R2019_2 *[106 marks]*

1. An object is projected vertically upwards at time *t* = 0. Air resistance is negligible. The object passes the same point above its starting position at times 2 s and 8 s. *[1 mark]*

   If g = 10 m s^{-2}, what is the initial speed of the object?

   A. 50

   B. 30

   C. 25

   D. 4

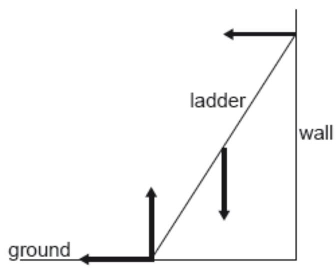
Markscheme

A

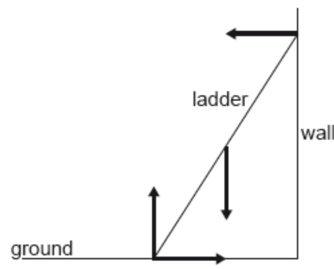
---

2. A uniform ladder resting in equilibrium on rough ground leans against a smooth wall. Which diagram correctly shows the forces acting on the ladder? *[1 mark]*

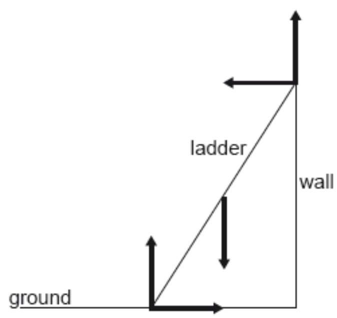
A.



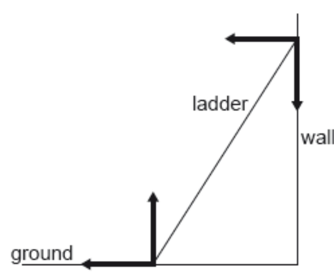
B.



C.



D.



Markscheme

B

3. An object falls from rest from a height h close to the surface of the Moon. The Moon has no atmosphere. *[1 mark]*

When the object has fallen to height $\frac{h}{4}$ above the surface, what is

$$\frac{\text{kinetic energy of the object at } \frac{h}{4}}{\text{gravitational potential energy of the object at } h}?$$

A. $\frac{3}{4}$

B. $\frac{4}{3}$

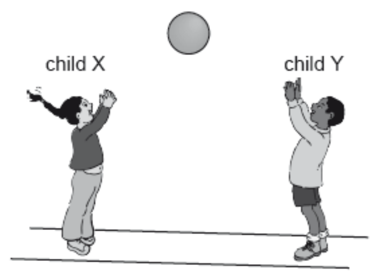
C. $\frac{9}{16}$

D. $\frac{16}{9}$

Markscheme

A

4. Child X throws a ball to child Y. The system consists of the ball, the children and the Earth. What is true for the system when the ball has been caught by Y? *[1 mark]*



[Source: https://pixabay.com/en/playing-ball-kids-boy-girl-31339/]

A. The momentum of child Y is equal and opposite to the momentum of child X.

B. The speed of rotation of the Earth will have changed.

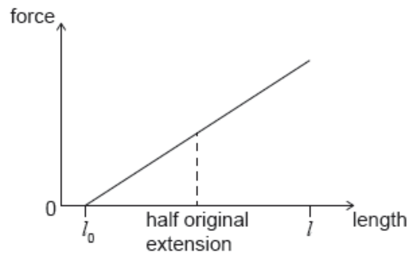
C. The ball has no net momentum while it is in the air.

D. The total momentum of the system has not changed.

Markscheme

D

5. An increasing force acts on a metal wire and the wire extends from an initial length l_0 to a new length l. The graph shows the variation of force with length for the wire. The energy required to extend the wire from l_0 to l is E. *[1 mark]*



The wire then contracts to half its original extension.

What is the work done by the wire as it contracts?

A. 0.25 E

B. 0.50 E

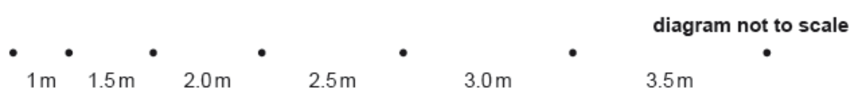
C. 0.75 E

D. E

Markscheme

C

6. The distances between successive positions of a moving car, measured at equal time intervals, are shown. *[1 mark]*



The car moves with

A. acceleration that increases linearly with time.

B. acceleration that increases non-linearly with time.

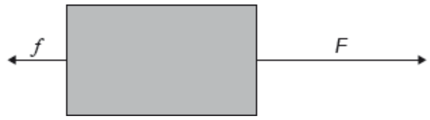
C. constant speed.

D. constant acceleration.

Markscheme

D

7. An object is moving in a straight line. A force *F* and a resistive force *f* act on the object along the straight line. *[1 mark]*



Both forces act for a time *t*.

What is the rate of change of momentum with time of the object during time *t* ?

A. $F + f$

B. $F - f$

C. $(F + f)t$

D. $(F - f)t$

Markscheme

B

8. A motor of input power 160 W raises a mass of 8.0 kg vertically at a constant speed of 0.50 m s^{-1}. *[1 mark]*

What is the efficiency of the system?

A. 0.63%

B. 25%

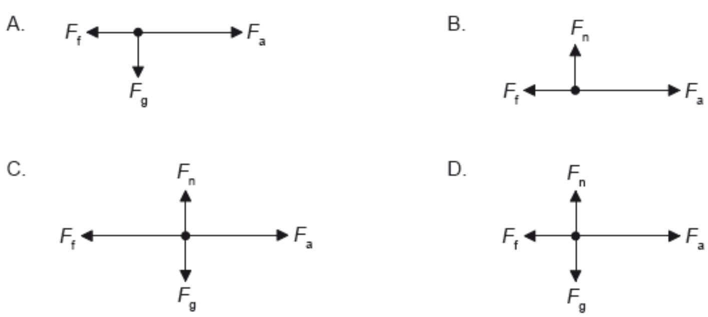
C. 50%

D. 100%

Markscheme

B

9. A box is accelerated to the right across rough ground by a horizontal force F_a. The force of friction is F_f. The weight of the box is F_g and the normal reaction is F_n. Which is the free-body diagram for this situation? *[1 mark]*

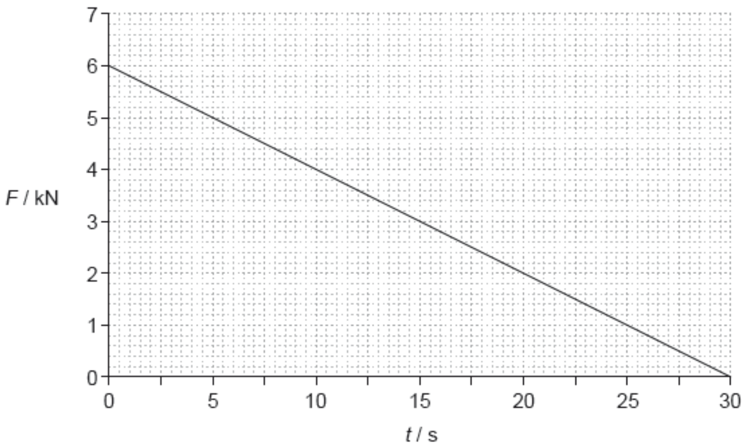


Markscheme

D

10. The graph shows the variation with time t of the force F acting on an object of mass 15 000 kg. *[1 mark]*

The object is at rest at $t = 0$.



What is the speed of the object when $t = 30$ s?

A. 0.18 m s^{-1}

B. 6 m s^{-1}

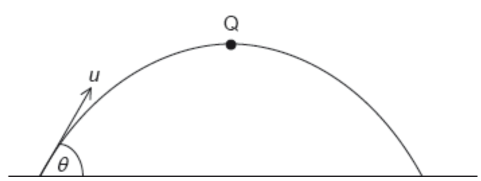
C. 12 m s^{-1}

D. 180 m s^{-1}

Markscheme

B

11. A ball of mass m is thrown with an initial speed of u at an angle θ to the horizontal as shown. Q is the highest point of the motion. Air resistance is negligible. *[1 mark]*



What is the momentum of the ball at Q?

A. zero

B. $mu \cos\theta$

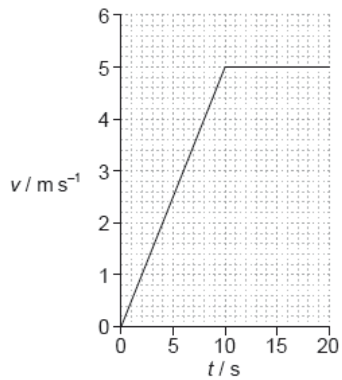
C. mu

D. $mu \sin\theta$

Markscheme

B

12. A boy runs along a straight horizontal track. The graph shows how his speed *v* varies with time *t*. *[1 mark]*



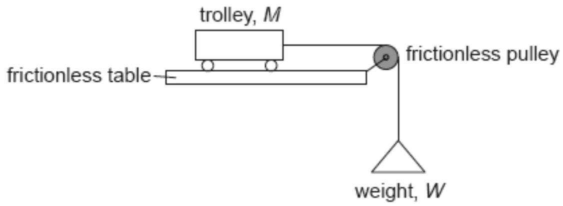
After 15 s the boy has run 50 m. What is his instantaneous speed and his average speed when *t* = 15 s?

	Instantaneous speed / m s^{-1}	Average speed / m s^{-1}
A.	3.3	3.3
B.	3.3	5.0
C.	5.0	3.3
D.	5.0	5.0

Markscheme

C

13. A weight *W* is tied to a trolley of mass *M* by a light string passing over a frictionless pulley. The trolley has an acceleration *a* on a frictionless table. The acceleration due to gravity is *g*. *[1 mark]*



What is *W* ?

A. $\frac{Mag}{(g-a)}$

B. $\frac{Mag}{(g+a)}$

C. $\frac{Ma}{(g-a)}$

D. $\frac{Ma}{(g+a)}$

Markscheme

A

---

14. Two balls X and Y with the same diameter are fired horizontally with the same initial momentum from the same height above the ground. The mass of X is greater than the mass of Y. Air resistance is negligible. *[1 mark]*

What is correct about the horizontal distances travelled by X and Y and the times taken by X and Y to reach the ground?

	Horizontal distances	Time to reach ground
A.	X and Y the same	X and Y times the same
B.	X and Y the same	X takes a shorter time than Y
C.	X less than Y	X and Y times the same
D.	X less than Y	X takes a shorter time than Y

Markscheme

C

---

15. A parachutist of total mass 70 kg is falling vertically through the air at a constant speed of 8 m s^{-1}. *[1 mark]*

What is the total upward force acting on the parachutist?

A. 0 N

B. 70 N

C. 560 N

D. 700 N

Markscheme

D

16. A stopper of mass 8 g leaves the opening of a container that contains pressurized gas.The stopper accelerates from rest for a time of 16 ms and leaves the container at a speed of 20 m s^{-1}. *[1 mark]*

What is the order of magnitude of the force acting on the stopper?

A. 10^{-3} N

B. 10^{0} N

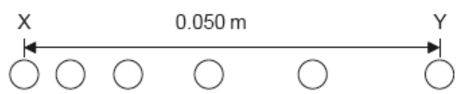
C. 10^{1} N

D. 10^{3} N

Markscheme

C

17. A ball starts from rest and moves horizontally. Six positions of the ball are shown at time intervals of 1.0 ms. The horizontal distance between X, the initial position, and Y, the final position, is 0.050 m. *[1 mark]*



What is the average acceleration of the ball between X and Y?

A. 2000 m s^{-2}

B. 4000 m s^{-2}

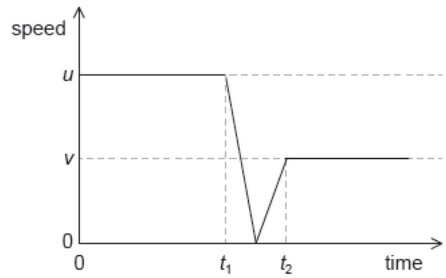
C. 5000 m s^{-2}

D. 8000 m s^{-2}

Markscheme

B

18. A ball of mass m collides with a vertical wall with an initial horizontal speed u and rebounds with a horizontal speed v. The graph shows the variation of the speed of the ball with time. *[1 mark]*



What is the magnitude of the mean net force on the ball during the collision?

A. $\frac{m(u-v)}{(t_2+t_1)}$

B. $\frac{m(u-v)}{(t_2-t_1)}$

C. $\frac{m(u+v)}{(t_2+t_1)}$

D. $\frac{m(u+v)}{(t_2-t_1)}$

Markscheme

D

19. The variation of the displacement of an object with time is shown on a graph. What does the area under the graph represent? *[1 mark]*

A. No physical quantity

B. Velocity

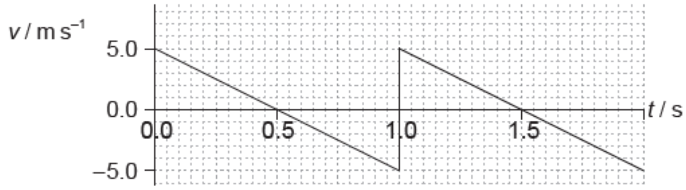
C. Acceleration

D. Impulse

Markscheme

A

20. An object is thrown upwards. The graph shows the variation with time *t* of the velocity *v* of the object. *[1 mark]*



What is the total displacement at a time of 1.5 s, measured from the point of release?

A. 0 m

B. 1.25 m

C. 2.50 m

D. 3.75 m

Markscheme

B

21. An object is released from a stationary hot air balloon at height *h* above the ground. *[1 mark]*

An identical object is released at height *h* above the ground from another balloon that is rising at constant speed. Air resistance is negligible. What does **not** increase for the object released from the rising balloon?

A. The distance through which it falls

B. The time taken for it to reach the ground

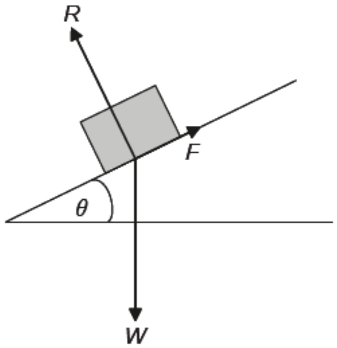
C. The speed with which it reaches the ground

D. Its acceleration

Markscheme

D

22. The diagram shows the forces acting on a block resting on an inclined plane. The angle θ is adjusted until the block is just at the point of sliding. R is the normal reaction, W the weight of the block and F the maximum frictional force. *[1 mark]*



not to scale

What is the maximum coefficient of static friction between the block and the plane?

A. sin θ

B. cos θ

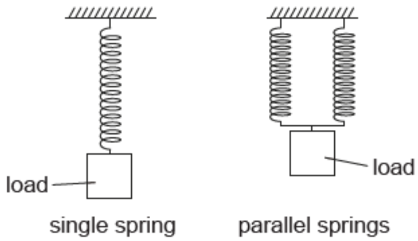
C. tan θ

D. $\frac{1}{\tan\theta}$

Markscheme

C

23. A system that consists of a single spring stores a total elastic potential energy E_p when a load is added to the spring. Another identical spring connected in parallel is added to the system. The same load is now applied to the parallel springs. *[1 mark]*



What is the total elastic potential energy stored in the changed system?

A. E_p

B. $\frac{E_p}{2}$

C. $\frac{E_p}{4}$

D. $\frac{E_p}{8}$

Markscheme

B

24. A moving system undergoes an explosion. What is correct for the momentum of the system and the kinetic energy of the system when they are compared immediately before and after the explosion? *[1 mark]*

	Momentum	Kinetic energy
A.	conserved	increased
B.	conserved	conserved
C.	increased	conserved
D.	increased	increased

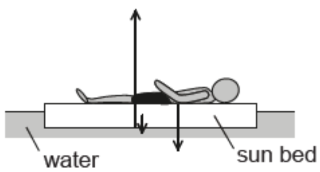
Markscheme

A

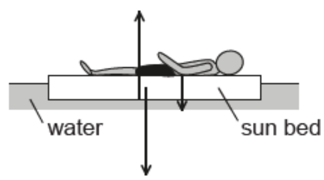
---

25. A sunbather is supported in water by a floating sun bed. Which diagram represents the magnitudes of the forces acting on the sun bed? *[1 mark]*

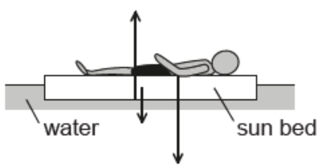
A.



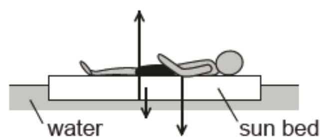
B.



C.



D.



Markscheme

D

---

26. A toy car of mass 0.15 kg accelerates from a speed of 10 cm s^{-1} to a speed of 15 cm s^{-1}. What is the impulse acting on the car? *[1 mark]*

A. 7.5 mN s

B. 37.5 mN s

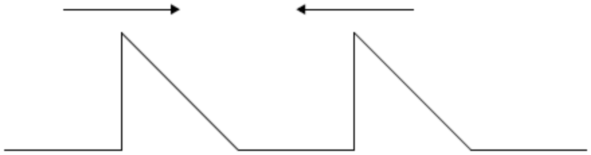
C. 0.75 N s

D. 3.75 N s

Markscheme

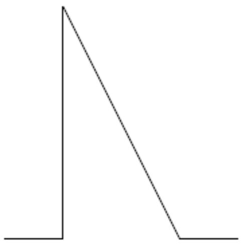
A

27. Two pulses are travelling towards each other. *[1 mark]*

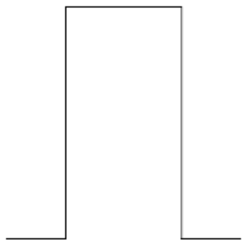


What is a possible pulse shape when the pulses overlap?

A.

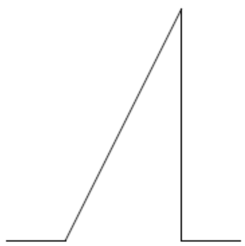


B.



C.

D.



Markscheme

A

---

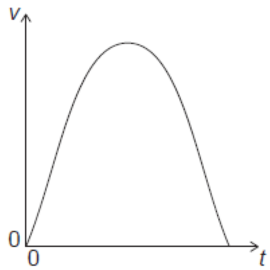
28. An object is released from rest in the gravitational field of the Earth. Air resistance is negligible. How far does the object move during the fourth second of its motion? *[1 mark]*

A. 15 m
B. 25 m
C. 35 m
D. 45 m

Markscheme

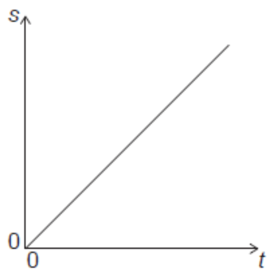
C

29. The graph shows the variation of speed v of an object with time t. *[1 mark]*

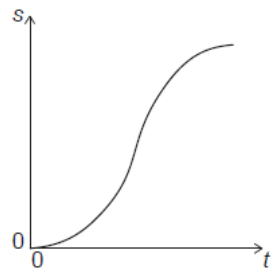


Which graph shows how the distance s travelled by the object varies with t?

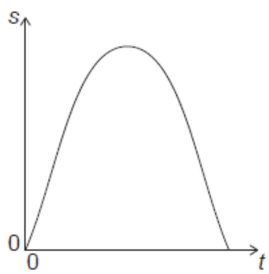
A.



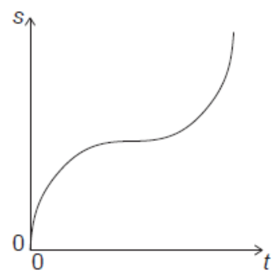
B.



C.



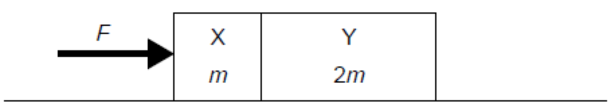
D.



Markscheme

B

30. Two boxes in contact are pushed along a floor with a force F. The boxes move at a constant speed. Box X has a mass m and box Y has a mass $2m$. *[1 mark]*



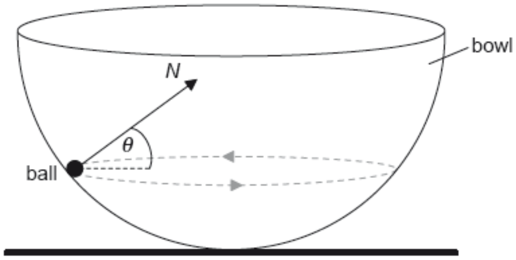
What is the resultant force acting on Y?

A. 0
B. $\frac{F}{2}$
C. F
D. $2F$

Markscheme

A

A small ball of mass m is moving in a horizontal circle on the inside surface of a frictionless hemispherical bowl.



The normal reaction force N makes an angle θ to the horizontal.

31a. State the direction of the resultant force on the ball. *[1 mark]*

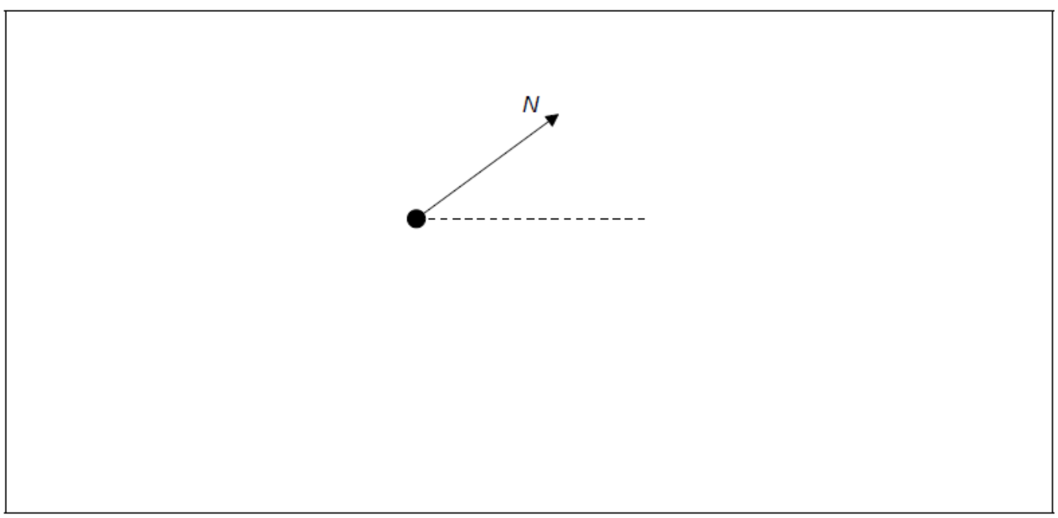
Markscheme

towards the centre «of the circle» / horizontally to the right

Do not accept towards the centre of the bowl

[1 mark]

31b. On the diagram, construct an arrow of the correct length to represent the weight of the ball. *[2 marks]*



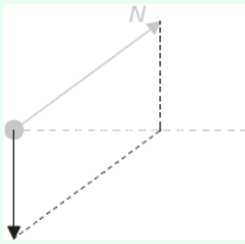
Markscheme

downward vertical arrow of any length

arrow of correct length

Judge the length of the vertical arrow by eye. The construction lines are not required. A label is not required

eg:



[2 marks]

31c. Show that the magnitude of the net force *F* on the ball is given by the following equation. *[3 marks]*

$$F = \frac{mg}{\tan\theta}$$

Markscheme

ALTERNATIVE 1

$F = N\cos\theta$

$mg = N\sin\theta$

dividing/substituting to get result

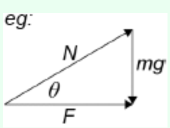
ALTERNATIVE 2

right angle triangle drawn with *F*, *N* and *W/mg* labelled

angle correctly labelled and arrows on forces in correct directions

correct use of trigonometry leading to the required relationship

eg:



$\tan\theta = \frac{O}{A} = \frac{mg}{F}$

[3 marks]

31d. The radius of the bowl is 8.0 m and $\theta = 22°$. Determine the speed of the ball. *[4 marks]*

Markscheme

$\frac{mg}{\tan\theta} = m\frac{v^2}{r}$

$r = R\cos\theta$

$v = \sqrt{\frac{gR\cos^2\theta}{\sin\theta}} / \sqrt{\frac{gR\cos\theta}{\tan\theta}} / \sqrt{\frac{9.81\times8.0\cos22}{\tan22}}$

v = 13.4/13 «ms^{-1}»

Award ***[4]*** *for a bald correct answer*

Award ***[3]*** *for an answer of 13.9/14 «ms^{-1}». MP2 omitted*

[4 marks]

31e. Outline whether this ball can move on a horizontal circular path of radius equal to the radius of the bowl. *[2 marks]*

Markscheme

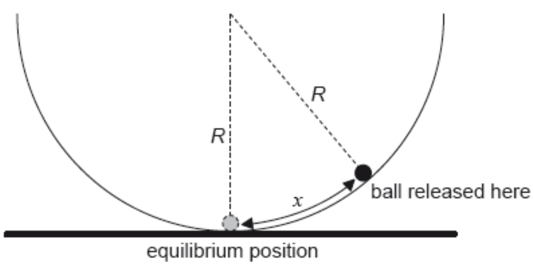
there is no force to balance the weight/N is horizontal

so no / it is not possible

Must see correct justification to award MP2

[2 marks]

The ball is now displaced through a small distance x from the bottom of the bowl and is then released from rest.



The magnitude of the force on the ball towards the equilibrium position is given by

$$\frac{mgx}{R}$$

where R is the radius of the bowl.

31f. Outline why the ball will perform simple harmonic oscillations about the equilibrium position. *[1 mark]*

Markscheme

the «restoring» force/acceleration is proportional to displacement

Direction is not required

[1 mark]

31g. Show that the period of oscillation of the ball is about 6 s. *[2 marks]*

Markscheme

ω = «

$\sqrt{\frac{g}{R}}$» = $\sqrt{\frac{9.81}{8.0}}$ «= 1.107 s^{-1}»

T = «

$\frac{2\pi}{\omega}$ =

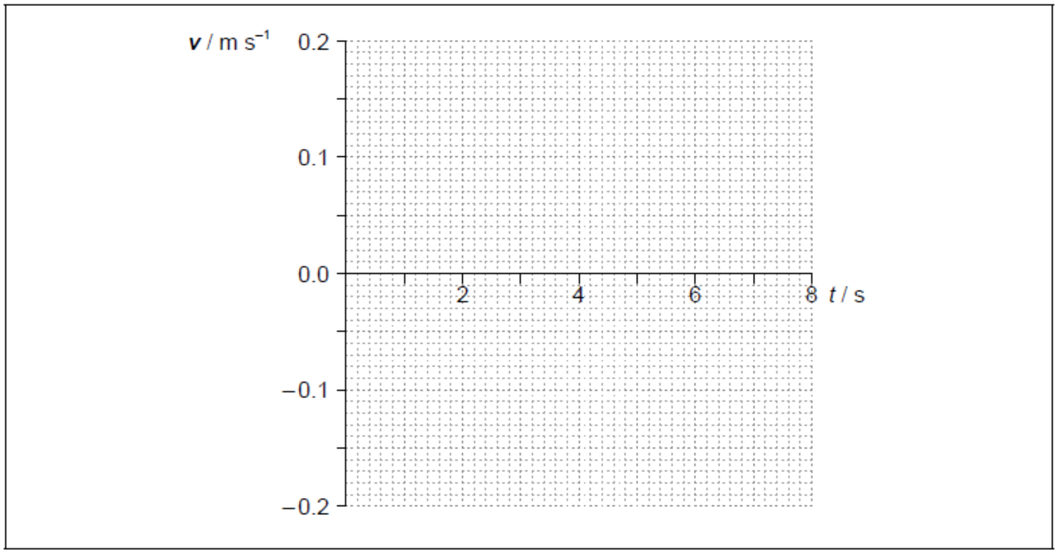
$\frac{2\pi}{1.107}$ =» 5.7 «s»

Allow use of or *g = 9.8 or 10*

Award ***[0]*** *for a substitution into T = 2π*$\sqrt{\frac{l}{g}}$

[2 marks]

31h. The amplitude of oscillation is 0.12 m. On the axes, draw a graph to show the variation with time *t* of the velocity ***v*** of the ball during one period. *[3 marks]*



Markscheme

sine graph

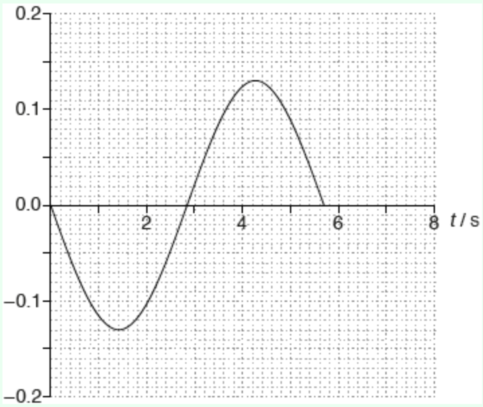
correct amplitude «0.13 m s^{-1}»

correct period and only 1 period shown

Accept ± sine for shape of the graph. Accept 5.7 s or 6.0 s for the correct period.

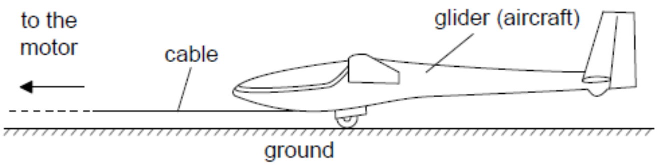
Amplitude should be correct to $\pm\frac{1}{2}$ square for MP2

eg: v /m s^{-1}



[3 marks]

A glider is an aircraft with no engine. To be launched, a glider is uniformly accelerated from rest by a cable pulled by a motor that exerts a horizontal force on the glider throughout the launch.



32a. The glider reaches its launch speed of 27.0 m s^{-1} after accelerating for 11.0 s. Assume that the glider moves horizontally until it leaves the ground. Calculate the total distance travelled by the glider before it leaves the ground. *[2 marks]*

Markscheme

correct use of kinematic equation/equations

148.5 ***or*** 149 ***or*** 150 «m»

Substitution(s) must be correct.

32b. The glider and pilot have a total mass of 492 kg. During the acceleration the glider is subject to an average resistive force of 160 N. Determine the average tension in the cable as the glider accelerates. *[3 marks]*

Markscheme

$a = \frac{27}{11}$ ***or*** 2.45 «m s^{-2}»

$F - 160 = 492 \times 2.45$

1370 «N»

Could be seen in part (a).
*Award **[0]** for solution that uses a = 9.81 m s^{-2}*

32c. The cable is pulled by an electric motor. The motor has an overall efficiency of 23 %. Determine the average power input to the motor. *[3 marks]*

Markscheme

ALTERNATIVE 1

«work done to launch glider» = 1370 x 149 «= 204 kJ»

«work done by motor» $= \frac{204 \times 100}{23}$

«power input to motor» $= \frac{204 \times 100}{23} \times \frac{1}{11} = 80$ ***or*** 80.4 ***or*** 81 k«W»

ALTERNATIVE 2

use of average speed 13.5 m s^{-1}

«useful power output» = force x average speed «= 1370 x 13.5»

power input = «$1370 \times 13.5 \times \frac{100}{23} =$» 80 ***or*** 80.4 ***or*** 81 k«W»

ALTERNATIVE 3

work required from motor = KE + work done against friction «$= 0.5 \times 492 \times 27^2 + (160 \times 148.5)$» = 204 «kJ»

«energy input» $= \frac{\text{work required from motor} \times 100}{23}$

power input $= \frac{883000}{11} = 80.3$ k«W»

*Award **[2 max]** for an answer of 160 k«W».*

32d. The cable is wound onto a cylinder of diameter 1.2 m. Calculate the angular velocity of the cylinder at the instant when the glider has a speed of 27 m s^{-1}. Include an appropriate unit for your answer. *[2 marks]*

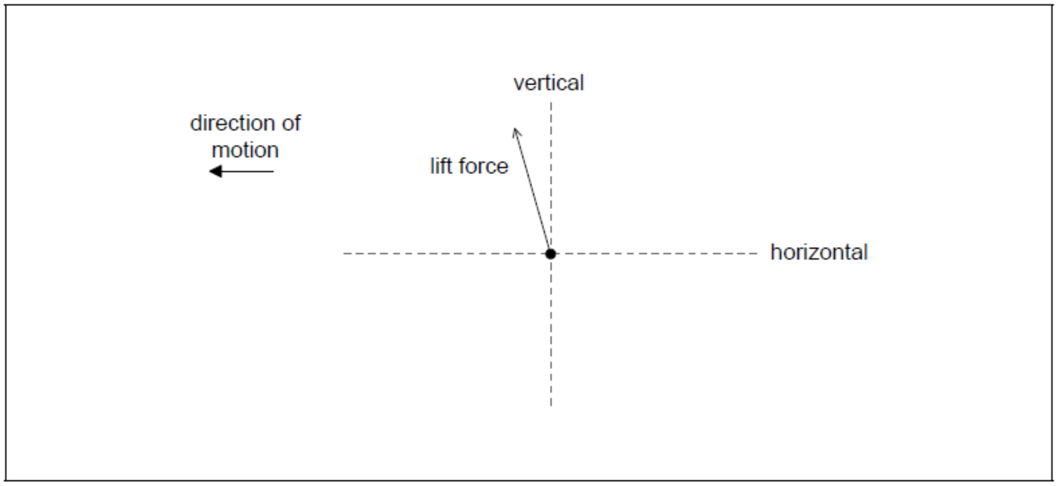
Markscheme

$\omega = «\frac{v}{r} =» \frac{27}{0.6} = 45$

rad s^{-1}

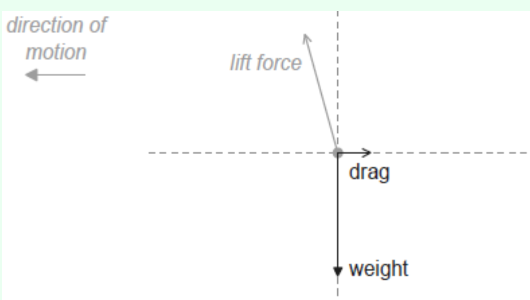
Do not accept Hz.
*Award **[1 max]** if unit is missing.*

32e. After takeoff the cable is released and the unpowered glider moves horizontally at constant speed. The wings of the glider provide a lift force. The diagram shows the lift force acting on the glider and the direction of motion of the glider. *[2 marks]*



Draw the forces acting on the glider to complete the free-body diagram. The dotted lines show the horizontal and vertical directions.

Markscheme



drag correctly labelled and in correct direction

weight correctly labelled and in correct direction ***AND*** no other incorrect force shown

*Award **[1 max]** if forces do not touch the dot, but are otherwise OK.*

32f. Explain, using appropriate laws of motion, how the forces acting on the glider maintain it in level flight. *[2 marks]*

Markscheme

name Newton's first law

vertical/all forces are in equilibrium/balanced/add to zero
OR
vertical component of lift mentioned

as equal to weight

32g. At a particular instant in the flight the glider is losing 1.00 m of vertical height for every 6.00 m that it goes forward horizontally. At this instant, the horizontal speed of the glider is 12.5 m s^{-1}. Calculate the **velocity** of the glider. Give your answer to an appropriate number of significant figures. *[3 marks]*

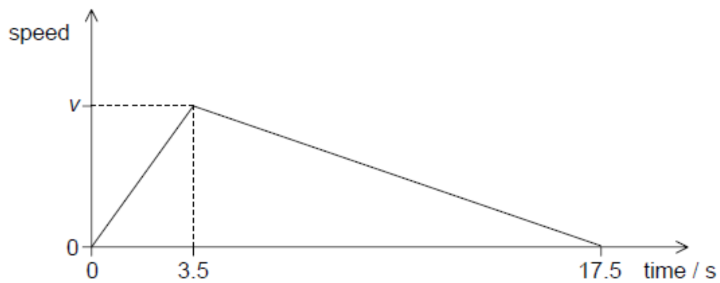
Markscheme

any speed and any direction quoted together as the answer

quotes their answer(s) to 3 significant figures

speed = 12.7 m s^{-1} ***or*** direction = 9.46° ***or*** 0.165 rad «below the horizontal» ***or*** gradient of $-\frac{1}{6}$

Curling is a game played on a horizontal ice surface. A player pushes a large smooth stone across the ice for several seconds and then releases it. The stone moves until friction brings it to rest. The graph shows the variation of speed of the stone with time.



The total distance travelled by the stone in 17.5 s is 29.8 m.

33a. Determine the coefficient of dynamic friction between the stone and the ice during the last 14.0 s of the stone's motion. *[3 marks]*

Markscheme

ALTERNATIVE 1

«deceleration» $= \frac{3.41}{14.0}$ «$= 0.243\,\mathrm{m\,s^{-2}}$»

F = 0.243 × *m*

$\mu = \frac{0.243 \times m}{m \times 9.81} = 0.025$

ALTERNATIVE 2

distance travelled after release = 23.85 «m»
KE lost = 5.81 *m* «J»

$\mu_\mathrm{d} = \frac{\mathrm{KE\ lost}}{mg \times \mathrm{distance}} = \frac{5.81m}{23.85mg} = 0.025$

*Award **[3]** for a bald correct answer.*

Ignore sign in acceleration.

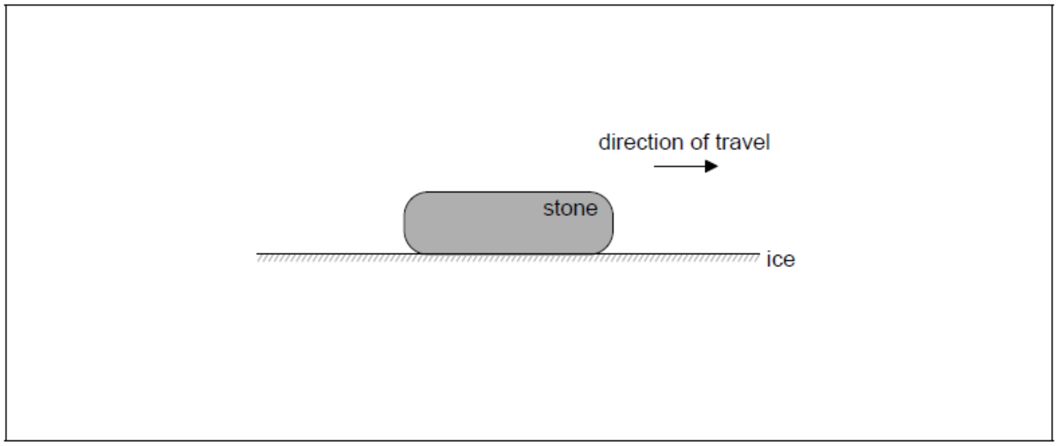
Allow ECF from (a) (note that
$\mu = 0.0073$ *x candidate answer to (a)).*

Ignore any units in answer.

Condone omission of m in solution.

Allow g = 10 N kg^{-1} (gives 0.024).

33b. The diagram shows the stone during its motion **after** release. *[3 marks]*



Label the diagram to show the forces acting on the stone. Your answer should include the name, the direction **and** point of application of each force.

Markscheme

normal force, upwards, ignore point of application

Force must be labeled for its mark to be awarded. Blob at poa not required.
Allow OWTTE for normal force. Allow N, R, reaction.
The vertical forces must lie within the middle third of the stone

weight/weight force/force of gravity, downwards, ignore point of application

Allow mg, W but not "gravity".

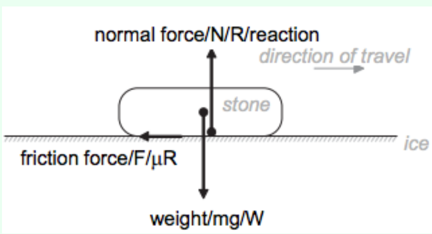
Penalise gross deviations from vertical/horizontal once only

friction/resistive force, to left, at bottom of stone, point of application must be **on** the interface between ice and stone

Allow F, μR. Only allow arrows/lines that lie on the interface. Take the tail of the arrow as the definitive point of application and expect line to be drawn horizontal.

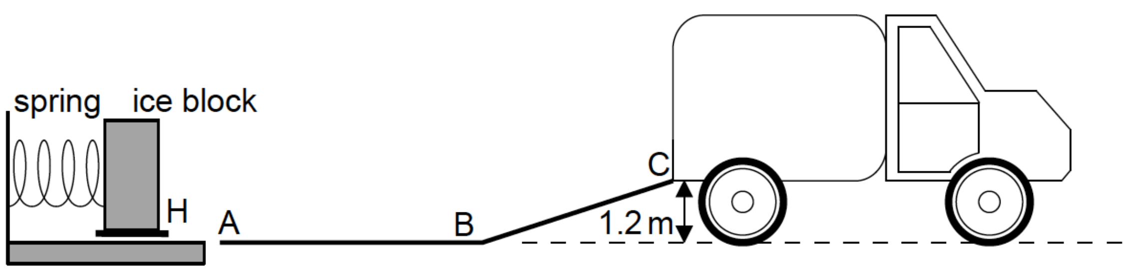
*Award **[2 max]** if any force arrow does not touch the stone*

Do not award MP3 if a "driving force" is shown acting to the right. This need not be labelled to disqualify the mark. Treat arrows labelled "air resistance" as neutral.



N.B: *Diagram in MS is drawn with the vertical forces not direction of travel collinear for clarity*

A company designs a spring system for loading ice blocks onto a truck. The ice block is placed in a holder H in front of the spring and an electric motor compresses the spring by pushing H to the left. When the spring is released the ice block is accelerated towards a ramp ABC. When the spring is fully decompressed, the ice block loses contact with the spring at A. The mass of the ice block is 55 kg.



Assume that the surface of the ramp is frictionless and that the masses of the spring and the holder are negligible compared to the mass of the ice block.

34a. (i) The block arrives at C with a speed of $0.90 ms^{-1}$. Show that the elastic energy stored in the spring is 670J. *[4 marks]*

(ii) Calculate the speed of the block at A.

Markscheme

(i)
$\ll E_{el} = \gg \frac{1}{2}mv^2 + mgh$
OR
«E_{el}=» E_P+E_K

$\ll E_{el} = \gg \frac{1}{2} \times 55 \times 0.90^2 + 55 \times 9.8 \times 1.2$

OR
669 J
«E_{el} = 669 ≈ 670J»

*Award **[1 max]** for use of g=10Nkg^{-1}, gives 682 J.*

(ii)
$\frac{1}{2} \times 55 \times v^2 = 670\text{J}$

$v = \ll \sqrt{\frac{2 \times 670}{55}} = \gg 4.9\text{ms}^{-1}$

If 682J used, answer is 5.0ms^{-1}.

34b. Describe the motion of the block *[3 marks]*

(i) from A to B with reference to Newton's first law.

(ii) from B to C with reference to Newton's second law.

Markscheme

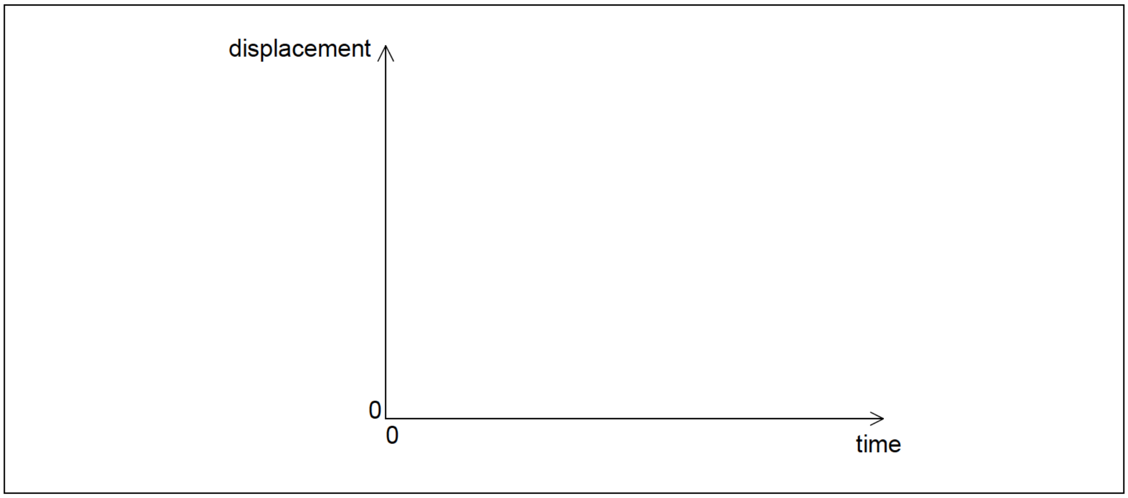
(i)
no force/friction on the block, hence constant motion/velocity/speed

(ii)
force acts on block ***OR*** gravity/component of weight pulls down slope

velocity/speed decreases ***OR*** it is slowing down ***OR*** it decelerates

Do not allow a bald statement of “N2” or “F = ma” for MP1.
Treat references to energy as neutral.

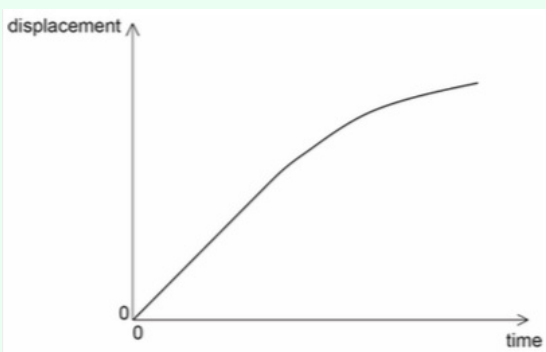
34c. On the axes, sketch a graph to show how the displacement of the block varies with time from A to C. (You do not have to put numbers on the axes.) *[2 marks]*



Markscheme

straight line through origin for at least one-third of the total length of time axis **covered by candidate line**

followed by curve with decreasing positive gradient



Ignore any attempt to include motion before A.

Gradient of curve must always be less than that of straight line.

34d. The spring decompression takes 0.42s. Determine the average force that the spring exerts on the block. *[2 marks]*

Markscheme

$F \ll = \frac{\Delta p}{\Delta t} \gg = \frac{55 \times 4.9}{0.42}$

F=642≈640N

Allow ECF from (a)(ii).

34e. The electric motor is connected to a source of potential difference 120V and draws a current of 6.8A. The motor takes 1.5s to compress the spring. *[2 marks]*

Estimate the efficiency of the motor.

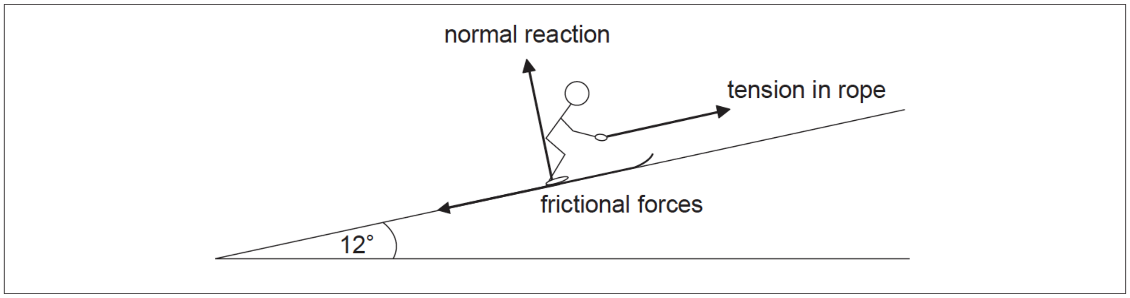
Markscheme

«energy supplied by motor =» 120 × 6.8 × 1.5 ***or*** 1224 J
OR
«power supplied by motor =» 120 × 6.8 ***or*** 816 W
e = 0.55 ***or*** 0.547 or 55% ***or*** 54.7%

Allow ECF from earlier results.

This question is about the forces on a skier.

A skier is pulled up a hill by a rope at a steady velocity. The hill makes an angle of 12° with the horizontal. The mass of the skier and skis is 73 kg. The diagram below shows three of the forces acting on the skier.



35a. On the diagram, draw and label **one** other force acting on the skier. *[1 mark]*

Markscheme

arrow vertically downwards labelled weight/W/mg/gravitational force/F_g/$F_{gravitational}$/force of gravity; *(judge by eye)*
Do not allow "gravity".

35b. Calculate the magnitude of the normal reaction acting on the skier. *[2 marks]*

Markscheme

(N=) $mg\cos\theta$ / correct substitution;

(=73×9.81×cos12°=)700N;

35c. The total frictional force acting is 65 N. Determine the tension in the rope. *[2 marks]*

Markscheme

tension = frictional force + component of weight parallel to slope /

tension = 65 + $mg\sin\theta$;

214/210 N;

35d. Explain, using Newton's first law of motion, why the resultant force on the skier must be zero. *[2 marks]*

Markscheme

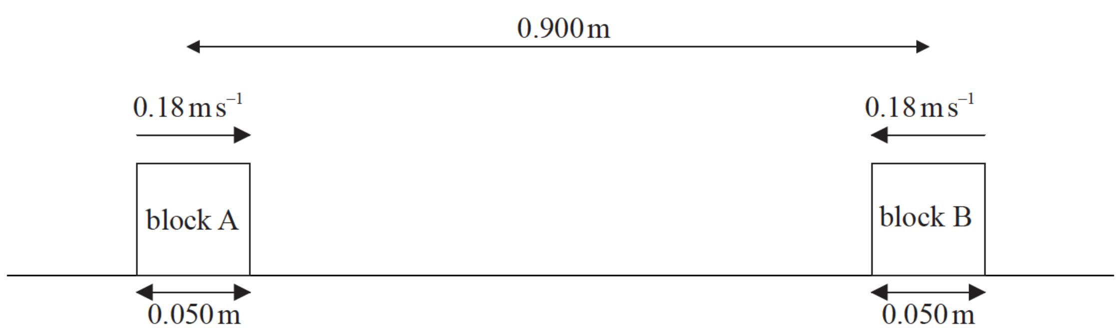
(Newton's first law states that a body remains at rest or moves with) constant velocity/steady speed/uniform motion unless external/net/resultant/unbalanced force acts on it;

clear link that in this case there is constant/steady <u>velocity</u> so no resultant force;

This question is in **two** parts. **Part 1** is about a collision. **Part 2** is about electric current and resistance.

Part 1 A collision

Two identical blocks of mass 0.17kg and length 0.050m are travelling towards each other along a straight line through their centres as shown below. Assume that the surface is frictionless.



The initial distance between the centres of the blocks is 0.900m and both blocks are moving at a speed of 0.18ms^{-1} relative to the surface.

36a. Determine the time taken for the blocks to come into contact with each other. *[3 marks]*

Markscheme

distance between surfaces of blocks=0.900-0.050=0.850m;
relative speed between blocks = 0.36ms^{-1};
$\text{time} = \frac{\text{distance}}{\text{speed}} = \frac{0.850}{0.36} = 2.4\text{s};$

or

blocks moving at same speed so meet at mid-point;
distance travelled by block=0.450-0.025=0.425m;
$\text{time} = \frac{\text{distance}}{\text{speed}} = \frac{0.425}{0.18} = 2.4\text{s};$

*Award **[3]** for bald correct answer.*
*Award **[2 max]** if distance of 0.90 m or 0.45 m used to get 2.5 s.*

36b. As a result of the collision, the blocks reverse their direction of motion and travel at the same speed as each other. During the collision, 20% of the kinetic energy of the blocks is given off as thermal energy to the surroundings. *[5 marks]*

(i) State and explain whether the collision is elastic or inelastic.

(ii) Show that the final speed of the blocks relative to the surface is 0.16 m s $^{-1}$.

Markscheme

(i) the collision is inelastic;
because kinetic energy is not conserved (although momentum is);

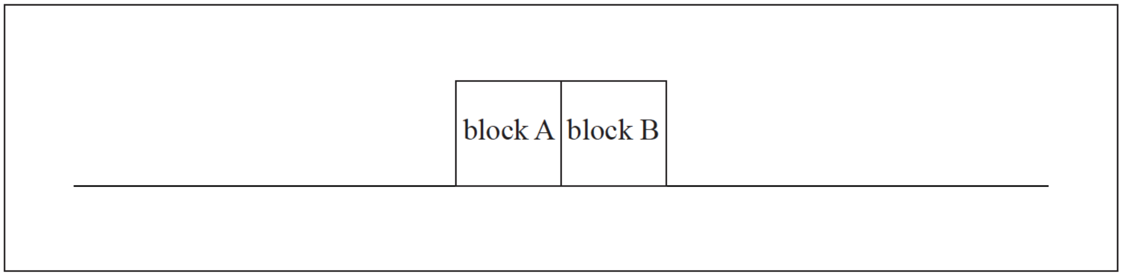
(ii) initial $E_K = \frac{1}{2} \times 0.17 \times 0.18^2 = 0.002754\text{J};$
final $E_K = 0.80 \times 0.002754 = 0.0022032\text{J};$
final speed $= \sqrt{\frac{2\times 0.0022032}{0.17}};$
=0.16ms^{-1}

or

0.8×initial E_K=final E_K;
$0.8 \times \frac{1}{2} \times 0.17 \times 0.18^2 = \frac{1}{2} \times 0.17 \times v^2;$
$v = \sqrt{0.8 \times 0.18^2};$
=0.16ms^{-1}

36c. (i) State Newton's third law of motion. *[7 marks]*

(ii) During the collision of the blocks, the magnitude of the force that block A exerts on block B is F_{AB} and the magnitude of the force that block B exerts on block A is F_{BA}. On the diagram below, draw labelled arrows to represent the magnitude and direction of the forces F_{AB} and F_{BA}.

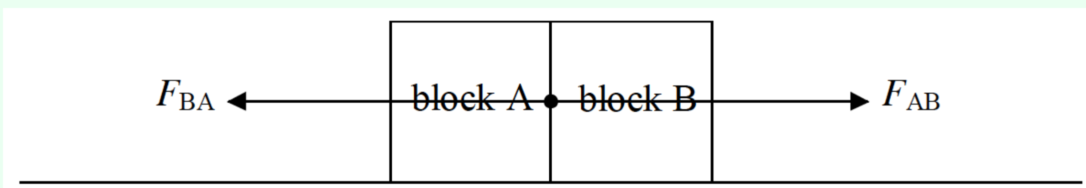


(iii) The duration of the collision between the blocks is 0.070 s. Determine the average force one block exerted on the other.

Markscheme

(i) if object A exerts a force on object B, then object B (simultaneously) exerts an equal and opposite force on object A / every action has an equal and opposite reaction / *OWTTE*;

(ii) arrows of equal length; *(judge by eye)*
acting through centre of blocks;
correct labelling consistent with correct direction;



(iii) $\Delta v = 0.16 - (-0.18) = 0.34\text{ms}^{-1}$;
$a = \frac{\Delta v}{\Delta t} = \frac{0.34}{0.070} = 4.857\text{ms}^{-2}$;
$F = ma = 0.17 \times 4.857 = 0.83\text{N}$;

or

$\Delta v = 0.16 - (-0.18) = 0.34\text{ms}^{-1}$;
$\text{impulse} = F\Delta t = m\Delta v \Rightarrow F = \frac{0.17 \times 0.34}{0.07}$;
F=0.83N;