Name:		Index Number:		Class:	

DUNMAN HIGH SCHOOL
Mid Year Examination
Year 5

H2 PHYSICS

9749

Multiple Choice and Structured Questions

Additional Materials:

Multiple Choice Answer Sheet

1 July 2021

2 hours

READ THESE INSTRUCTIONS FIRST

Write your class, index number and name on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Section A

There are **fifteen** questions in this section.
Answer **all** questions.
For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

You are advised **not** to spend more than 30 minutes on Section A.

Section B

Answer **all** questions.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

You are advised **not** to spend more than 1 hour 30 minutes on Section B.

For Examiner's Use	
Section A	
MCQ	15
Section B	
1	10
2	10
3	10
4	10
5	10
6	10
s.f.	-1
Total	75

Data

speed of light in free space,	c =	3.00×10^{8} m s^{-1}
permeability of free space,	μ_o =	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o =	8.85×10^{-12} F m^{-1}
	=	$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e =	1.60×10^{-19} C
the Planck constant,	h =	6.63×10^{-34} J s
unified atomic mass constant,	u =	1.66×10^{-27} kg
rest mass of electron,	m_e =	9.11×10^{-31} kg
rest mass of proton,	m_p =	1.67×10^{-27} kg
molar gas constant	R =	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A =	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k =	1.38×10^{-23} J K^{-1}
gravitational constant,	G =	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g =	9.81 m s^{-2}

Formulae

uniformly accelerated motion,	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas,	W	=	$p\Delta V$
hydrostatic pressure,	p	=	ρgh
gravitational potential,	ϕ	=	$-Gm/r$
temperature,	T/K	=	T/°C + 273.15
pressure of an ideal gas,	p	=	$\frac{1}{3}\frac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal gas molecule,	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.,	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.,	v	=	$v_0 \cos \omega t$
		=	$\pm\omega\sqrt{x_o^2 - x^2}$
electric current,	I	=	$Anvq$
resistors in series,	R	=	$R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential,	V	=	$\frac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage,	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire,	B	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux denxity due to a flat circular coil,	B	=	$\frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid,	B	=	$\mu_0 nI$
radioactive decay,	x	=	$x_0 \exp(-\lambda t)$
decay constant,	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

[Turn over

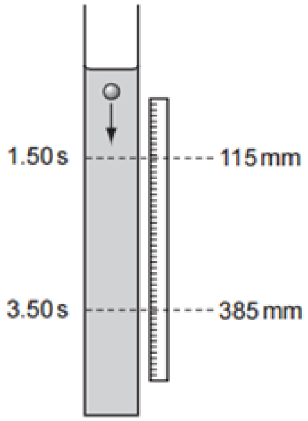
Section A

Answer **all** the questions.

1 Which of the following gives the best estimate of the typical cruising speed of a 300-seater commercial passenger aircraft?

A 500 km h^{-1} **B** 1000 km h^{-1} **C** 2000 km h^{-1} **D** 2500 km h^{-1}

2 The diagram shows an experiment to measure the speed of a small ball falling at constant speed through a clear liquid in a glass tube.



There are two marks on the tube. The top mark is positioned at (115 ± 1) mm on the adjacent rule and the lower mark at (385 ± 1) mm. The ball passes the top mark at (1.50 ± 0.02) s and passes the lower mark at (3.50 ± 0.02) s.

The constant speed of the ball is calculated to be $\dfrac{385-115}{3.50-1.50}=\dfrac{270}{2.00}=135$ mm s^{-1}.

Which expression calculates the fractional uncertainty in the value of this speed?

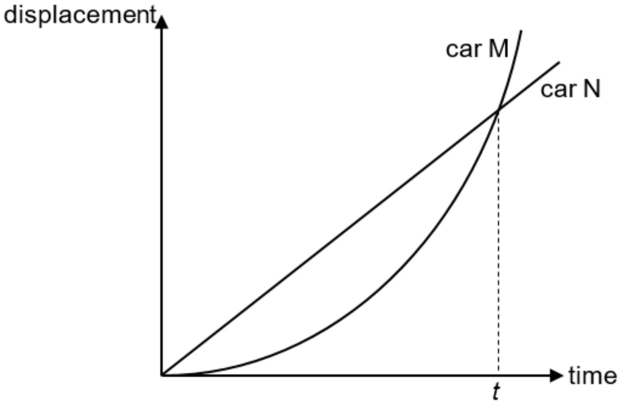
A $\dfrac{0.02}{2.00}+\dfrac{1}{270}$

B $\dfrac{0.04}{2.00}+\dfrac{2}{270}$

C $\dfrac{2}{270}\div\dfrac{0.04}{2.00}$

D $\dfrac{1}{270}\div\dfrac{0.02}{2.00}$

3 The diagram shows the variation with time of the displacement of two cars M and N.



Which statement is **incorrect**?

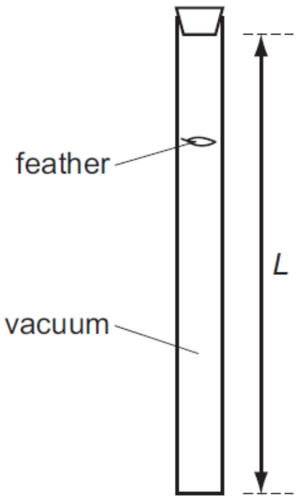
A Car M overtakes car N at time t.

B Throughout the motion, both cars are accelerating.

C At time t, the average velocities of both cars are equal.

D At time t, the rate of change of displacement of car N is less than that of car M.

4 The diagram shows a laboratory experiment in which a feather falls from rest in a long evacuated vertical tube of length L.



The feather takes time T to fall from the top to the bottom of the tube.

How long will the feather take to fall 0.50 L from the top of the tube?

A $0.25T$ **B** $0.29T$ **C** $0.71T$ **D** $0.75T$

5 A ball falls vertically and bounces on the ground.

The following statements are about the forces acting while the ball is in contact with the ground.

Which statement is correct?

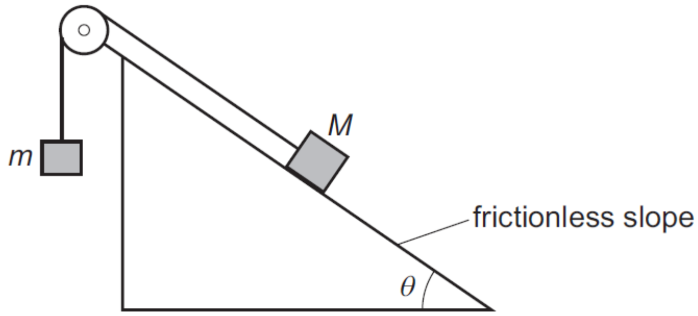
A The force that the ball exerts on the ground is always equal to the weight of the ball.

B The force that the ball exerts on the ground is always equal in magnitude and opposite in direction to the force the ground exerts on the ball.

C The force that the ball exerts on the ground is always less than the weight of the ball.

D The weight of the ball is always equal in magnitude and opposite in direction to the force that the ground exerts on the ball.

6 Two masses, *M* and *m*, are connected by an inextensible string which passes over a frictionless pulley. Mass *M* rests on a frictionless slope, as shown.



The slope is at an angle θ to the horizontal.

The two masses are initially held stationary and then released. Mass *M* moves down the slope.

Which expression **must** be correct?

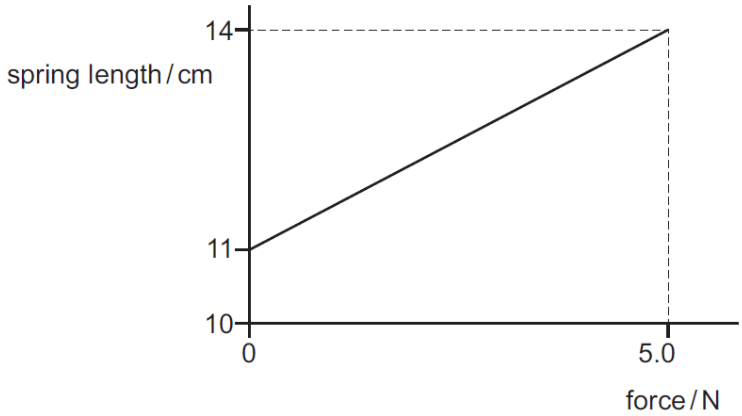
A $\sin\theta < \frac{m}{M}$

B $\cos\theta < \frac{m}{M}$

C $\sin\theta > \frac{m}{M}$

D $\cos\theta > \frac{m}{M}$

7 The graph shows the effect of applying a force of up to 5.0 N to a spring.

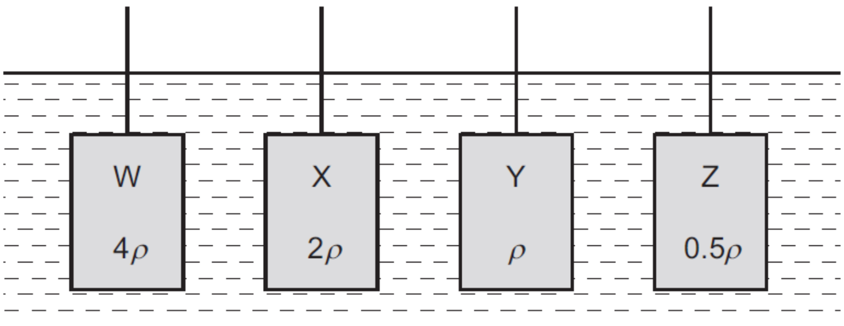


The spring obeys Hooke's law for forces up to 7.0 N.

What is the total extension of the spring produced by a 7.0 N force?

A 4.2 cm **B** 5.6 cm **C** 15 cm **D** 20 cm

8 Four cuboids with identical lengths, breadths and heights are immersed in water. The cuboids are held at the same depth and in identical orientations by vertical rods, as shown.



Water has density ρ.
Cuboid W is made of material of density 4ρ.
Cuboid X is made of material of density 2ρ.
Cuboid Y is made of material of density ρ.
Cuboid Z is made of material of density 0.5ρ.

Which statement is correct?

A The upthrust of the water on each of the cuboids is the same.

B The upthrust of the water on W is twice the upthrust of the water on X.

C The upthrust of the water on X is twice the upthrust of the water on W.

D The upthrust of the water on Y is zero.

9 An electric motor is required to haul a cage of mass 400 kg up a mine shaft through a vertical height of 1200 m in 2.0 minutes. The motor used is 80% efficient.

What is the power supplied to the motor?

A 31 kW **B** 49 kW **C** 73 kW **D** 79 kW

10 A toy car of mass 7.0 kg is moving at a constant velocity of 20 m s^{-1} up a track that is inclined at an angle of 30° to the horizontal.

A constant resistive force of 12 N acts on the toy car throughout its motion.

What is the power supplied by the motor of the toy car?

A 240 W **B** 450 W **C** 930 W **D** 1600 W

11 A ball of mass 0.30 kg is attached to a string and moves in a vertical circle of radius 0.60 m at a constant speed of 5.0 m s^{-1}.

Which row in the table gives the correct values of the minimum and maximum tension in the string?

	minimum tension / N	maximum tension / N
A	2.5	5.4
B	6.7	9.6
C	13	13
D	9.6	15

12 The Earth experiences gravitational forces from the Sun, mass M_S, and from the Moon, mass M_m. The distance of the Sun from the Earth is r_S and the distance of the Moon from the Earth is r_m.

Which of the following expressions gives the ratio $\dfrac{\text{force on the Earth due to the Moon}}{\text{force on the Earth due to the Sun}}$?

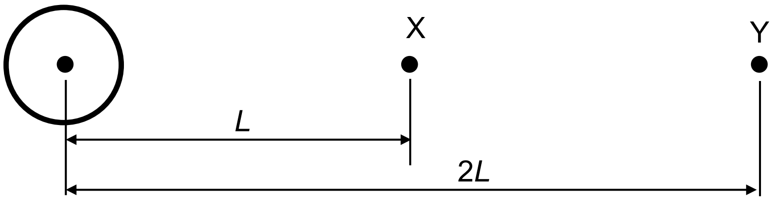
A $\dfrac{M_S}{M_m}\left(\dfrac{r_m}{r_S}\right)$ **B** $\dfrac{M_m}{M_S}\left(\dfrac{r_S}{r_m}\right)$ **C** $\dfrac{M_S}{M_m}\left(\dfrac{r_m}{r_S}\right)^2$ **D** $\dfrac{M_m}{M_S}\left(\dfrac{r_S}{r_m}\right)^2$

13 At a point outside the Earth and a distance x from its centre, the Earth's gravitational field strength is about 5.0 N kg^{-1} while at the Earth's surface, the gravitational field strength is about 10 N kg^{-1}.

Which one of the following gives an approximate value for the radius of the Earth?

A $\frac{x}{5}$ **B** $\frac{x}{2\sqrt{2}}$ **C** $x\sqrt{2}$ **D** $\frac{x}{\sqrt{2}}$

14 The diagram below shows two points X and Y at distance L and $2L$, respectively, from the centre of the Earth. The gravitational potential at X is −8.0 kJ kg^{-1}.



What is the gain in gravitational potential energy of a 1.0 kg mass when it is moved from X to Y?

A −4.0 kJ **B** −2.0 kJ **C** +4.0 kJ **D** +8.0 kJ

15 A satellite of mass m is placed in an equatorial orbit so that it remains vertically above a fixed point on the Earth's surface.

If ω is the Earth's angular velocity of rotation and M is the Earth's mass, what is the radius of the satellite's orbit?

A $\left[\frac{GM}{\omega^2}\right]^{\frac{1}{3}}$ **B** $\left[\frac{Gm}{\omega^2}\right]^{\frac{1}{3}}$ **C** $\left[\frac{GmM}{\omega^2}\right]^{\frac{1}{3}}$ **D** $\left[\frac{GM}{\omega^3}\right]^{\frac{1}{2}}$

END OF SECTION A

Section B

Answer **all** the questions.

1 A student takes readings to measure the mean diameter of a wire using a micrometer screw gauge.

(a) Make suggestions, one in each case, that the student may adopt in order to

(i) reduce systematic errors in the readings,

....

.... [1]

(ii) take into account the varying diameter along the length of the wire,

....

.... [1]

(iii) take into account the non-circular cross-section of the wire.

....

.... [1]

(b) It is suggested that the mass flow rate Q of grains through a hopper can be given by

$$Q = C\rho\sqrt{g}\,(D - kd)^{\frac{3}{2}}$$

where C and k are constants, ρ is the density of the grains, D is the diameter of the aperture of the hopper, d is the diameter of the circular grain and g is the acceleration of free fall.

Determine the units of C and k in terms of the SI base units.

units of k = ………………………………..

units of C = ……………………………….. [3]

(c) A ball approaches a ramp with an inclination of 20°. It hits the surface of the ramp at a speed of 5.0 m s^{-1} at 70° to the normal and bounces off with a speed of 5.0 m s^{-1} as shown in Fig. 1.1.

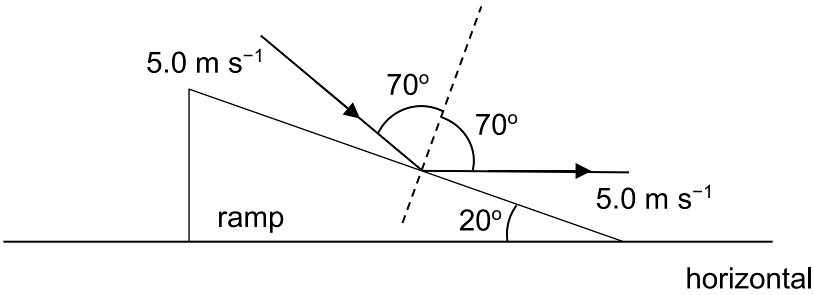


Fig. 1.1

Determine the change in velocity of the ball.

magnitude of change in velocity = ……………………… m s^{-1} [2]

direction of change in velocity is ……………………… ° with respect to the horizontal [2]

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2 **(a)** A projectile is launched from the ground with an initial velocity u at an angle θ to the horizontal, as shown in Fig. 2.1.

Fig. 2.1

Ignoring the effects of air resistance, show that the time t_0 taken by the projectile to land on the ground is given by

$$t_0 = \frac{2u\sin\theta}{g}$$

Explain your working. [2]

(b) Fig. 2.2 shows a cart moving with constant velocity v in front of the projectile launcher.

A projectile is launched from the ground with an initial velocity u = 35 m s^{-1} at an angle θ = 23° to the horizontal. At this instant, the back of the cart is 45 m from the position of launch.

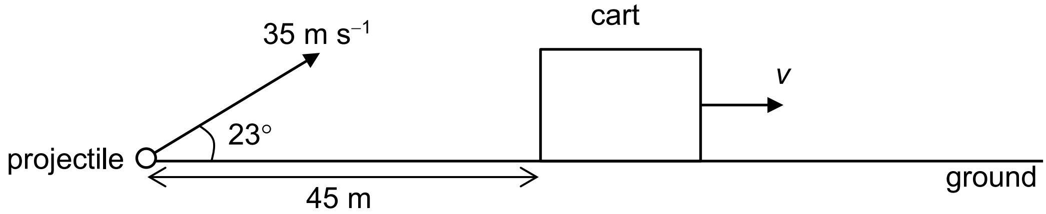

Fig. 2.2

Ignoring the effects of air resistance, determine the velocity v of the cart such that the projectile will land just behind it.

v = ……………………… m s^{-1} [3]

(c) On Fig. 2.3, sketch the variation with time t of

(i) the horizontal velocity v_x and

(ii) the vertical velocity v_y

of the projectile from the time it was launched to the time it just lands behind the cart. Include all relevant numerical values on the axis. [4]

Fig. 2.3

(d) Suggest how the projectile should be launched such that it will still land just behind the cart, if the effects of air resistance on the projectile are not negligible.

……

…… [1]

[Turn over

3 **(a)** State

(i) what is meant by the *mass* of a body.

....

.... [1]

(ii) the principle of conservation of momentum.

....

....

.... [2]

(b) Two blocks travel directly towards each other along a horizontal and frictionless surface. The blocks collide, as illustrated in Fig. 3.1.

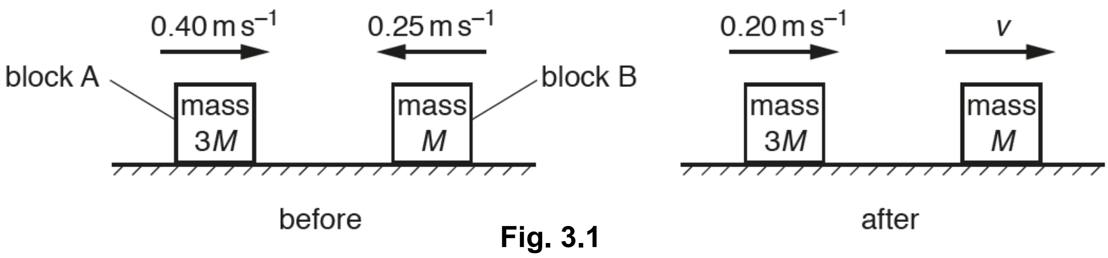

Fig. 3.1

Block A has mass 3*M* and block B has mass *M.*

Before the collision, block A moves to the right with speed 0.40 m s^{-1} and block B moves to the left with speed 0.25 m s^{-1}.

After the collision, block A moves to the right with speed 0.20 m s^{-1} and block B moves to the right with speed *v*.

(i) Use Newton's third law to explain why, during the collision, the change in momentum of block A is equal and opposite to the change in momentum of block B.

....

....

....

.... [2]

(ii) Determine speed v.

v = ………………………….. m s^{-1} [2]

(iii) Calculate, for the blocks,

1. the relative speed of approach,

relative speed of approach = ... m s^{-1} [1]

2. the relative speed of separation.

relative speed of separation = ... m s^{-1} [1]

(iv) Use your answers in **(b)(iii)** to state and explain whether the collision is elastic or inelastic.

...…………………………………………..……………………………………………..………

...………………………………………………………………………………….…………….. [1]

4 **(a)** A cylinder is made from a material of density 2.7 g cm^{-3}. The cylinder has diameter 2.4 cm and length 5.0 cm.

Show that the cylinder has weight 0.60 N. [3]

(b) The cylinder in **(a)** is hung from the end A of a non-uniform bar AB, as shown in Fig. 4.1.

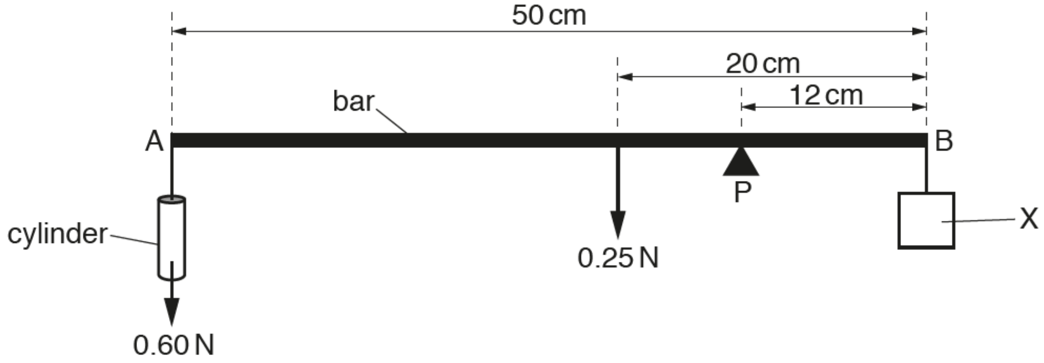

Fig. 4.1

The bar has length 50 cm and has weight 0.25 N. The centre of gravity of the bar is 20 cm from B. The bar is pivoted at P. The pivot is 12 cm from B.

An object X is hung from end B. The weight of X is adjusted until the bar is horizontal and in equilibrium.

(i) State the two conditions that must be satisfied for a body to be in equilibrium.

1. ....

....

2. ....

.... [2]

(ii) Calculate the weight of X.

weight = ... N [2]

(c) The cylinder is now immersed in water, as illustrated in Fig. 4.2.

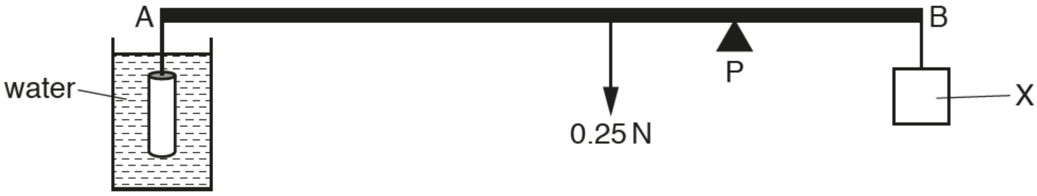

Fig. 4.2

An upthrust acts on the cylinder and the bar is not in equilibrium.

(i) Explain the origin of the upthrust.

....

....

....

.... [2]

(ii) Explain why the weight of X must be reduced in order to obtain equilibrium for AB.

....

.... [1]

5 A cyclist travels up an inclined road of constant slope. The cyclist takes 8.0 s to ascend the road. The variation with time t of the speed v of the cyclist is shown in Fig. 5.1.

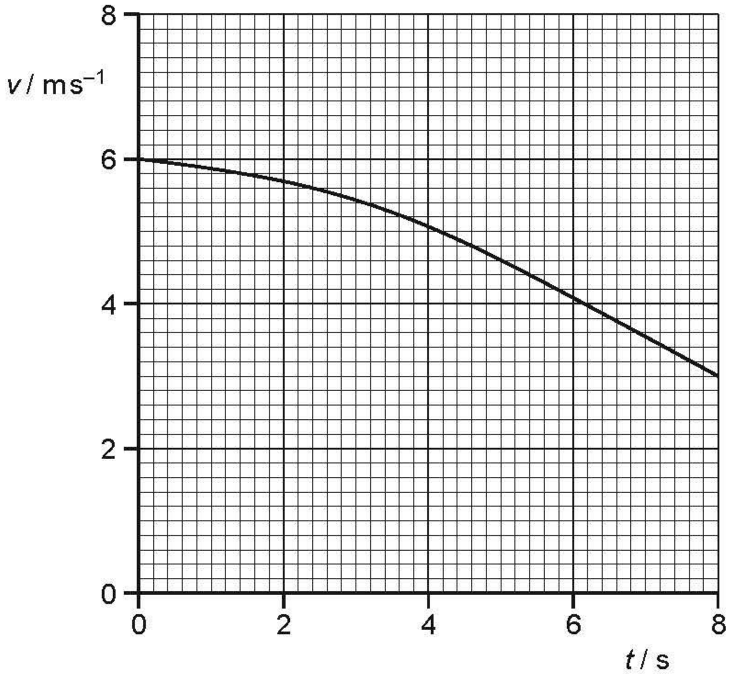

Fig. 5.1

(a) Use Fig. 5.1 to determine the total distance travelled up the inclined road.

total distance = ………………………….. m [2]

(b) The bicycle and cyclist have a combined mass of 95 kg and the slope of the inclined road is such that the cyclist rises 1 m for every 30 m he travels along the road.

For the movement of the bicycle and cyclist between t = 0 s and t = 8.0 s,

(i) use Fig. 5.1 to calculate the change in kinetic energy,

change in kinetic energy = ………………………….. J [1]

(ii) calculate the change in gravitational potential energy.

change in gravitational potential energy = ………………………….. J [2]

(c) The cyclist pedals continuously so that the average power delivered to the bicycle is 75 W in 8.0 s. Assume energy is lost in overcoming the resistive forces.

Calculate the work done in overcoming the resistive forces.

work done = ………………………….. J [2]

(d) **(i)** Use Fig. 5.1 to describe how the acceleration of the cyclist varies with time as he travels up the inclined road.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [1]

(ii) The resistive force acting on the cyclist and bicycle is predominantly air resistance. By reference to the forces acting on the cyclist and bicycle, and your answer in **(d) (i)**, state and explain the changes in the driving force by the cyclist in moving up along the inclined road.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [2]

6 **(a)** Use Newton's laws of motion to explain why a body moving with uniform speed in a circle must experience a force towards the centre of the circle.

....

....

....

....

....

....

....

.... [3]

(b) A small mass *m* and a heavy mass *M* are connected to the ends of an inextensible string. The string is threaded through a glass tube as shown in Fig. 6.1. The tube is then held by a student and is whirled so that the mass *m* rotates with a constant radius *r* at a frequency of 175 revolutions per minute.

Given that m = 0.30 kg and M = 0.90 kg.

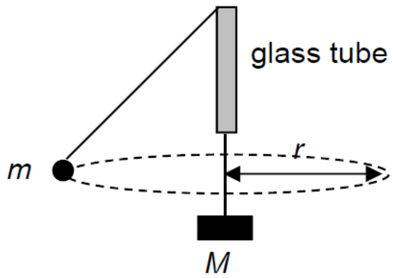

Fig. 6.1

(i) Calculate the angular velocity ω of the mass *m*.

ω = ... rad s^{-1} [1]

(ii) Calculate the resultant force acting on the mass m.

resultant force = ... N [2]

(iii) Hence, calculate the radius r of the circle.

r = ...m [2]

(iv) Explain whether it is possible for the small mass m to be whirled in such a way that the string attached to it becomes horizontal.

....

....

....

.... [2]

END OF PAPER

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