AQA A-LEVEL PHYSICS · 7408

PHYSICS



EXAM QUESTION PACK

3.4.1 FORCE, ENERGY AND MOMENTUM · PACK 3

SCORE	PERCENTAGE
/158	%

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1. A body of constant mass falls freely due to gravity.

The rate of change of momentum of the body is equal to its

A kinetic energy. ⬭

B mass. ⬭

C gravitational potential energy. ⬭

D weight. ⬭

(Total 1 mark)

2. An electric vehicle is driven by a motor which produces a constant driving force.
The vehicle travels from rest along a straight horizontal road.
Friction and air resistance are negligible.

Which statement describes the variation with time of the power developed by the motor?

A It stays constant. ⬭

B It increases linearly from zero. ⬭

C It increases non-linearly from zero. ⬭

D It increases from zero to a maximum and then decreases. ⬭

(Total 1 mark)

3. Immediately after take-off from the surface of the Earth, a rocket of mass 12 000 kg accelerates vertically upwards at 1.4 m s^{-2}

What is the thrust produced by the rocket motor?

A 1.7×10^4 N ⬭

B 1.0×10^5 N ⬭

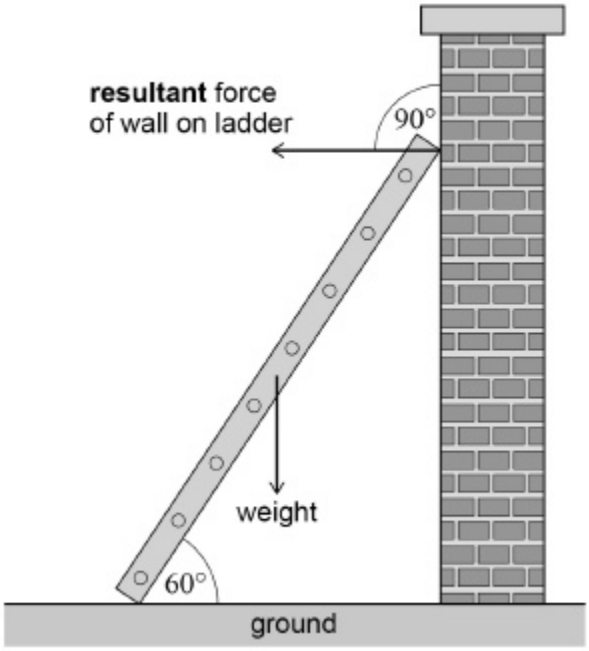
C 1.3×10^5 N ⬭

D 1.6×10^5 N ⬭

(Total 1 mark)

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4. The diagram shows two of the forces acting on a uniform ladder resting against a vertical wall. The ladder is at an angle of 60° to the ground.



(a) Explain how the diagram shows that the friction between the ladder and the wall is negligible.

_____

_____

_____

_____

(1)

(b) The forces acting on the ladder are in equilibrium.

Draw an arrow on the diagram to show the direction of the resultant force from the ground acting on the ladder. Label your arrow **G**.

(2)

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(c) The ladder is 8.0 m long and weighs 390 N.

Calculate the magnitude of the resultant force from the wall on the ladder.

resultant force = _____ N

(2)

(d) Suggest the changes to the forces acting on the ladder that occur when someone climbs the ladder.

_____

_____

_____

_____

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_____

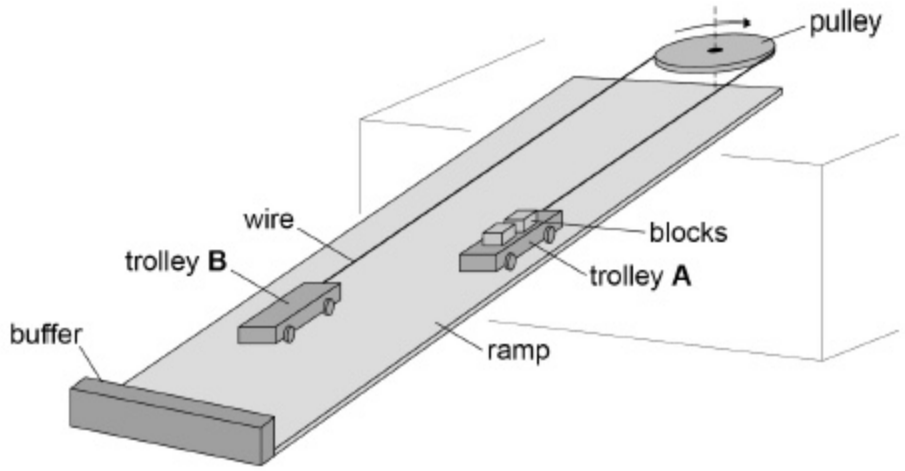
(3)

(Total 8 marks)

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5. **Figure 1** shows a model of a system being designed to move concrete building blocks from an upper to a lower level.

Figure 1

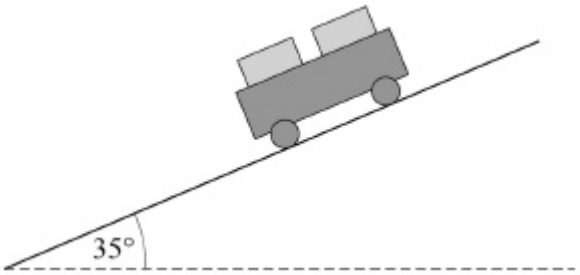


The model consists of two identical trolleys of mass *M* on a ramp which is at 35° to the horizontal. The trolleys are connected by a wire that passes around a pulley of negligible mass at the top of the ramp.

Two concrete blocks each of mass *m* are loaded onto trolley **A** at the top of the ramp. The trolley is released and accelerates to the bottom of the ramp where it is stopped by a flexible buffer. The blocks are unloaded from trolley **A** and two blocks are loaded onto trolley **B** that is now at the top of the ramp. The trolleys are released and the process is repeated.

Figure 2 shows the side view of trolley **A** when it is moving **down** the ramp.

Figure 2



(a) The tension in the wire when the trolleys are moving is T.

Draw and label arrows on **Figure 2** to represent the magnitudes and directions of any forces and components of forces that act on trolley **A** parallel to the ramp as it travels down the ramp.

(1)

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(b) Assume that no friction acts at the axle of the pulley or at the axles of the trolleys and that air resistance is negligible.

Show that the acceleration a of trolley **B** along the ramp is given by

$$a = \frac{mg \sin 35^\circ}{M + m}$$

(2)

(c) Compare the momentum of loaded trolley **A** as it moves downwards with the momentum of loaded trolley **B**.

_____

_____

_____

_____

_____

_____

(2)

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(d) In practice, for safety reasons there is a friction brake in the pulley that provides a resistive force to reduce the acceleration to 25% of the maximum possible acceleration.

The distance travelled for each journey down the ramp is 9.0 m.

The following data apply to the arrangement.

Mass of a trolley M = 95 kg

Mass of a concrete block m = 30 kg

Calculate the time taken for a loaded trolley to travel down the ramp.

time = _____ s

(3)

(e) It takes 12 s to remove the blocks from the lower trolley and reload the upper trolley.

Calculate the number of blocks that can be transferred to the lower level in 30 minutes.

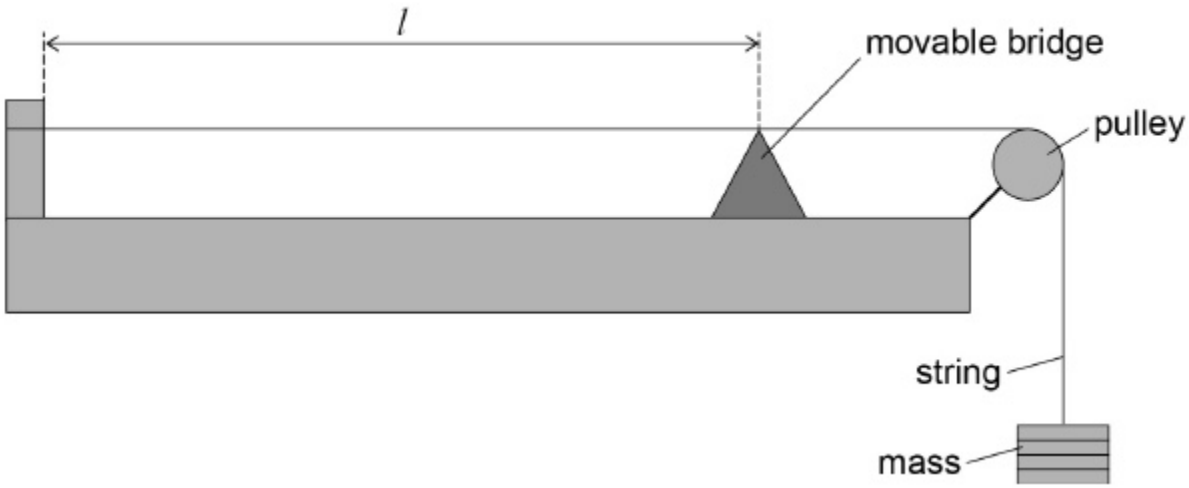
number = _____

(2)

(Total 10 marks)

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6. The diagram shows an arrangement used by a student to investigate vibrations in a stretched nylon string of fixed length l. He measures how the frequency f of first-harmonic vibrations for the string varies with the mass m suspended from it.



The table shows the results of the experiment.

m / kg	f / Hz
0.50	110
0.80	140
1.20	170

(a) Show that the data in the table are consistent with the relationship

$$f \propto \sqrt{T}$$

where T is the tension in the nylon string.

(2)

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(b) The nylon string used has a density of 1150 kg m^{-3} and a uniform diameter of 5.0×10^{-4} m.

Determine the length l of the string used.

l = _____ m

(3)

(c) The student uses the relationship in question (a) to predict frequencies for tensions that are much larger than those used in the original experiment.

Explain how the actual frequencies produced would be different from those that the student predicts.

_____

_____

_____

_____

(2)

(Total 7 marks)

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7. Two identical balls, **X** and **Y**, are at the same height and a horizontal distance of 25 cm apart.

X is projected horizontally with a velocity of 0.10 m s^{-1} towards **Y** at the same time that **Y** is released from rest. Both **X** and **Y** move freely in the absence of air resistance.

What is the distance between the balls 1.0 s later?

A 0.15 m ⬭

B 0.25 m ⬭

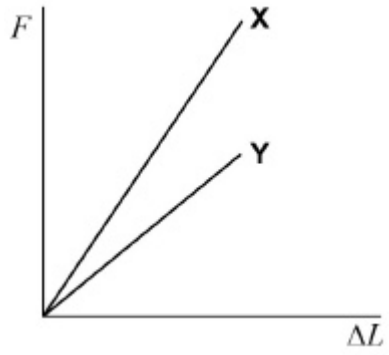
C 2.4 m ⬭

D 4.9 m ⬭

(Total 1 mark)

8. Two separate wires **X** and **Y** have the same original length and cross-sectional area.

The graph shows the extension ΔL produced in **X** and **Y** when the tensile force F applied to the wires is increased up to the point where they break.



Which statement is **incorrect**?

A For a given extension more energy is stored in **X** than in **Y**. ⬭

B The Young modulus of the material of wire **Y** is greater than that of wire **X**. ⬭

C Both wire **X** and wire **Y** obey Hooke's law. ⬭

D Wire **X** has a greater breaking stress than wire **Y**. ⬭

(Total 1 mark)

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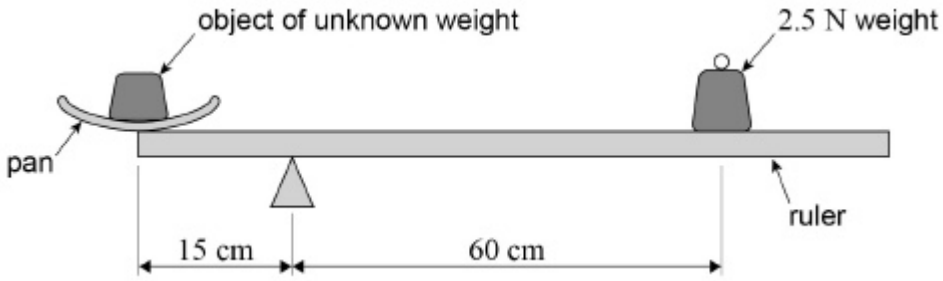
9. Two bodies of different masses undergo an elastic collision in the absence of any external force.

Which row gives the effect on the total kinetic energy of the masses and the magnitudes of the forces exerted on the masses during the collision?

	Total kinetic energy	Magnitudes of forces	
A	remains unchanged	same on both masses	⬭
B	remains unchanged	greater on the smaller mass	⬭
C	decreases	same on both masses	⬭
D	decreases	greater on the smaller mass	⬭

(Total 1 mark)

10. The diagram shows a uniform metre ruler of weight 1.5 N pivoted 15 cm from one end for use as a simple balance.



A scale pan of weight 0.5 N is placed at the end of the ruler and an object of unknown weight is placed in the pan. The ruler moves to a steady horizontal position when a weight of 2.5 N is added at a distance of 60 cm from the pivot as shown.

What is the weight of the object?

A 9.5 N ⬭

B 10.0 N ⬭

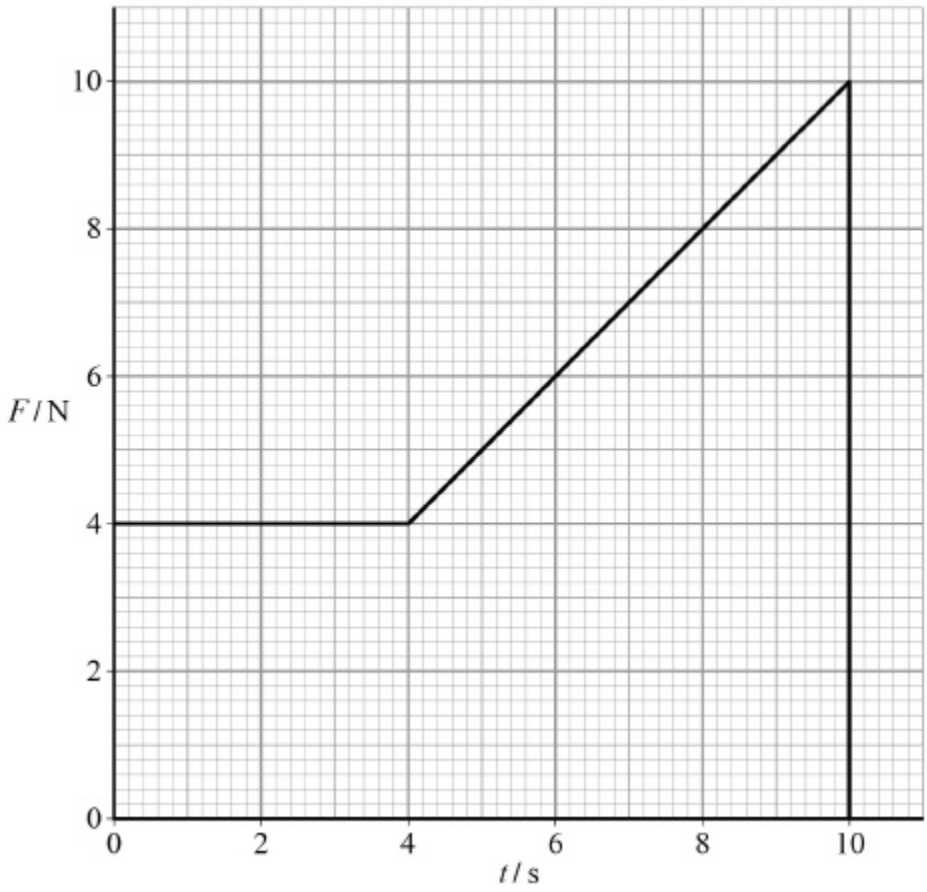
C 13.0 N ⬭

D 13.5 N ⬭

(Total 1 mark)

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11. The graph shows how the force F applied to an object varies with time t.



What is the momentum gained by the object from $t = 0$ to $t = 10$ s?

A 18 kg m s^{-1} ⬭

B 32 kg m s^{-1} ⬭

C 40 kg m s^{-1} ⬭

D 58 kg m s^{-1} ⬭

(Total 1 mark)

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12. What is the name given to a material that breaks without deformation when a force is applied to it?

A Plastic ⬭

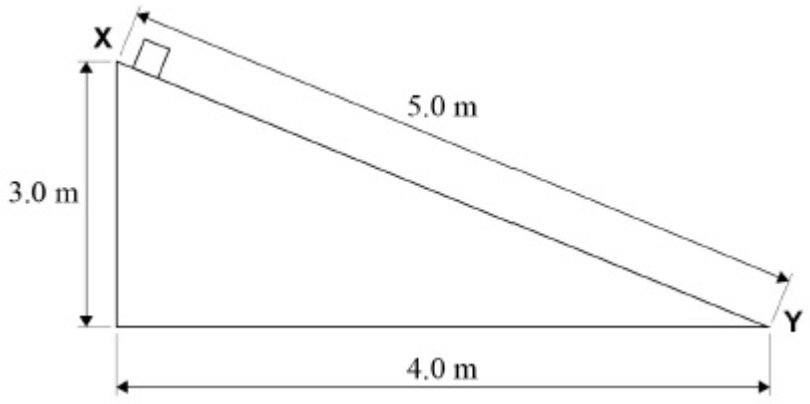
B Brittle ⬭

C Stiff ⬭

D Elastic ⬭

(Total 1 mark)

13. A mass of 2.5 kg is released from rest at **X** and slides down a ramp, of height 3.0 m, to point **Y** as shown.



When the mass reaches **Y** at the bottom of the ramp it has a velocity of 5.0 m s^{-1}.

What is the average frictional force between the mass and the ramp?

A 8.5 N ⬭

B 10.6 N ⬭

C 14.7 N ⬭

D 24.5 N ⬭

(Total 1 mark)

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14. Which row correctly states whether momentum, mass and velocity are scalar or vector quantities?

	Momentum	Mass	Velocity	
A	scalar	scalar	vector	⬭
B	vector	scalar	scalar	⬭
C	scalar	vector	scalar	⬭
D	vector	scalar	vector	⬭

(Total 1 mark)

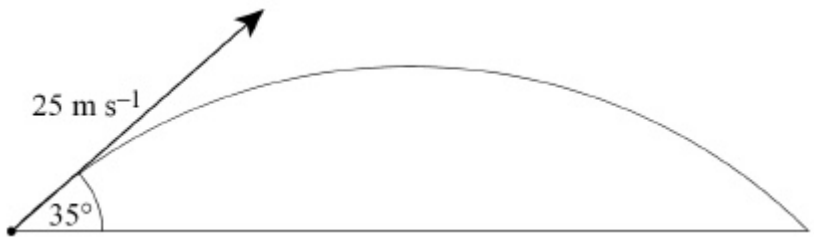
15. A bullet of mass 10 g is fired with a velocity of 100 m s^{-1} from a stationary rifle of mass 4.0 kg. Consider the rifle and bullet to be an isolated system.

What are the recoil velocity of the rifle and the total momentum of the rifle and bullet just after firing?

	Recoil velocity / m s^{-1}	Total momentum / kg m s^{-1}	
A	0.25	0	⬭
B	0.25	1.0	⬭
C	0.40	0	⬭
D	0.40	1.0	⬭

(Total 1 mark)

16. A projectile is launched with a speed of 25 m s^{-1} at an angle of 35° to the horizontal, as shown in the diagram.



Air resistance is negligible.

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What is the time taken for the projectile to return to the ground?

A 1.5 s ⬭

B 2.1 s ⬭

C 2.9 s ⬭

D 4.2 s ⬭

(Total 1 mark)

17. An electric wheelchair, powered by a battery, allows the user to move around independently.

One type of electric wheelchair has a mass of 55 kg. The maximum distance it can travel on level ground is 12 km when carrying a user of mass 65 kg and travelling at its maximum speed of $1.5\ m\ s^{-1}$.

The battery used has an emf of 12 V and can deliver 7.2×10^4 C as it discharges fully.

(a) Show that the average power output of the battery during the journey is about 100 W.

(3)

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(b) During the journey, forces due to friction and air resistance act on the wheelchair and its user.

Assume that all the energy available in the battery is used to move the wheelchair and its user during the journey.

Calculate the total mean resistive force that acts on the wheelchair and its user.

total mean resistive force = _____ N

(2)

The diagram below shows the wheelchair and its user travelling up a hill. The hill makes an angle of 4.5° to the horizontal.



(c) Calculate the force that gravity exerts on the wheelchair and its user parallel to the slope.

force parallel to the slope = _____ N

(1)

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(d) Calculate the maximum speed of the wheelchair and its user when travelling up this hill when the power output of the battery is 100 W.

Assume that the resistive forces due to friction and air resistance are the same as in part (b).

maximum speed = _____ m s^{-1}

(2)

(e) Explain how and why the maximum range of the wheelchair on level ground is affected by

- the mass of the user
- the speed at which the wheelchair travels.

Effect of mass _____

_____

_____

_____

_____

_____

Effect of speed _____

_____

_____

_____

_____

_____

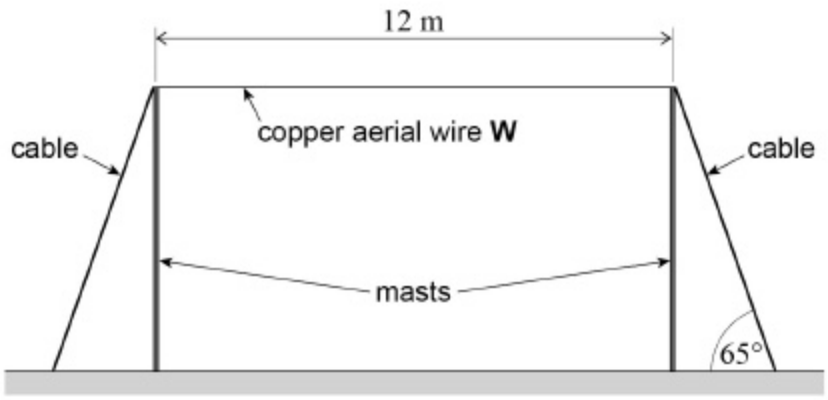
(4)

(Total 12 marks)

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18. **Figure 1** shows a structure that supports a horizontal copper aerial wire **W** used for transmitting radio signals.

Figure 1



The copper aerial wire is 12 m long and its area of cross-section is 1.6×10^{-5} m^2.
The tension in the copper aerial wire is 5.0×10^2 N.

Young modulus of copper = 1.2×10^{11} Pa

(a) Show that the extension produced in a 12 m length of the aerial wire when the tension is 5.0×10^2 N is less than 4 mm.

(2)

(b) The cables that support each mast are at an angle of 65° to the horizontal.

Calculate the tension in each supporting cable so that there is no resultant horizontal force on either mast.

tension = _____ N

(1)

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(c) When wind blows, stationary waves can be formed on the aerial wire.

Explain how stationary waves are produced and why only waves of specific frequencies can form on the aerial wire.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(d) Calculate the mass of a 1.0 m length of the aerial wire.

Density of copper = 8900 kg m^{-3}

mass = _____ kg

(1)

(e) Calculate the frequency of the wave when the third harmonic is formed on the aerial wire.

frequency = _____ Hz

(2)

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(f) Sketch, on **Figure 2**, the standing wave on the wire when the third harmonic is formed.

Figure 2



(1)

(g) High winds produce large amplitudes of vibration of the aerial wire.

Explain why the wire may sag when the high wind stops.

_____

_____

_____

_____

(2)

(Total 13 marks)

19. Which is a correct statement about mechanical power?

A It is a vector quantity. ⬭

B It is measured in J. ⬭

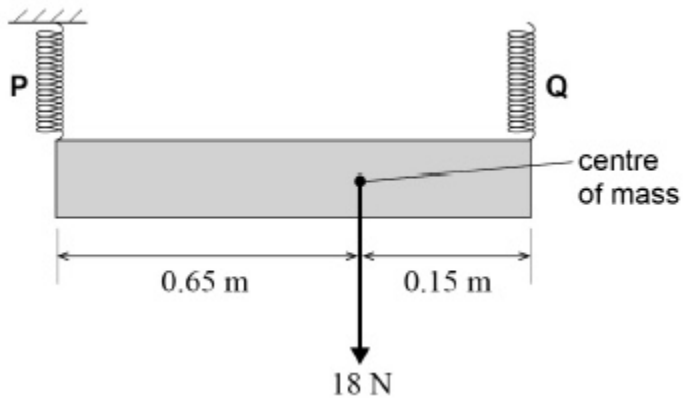
C In fundamental units, its unit is kg m^2 s^{-3} ⬭

D It can be calculated from force × distance moved. ⬭

(Total 1 mark)

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20. A non-uniform sign is 0.80 m long and has a weight of 18 N
It is suspended from two vertical springs **P** and **Q**. The springs obey Hooke's law and the spring constant of each spring is 240 N m^{-1}



The top end of spring **P** is fixed and the top end of spring **Q** is adjusted until the sign is horizontal and in equilibrium.

What is the extension of spring **Q**?

A 0.014 m ⬭

B 0.038 m ⬭

C 0.049 m ⬭

D 0.061 m ⬭

(Total 1 mark)

21. The diagram shows two railway trucks **A** and **B** travelling towards each other on the same railway line which is straight and horizontal.



The trucks are involved in an inelastic collision. They join when they collide and then move together.

The trucks move a distance of 15 m before coming to rest.

Truck **A** has a total mass of 16 000 kg and truck **B** has a total mass of 12 000 kg

Just before the collision, truck **A** was moving at a speed of 2.8 m s^{-1} and truck **B** was moving at a speed of 3.1 m s^{-1}

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(a) State the quantity that is **not** conserved in an inelastic collision.

_____

(1)

(b) Show that the speed of the joined trucks immediately after the collision is about 0.3 m s^{-1}

(3)

(c) Calculate the impulse that acts on each truck during the collision.
Give an appropriate unit for your answer.

impulse = _____ unit _____

(2)

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(d) Explain, without doing a calculation, how the motion of the trucks immediately after the collision would be different for a collision that is perfectly elastic.

_____

_____

_____

_____

_____

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_____

_____

_____

(2)

(Total 8 marks)

22. Three coplanar forces F_1, F_2 and F_3 act on a point object.

Which combination of forces can never produce a resultant force of zero?

	F_1 / N	F_2 / N	F_3 / N	
A	3	4	5	⬭
B	8	8	8	⬭
C	2	10	10	⬭
D	3	6	10	⬭

(Total 1 mark)

23. What is a correct unit for the area under a force–time graph?

A N m ⬭

B kg m s^{-1} ⬭

C kg m s^{-2} ⬭

D N s^{-1} ⬭

(Total 1 mark)

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24. Objects **P** and **Q** are initially at rest at time $t = 0$

The same resultant force F is applied to **P** and **Q** for time T.

The mass of **P** is 10 times greater than the mass of **Q**.

What is the ratio $\frac{\text{kinetic energy of } \mathbf{P}}{\text{kinetic energy of } \mathbf{Q}}$?

A 0.1 ⬭

B 1 ⬭

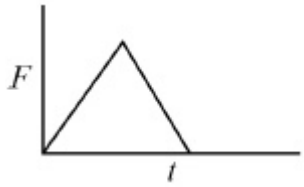
C 10 ⬭

D 100 ⬭

(Total 1 mark)

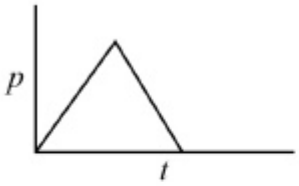
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25. The graph shows how the resultant force F on a football, which is initially at rest, varies with time t.

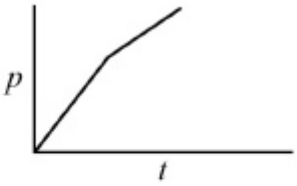


Which graph shows how the momentum p of the football varies with time t?

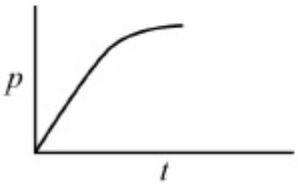
A



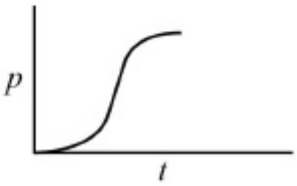
B



C



D



A ⬭

B ⬭

C ⬭

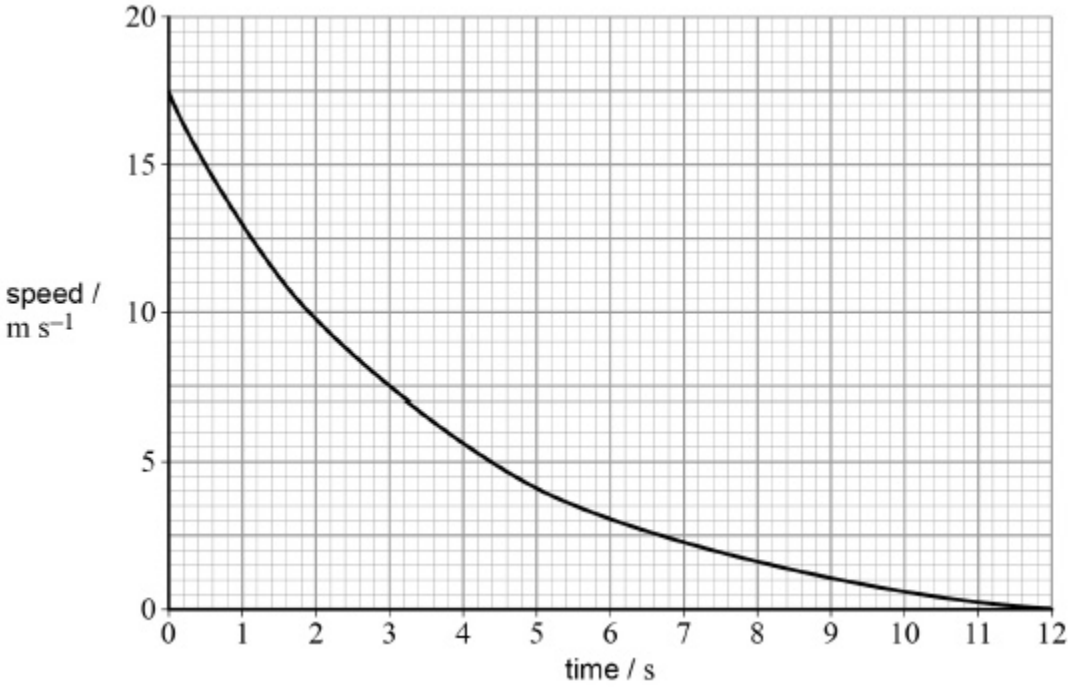
D ⬭

(Total 1 mark)

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26. Horizontal escape lanes made of loose gravel have been constructed at the side of some roads on steep hills so that vehicles can stop safely when their brakes fail.

The graph shows an engineer's prediction of how the speed of an unpowered vehicle of mass 1.8×10^4 kg will vary with time as the vehicle comes to rest in an escape lane.



(a) Determine the force decelerating the vehicle 2.0 s after entering the escape lane.

force decelerating the vehicle = _____ N

(3)

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(b) Deduce whether a lane of length 85 m is long enough to stop the vehicle, assuming that the engineer's graph is correct.

(3)

(c) Discuss the energy transfers that take place when a vehicle is decelerated in an escape lane.

(2)

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(d) An alternative to an escape lane containing gravel is an escape lane that consists of a ramp. An escape ramp is a straight road with a concrete surface that has a constant upward gradient.

One escape ramp makes an angle of 25° to the horizontal and is 85 m long.

Deduce whether this escape ramp is sufficient to stop the vehicle.

Assume that any frictional forces and air resistance that decelerate the vehicle are negligible.

_____

_____

(3)

(e) Discuss whether an escape lane containing gravel or an escape ramp would provide the safer experience for the driver of the vehicle as it comes to rest.

_____

_____

_____

_____

_____

_____

(1)

(Total 12 marks)

27. A girl is bouncing on a trampoline.

Assuming that air resistance is negligible, her acceleration

A is zero when she is at maximum height. ⬭

B is constant when she is in the air. ⬭

C changes direction as she rises and then falls. ⬭

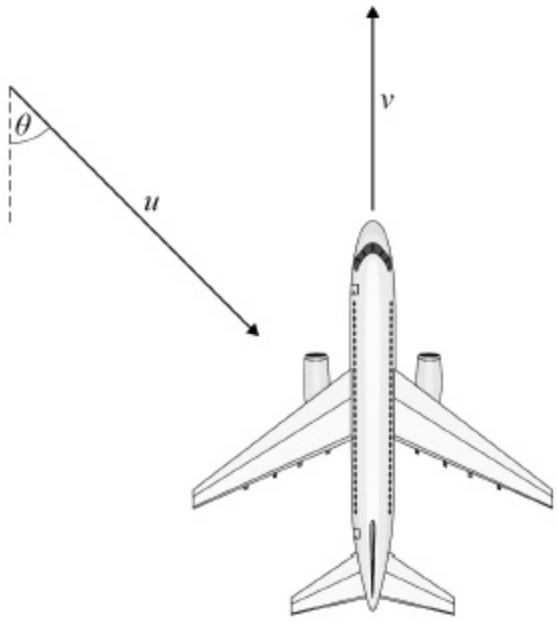
D is maximum just before she lands on the trampoline. ⬭

(Total 1 mark)

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28. An aircraft is flying due north through still air with a speed v

The aircraft enters a region where the wind is blowing with a speed u from a direction which makes an angle of θ with due south.



What is the time taken for the aircraft to fly a distance D due north of its current position in this windy region?

A $\dfrac{D}{v - u\cos\theta}$ ⬭

B $\dfrac{D}{v - u\sin\theta}$ ⬭

C $\dfrac{D}{v + u\cos\theta}$ ⬭

D $\dfrac{D}{v + u\sin\theta}$ ⬭

(Total 1 mark)

29. Two spheres, **P** and **Q**, have the same volume but **P** has a greater mass. The spheres fall in air at their terminal velocities v_P and v_Q respectively.

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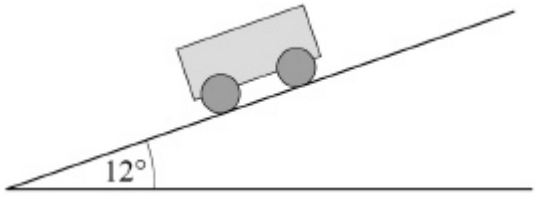
Which row states the relationship between v_P and v_Q and the reason?

	Relationship between v_P and v_Q	Reason	
A	$v_P = v_Q$	Terminal velocity is unaffected by mass	⬭
B	$v_Q > v_P$	The mass of **Q** is less and it accelerates more	⬭
C	$v_Q > v_P$	**P** reaches equilibrium at a lower terminal velocity	⬭
D	$v_P > v_Q$	**Q** reaches equilibrium at a lower terminal velocity	⬭

(Total 1 mark)

30. A car's engine produces a useful output power of 6.5×10^4 W

The car of mass 950 kg is moving up a hill at a steady speed.
The slope of the hill is 12° to the horizontal. Resistive forces on the car are negligible.



What is the steady speed of the car?

A 7.0 m s^{-1} ⬭

B 12 m s^{-1} ⬭

C 34 m s^{-1} ⬭

D 68 m s^{-1} ⬭

(Total 1 mark)

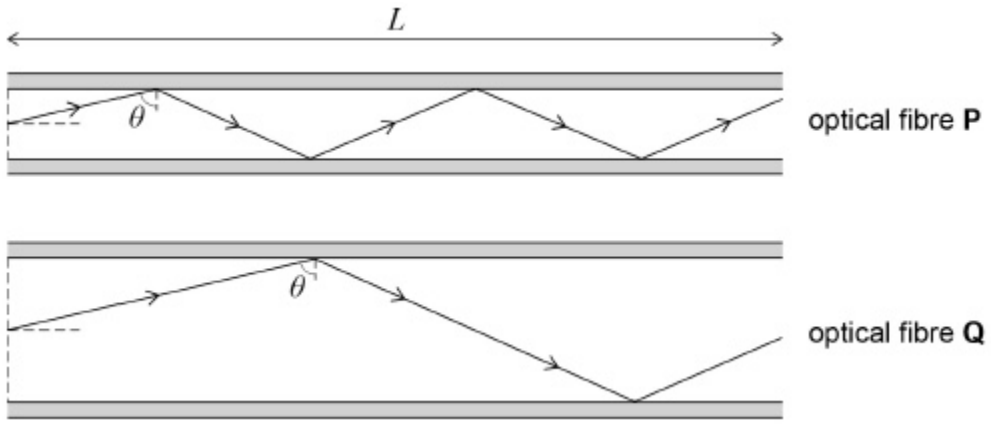
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31. Rays of light are incident at the same angle θ on the core–cladding boundary of optical fibres **P** and **Q**.

The cores of **P** and **Q** have the same refractive index n.

P and **Q** are the same length L.

The core diameter of **P** is half that of **Q**.



The time for the ray to travel along optical fibre **P** is

$$\frac{nL}{c\sin\theta}$$

where c is the speed of light in a vacuum.

What is the time for the ray to travel along optical fibre **Q**?

A $\frac{nL}{c\sin\theta}$ ⬭

B $\frac{nL}{2c\sin\theta}$ ⬭

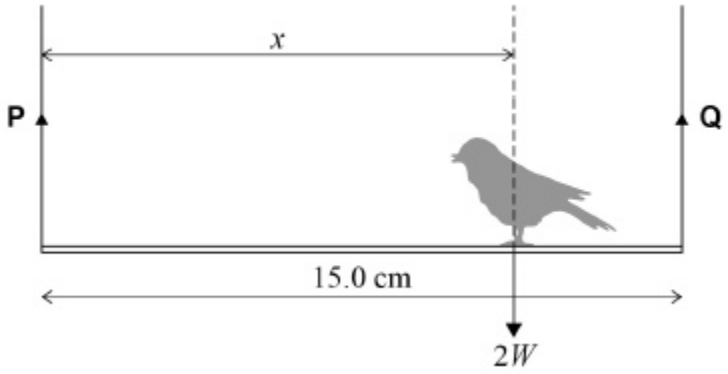
C $\frac{2nL}{c\sin\theta}$ ⬭

D $\frac{4nL}{c\sin\theta}$ ⬭

(Total 1 mark)

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32. A bird sits on a uniform rod suspended from vertical wires **P** and **Q**.



The rod has a weight W and is 15.0 cm long.
The weight of the bird is $2W$ and acts at a distance x from **P**.

What is the value of x when the tension in **P** is half the tension in **Q**?

A 7.50 cm ⬭

B 10.0 cm ⬭

C 11.3 cm ⬭

D 15.0 cm ⬭

(Total 1 mark)

33. Which list puts the forces in order of increasing magnitude?

A 2 pN < 2 fN < 2 TN < 2 GN ⬭

B 2 pN < 2 fN < 2 GN < 2 TN ⬭

C 2 fN < 2 pN < 2 TN < 2 GN ⬭

D 2 fN < 2 pN < 2 GN < 2 TN ⬭

(Total 1 mark)

34. A radioactive source emits alpha particles each with 8.1×10^{-13} J of kinetic energy.

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(a) Show that the velocity of an alpha particle with kinetic energy 8.1×10^{-13} J is approximately 2×10^{7} m s^{-1}

specific charge of an alpha particle = 4.81×10^{7} C kg^{-1}

_____

_____

_____

_____

(2)

(b) The alpha particles travel through air in straight lines with a range of 3.5 cm

Calculate the average force exerted on an alpha particle as it is stopped by the air.

average force = _____ N

(2)

(c) An alpha particle transfers all its kinetic energy to air molecules and produces 5.1×10^{4} ions per centimetre over its range of 3.5 cm

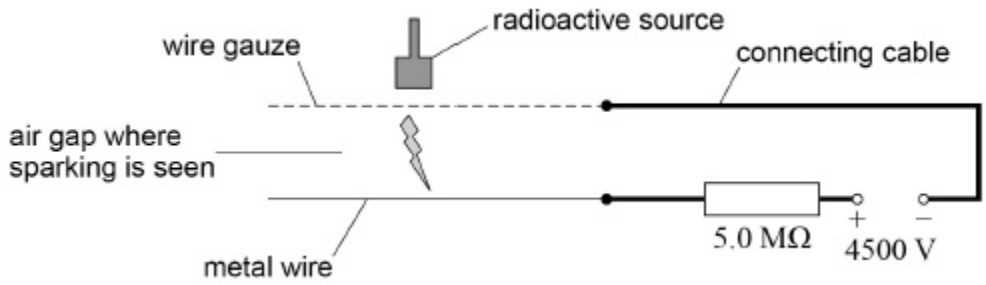
Calculate the average ionisation energy, in eV, of a molecule of air.

ionisation energy = _____ eV

(3)

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(d) A spark counter consists of a wire gauze separated from a metal wire by a small air gap. A power supply with an output of 4500 V is connected in series with a 5.0 MΩ resistor and the spark counter as shown in the diagram. When the radioactive source is moved close to the wire gauze, sparking is seen in the air gap.



Sparks are produced when alpha particles produce ionisation in the air gap.

One ionisation event produces a current of 0.85 mA for a time of 1.2 ns

Calculate the number of charge carriers that pass a point in the connecting cable during this ionisation event.

number of charge carriers = _____

(2)

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(e) The radioactive source was positioned 10 cm above the wire gauze before being moved slowly towards the wire gauze leading to the ionisation event in part **(d)**.

Discuss how the potential difference across the air gap varied as the radioactive source was moved over this distance.

Assume the power supply has negligible internal resistance.

(3)

(Total 12 marks)

35. An electric motor lifts a load of weight W through a vertical height h in time t.
The potential difference across the motor is V and the current through it is I.

What is the efficiency of the motor?

A $\frac{Wht}{VI}$ ⬭

B $\frac{VI}{Wht}$ ⬭

C $\frac{Wh}{VIt}$ ⬭

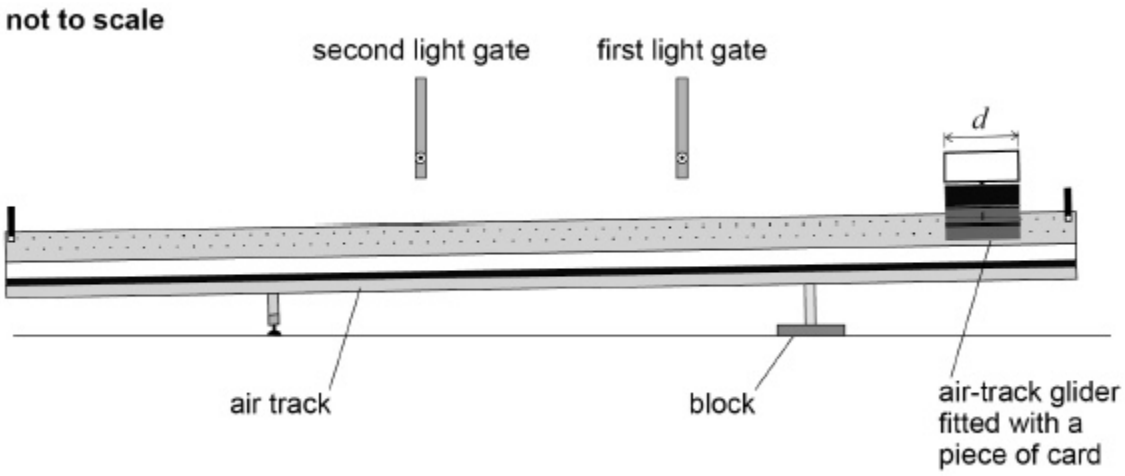
D $\frac{VIt}{Wh}$ ⬭

(Total 1 mark)

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36. **Figure 1** shows the apparatus used by a student in an experiment to measure the acceleration due to gravity, g.

Figure 1



In the experiment:

- a block is used to raise one end of the air track as shown in **Figure 1**
- an air-track glider is released from rest near the raised end of the air track and passes through the first light gate and then through the second light gate
- a piece of card of length *d* fitted to the air-track glider interrupts a light beam as the air-track glider passes through each light gate
- a data logger records the time taken by the piece of card to pass through each light gate and also the time for the piece of card to travel from one light gate to the other.

(a) **Table 1** gives measurements made with the light gates as shown in **Figure 1**.

Table 1

Time to pass through first light gate / s	Time to pass through second light gate / s	Time to travel from first to second light gate / s
0.50	0.40	1.19

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The length d of the piece of card is 10.0 cm

Assume there is negligible change in velocity while the air-track glider passes through a light gate.

Determine the acceleration a of the air-track glider.

a = _____ m s^{-2}

(3)

(b) Two further sets of readings, **A** and **B**, are taken each with the light gates in different positions along the air track.
Assume the acceleration is the same in each set.

Table 2 shows these additional sets of results.

Table 2

Set	Time to pass through first light gate / s	Time to pass through second light gate / s	Time to travel from first to second light gate / s
A	0.61	0.42	1.77
B	0.55	0.37	2.11

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Explain how the data in **Table 2** show that the distance between the light gates in set **B** is greater than in set **A**.

Assume there is negligible change in velocity while the air-track glider passes through a light gate.

_____

_____

_____

_____

_____

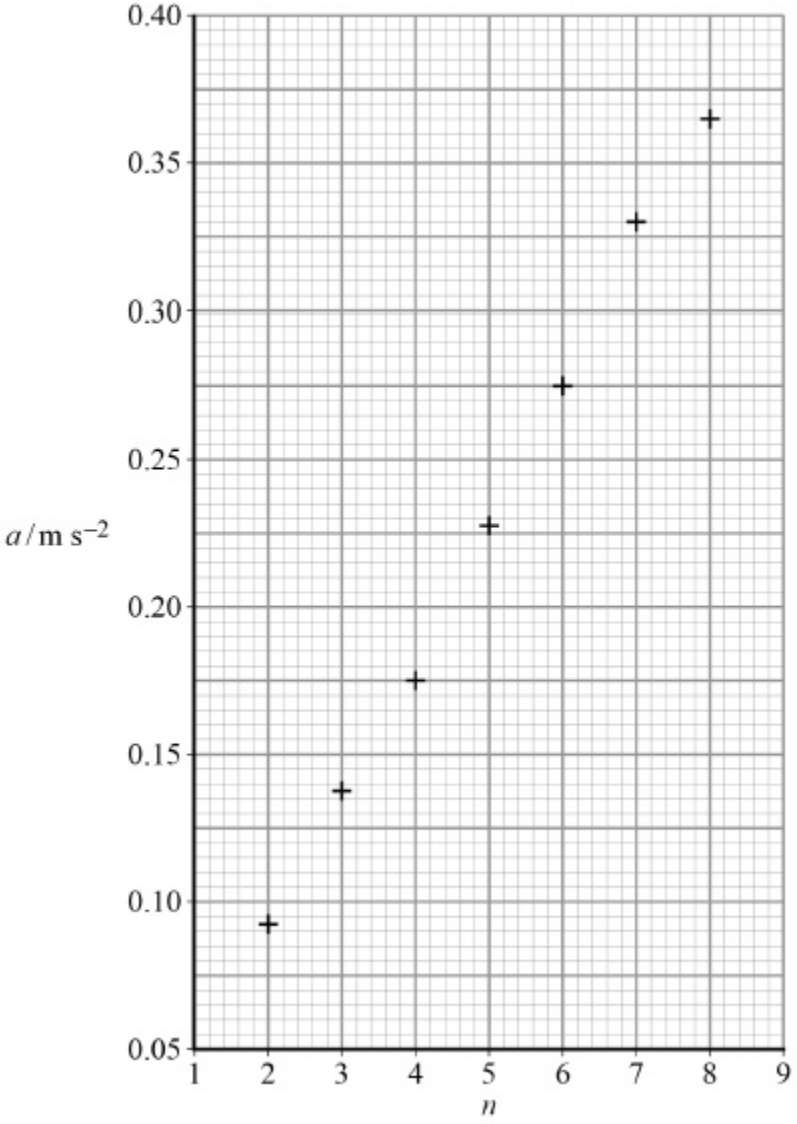
(2)

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(c) Additional values for the acceleration of the air-track glider are obtained by further raising the end of the air track by using a stack consisting of identical blocks.
Adding each block to the stack raises the end of the air track by the same distance.

Figure 2 is a graph of these results showing how a varies with n, the number of blocks in the stack.

Figure 2



Draw a suitable best-fit straight line on **Figure 2** and determine G, the gradient of your line.

G = _____

(2)

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(d) It can be shown that, for the apparatus used by the student, g is equal to $\frac{2G}{h}$ where h is the thickness of each block used in the experiment.

The student obtains a value for g of 9.8 m s^{-2}

Calculate h.

h = _____ m

(1)

(e) Explain how you could find out, without drawing another graph, whether the data presented in the graph in **Figure 2** support the suggestion that a is directly proportional to n.

_____

_____

_____

_____

_____

(1)

(Total 9 marks)

37. (a) Calculate the weight of an ice cube that has volume 4.0 × 10^{-6} m^3

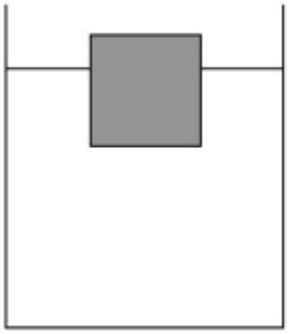
density of ice = 920 kg m^{-3}

weight = _____ N

(2)

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(b) The diagram shows the ice cube floating in a beaker of water.



When the ice cube is placed in the beaker, it displaces a volume of water causing the water level to rise.
The weight of water displaced is equal to the weight of the ice cube.

Calculate the volume of water displaced by the ice cube.

density of water = 1000 kg m^{-3}

volume = _____ m^3

(1)

(c) The ice cube in the diagram is replaced by another cube also with volume 4.0×10^{-6} m^3
This cube is made of ice containing a small piece of iron.
The mass of water now displaced is 3.9×10^{-3} kg

Calculate the volume of the piece of iron.

density of iron = 7800 kg m^{-3}

volume = _____ m^3

(3)

(Total 6 marks)

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38. An object of mass m moves in a circle of radius r. It completes n revolutions every second.

What is the kinetic energy of the object?

A $\frac{mn^2r^2}{8\pi^2}$ ⬭

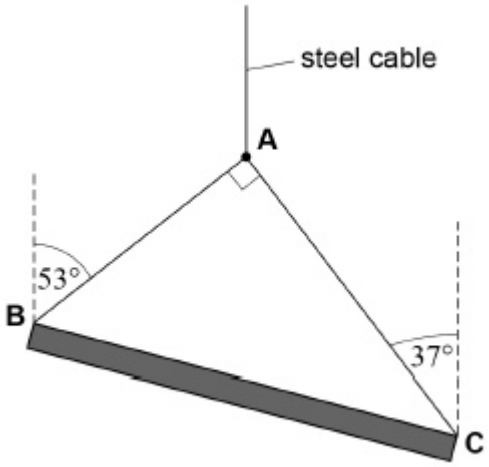
B $\frac{mn^2r^2}{4\pi^2}$ ⬭

C $2m\pi^2n^2r^2$ ⬭

D $4m\pi^2n^2r^2$ ⬭

(Total 1 mark)

39. The diagram shows a uniform beam supported by two light cables, **AB** and **AC**, which are attached to a single steel cable from a crane. The beam is stationary and in equilibrium.



(a) State **two** necessary conditions for the beam to be in equilibrium.

Condition 1 _____

_____

_____

Condition 2 _____

_____

_____

(2)

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(b) State what is meant by the centre of mass.

_____

_____

(1)

(c) Explain why the centre of mass of the beam in the diagram must be vertically below **A**.

_____

_____

_____

_____

(2)

(d) The weight of the beam is 12 000 N

Calculate the tension T_1 in cable **AB** and the tension T_2 in cable **AC**.

T_1 = _____ N

T_2 = _____ N

(4)

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(e) The steel cable from the crane has a circular cross-section of diameter 1.5×10^{-2} m
The cable is 12 m long.

Calculate the extension of the cable caused by the weight of the beam. You can assume that the weights of **all cables** are negligible.

Young modulus of steel = 2.0×10^{11} Pa

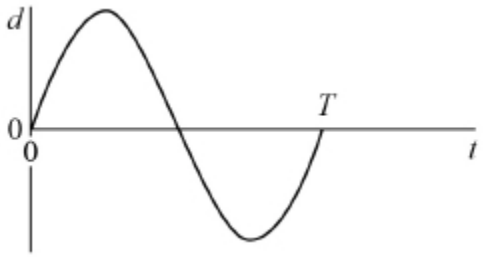
extension = _____ m

(3)

(Total 12 marks)

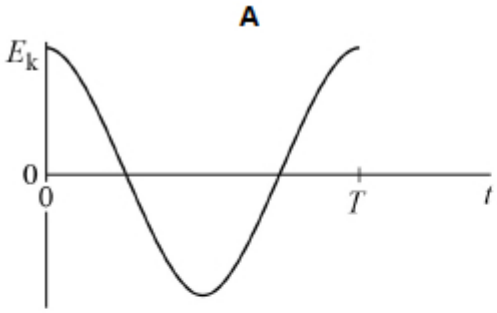
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40. The graph shows the variation of displacement d with time t for a particle moving with simple harmonic motion of period T.

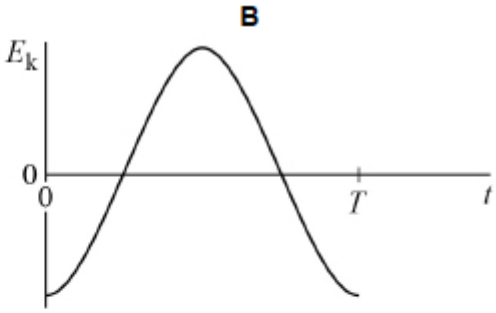


Which graph shows the variation of kinetic energy E_k of the particle with time?

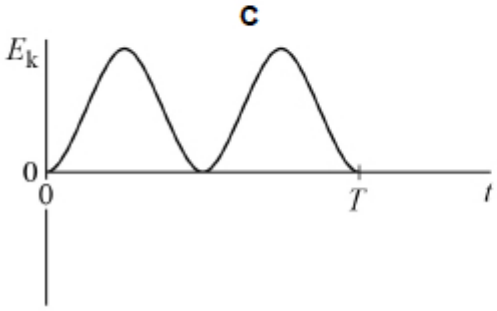
A



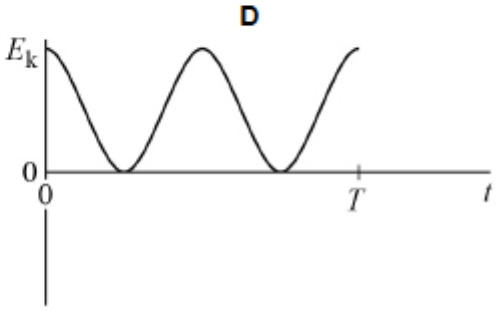
B



C



D



A ⬭

B ⬭

C ⬭

D ⬭

(Total 1 mark)

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41. The frequency of oscillation of a vertical spring is f when the mass hanging from the spring is m.

What is the relationship between f and m?

A $f \propto m^{-\frac{1}{2}}$ ⬭

B $f \propto m^{-2}$ ⬭

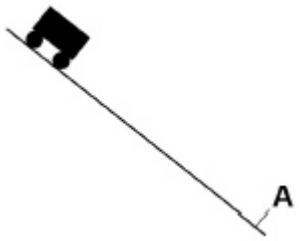
C $f \propto m^{\frac{1}{2}}$ ⬭

D $f \propto m^{2}$ ⬭

(Total 1 mark)

42. (a) **Figure 1** shows a truck moving freely down a ramp inclined at an angle to the horizontal.

Figure 1



The truck starts from rest at the top of the ramp and reaches point **A**. Friction and air resistance are negligible.

As the truck moves down the ramp to point **A**, its centre of mass has a total vertical displacement of 8.0 m

Calculate the speed of the truck at point **A**.

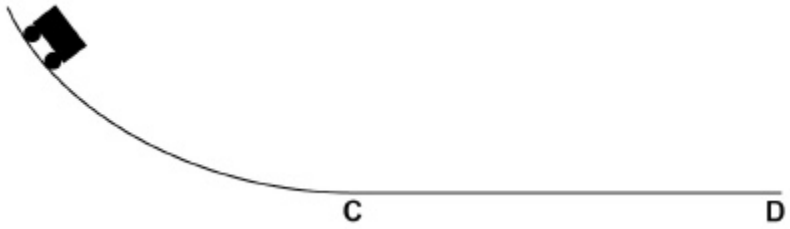
speed = _____ m s^{-1}

(2)

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(b) **Figure 2** shows the truck moving down a ramp with a varying slope.

Figure 2



The truck starts from rest and moves freely down the ramp. It reaches point **C** and then moves along the horizontal runway to **D**. Friction and air resistance are negligible.

Discuss how the acceleration of the truck in **Figure 2** differs from the acceleration of the truck in **Figure 1**.

(3)

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(c) The total vertical displacement of the centre of mass of the truck in **Figure 2** is also 8.0 m

The speed of the truck when it reaches the horizontal runway is the same as the speed of the truck in **Figure 1** when it reaches point **A**.

Explain why.

_____

_____

_____

_____

(1)

(d) The horizontal runway in **Figure 2** has negligible friction and air resistance. As the truck moves along the runway, it starts to rain. The rain falls vertically and water collects in the truck.

Discuss whether there are any changes in the momentum of the truck and collected water.

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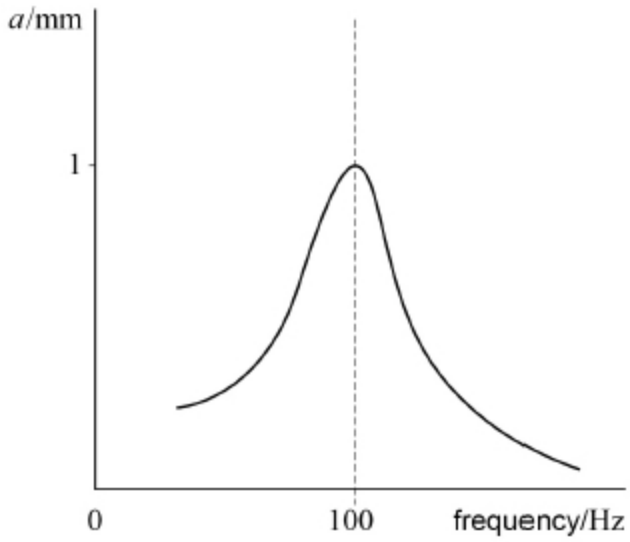
_____

(3)

(Total 9 marks)

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43. A metal panel is driven to vibrate at different frequencies. The amplitude a of the vibration is measured at each frequency. The graph shows the variation of amplitude with driven frequency.

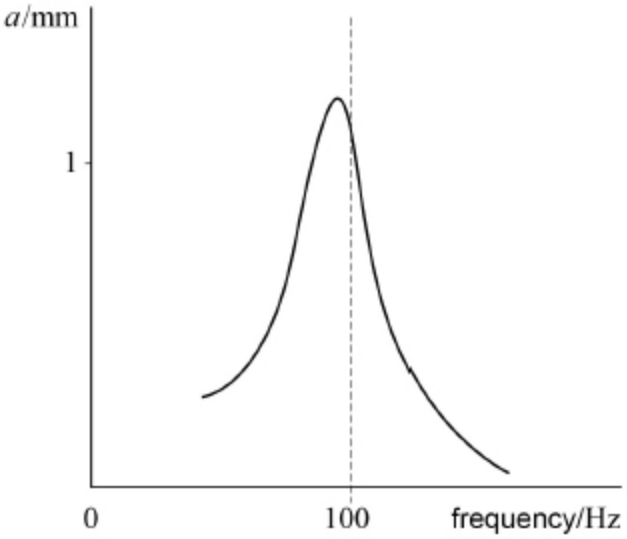


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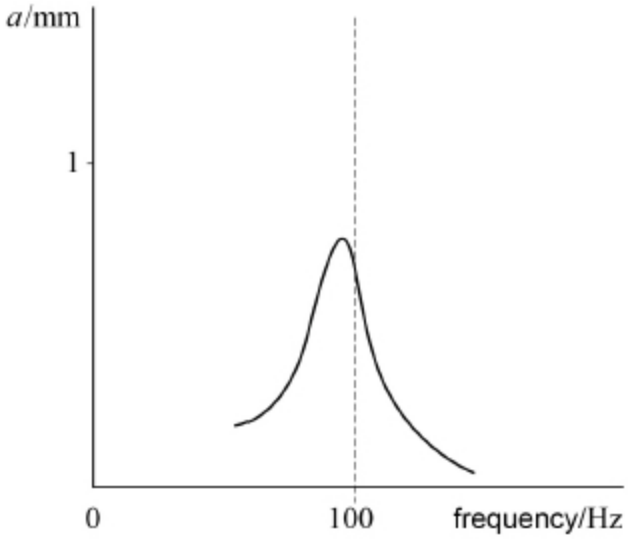
The damping of the metal panel is increased without changing the mass of the panel.

Which graph shows the variation of a with frequency with increased damping?

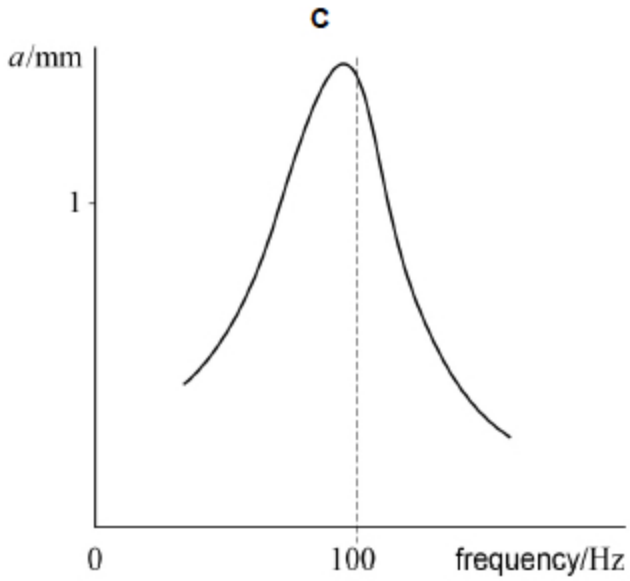
A



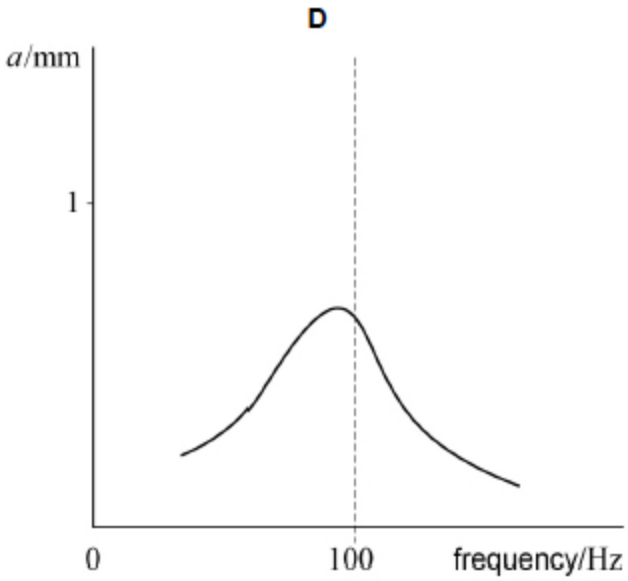
B



C



D



A ⬭

B ⬭

C ⬭

D ⬭

(Total 1 mark)

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44. Two pendulums **A** and **B** oscillate with simple harmonic motion.
The time period of **A** is 2.00 s and the time period of **B** is 1.98 s.

A and **B** are released in phase.

What is the number of oscillations of **A** before **A** and **B** are next in phase?

A 49 ⬭

B 50 ⬭

C 99 ⬭

D 100 ⬭

(Total 1 mark)

45. **Figure 1** shows a side view of an act performed by two acrobats. **Figure 2** shows the view from above.

Figure 1

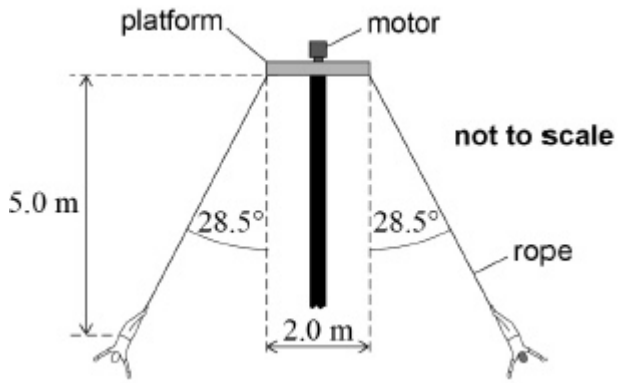
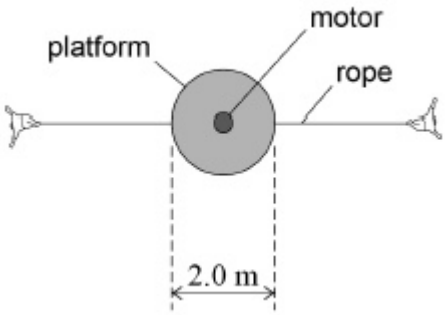


Figure 2



The acrobats, each of mass 85 kg, are suspended from ropes attached to opposite edges of a circular platform that is at the top of a vertical pole. The platform has a diameter of 2.0 m
A motor rotates the platform so that the acrobats move at a constant speed in a horizontal circle, on opposite sides of the pole.

When the period of rotation of the platform is 5.2 s, the centre of mass of each acrobat is 5.0 m below the platform and the ropes are at an angle of 28.5° to the vertical as shown in **Figure 1**.

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(a) Show that the linear speed of the acrobats is about 4.5 m s^{-1}

(2)

(b) Determine the tension in each rope that supports the acrobats.

tension = _____ N

(3)

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(c) Discuss the consequences for the forces acting on the pole when one acrobat has a much greater mass than the other.

_____

_____

_____

_____

_____

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_____

_____

_____

(3)

(Total 8 marks)

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