1.7 \times 10^{-27}$

$v = 1.5 \times 10^{3}$ (ms^{-1}) (Allow uae of $m_n = 1.67 \times 10^{-27}$ kg)

(3 Marks)

(Marks available: 6)

Work, Energy and Efficiency (Questions) *

1. The front of a lorry can be considered a flat vertical surface of area $8.0 m^2$. The average pressure due to air resistance is 150 Pa when the lorry travels at a constant speed of $16 m s^{-1}$. You may assume the air resistance force acts perpendicular to the front of the lorry. When the lorry travels at $16 m s^{-1}$.

   a) calculate the force due to the air resistance

   force due to air resistance = ... N

   (2 Marks)

   b) calculate the power dissipated in overcoming the air resistance.

   power = ... W

   (3 Marks)

   c) State and explain how the values of the quantities calculated above would change if the lorry increased its speed.

   (3 Marks)

   (Marks available: 8)

2. Fig. 4.1 shows part of a fairground ride with a carriage on rails.

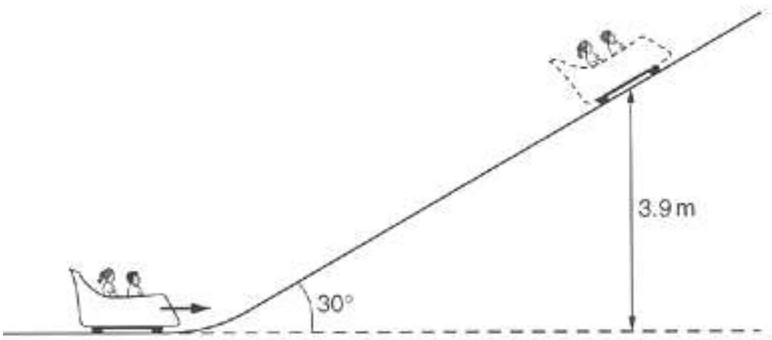


Fig. 4.1

The carriage of mass 500 kg is travelling towards a slope inclined at 30° to the horizontal. The carriage has a kinetic energy of 25 kJ at the bottom of the slope. The carriage comes to rest after travelling up the slope to a vertical height of 3.9 m.

a) Show that the potential energy gained by the carriage is 19 kJ.

(2 Marks)

b) Calculate the work done against the resistive forces as the carriage moves up the slope.

work done = ... kJ

(1 Mark)

c) Calculate the resistive force acting against the carriage as it moves up the slope.

resistive force = ... N

(3 Marks)

(Marks available: 6)

Work, Energy and Efficiency (Answers)

Answer outline and marking scheme for question:

1. **a)** force = pressure x area / 150 x 8

= 1200 (N)

(2 Marks)

b) power = F x v

= 1200 x 16 ecf

= 19200 (W)

(3 Marks)

c) (force greater as) air resistance is greater explanation of why: correct quantification, air resistance proportional to v or v^2 or in terms of molecules harder collisions or increased rate of collision.

power greater as force is greater

power greater as velocity is greater

(3 Marks)

(Marks available: 8)

2. **a)** potential energy = mgh / weight x height

= 500 x 9.81 x 3.9

= 19. (130) (kJ).

(2 Marks)

b) work done = 25 - 19

= 6 (5.870) (kJ)

(1 Mark)

c) distance up the slope = 7.8m

work done = force x distance

force = 5870 / 7.8

= 753 (N) (769 N if 6000 J is used)

(3 Marks)

(Marks available: 6)