JURONG JUNIOR COLLEGE
JC2 Preliminary Examination 2017

Name		Class	17S

PHYSICS **9749/1**
Higher 2

Multiple Choice **15 September 2017**

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

Write your **name** and **class** in the spaces provided at the top of this page.

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, class and index number on the Answer Sheet in the spaces provided.

There are **thirty** questions on this paper. 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.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.

(This question paper consists of 18 printed pages)

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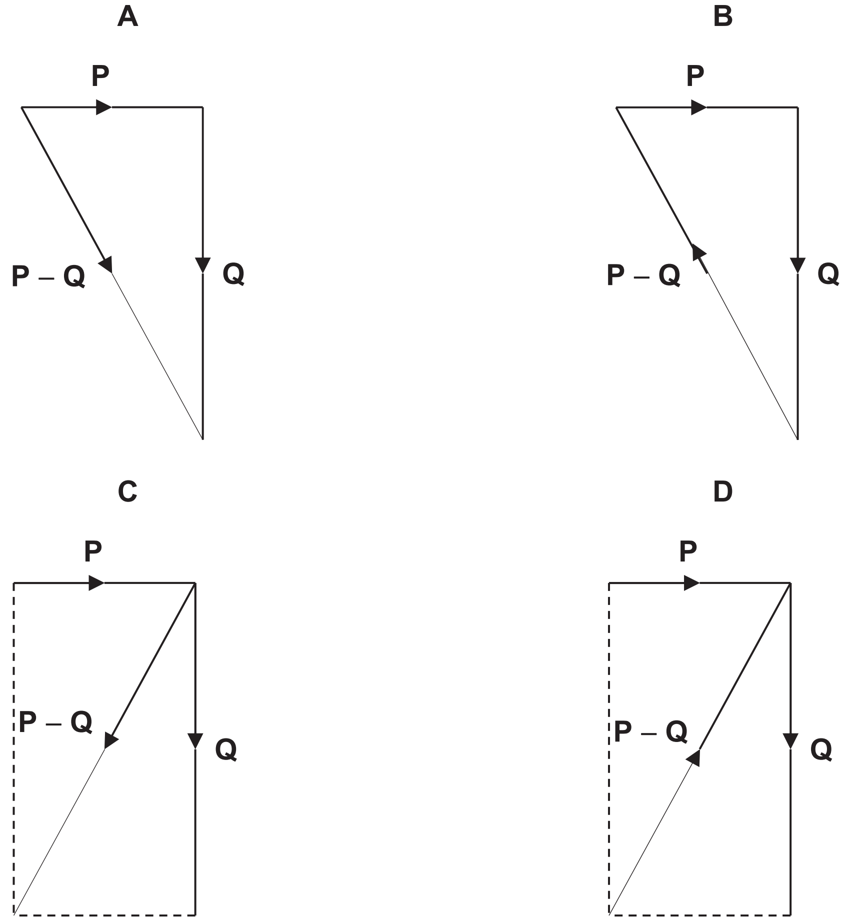
Data

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

Formulae

uniformly accelerated motion,	s	$= ut + \frac{1}{2}at^2, \qquad v^2 = u^2 + 2as$
work done on/by a gas,	W	$= p\,\Delta V$
hydrostatic pressure,	p	$= \rho g h$
gravitational potential,	ϕ	$= -\dfrac{Gm}{r}$
temperature,	T/K	$= T$/°C + 273.15
pressure of an ideal gas,	p	$= \dfrac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
mean translational kinetic energy of an ideal gas molecule,	E	$= \frac{3}{2}kT$
displacement of particle in s.h.m.,	x	$= x_o \sin \omega t$
velocity of particle in s.h.m.,	v	$= v_o \cos \omega t$
	v	$= \pm\,\omega\sqrt{(x_o^2 - x^2)}$
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	$= \dfrac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage,	x	$= x_o \sin \omega t$
magnetic flux density due to a long straight wire	B	$= \dfrac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	$= \dfrac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid	B	$= \mu_o n I$
radioactive decay	x	$= x_o \exp(-\lambda t)$
decay constant	λ	$= \dfrac{\ln 2}{t_{1/2}}$

1 Which vector triangle shows the resultant of the vector subtraction **P** – **Q**?



2 A crew of an oil tanker spotted an iceberg in its path and immediately sounded the alarm. At the time when the engine of the oil tanker was driven to slow it down, the oil tanker was moving at 10 m s^{-1}, the iceberg was 800 m away and moving at 0.5 m s^{-1} in the same direction as the oil tanker. The oil tanker managed to stop just 20 m from the iceberg.

Determine the average deceleration of the oil tanker.

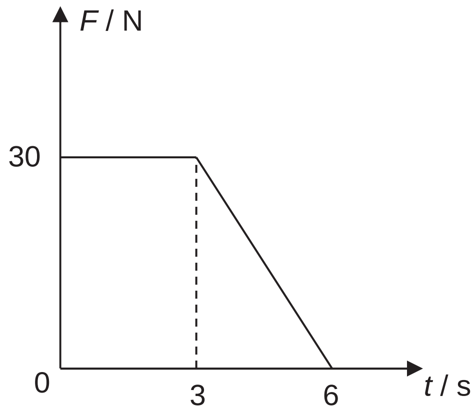
A 0.055 m s^{-2}

B 0.058 m s^{-2}

C 0.067 m s^{-2}

D 0.071 m s^{-2}

3 An object of mass 20 kg moves along a straight line on a smooth horizontal surface. A force F acts on the object in its direction of motion. The variation with time t of force F is shown.



What is the velocity of the object at t = 6 s if its velocity at t = 4 s is 4.5 m s^{-1}?

A 3.5 m s^{-1}

B 5.5 m s^{-1}

C 6.8 m s^{-1}

D 11 m s^{-1}

4 Rubber bullets, each of mass m, are fired at the rate of n bullets per second on a vertical wall. The speed of each bullet is u and they rebound from the wall with the same speed.

Determine the average force exerted on the wall.

A mnu

B $2mnu$

C $mnug$

D $2mnug$

5 Blocks A and B have the same mass but different roughness. When block A is pulled with a force of 10 N, blocks A and B experience frictional forces of 4 N and 2 N respectively.

What is the tension in the rope joining blocks A and B?

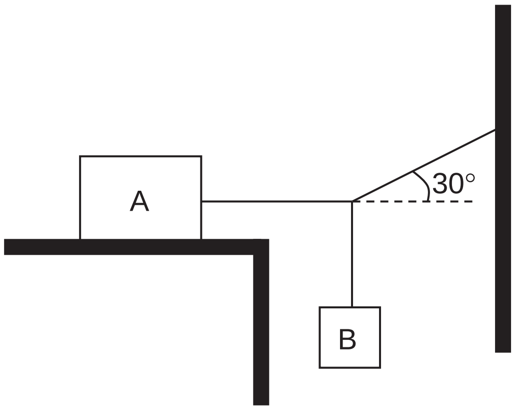
A 2 N

B 4 N

C 6 N

D 8 N

6 Inextensible strings hold blocks A and B in equilibrium as shown in the diagram. The static friction between block A and the rough horizontal surface is 1.8 N.



Determine the weight of block B.

A 0.90 N

B 1.0 N

C 1.6 N

D 3.1 N

7 A small metal sphere of mass m moves through a viscous liquid.

When it reaches a constant downward velocity v, which of the following describes the changes with time in the kinetic energy and gravitational potential energy of the sphere?

	change in kinetic energy	**gravitational potential energy**
A	$\frac{1}{2}mv^2$	decreases at a rate of mgv
B	$\frac{1}{2}mv^2$	decreases at a rate of $(mgv - \frac{1}{2}mv^2)$
C	zero	decreases at a rate of $(\frac{1}{2}mv^2 - mgv)$
D	zero	decreases at a rate of mgv

8 One end of an inextensible string is attached to the handle of a pail of water. The other end is held by a student. The student swings the pail of water such that its trajectory is a circle in a vertical plane with a fixed centre (i.e. the hand that holds the string remains at the same position as it swings the pail of water in the vertical circle).

Which of the following statements is true?

A The velocity of the pail at the top is more than the velocity at the bottom.

B To keep the water in the pail at the top, the centripetal force must be greater than or equal to the weight of the water.

C The centripetal force acting on the pail of water at the top is due to the tension only.

D At the lowest point of the vertical circle, the weight of the water is balanced by the normal contact force acting on the water by the pail.

9 The acceleration of free fall at the surface of a distant planet was found to be equal to that at the surface of the Earth. If the diameter of the planet were twice the diameter of Earth, then the ratio of the mean density of the planet to that of Earth would be

A 1 : 2 **B** 1 : 4 **C** 2 : 1 **D** 4 : 1

10 A fixed mass of ideal gas at a constant pressure of 2.0×10^4 Pa releases 1500 J of heat and as a result contracts from a volume of 0.050 m^3 to a volume of 0.025 m^3.

What is the change in its internal energy?

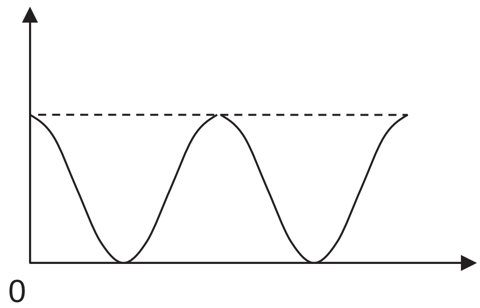
A decreases by 2000 J

B decreases by 1000 J

C increases by 1000 J

D increases by 2000 J

11 The diagram shows one possible graph for an object undergoing simple harmonic motion.



Which quantities could have been plotted to produce this graph?

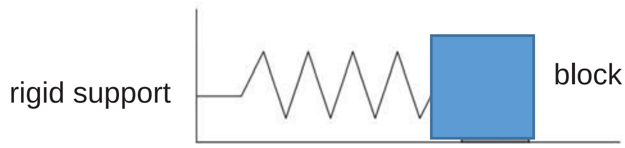
A velocity vs displacement

B kinetic energy vs displacement

C potential energy vs time

D acceleration vs displacement

12 A wooden block is at rest on a horizontal frictionless surface. A horizontal spring is attached between the block and a rigid support.



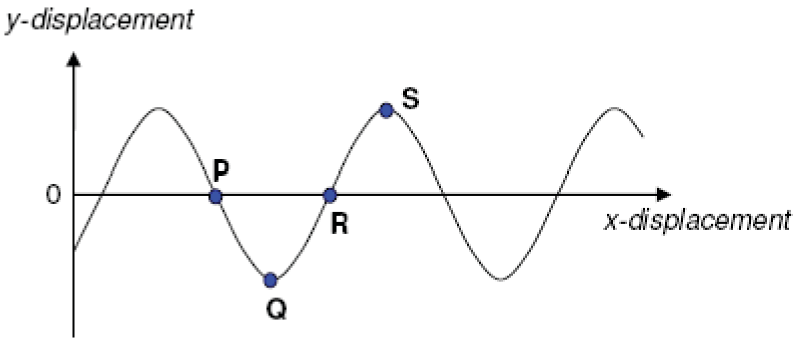
The block is displaced to the right by an amount X and is then released. The period of oscillations is T and the total energy of the system is E.

For an initial displacement of $\frac{X}{2}$ which of the following is the best estimate for the period of oscillations and the total energy of the system?

	Period	Total energy
A	T	$\frac{E}{4}$
B	T	$\frac{E}{2}$
C	$\frac{T}{2}$	$\frac{E}{4}$
D	$\frac{T}{2}$	$\frac{E}{2}$

13 The graph below shows the profile of a progressive transverse wave at a particular instant of time. The waveform progress from left to right.

The particles **P**, **Q**, **R** and **S** all oscillate with uniform amplitude.



Which one of the following statements is correct?

A Particles P and R have zero kinetic energy.

B Particle P will move to the right after a while.

C Particles P and R are in anti-phase to each other.

D Particle S has the highest total energy.

14 A stationary sound wave has a series of nodes. The distance between the first and fourth node is 15.0 cm.

What is the wavelength of the sound wave?

A 4.0 cm

B 5.0 cm

C 10.0 cm

D 13.3 cm

15 Light of wavelength 650 nm passes through a slit 1.0×10^{-3} mm wide.

Determine how wide the central maximum is on a screen 30 cm away.

A 2.0×10^{-4} m

B 4.0×10^{-4} m

C 0.27 m

D 0.51 m

16 A beam of white light was projected onto a diffraction grating with 400 lines per mm.

How many orders of the entire visible spectrum (400 nm – 700 nm) can it produce?

A 3 **B** 4 **C** 6 **D** 7

17 Which of the following statements about an electric field is incorrect?

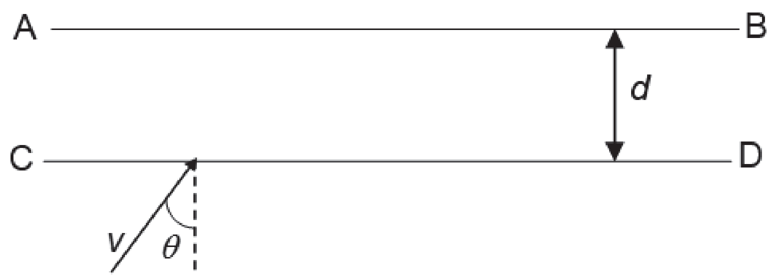
A The electric field strength at a point is a measure of the force exerted on a unit positive charge at that point.

B The electric field strength is zero at all points where the potential is zero.

C The electric field strength at a point is a measure of the potential gradient at that point.

D The electric field strength due to a point charge varies as $1/r^2$ where r is the distance from the charge.

18 The figure below shows two long parallel metal plates AB and CD in an evacuated enclosure. CD is maintained at a positive potential V relative to AB. Electrons of velocity v enter the space between the plates. The separation between the plates is d.



Given that the electron charge is $-e$ and the electron mass is m_e, the electrons will just reach AB if

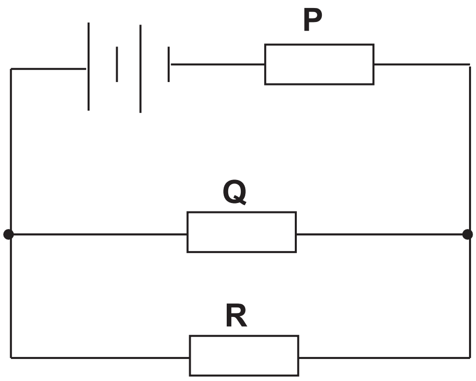
A $\frac{1}{2}m_e(v\cos\theta)^2 = eV$.

B $\frac{1}{2}m_e(v\sin\theta)^2 = eV$.

C $\frac{1}{2}m_e v^2 = \frac{e}{4\pi\varepsilon_o d}$.

D $\frac{1}{2}m_e v^2 = eV$.

19 The resistors **P**, **Q** and **R** in the circuit shown below have equal resistance.



The battery, of negligible internal resistance, supplies a total power of 12 W.

What is the power dissipated in resistor **R**?

A 2.0 W **B** 3.0 W **C** 4.0 W **D** 6.0 W

20 In an electrostatic machine, a belt of width w, having surface charge density ρ, travels with velocity v. As the belt passes a certain point, all the charge is removed and is carried away as an electric current.

What is the magnitude of this current?

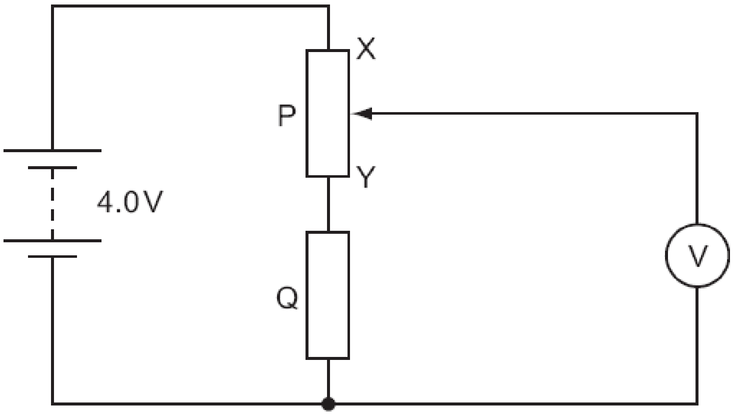
A $\rho w v$

B $\rho w v^2$

C $\dfrac{\rho w}{v}$

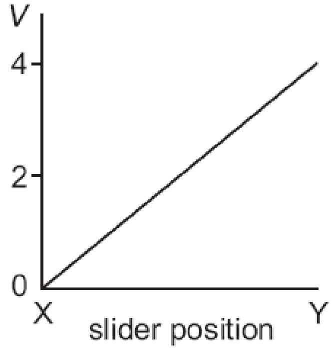
D $\dfrac{\rho v}{w}$

21 In the circuit below, P is a potentiometer of total resistance 10 Ω and Q is a fixed resistor of resistance 10 Ω. The battery has an e.m.f. of 4.0 V and negligible internal resistance. The voltmeter has a very high resistance. The slider on the potentiometer is moved from X to Y and a graph of voltmeter reading V is plotted against slider position.

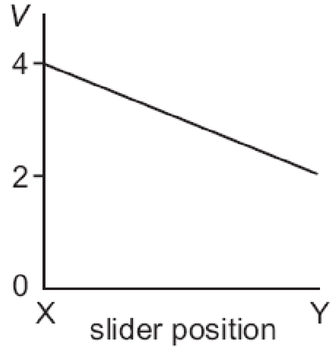


Which graph is obtained?

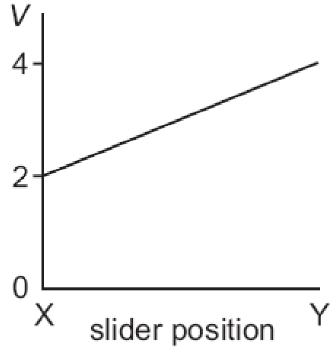
A



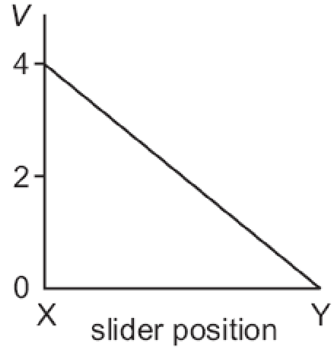
B



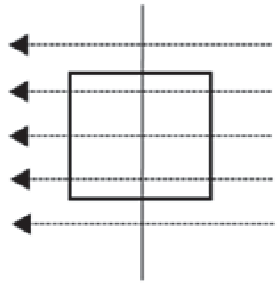
C



D



22 A 20-turns square coil of side 8.0 mm is pivoted at its centre and placed in a magnetic field of flux density 0.010 T. The two sides of the coil are parallel to the field and two sides of the coil are perpendicular to the field as shown below. A current of 5.0 mA is passed through the coil.



What is the magnitude of the torque acting on the square coil?

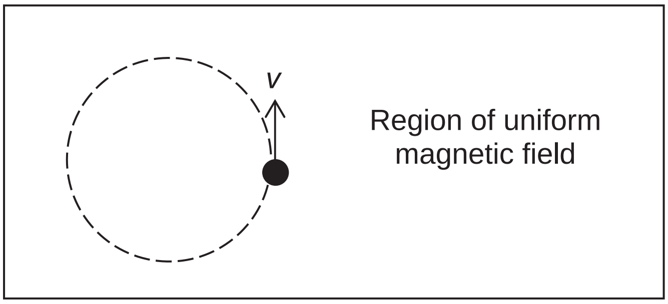
A 1.6×10^{-9} N m

B 3.2×10^{-8} N m

C 6.4×10^{-8} N m

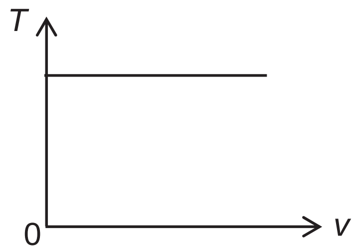
D 3.2×10^{-5} N m

23 The figure below shows a charged particle projected with a speed v perpendicularly into a uniform magnetic field such that it moves in a circular path.

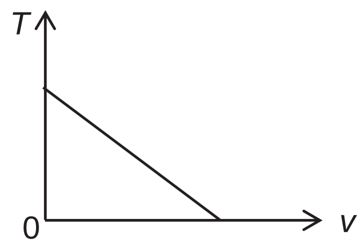


Which of the following represents the variation with v of its period T?

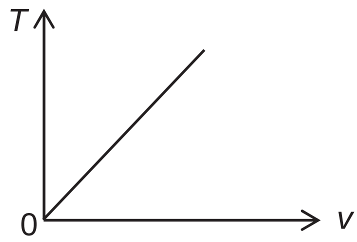
A



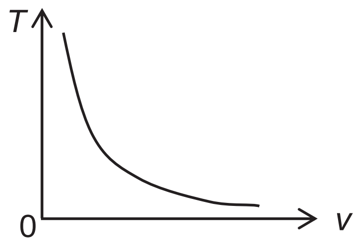
B



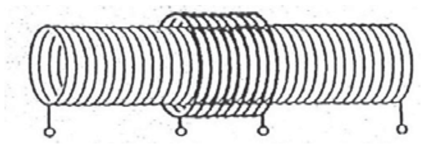
C



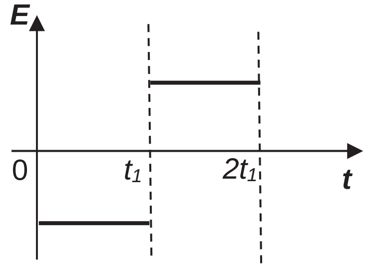
D



24 The figure shows a short coil wound over the middle part of a solenoid.

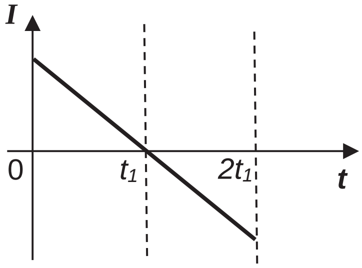


The variation of the e.m.f. E induced in the short coil with time t is as shown in the graph below.

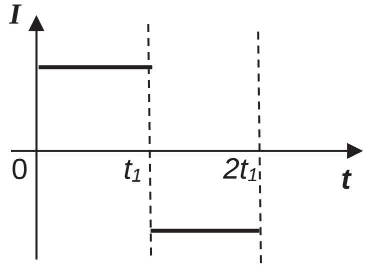


Which one of the following graphs best represents the variation of the current I in the solenoid with time?

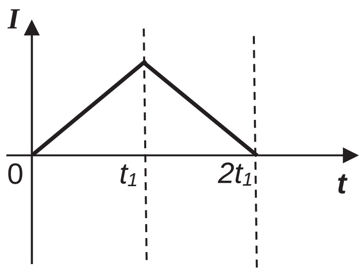
A



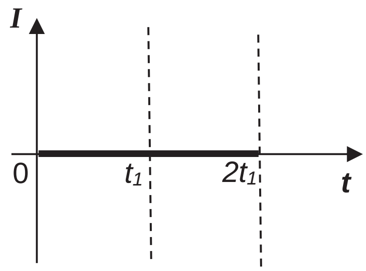
B



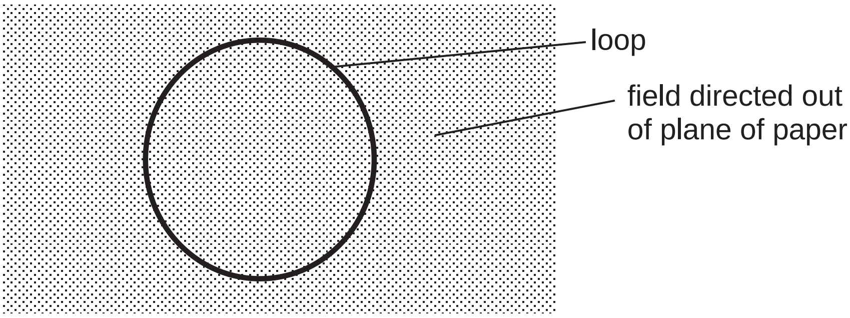
C



D



25 A uniform magnetic field is perpendicular to the plane of a loop of conducting wire.

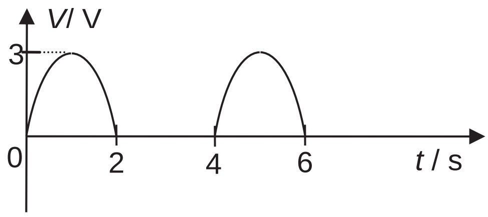


The field is directed out of the plane of paper. The magnitude of the magnetic flux density is decreasing at a constant rate.

Which of the following gives the correct state and correct direction of the induced current in the wire?

	Induced current	direction
A	varying	clockwise
B	constant	clockwise
C	varying	counter-clockwise
D	constant	counter-clockwise

26 The graph shows the variation with time *t* of the e.m.f. in a coil.



The resistance of the coil is 5.0 Ω. Which of the following is the average power dissipated in the coil?

A 0.45 W

B 0.90 W

C 1.5 W

D 2.1 W

27 If the de Broglie waves associated with each of the following particles are to have the same wavelength, which particle must have the smallest velocity?

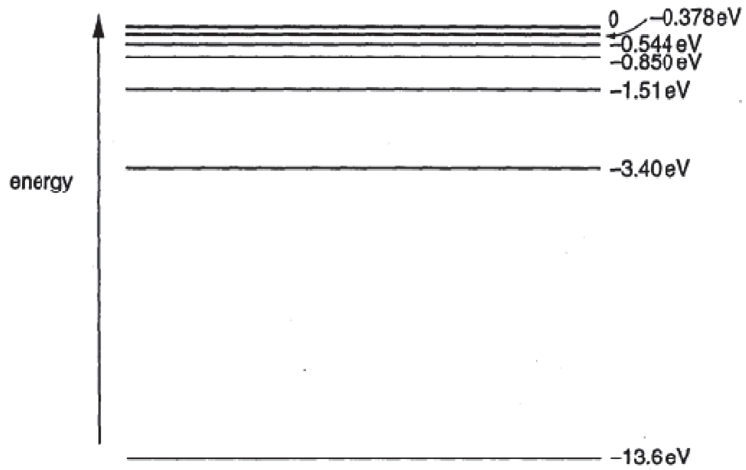
A proton

B electron

C neutron

D alpha particle

28 Some of the energy levels in atomic hydrogen are shown in the figure below.



Electrons having kinetic energy of 13.00 eV are incident on a sample of cold hydrogen gas.

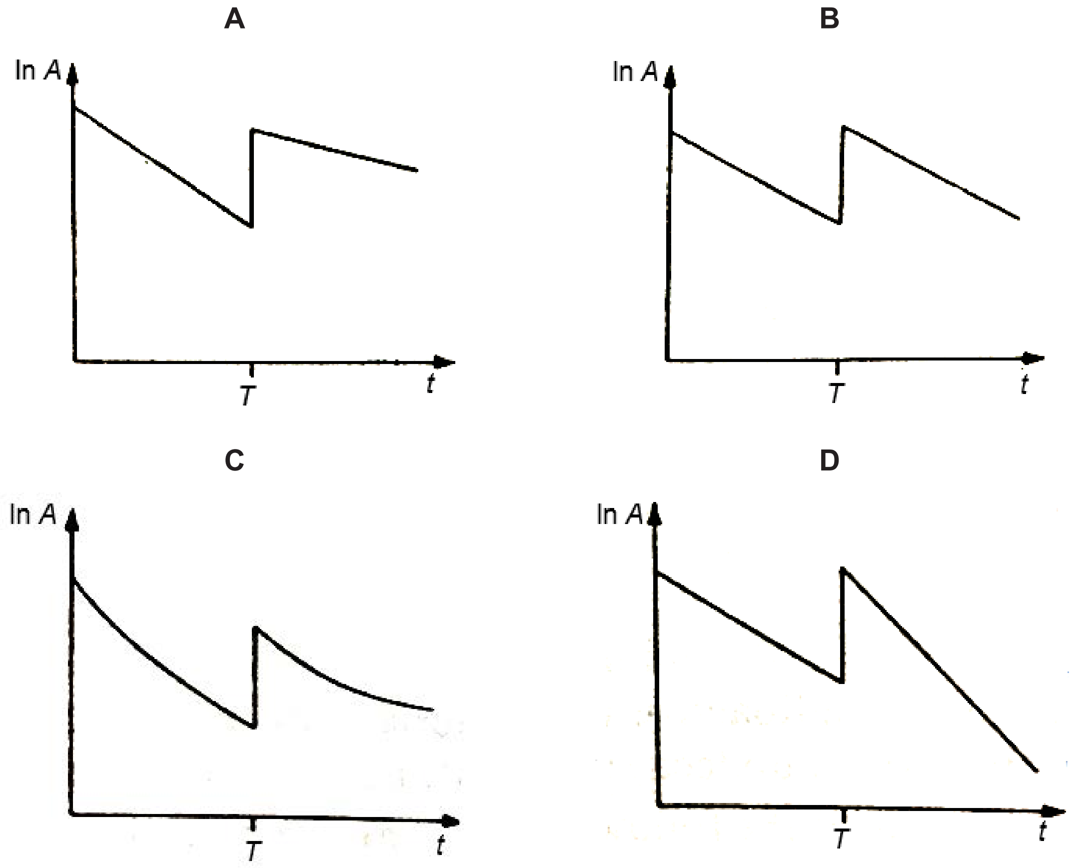
Assume that the photon energies corresponding to wavelengths within the visible light spectrum are between 1.78 eV and 3.11 eV.

What is the maximum number of visible spectral lines that can be observed from the emission spectrum of the gas?

A zero **B** 2 **C** 3 **D** 6

29 At time $t = 0$ some radioactive gas is injected into a sealed vessel. At time T some more of the same gas is injected into the same vessel.

Which one of the following graphs best represents the variation of the logarithm of the activity A of the gas with time t?



30 Radioactive ^{14}C dating was used to find the age of a wooden archeological specimen. Measurements were taken in three situations for which the following count rates were obtained:

specimen	*count rate*
1 g sample of living wood	80 counts per minute
1 g sample of archeological specimen	35 counts per minute
no sample	20 counts per minute

If the half-life of ^{14}C is known to be 5700 years, what was the approximate age of the archeological specimen?

A 2500 years

B 7000 years

C 11 000 years

D 13 000 years

End of Paper

JURONG JUNIOR COLLEGE
JC2 Preliminary Examination 2017

Name		Class	17S

PHYSICS **9749/2**

Higher 2

Structured Questions

25 August 2017

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

Write your **name** and **class** in the spaces provided at the top of this page.

Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use paper clips, highlighters, glue or correction fluid.

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.

For Examiner's Use	
1	
2	
3	
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7	
8	
9	
Total	

(This question paper consists of 22 printed pages)

Data

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permeability of free space,	μ_o	$= 4\pi \times 10^{-7}$ H m^{-1}
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gravitational potential,	ϕ	$= -\dfrac{Gm}{r}$
temperature,	T/K	$= T/°C + 273.15$
pressure of an ideal gas,	p	$= \dfrac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
mean translational kinetic energy of an ideal gas molecule,	E	$= \frac{3}{2}kT$
displacement of particle in s.h.m.,	x	$= x_o \sin \omega t$
velocity of particle in s.h.m.,	v	$= v_o \cos \omega t$
	v	$= \pm\,\omega\sqrt{(x_o^2 - x^2)}$
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	$= \dfrac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage,	x	$= x_o \sin \omega t$
magnetic flux density due to a long straight wire	B	$= \dfrac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	$= \dfrac{\mu_o NI}{2r}$
magnetic flux density due to a long solenoid	B	$= \mu_o nI$
radioactive decay	x	$= x_o \exp(-\lambda t)$
decay constant	λ	$= \dfrac{\ln 2}{t_{1/2}}$

1 Fig. 1 shows an experimental setup used to measure the acceleration of free fall.

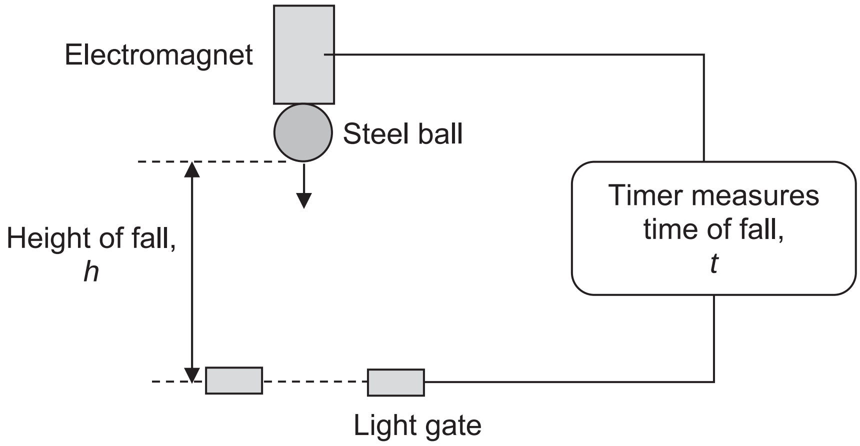


Fig. 1

The steel ball is suspended at the top by an electromagnet. The electronic timer starts when the electromagnet is turned off. As the steel ball falls by height *h* and goes through the light gate, the timer stops and displays the time of fall, *t*.

Only one set of data was collected:

$$h = (0.600 \pm 0.001) \text{ m}$$

$$t = (354 \pm 1) \text{ ms}$$

(a) Determine the acceleration of free fall with its associated uncertainty.

acceleration of free fall = ... ± .... m s^{-2} [3]

(b) It was later found out that when the electromagnet was turned off, there is some constant delay before the steel ball starts falling.

(i) Suggest a cause for this delay.

....

.... [1]

(ii) State and explain the type of error caused by this delay.

....

....

....

.... [2]

(iii) Suggest how this delay can be determined.

....

....

....

.... [2]

2 **(a)** Two objects, P and Q, of masses 1.5 kg and 0.30 kg respectively, are connected by a string that passes over a pulley as shown in Fig. 2.1. The pulley is frictionless and the string is inelastic. Object P rests on a horizontal hard surface.

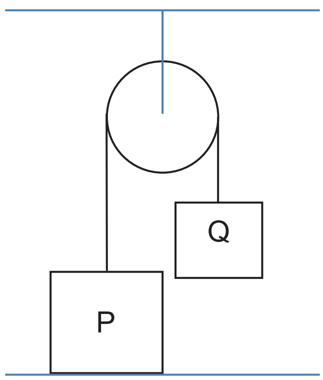


Fig. 2.1

(i) Draw the forces acting on objects P and Q. [3]

(ii) Show that the contact force between the horizontal hard surface and object P is 12 N. [2]

(b) The setup in **(a)** was modified such that object P floats horizontally in a fluid of density 1000 kg m^{-3}, with its lower face at a depth of 12 cm in the fluid, as shown in Fig. 2.2.

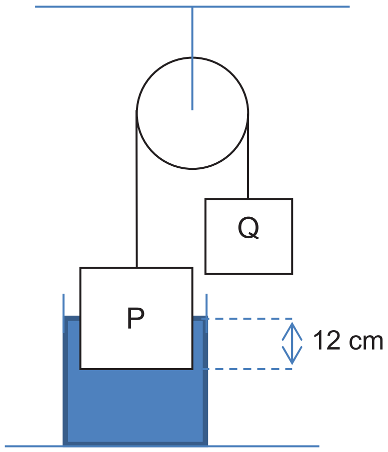


Fig. 2.2

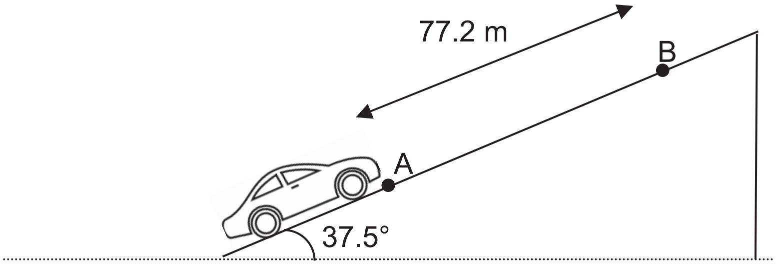
(i) Explain what is meant by *upthrust*.

[1]

(ii) Determine the horizontal cross sectional area of object P.

horizontal cross sectional area = ________________ m^2 [2]

3 A drunk tourist at a ski resort drives his 1800 kg car up a snow-covered ski-jump at a constant speed of 60 km h^{-1} between points A and B as shown in Fig. 3. The ski-jump is inclined at an angle of 37.5° and points A and B are 77.2 m apart.



(Not drawn to scale)

Fig. 3

(a) Define *power*.

....

.... [1]

(b) Determine the minimum power required for the car to perform the feat.

minimum power = ... kW [3]

(c) At point B, a braking mechanism enables the car to be held at that position when it is stationary. If the braking mechanism suddenly fails and the car slides down the ski jump, calculate its speed when it reaches point A.

speed = ... m s^{-1} [2]

4 Fig. 4 shows Graph A, which is the displacement-distance graph of a progressive transverse wave at time t = 0 s. Graph B represents the displacement-distance graph of the same wave at t = 0.1 s.

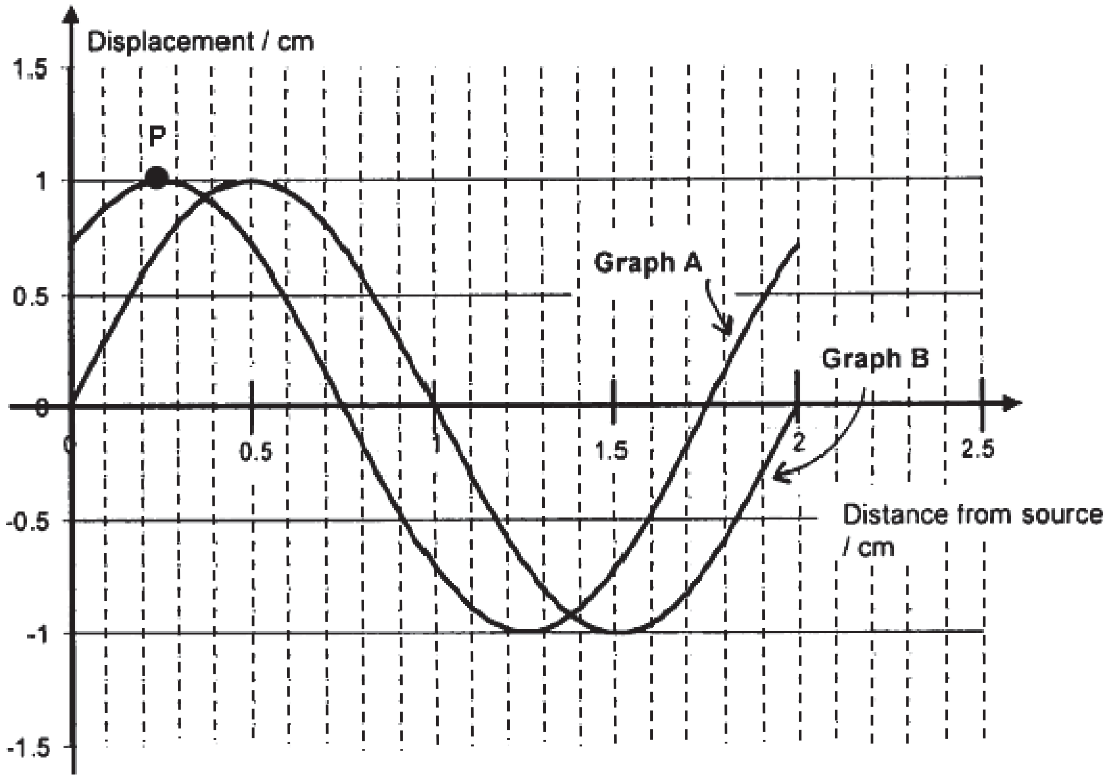


Fig 4

(a) Define *period* of a wave particle.

....

.... [1]

(b) State the wavelength of the progressive wave.

wavelength = ... m [1]

(c) A certain particle is at position P at time t = 0 s. On Graph B, draw a dot (labelling it **Q**), to represent the new position of this particle at t = 0.1 s. [1]

(d) Determine the phase difference between Graph A and Graph B.

phase difference = ... rad [2]

(e) Determine the period of the wave.

period = ... s [2]

5 An old motor car travels at steady speed over a rough road on which the height varies in a sinusoidal way. The car's shock absorber mechanism which normally damps vertical oscillation is not working, and as a result, the car experiences rapid vertical oscillations.

Fig. 5 below shows the variation with vertical displacement x from the equilibrium position of the acceleration a, for the vertical motion of the car.

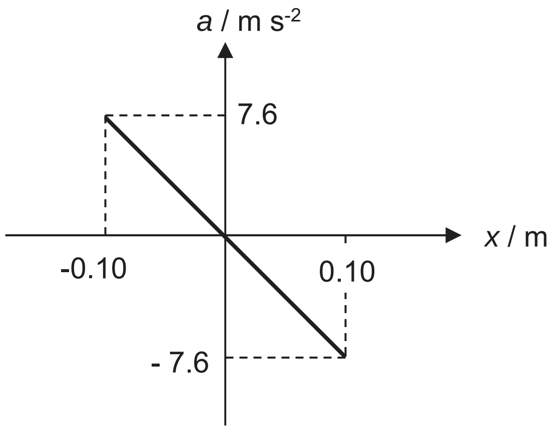


Fig. 5

(a) **(i)** Show that the angular frequency of the vertical oscillation is 8.7 rad s^{-1}. [2]

(ii) Hence, or otherwise, calculate the period of the vertical oscillation.

period = ... s [1]

(b) **(i)** The car is at the lowest point of the vertical oscillation at $t = 0$ s.

Write down an equation to represent the variation with time t of the vertical displacement x from the equilibrium position, in terms of x, amplitude x_o, angular frequency ω and t. [1]

(ii) Determine the shortest time taken t for the car to oscillate from its lowest point to a point 0.025 m below its equilibrium position.

time = ______________ s [2]

(c) If the car travels at a certain speed along this rough road, the vertical oscillations may become very large. Explain why this is so.

____

____

____

____ [2]

6 Fig. 6 shows a wire frame ABCD supported on two knife-edges P and Q so that the section PBCQ of the frame lies within a solenoid. Side BC has a length of 5.0 cm and QC has a length of 12.0 cm.

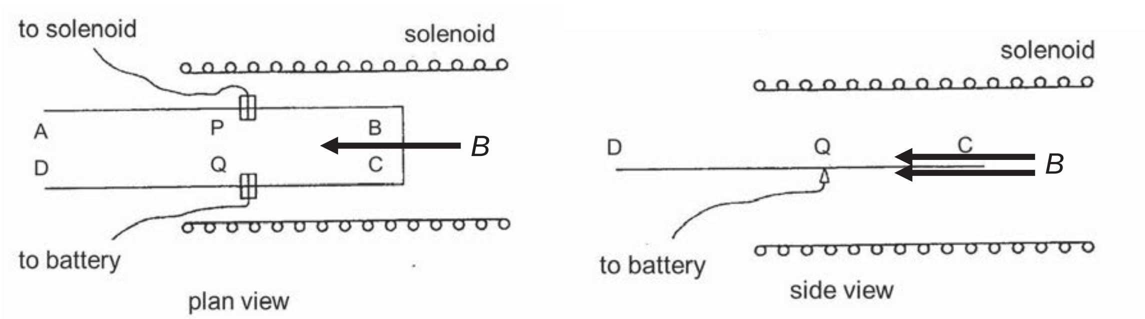


Fig. 6

Electrical connections are made to the frame through the knife-edges so that the part PBCQ of the frame and the solenoid can be connected in series with a battery. When there is no current in the circuit, the frame is horizontal.

(a) When the frame is horizontal and a current passes through both the frame and solenoid, the magnetic flux density *B* of the solenoid in the region of side BC of the frame is towards the left and the current flows from B to C.

State and explain the direction of the force, if any, due to the magnetic flux density *B* of the solenoid acting on

(i) side BC, and

[2]

(i) side AB.

[1]

(b) **(i)** The solenoid has 700 turns m^{-1} and carries a current of 3.5 A.

Calculate the magnetic flux density B in the region of side BC of the frame.

magnetic flux density = ____________________ T [1]

(ii) Determine the force acting on BC due to the magnetic field in the solenoid.

force acting on BC = ____________________ N [2]

(iii) A small piece of paper of mass 0.100 g is placed on the side DQ and positioned so as to keep the frame horizontal.

Determine the distance d from the knife-edge the paper must be positioned.

distance d = ____________________ m [2]

(iv) The current through both the solenoid and frame is doubled.

State and explain the changes, if any, that must be made to the mass of the piece of paper in order to keep the frame horizontal.

[2]

7 **(a)** Explain what is meant by the *half-life* of a nuclide.

[1]

(b) The decay of a radioactive nuclide may be represented by the equation

$$^{220}_{86}Rn \rightarrow Po + ^{4}_{2}He$$

The binding energy per nucleon *E* for the three particles are given in Fig. 7.1 below.

particle	*E* / MeV
$^{220}_{86}Rn$	7.72
Po	7.76
$^{4}_{2}He$	6.51

Fig. 7.1

(i) Explain what is meant by the term *binding energy per nucleon* of a nucleus.

[1]

(ii) Deduce values for the nucleon number and proton number of Po.

nucleon number = ...

proton number = ... [1]

(iii) Calculate the energy change in this nuclear reaction in joules.

energy change = ... J [3]

(iv) State and explain if the energy calculated in (iii) is released in or supplied to this reaction.

....

....

....

....

.... [3]

(v) Sketch on Fig. 7.2, a labelled graph showing how the *binding energy per nucleon E* varies with *mass number*, indicating clearly:

1. the approximate positions of ${}^{2}_{1}H$, ${}^{56}_{26}Fe$ and ${}^{238}_{92}U$; and

2. the maximum value (in MeV) of the binding energy per nucleon.

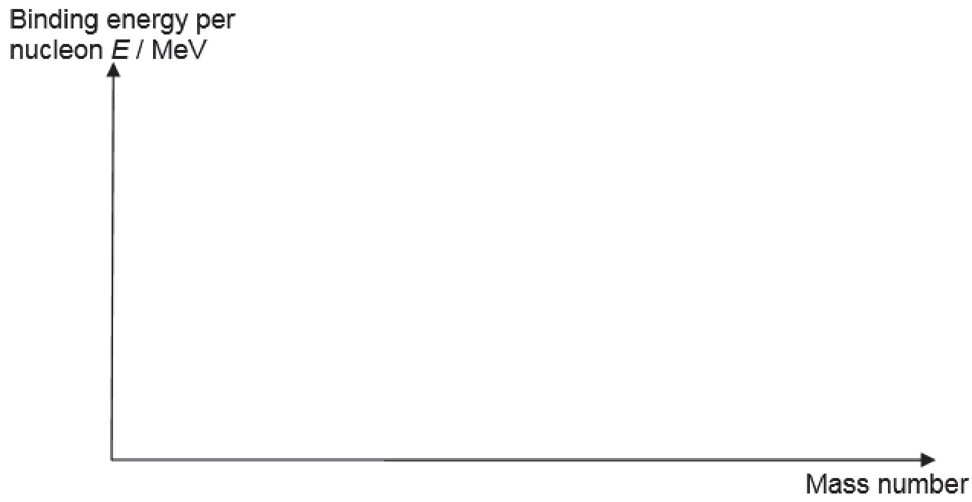


Fig. 7.2

[3]

8 Most man-made objects launched into space are satellites placed in a particular orbit around the Earth to function as TV transmitters, telephone relays or weather stations. Some spacecraft have been launched, however, to travel into much deeper space to explore the outer planets of our solar system. All spacecraft, whether satellites or deep space probes, must communicate with Earth by transmitting a radio signal.

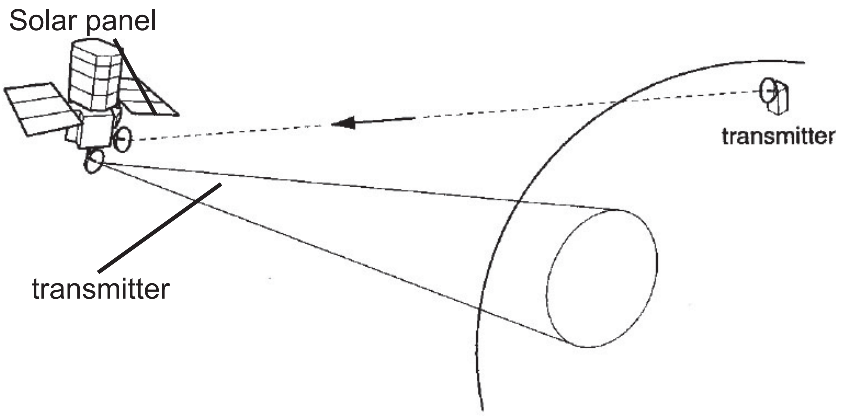


Fig. 8.1

The period and average orbital radius of three such satellites are given in the Fig. 8.2.

Satellite	Period T /h	Orbital radius R /km
A	1.63	7010
B	48.1	67100
C	57.2	75200

Fig. 8.2

(a) **(i)** Use data from Fig. 8.2 to show, without drawing a graph, that T^2 is proportional to R^3. [2]

(ii) Use the data from Fig. 8.2, or otherwise, to calculate the orbital radius for a satellite with a period of 35.0 hours.

radius = ……………………… km [2]

(b) Most satellites in orbit around the Earth derive their power from a panel of solar cells which convert sunlight into electrical power. One such telecommunications satellite transmits a continuous 360 W signal powered from its battery for 24 hours per day. The battery is recharged from a solar panel which has an efficiency of 16% while in direct sunlight of light intensity 1.5 kW m^{-2}.

(i) Calculate the minimum surface area of solar panel required to produce the 360 W for the transmitter.

surface area = ……………………… m^2 [2]

(ii) Suggests two reason why the surface area would have to be much greater than your answer in (b)(i).

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [2]

(iii) For a spacecraft launched into the outer regions of the solar system, it is not practical to have its battery recharged by solar panels. State one reason why solar panels are not practical in deep space, that is, far away from the solar system.

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [1]

9 Multi-bladed low-speed wind turbines (windmills) similar to the one shown in Fig. 9.1 have been used since 1870, particularly for pumping water on farms.

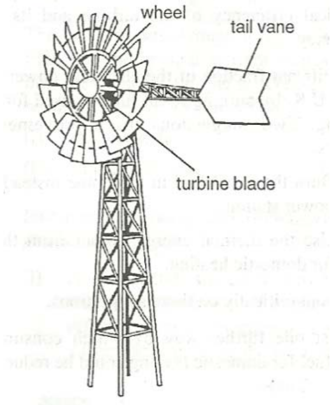


Fig. 9.1

The turbine blades cover almost the whole surface of the wheel and a tail vane behind the windmill keeps the wheel facing the wind. The diameters of the wheel of windmills of this type vary from 2 m to a practical maximum of about 12 m. Because of this size limitation, they are not suited to large power outputs. They will start freely with wind speeds as low as 2 m s^{-1} and, at these low speeds, can produce large torques.

Fig. 9.2 shows how P, the output power of these windmills, varies with the overall diameter of the wheel for different wind speeds, v.

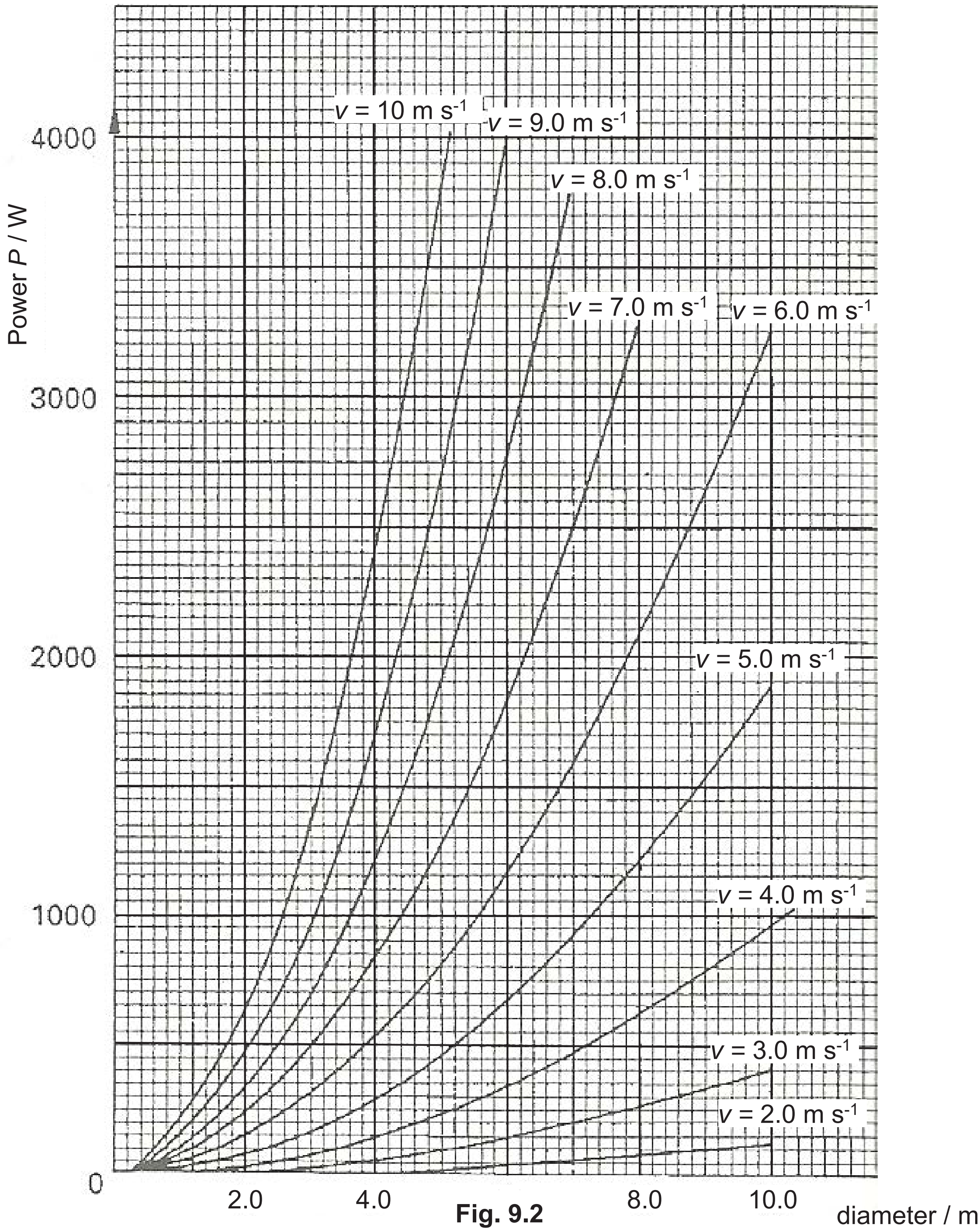


Fig. 9.2

It is thought that, for a given diameter, the output power is related to the wind speed by the equation

$$P = k\,v^{n},$$

where n and k are constants.

(a) **(i)** Use Fig. 9.2 to determine lg (P / W) for a particular multi-bladed low-speed windmill with a wheel of diameter 6.0 m and wind speed 3.0 m s^{-1}.

lg (P / W) = ____________________ [1]

(ii) On Fig. 9.3,

1. Plot the point corresponding to a wheel diameter of 6.0 m and a wind speed of 3.0 m s^{-1},

2. Draw the line of best fit for the points.

[2]

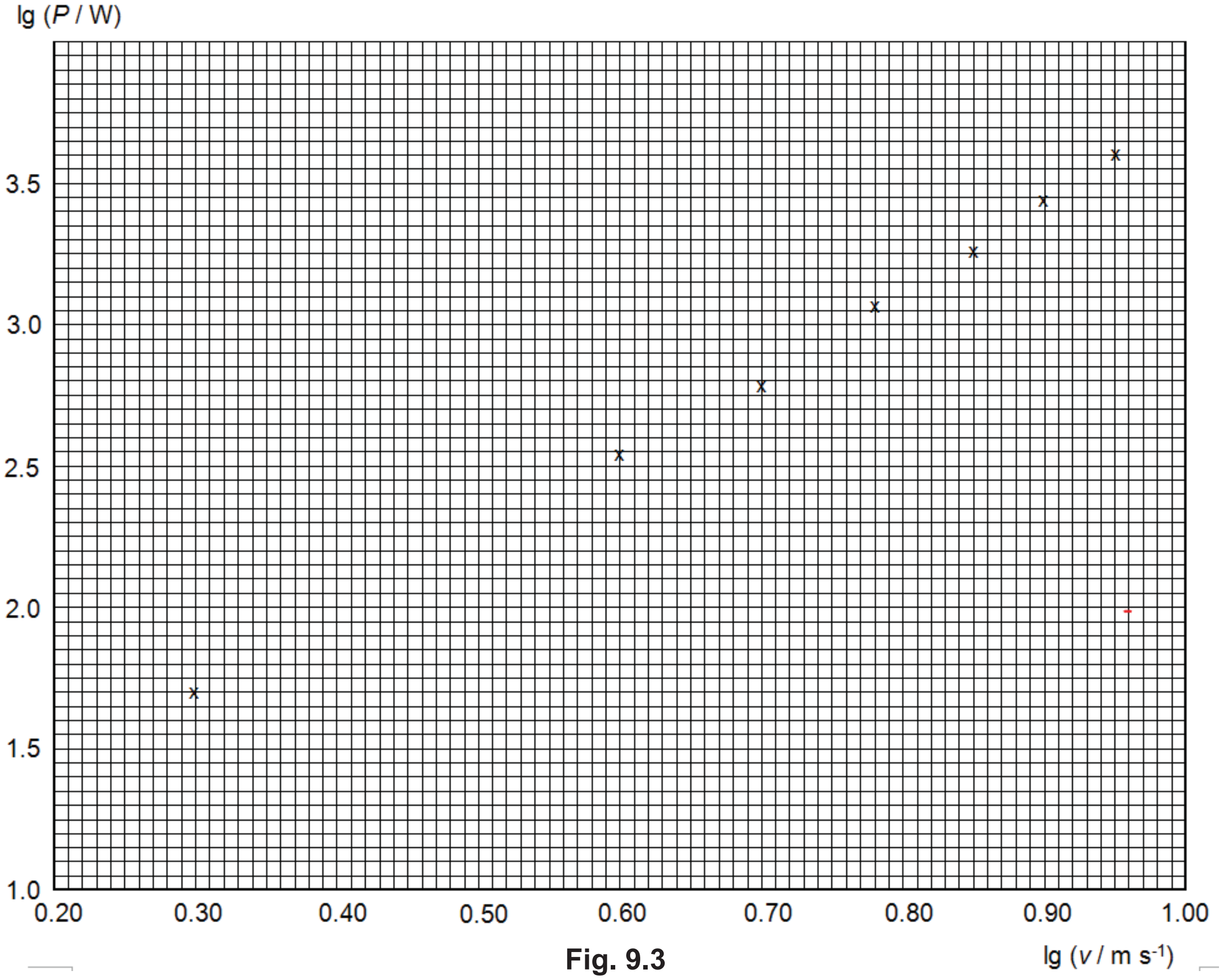


Fig. 9.3

(iii) Use the line drawn in **(a)(ii)** to determine the magnitudes of the constants n and k in the expression given.

n = ...

k = ... [3]

(b) **(i)** When the wind speed is 8.0 m s^{-1}, calculate the volume of air that reaches the 6.0 m diameter wheel of the windmill in one second.

volume = ... m^3 [1]

(ii) The density of air is 1.3 kg m^{-3}. Calculate the kinetic energy of the volume of moving air in **(b)(i)**.

kinetic energy = ... J [2]

(c) Use your answer in **(b)(ii)**, together with data from Fig. 9.2 to find the fraction of this power converted into useful output power.

fraction = ... [1]

(d) State one factor, other than wind speed and diameter of wheel, that is likely to influence the output power. In each case, indicate how the power output is likely to be affected.

[1]

(e) In practice, it has been found difficult to scale up a windmill such as this to a wheel of 30 m diameter, to achieve power outputs of the order of megawatts. Suggest one reason for this.

[1]

End of Paper

JURONG JUNIOR COLLEGE
JC2 Preliminary Examination 2017

Name		Class	17S

PHYSICS **9749/03**
Higher 2

Longer Structured Questions

11 September 2017

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

Write your **name** and **class** in the spaces provided at the top of this page.

Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use highlighters, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer any **one** question.

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.

For Examiner's Use	
1	/10
2	/9
3	/10
4	/10
5	/11
6	/10
7	/20
8	/20
Total	/80

(This question paper consists of 21 printed pages)

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Data

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

Formulae

uniformly accelerated motion,	s	$= ut + \frac{1}{2}at^2, \quad v^2 = u^2 + 2as$
work done on/by a gas,	W	$= p\,\Delta V$
hydrostatic pressure,	p	$= \rho gh$
gravitational potential,	ϕ	$= -\dfrac{Gm}{r}$
temperature,	T/K	$= T/°C + 273.15$
pressure of an ideal gas,	p	$= \dfrac{1}{3}\dfrac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule,	E	$= \frac{3}{2}kT$
displacement of particle in s.h.m.,	x	$= x_o \sin \omega t$
velocity of particle in s.h.m.,	v	$= v_o \cos \omega t$
	v	$= \pm \omega \sqrt{(x_o^2 - x^2)}$
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	$= \dfrac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage,	x	$= x_o \sin \omega t$
magnetic flux density due to a long straight wire	B	$= \dfrac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	$= \dfrac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid	B	$= \mu_o n I$
radioactive decay	x	$= x_o \exp(-\lambda t)$
decay constant	λ	$= \dfrac{\ln 2}{t_{1/2}}$

Section A

Answer **all** the questions in this section.

1 Fig. 1.1 shows a smooth table on which there are two objects A and B of masses 1.5 kg and 5.0 kg respectively. Object B is initially stationary. Object A is moving to the right towards object B and hits it at a speed of 4.0 m s^{-1}. The collision is elastic.

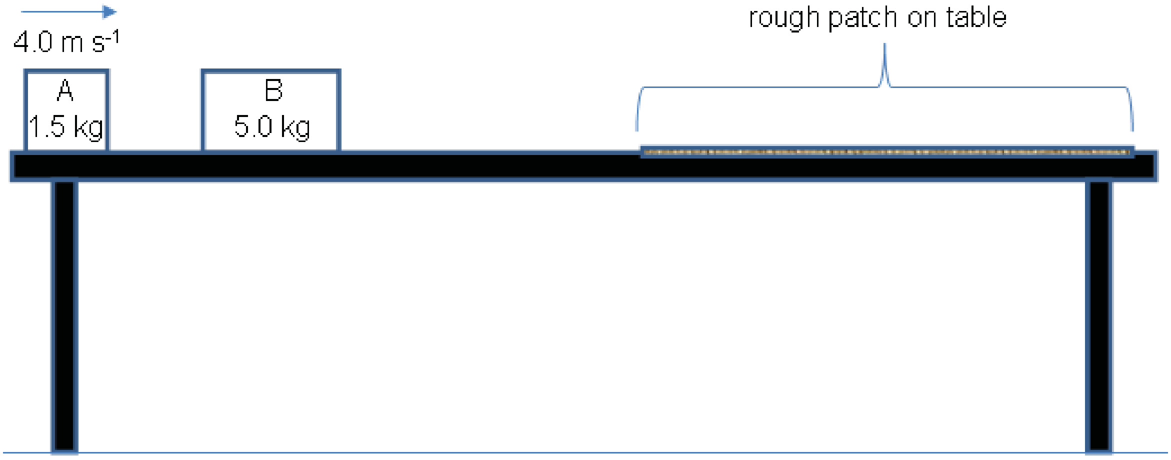

Fig. 1.1

(a) **(i)** State the principle of conservation of linear momentum.

....

.... [1]

(ii) Determine the final velocities of objects A and B after the collision.

final velocity of object A = ... m s^{-1} [2]

final velocity of object B = ... m s^{-1} [2]

(b) After the collision, object B slides on the horizontal smooth table surface and then over the rough patch on the table before falling off the edge of the table with a horizontal velocity of 1.2 m s^{-1}. Object B lands in the middle of a sand bath whose top surface is 0.60 m below the top surface of the table as shown in Fig. 1.2. Assume air resistance is negligible.

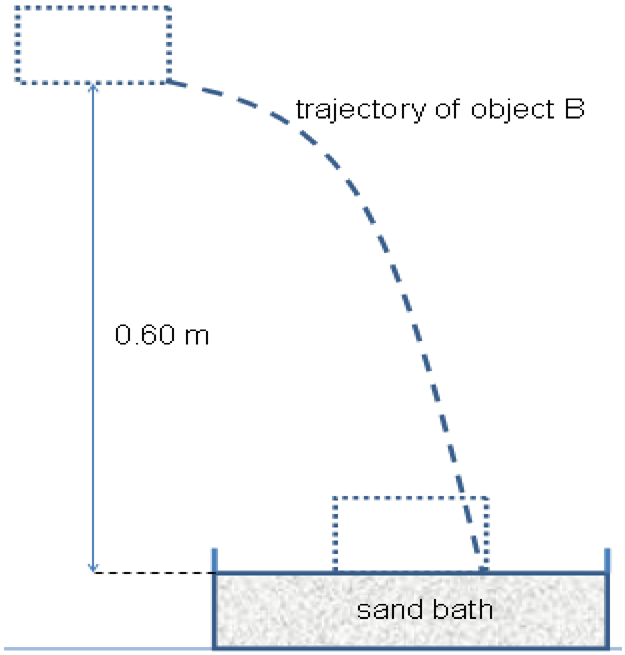

Fig. 1.2

Determine the horizontal distance from the edge of the table moved by object B when it just hits the sand bath.

horizontal distance = ... m [3]

(c) Object B is eventually embedded in the sand bath, entering vertically by 8.0 cm. Determine the magnitude of the average vertical retarding force.

magnitude of average vertical retarding force = ... N [2]

2 **(a)** Explain how molecular movement causes the pressure exerted by a gas on the walls of a container.

....

....

....

....

....

....

....

.... [3]

(b) One mole of oxygen gas has a mass of 32 g. Assume oxygen behaves as an ideal gas at temperature 300 K and pressure 1.0×10^5 Pa. For this temperature and pressure,

(i) show that the volume of one mole of oxygen gas is 0.025 m^3, [1]

(ii) calculate the density of oxygen gas,

density = ____________ kg m^{-3} [1]

(iii) determine the root-mean-sqaure speed of the oxygen molecules,

root-mean-square speed = ____________ m s^{-1} [2]

(iv) determine the average kinetic energy of the oxygen molecules.

average kinetic energy = ____________ J [2]

3 A student sets up the apparatus illustrated in Fig. 3.1 in order to observe two-source interference fringes. The double slit with slit separation 0.800 mm, situated 2.50 m from the screen, is illuminated with coherent red light of wavelength 690 nm. Fringes are observed on the screen.

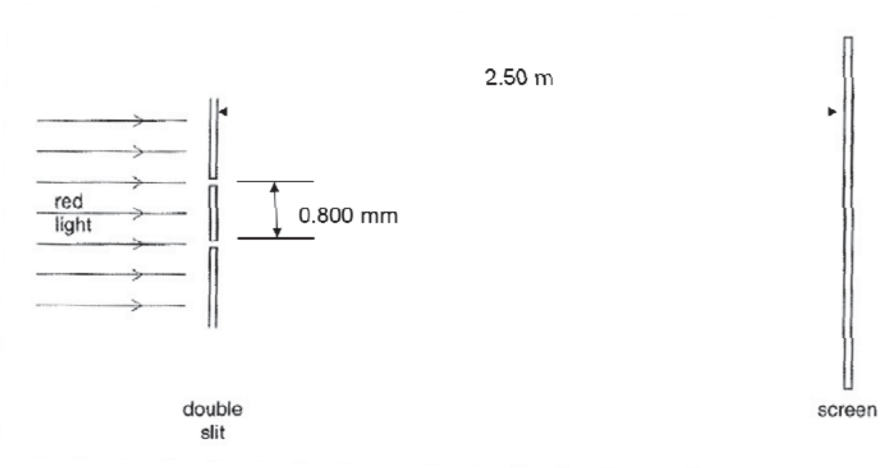

Fig 3.1

(a) Calculate the separation of the fringes.

separation = ... m [3]

(b) State and explain what change, if any, occurs in the separation of the fringes and in the contrast between bright and dark fringes observed on the screen, when each of the following changes is made separately.

(i) increasing the intensity of the red light incident on the double slit

....

....

....

.... [2]

(ii) increasing the distance between the double slit and the screen

....

....

....

....

.... [3]

(iii) changing the red light into green light

....

....

....

....

.... [2]

4 **(a)** The I-V characteristic of a 12 V car headlamp is drawn in Fig. 4.1. Only positive values of V and I are shown.

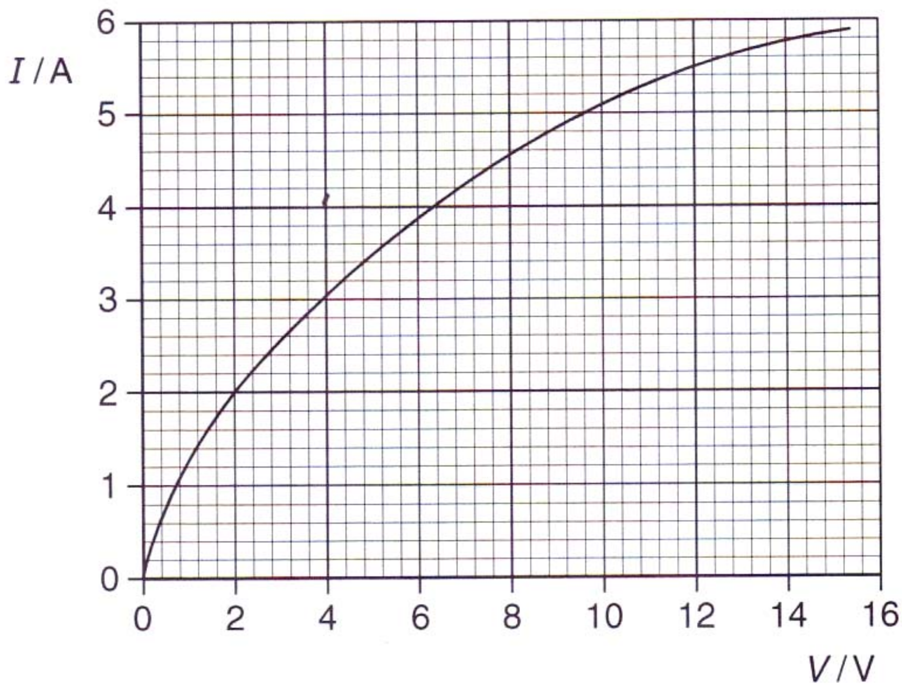

Fig. 4.1

(i) Deduce the resistance of the headlamp at 2 V and 10 V.

resistance at 2 V = ... Ω

resistance at 10 V = ... Ω [3]

(ii) Explain in terms of the movement of charged particles why the resistance increases with potential difference as shown in Fig. 4.1.

....

....

....

.... [2]

(b) The filament of a headlamp could be manufactured from a straight piece of tungsten wire of diameter 0.084 mm.

(i) Calculate the length of wire required for a resistance of 0.50 Ω when the wire is at room temperature. The resistivity of tungsten at room temperature is 5.5×10^{-8} Ω m.

length = ... m [4]

(ii) Explain why this straight length of wire is not practical.

....

.... [1]

5 **(a)** Define *electric field strength*.

[1]

(b) Two charged solid metal spheres A and B are situated in a vacuum. Their centres are separated by a distance of 12.0 cm, as illustrated in Fig. 5.1. The diagram is not drawn to scale.

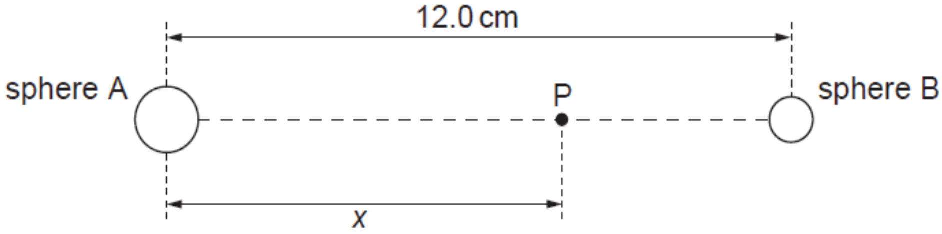

Fig. 5.1

Point P is a point on the line joining the centres of the two spheres. Point P is a distance *x* from the centre of sphere A.

The variation with distance *x* of the electric field strength *E* at point P is shown in Fig. 5.2. A positive value of *E* on the graph at a point corresponds to an electric field vector pointing horizontally to the right.

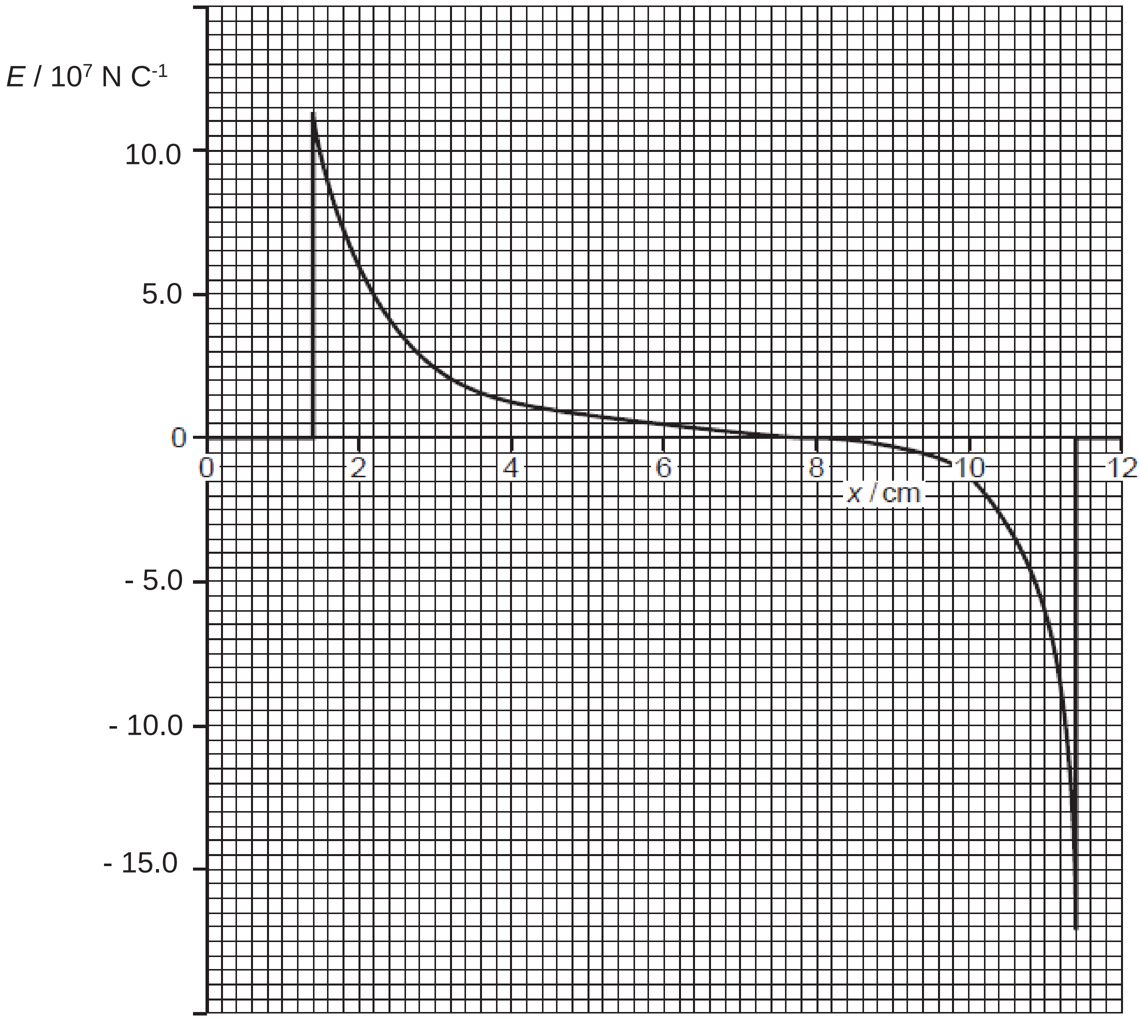

Fig. 5.2

(i) State and explain

1. whether the charge of sphere B is positive or negative,

[1]

2. the variation of electric potential within spheres A and B.

[2]

(ii) The ratio of the magnitude of the charges of spheres A and B respectively is 4:1.

If the electric field strength at x = 4.0 cm is 1.25×10^7 N C^{-1}, calculate the numerical value of the charge of sphere B.

charge of sphere B = ______________ C [3]

(iii) A proton moves along the line joining the centres of the two spheres.

Estimate the energy gained by this proton as it moves from the point where x = 3.0 cm to the point where x = 1.4 cm.

energy = ______________ J [4]

6 **(a)** With reference to the photoelectric effect, state what is meant by *work function* of a metal.

....

....

.... [1]

(b) In an experiment to investigate the photoelectric effect, a student measures the wavelength λ of the light incident on a metal surface and the maximum kinetic energy E_{max} of the emitted electrons. The variation with E_{max} of λ is shown in Fig. 6.

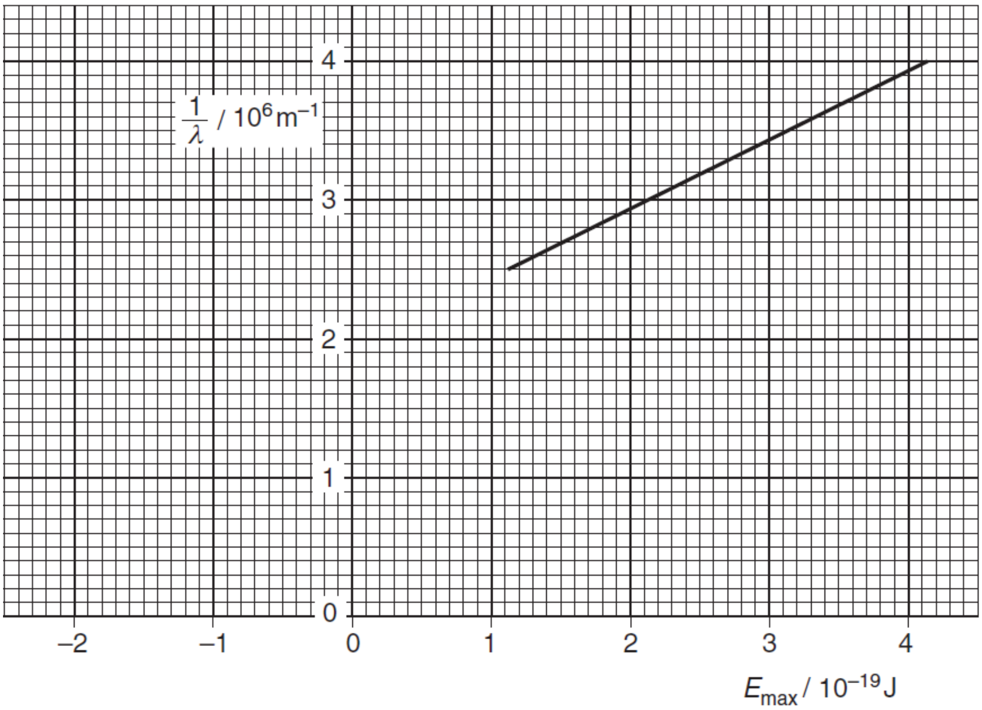

Fig. 6

(i) State an equation, in terms of λ, E_{max}, work function ϕ, speed of light c and Planck constant h to represent conservation of energy for the photoelectric effect.

[1]

(ii) Determine the threshold frequency f_0 of the metal.

threshold frequency f_0 = ... Hz [3]

(iii) On **Fig. 6**, sketch a second graph to represent the results for an experiment using a metal plate of higher work function. Label this graph **W**. [1]

(c) If the intensity of the light is increased while keeping the frequency constant, state and explain the effect, if any, on the

(i) number of electrons emitted per unit time; and

....

....

.... [1]

(ii) the maximum kinetic energy of these emitted electrons.

....

....

....

....

.... [3]

Section B

Answer **one** question from this Section.

7 **(a)** State what is meant by *angular velocity*.

____

____ [1]

(b) Fig. 7 shows two satellites A and B orbiting clockwise around Earth at radii of 1.0×10^4 km and 2.0×10^4 km respectively. The mass of Earth is 6.0×10^{24} kg and the radius of Earth is 6.4×10^3 km.

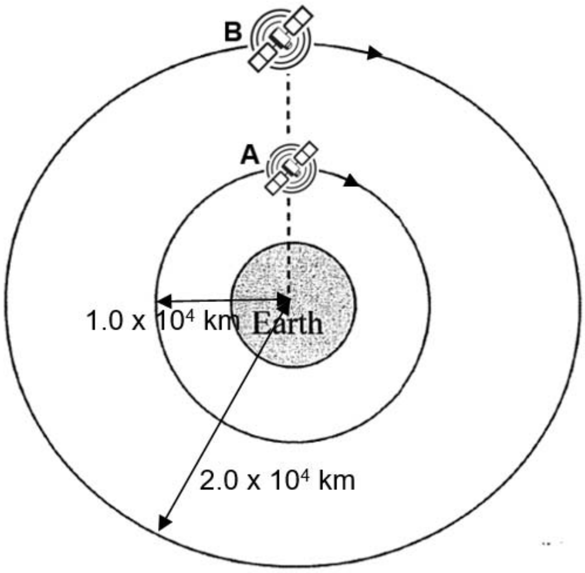

Fig. 7

(i) Determine the angular velocities of satellites A and B.

angular velocity of satellite A = ... rad s^{-1}

angular velocity of satellite B = ... rad s^{-1} [4]

(ii) At t = 0 s, Satellite B is seen to be directly above Satellite A. Determine the time taken before they are diametrically opposite to each other.

time taken = ______________ s [3]

(c) Define *gravitational potential* at a point in a gravitational field.

____

____

____ [1]

(d) Satellite B in part (b) gradually moves to the same orbit as for Satellite A. Given that the mass of Satellite B is 100 kg, calculate for this satellite, the change in

(i) gravitational potential,

change in gravitational potential = ______________ J kg^{-1} [2]

(ii) gravitational potential energy,

change in gravitational potential energy = ______________ J [1]

(iii) kinetic energy,

change in kinetic energy = ______________ J [2]

(iv) total energy,

change in total energy = ______________ J [1]

(e) It is common for satellites in real life to gradually lose energy due to small resistive forces. With reference to your answers in (d), suggest why many such satellites eventually 'burn up' in the Earth's atmosphere.

[3]

(f) An object is projected from Earth's surface. Determine the object's minimum projected velocity for it to escape from Earth's gravitational field.

minimum projected velocity = ______________ $m\ s^{-1}$ [2]

8 **(a)** A vertical peg is fixed to the rim of a horizontal metal disc of radius r, rotating with a constant angular velocity ω as shown in Fig. 8.1.

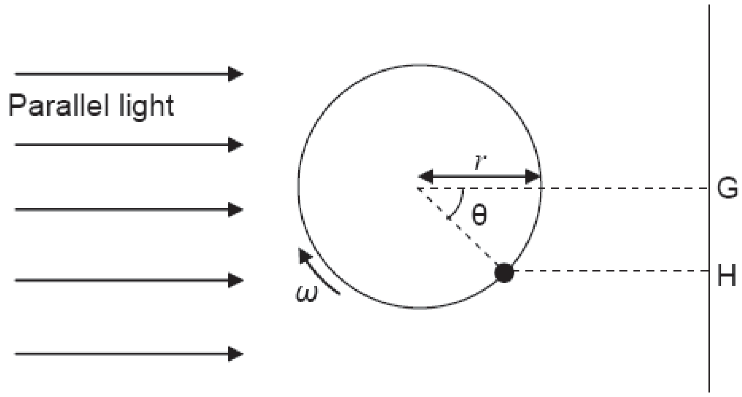

Fig. 8.1

Parallel light is incident on the disc so that the shadow of the peg is observed on a screen which is normal to the incident light. At time t = 0, θ = 0 and the shadow of the peg is seen at G.

At some later time t, the shadow is seen at H.

(i) Write an expression for θ in terms of ω and t.

[1]

(ii) Derive an expression for the distance GH in terms of r, ω and t.

[1]

(iii) By referring to your answer to **(a)(ii),** explain why the motion executed by the shadow on the screen is simple harmonic in nature.

[3]

(iv) The disc has a radius r of 10 cm and an angular speed ω of 3.5 rad s^{-1}.

Calculate, for the motion of the shadow on the screen at H when $\theta = \frac{\pi}{6}$ rad,

1. the speed of the shadow,

speed = ... m s^{-1} [2]

2. the magnitude of acceleration of the shadow.

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

(v) On Fig 8.2, sketch a graph to show how the acceleration of the shadow varies with angle θ during one revolution of the disc.

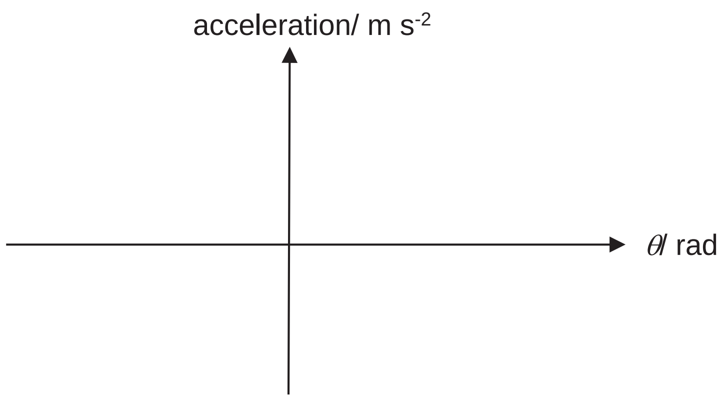

Fig. 8.2

[2]

(b) The vertical peg is removed and the metal disc is rotating clockwise with a constant angular speed ω about its centre C in a magnetic field of flux density B directed into the paper. The disc makes contact at a point on its rim at R with a conductor Y while its centre C makes contact with another conductor X, as shown in Fig. 8.3.

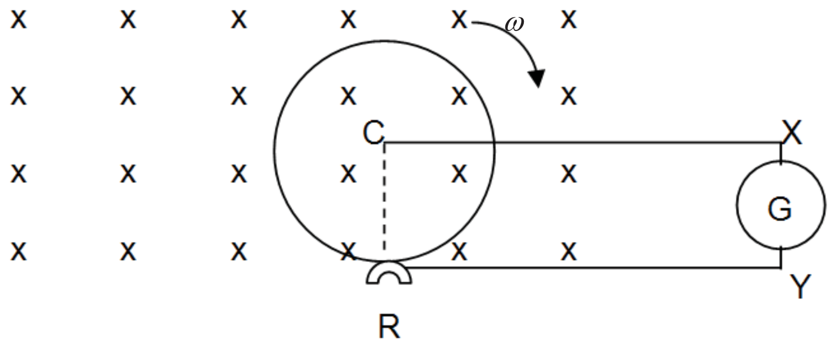

Fig. 8.3

Between C and R, there would be an induced e.m.f., which may be indicated by a galvanometer connected between X and Y

(i) Explain why an e.m.f. is generated.

[2]

(ii) Show that e.m.f. induced can be expressed as ½ $B\omega r^2$.

[2]

(iii) This disc of radius *r* of 10 cm is rotating at 15 revolutions per second with its plane perpendicular to a uniform magnetic field of magnetic flux density 0.25 T.

Calculate the value of e.m.f. induced between C and R.

e.m.f = ... V [2]

(iv) State and explain the direction of induced current between C and R.

....

....

....

....

....

....

.... [3]

End of Paper

JURONG JUNIOR COLLEGE
JC2 Preliminary Examination 2017

Name:		Class:	
		Index number:	

PHYSICS
Higher 2

9749/04

Paper 4 Practical

15 Aug 2017

2 hours 30 minutes

Candidates answer on the Question Paper.

READ THESE INSTRUCTIONS FIRST
Do not open this booklet until you are told to do so.

Write your name, index number and class in the spaces provided at the top of this page.
Write in dark blue or black pen on both sides of paper.
You may use an HB pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions.

Write your answers in the spaces provided on the question paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

Give details of the practical shift and laboratory where appropriate in the boxes provided.

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.

Shift	
Laboratory	
For Examiner's Use	
Q1	/15
Q2	/08
Q3	/20
Q4	/12
Total:	/55

(This document consists of 16 printed pages)

1. This investigation considers the depth of hole in the container for water to flow at a suitable rate.

(a) You have been provided with a beaker labelled P containing 200g of water as shown in Fig. 1.1.

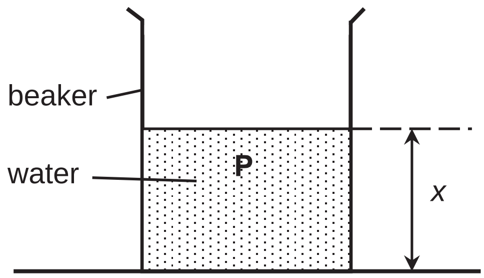

Fig. 1.1

(i) Measure and record the depth *x* of water in beaker P.

x = ... [1]

(ii) Estimate the percentage uncertainty in your value of *x*.

percentage uncertainty = ... [1]

(b) You have been provided with a plastic cup with a hole with 2 markings as shown in Fig. 1.2

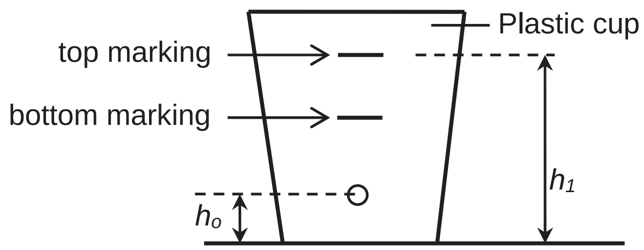

Fig. 1.2

(i) Measure and record the height of hole h_o.

h_o = ...

(ii) Measure and record the height of the top marking h_1.

h_1 = ...

(iii) Determine the difference in height between the hole and the top marking H_1.

H_1 = ... [1]

(c) Fill the cup with water to the top marking level and cover the hole with your finger.

Place the cup on the edge of the table near the basin.

Place the beaker labelled Q in the basin, at a position where it would collect all the water that flows out of the cup when you remove your finger.

Remove your finger, start the stopwatch and allow the water to flow through the hole into the beaker Q.

When the flow of water touches the edge of the paper cup as shown in Fig. 1.3, stop the stopwatch and remove the beaker Q immediately.

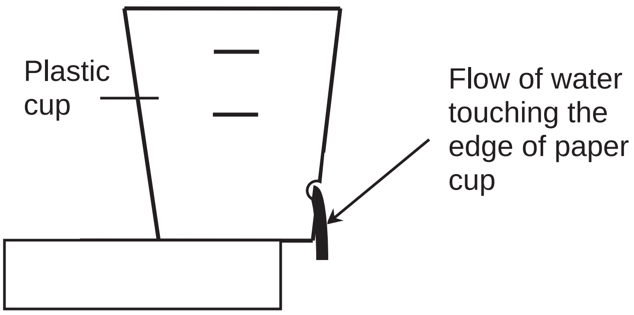

Fig. 1.3

(i) Record the time taken t_1.

t_1 = ... [1]

(ii) Measure and record the depth x_1 of water in beaker Q.

x_1 = ... [1]

(iii) Using data from **(a)(i)** and **(c)(ii)** to estimate the mass m_1 of water collected in beaker Q.

m_1 = ... [1]

(iv) Calculate the rate of flow of water, R_1 during this time.

R_1 = ... [1]

(d) It is suggested that the rate of flow of water R is proportional to the square root of the depth of water H in the cup (i.e. the difference in height between the hole and the marking).

Use the bottom marking level on the same cup to take further measurements to investigate this suggestion.

State and explain whether or not you agree with this suggestion.
Present your measurements and calculated results clearly.

[6]

(e) A statement found on the internet says that:

"The exit velocity of the liquid (water) decreases as the size of the hole decreases."

Suggest changes that could be made to the current investigation to study how the size of hole affects the exit velocity.

[2]

[Total: 15 marks]

2 In this experiment, you will determine the length of a metal in the form of a wire.

(a) Measure and record the diameter *d* of the short sample A that is attached to the card.

d = ... [1]

(b) Setup the circuit as shown in Fig. 2.1.

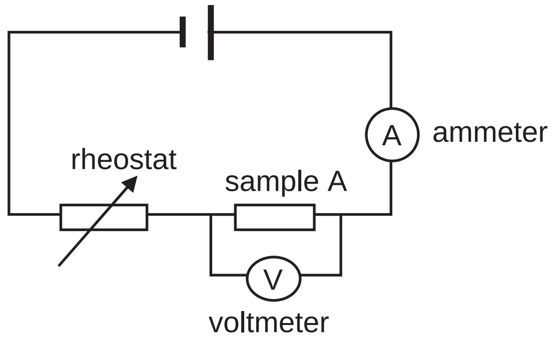

Fig. 2.1

(i) Set the rheostat to its maximum resistance.

Close the circuit

Measure the current I and the potential difference V across sample A.

I = ...

V = ... [1]

(ii) Open the circuit

(iii) Vary the resistance of the rheostat and repeat **(b)(i)**, **(b)(ii)** until you have 3 more sets of I and V.

[2]

(c) Plot your values from **(b)(iii)** on Fig. 2.2.

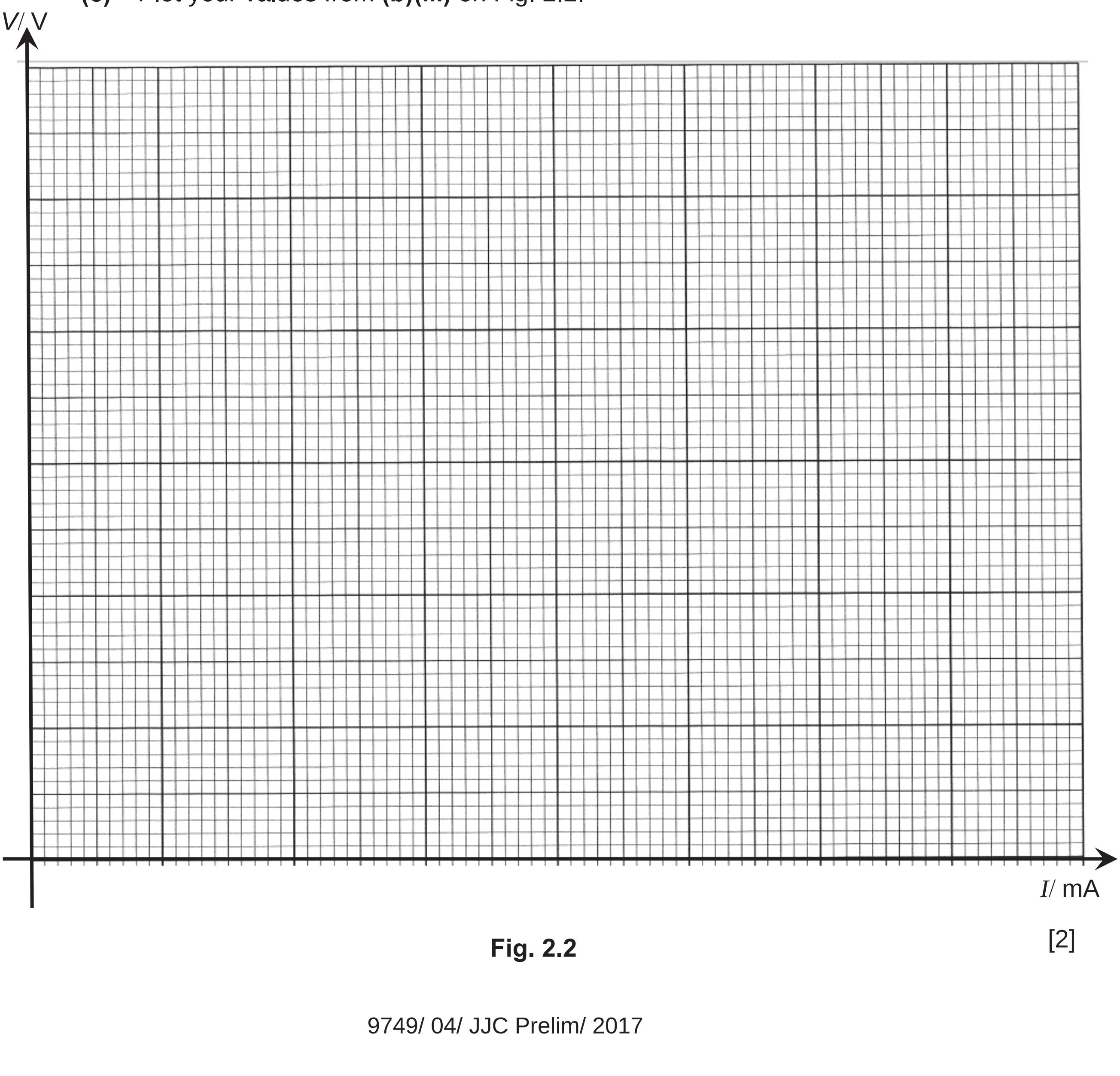

Fig. 2.2

[2]

(d) The gradient of the graph represent the resistance of the sample A. Given that the resistance is given by

$$R=\frac{\rho L}{A}$$

where ρ is the resistivity of the metal from which the wire is made, L is the length of the wire and A is its cross-sectional area.

The resistivity of the given wire is $1.04 \times 10^{-6}\ \Omega$ m.

Estimate the length of the sample.

L = ... [2]

[Total: 8 marks]

3 In this experiment you will set up an oscillating system which consists of a horizontal metre rule suspended by two cords from a fixed horizontal metre rule

(a) **(i)** Using the strings supplied, suspend a metre rule from the top fixed horizontal metre rule as shown in Fig. 3.1.

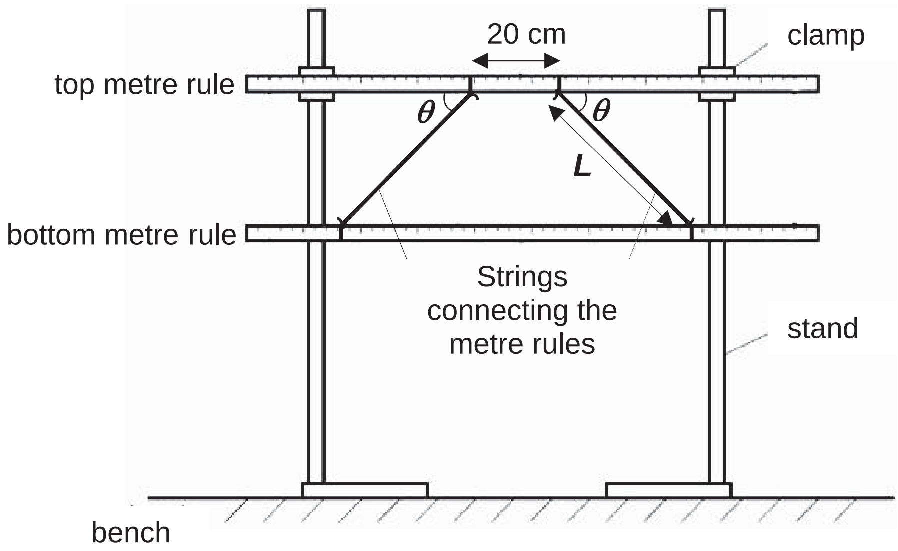

Fig. 3.1

(ii) Secure one string to the top metre rule at the 40 cm mark and another string at the 60 cm mark.

(iii) Firmly tie the ends of the strings to the bottom metre rule such that L, the length of string between the two metre rules, is about 50 cm.

(b) **(i)** Measure L, the length of the string between the two metre rules.

L = ...

(ii) Move the strings on the bottom rule to the 10 cm and 90 cm mark. Measure the angle θ.

θ = ... [1]

(iii) Estimate the percentage uncertainty in your value of θ.

percentage uncertainty = ... [1]

(c) **(i)** Gently displace the bottom metre rule through a small angle about its centre and let it oscillate about a vertical axis through its centre as shown in Fig. 3.2.

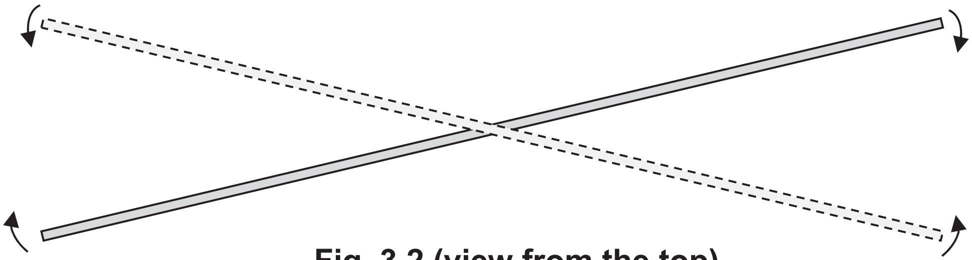

Fig. 3.2 (view from the top)

(ii) Make and record measurements to determine the period *T* of these oscillations.

T = ... [1]

(d) By moving the strings at the bottom metre rule, vary the angle θ to obtain further values for θ and *T*.

The value of *L* should remain constant throughout.

[6]

(e) It is suggested that the relationship between T and θ is

$$T^2 = A(\cos\theta) + B$$

where A and B are constants.

Plot a suitable graph to determine the values of A and B.

A = ...

B = ... [4]

[3]

(f) Comment on any anomalous data or results that you may have obtained.
Explain your answer.

[1]

(g) State two significant source of errors in this experiment

1.

2.

[2]

(h) Suggest an improvement that could be made to the experiment to address one of the sources of errors/ limitations in **(g)**. You may suggest the use of other apparatus or a different procedure.

[1]

[Total: 20 marks]

4 A light dependent resistor (LDR) is a resistor whose resistance decreases with increasing incident light intensity. It can also be referred to as photoconductor. The LDR has a resistance of 100 Ω when it is in bright light and a resistance of 1000 Ω when no light falls on it.

Some of the practical applications of the LDR are the burglar alarm system and the automatic switch for the street lamp.

Design a laboratory experiment to investigate how the resistance R of the LDR varies with the distance d from an intense light source.

The apparatus available includes the following:

Light dependent resistor, 12 V battery, 200 Ω resistor, voltmeter, ammeter, lamp and intensity meter

You should draw diagram(s) to show the arrangement of your apparatus. In your account, you should pay attention to

(a) the apparatus you would use for the investigation,

(b) the procedure to be followed,

(c) the control of variables,

(d) any safety precautions,

(e) any precautions that you would take to improve the accuracy of the experiment.

Diagram

[12]

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JC2 Preliminary Examination 2017
9749 H2 Physics Paper 1 solutions

Qn	Ans	Suggested solution (Font Arial, 11 pt)
1	D	**A** shows **P + Q**, **B** shows – **P** – **Q**, **C** shows **Q** – **P**.
2	B	Let the time taken for the oil tanker to stop be t. 800 + 0.5t – 0.5(10)t = 20 $\Rightarrow$ t = 173.333 s Deceleration = $\dfrac{10}{173.333} = 0.058$ m s^{-2}
3	B	At t = 4 s, F = 20 N. Impulse Δp = area under the graph from t = 4 s to t = 6 s = $\frac{1}{2}(2)(20) = 20$ N s [$\Delta p = m\Delta v$] 20 = 20(Δv) $\Rightarrow$ Δv = 1.0 m s^{-1} Final velocity $v_f = v_i + \Delta v$ = 4.5 + 1.0 = 5.5 m s^{-1}
4	B	In one second, mass of bullets hitting the wall = mn momentum of bullets hitting the wall = mnu change in momentum of bullets = 2mnu = momentum imparted to wall = force on wall
5	B	Both objects have the same mass and experience the same acceleration. Object A: 10 – 4 – T = ma $\Rightarrow$ 6 – T = ma Object B: T – 2 = ma Solving simultaneously, T = 4 N
6	B	Horizontal component of tension in string balances static friction: $T\cos 30° = 1.8$ Vertical component of tension in string balances weight of block B: $T\sin 30° = W_B$ $\tan 30° = \dfrac{W_B}{1.8} \Rightarrow W_B = (1.8)(\tan 30°) = 1.04$ N
7	D	Since the sphere reaches a constant velocity, the kinetic energy must be constant. Hence the change in kinetic energy is zero. The gravitational potential energy is given by $E_P = mgh$ where h is the vertical height. Since the sphere is falling at velocity v, $h = h_0 - vt$ where h_0 is the initial height and is a constant. $E_P = mg(h_0 - vt) \quad \Rightarrow \quad \dfrac{dE_P}{dt} = -mgv$ Hence the gravitational potential energy decreases (as indicated by the negative sign) at a rate of mgv.
8	B	**A** is wrong. The magnitude of the velocity is constant since it Is assumed that the pail is moving in uniform circular motion. **B** is correct. When we consider the most critical point at the top, the reaction force and the weight contributes to the centripetal force. As such, the centripetal force has to be greater than the weight. **C** is wrong because the centripetal force acting on the pail of water at the top is due to the tension and its weight **D** is wrong as the weight is not equal to the normal contact force at the lowest point of the circle.

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Qn	Ans	Suggested solution (Font Arial, 11 pt)
9	A	Let the radius of the distant planet be R_1 and the radius of earth be R. Since the diameter of the distant planet is twice that of earth, $R_1 = 2R$ $\frac{GM}{R^2} = \frac{GM_1}{R_1^2}$ $\frac{M}{R^2} = \frac{M_1}{(2R)^2}$ $M = \frac{1}{4}M_1$ $\rho(\frac{4}{3}\pi R^3) = \frac{1}{4}\rho_1(\frac{4}{3}\pi(2R)^3)$ $\frac{1}{2} = \frac{\rho_1}{\rho}$
10	B	$\Delta U = Q + W = (-1500) + (2.0\times10^4)(0.050-0.025) = (-1500) + (500) = -1000$ J
11	C	Potential energy vs time, for a situation of oscillating object at extreme position at t = 0 s.
12	A	Period is not affected by amplitude. (period of spring-mass system depends on mass of object m, and spring constant k; $k = m(\frac{2\pi}{T})^2$ Total energy, E_T = max E_p = ½ $k\, x_o^2$ (where x_o = amplitude) therefore total energy is proportional to (amplitude)^2 i.e. $E_T \alpha\, x_o^2$ $\frac{E}{E_{new}} = \frac{X^2}{(X/2)^2}$ $E_{new} = \frac{E}{4}$
13	C	A: Both particles have the highest KE at the equilibrium position. B: The particles moves up and down, not left or right. D: All the particles have the same total energy at all times.
14	C	Between 1st to 4th nodes is 1.5 wavelengths = 15 cm. Thus the wavelength is 10 cm.
15	D	Using $\sin\theta = \frac{\lambda}{b}$ $= \frac{650\times10^{-9}}{(1.0\times10^{-3})\times10^{-3}}$ = 0.65 θ = **<u>40.5º</u>** Let distance between straight-through position and first minimum (on screen) be x, $\tan 40.5^{\circ} = \frac{x}{30\times10^{-2}}$ Hence, width of central maximum = 2x = (2)(tan40.5º)(20×10^{-2}) = **<u>0.51 m</u>**

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Qn	Ans	Suggested solution (Font Arial, 11 pt)
16	**A**	$n\lambda p < \sin 90$ $n(700 \times 10^{-9})400000 < 1$ $n < 3.57$ Maximum order = 3
17	**B**	$E = -\frac{dV}{dr} = 0$ where V = constant If the electric field strength is zero at a point, it only means that the potential gradient is zero at that point. But the value of the potential at that point need not be zero.
18	**A**	Resolving the initial velocity into its vertical component, $u_y = v\cos\theta$ By conservation of energy, for the electron to just reach plate AB (that is, $v_y = 0$), work done against electric force = loss in kinetic energy of electron $eV = \frac{1}{2}m_e(v\cos\theta)^2$
19	**A**	The current passing through Q and R is half of the current passing through P. Using $P = I^2R$, the power of Q and R should ¼ of P, thus the power of Q and R should be 2 W.
20	**A**	$I = \frac{Q}{t} = \frac{\rho ws}{t} = \rho wv$
21	**B**	When the slider is at position X, the voltmeter will measure the e.m.f = 4.0 V. When the slider is at position Y, the voltmeter will measure the p.d. of Q = 2.0 V.
22	**C**	$\tau = Fd$ $= 2F_B\frac{L}{2}$ $= NBIL \times L$ $= 20 \times 0.01 \times 5 \times 10^{-3} \times (8 \times 10^{-3})^2$ $= 6.4 \times 10^{-8}$ N m
23	**A**	$Bqv = m\,\omega\,v$ $Bq = m\,\omega$ $Bq = m\,(2\pi/T)$ Hence T = constant (since B , m and q are unchanged in this question). What changes when particle is projected with larger v, is that the radius increases, with the period remaining the same as before.
24	**C**	$E = -\frac{d\Phi}{dt} = -\frac{d(BA)}{dt} = -\frac{d(\mu_o nI)A}{dt}$ The gradient of I-t graph is E
25	**D**	The magnitude of the magnetic flux density is decreasing at a constant rate implies that the e.m.f induced is constant. By Lenz's law, the induced current will flow so as to oppose the decreasing magnetic field, and using Right Hand Grip Rule, current will flow counter-clockwise.

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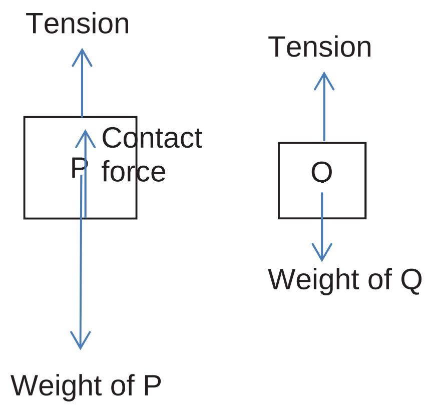
Qn	Ans	Suggested solution (Font Arial, 11 pt)
26	A	$P_{mean} = \frac{1}{4}P_o = \frac{1}{4}(\frac{3^2}{5}) = 0.45$ W
27	D	$p = mv = \frac{h}{\lambda} \Rightarrow v = \frac{h}{mv}$ Hence, the most massive particle would have the smallest velocity.
28	B	Assuming range of wavelength for visible light to be 400 – 700 nm, the range of photon energies that would lead to visible spectral lines is about 1.8 – 3.1 eV. Since the gas is cold, the atom is at the ground state i.e. –13.6 eV level. Electrons of KE 13.00 eV would be able to excite it up to only the –0.850 eV level. From the –0.850 eV level, only the following transitions would lead to emission of photons with energies in the range of 1.8 – 3.1 eV. • from –0.850 eV to –3.40 eV level • from –1.51 eV to –3.40 eV level
29	B	$A = A_0 \exp(-\lambda t)$ $\ln A = \ln A_0 - \lambda t$ Hence, gradient of graph of ln A against t is $-\lambda$ (which is a constant for the same radioactive gas since $\lambda = \ln 2/t_{1/2}$).
30	C	$\frac{A}{A_0} = (\frac{1}{2})^n$ => $\frac{(35-20)}{(80-20)} = (\frac{1}{2})^n$ => n = 2 half-lives = 2 x 5700 years $\approx$ 11 000 years

Qn	Suggested solutions	Remarks
1(a)	Using $s = ut + \frac{1}{2}at^2 \rightarrow h = \frac{1}{2}at^2$ $a = \frac{2h}{t^2} = \frac{2(0.600)}{(354\times10^{-3})^2}$ $a = 9.5758 \text{ m s}^{-2}$ $\frac{\Delta a}{a} = \frac{\Delta h}{h} + \frac{2\Delta t}{t}$ $\frac{\Delta a}{9.5758} = \frac{0.001}{0.600} + \frac{2(1)}{354}$ $\Delta a = 0.07 \text{ m s}^{-2}$ $a = (9.58 \pm 0.07) \text{ m s}^{-2}$	**[1] ans: acceleration [1] ans: uncertainty [1] e.c.f. final expression (correct s.f. for uncertainty, correct d.p. for acceleration of free fall)**
(b)(i)	The delay is due to the time taken for the electromagnet and steel ball to lose their magnetism.	**[1]**
(ii)	Systematic error. The constant delay causes the timing measured to be consistently too long.	**[1] [1]**
(iii)	Graphical methiod: Measure the timings for different heights of fall and plot a graph of h against t^2. Details: The constant delay is the square root of the x-intercept. OR Experimental method: Use of light gates / high speed camera / etc. Details: Positioning of light gates / view video in slow motion / etc.	**[1] accept graphical or experimental method [1] some details**
2(a)(i)		**[2] for 3 forces on P, [1] for 2 forces on Q. Minus 1 mark if no label and/or wrong point(s) of application and/or wrong relative magnitudes showing non-equilibrium.**
(ii)	Object Q: tension balances the weight of object Q Object P: tension + contact force balances the weight of object P (0.3)(9.81) + contact force = (1.5)(9.81) Contact force = (1.2)(9.81) = 11.8 = 12 N (shown)	**[1] equate tension to weight of object Q [1] sub**
(b)(i)	<u>Upthrust is the upward force exerted on an object immersed in a fluid.</u> It is equal to the weight of fluid displaced.	**[1]**
(ii)	12 = (A)(0.120)(1000)(9.81) A = 0.010 m^2	**[1] sub [1] ans**

Qn	Suggested solutions	Remarks
3(a)	Power is defined as the rate of work done/ work done per unit time/ rate of energy conversion.	**[1]**
(b)	For car to move at constant velocity, the minimum engine force required must be equal in magnitude to component of car's weight along slope. Hence, $F = mg\sin\theta$ $= (1800)(9.81)\sin(37.5°)$ $= 1.07 \times 10^4$ N Minimum power $P = Fv = (1.07 \times 10^4)(60 \times 10^3/3600)$ $= 179$ kW	**[1]-sub** **[1]-sub** **[1]-ans**
(c)	Gain in KE = Loss in GPE $\frac{1}{2} mv^2 = mgh$ $\frac{1}{2} v^2 = (9.81)(77.2 \sin 37.5°)$ $v = 30.4$ m s^{-1}	 **[1]-sub** **[1]-ans**
4(a)	Period is the time taken for a wave particle to complete one oscillation.	**[1]**
(b)	2 cm	**[1]**
(c)	Q directly below P	**[1]**
(d)	Phase difference $= (0.25/2) \times 2\pi$ $= \pi/4$ rad	**Subst- [1]** **Ans- [1]**
(e)	$\frac{0.1}{T} = \frac{\frac{\pi}{4}}{2\pi}$ $T = 0.80$ s	**Subst- [1]** **Ans- [1]**
5(a)(i)	$a = -\omega^2 x$ $\omega = \sqrt{gradient}$ $= \sqrt{\frac{7.6-0}{0.10-0}}$ $= 8.7$ rad s^{-1}	**[1] relating gradient to ω^2** **[1] working**
(a)(ii)	$T = 2\pi / \omega$ $= 2\pi / 8.7$ $= 0.72$ s	 **[1] ans**
(b)(i)	$x = -x_o \cos \omega t$ (Since starting point is at lowest point of motion)	**[1]**
(b)(ii)	$-0.025 = -0.10 \cos (8.7\, t)$ $t = 0.15$ s	*Ecf from (b)(i)* **[1] working** **[1] ans**
(c)	**Resonance** occurs. The **frequency of passing over the bumps matches the natural frequency** of the suspension of the truck.	**[1]** **[1]**
6(a)(i)	Magnetic force is acting **downward**. Since **side BC is perpendicular to the magnetic field** *B* of the solenoid, it would **experience a magnetic force whose direction is given by Fleming's Left Hand Rule**.	**[1]** **[1]**

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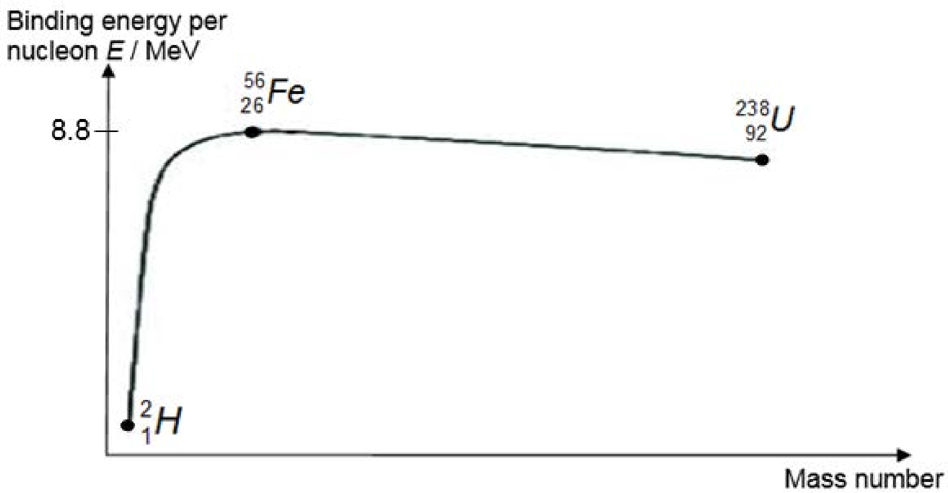
Qn	Suggested solutions	Remarks
(a)(ii)	Since side AB is **parallel with the magnetic field** *B* of the solenoid, **no magnetic force** acts on it.	**[1]**
(b)(i)	$B = \mu_0 n I$ $= 4\pi \times 10^{-7} \times 700 \times 3.5$ $= 3.08 \times 10^{-3}$ T	**[1] ans**
(b)(ii)	Force acting on BC $F = BIL$ $= 3.08 \times 10^{-3} \times 3.5 \times 5.0 \times 10^{-2}$ $= 5.39 \times 10^{-4}$ N	**[1] sub** **[1] ans**
(b)(iii)	Since frame is horizontal, applying Principle of Moments, Sum of anti-clockwise moments = Sum of clockwise moment $mgd = Fd_{QC}$ $(0.100 \times 10^{-3})(9.81)(d) = (5.39 \times 10^{-4})(12 \times 10^{-2})$ $d = 0.0659$ m	**[1] sub** **[1] ans**
(b)(iv)	The **clockwise moment will increase by 4 times** as magnetic field strength through solenoid and current is doubled. The mass of the paper must be **increased by 4 times** so that the anticlockwise moment will be increased by 4 times.	**[1]** **[1]**
7(a)	*Half-life* of a radioactive nuclide is defined as the <u>average time taken for half of the original number of radioactive nuclei in a sample to decay</u>. Or any of the following: - half of the original number of radioactive nuclei in a sample to remain undecayed; - the activity of a radioactive sample to decrease to half its original value; - the received count rate to reduce to half its original value. (assume no background count rate).	**[1]**
(b)(i)	The *binding energy per nucleon* is the <u>minimum energy per nucleon needed to split a nucleus into separate nucleons</u>.	**[1]**
(ii)	Nucleon number = 216 Proton number = 84	**[1] - ans**
(iii)	Energy change = [(7.76)(216) + (6.51)(4)] - (7.72)(220) = 3.80 MeV $= 3.80 \times 10^6 \times 1.6 \times 10^{-19}$ $= 6.08 \times 10^{-13}$ J	**[1] – sub (ecf for (ii))** **[1] – ans (MeV)** **[1] – ans (J)**

Qn	Suggested solutions	Remarks
(iv)	Energy is **<u>released</u>** in this reaction. <u>The total binding energies of the reactants is lower than the total binding energy of the product.</u> It means that the reaction <u>involves reactants of higher energy content</u> to <u>products with lower energy content.</u> <u>OR</u> <u>The mass-energy of reactants is greater than mass energy of products.</u> <u>OR</u> <u>Products are more stable than reactants.</u> *Therefore, 3.80 MeV energy which is the difference in the energy content is released in this reaction in the form of K.E. of the products. (note)*	**[1]** **[1]** **[1]**
(v)		**[1] correct axes and correct shape of graph** **[1] position of nuclides** **[1] correct maximum value of 8.8 MeV**
8(a)(i)	$T^2 \propto r^3 \Rightarrow T^2 = kr^3 \Rightarrow k = \frac{T^2}{r^3}$ $k_1 = \frac{1.63^2}{(7010)^3} = 7.71\times10^{-12}$ $k_2 = \frac{48.1^2}{(67100)^3} = 7.65\times10^{-12}$ $k_2 = \frac{57.2^2}{(75200)^3} = 7.69\times10^{-12}$ Since k_1,k_2 and $k_3$are about the same, the relationship is true.	**[1] for method** **[1] for comparing at least 2 correct values**
(ii)	$k_{ave} = 7.68\times10^{-12}$ Since $T^2 = (7.68\times10^{-12})r^3$ $\Rightarrow 35^2 = (7.68\times10^{-12})r^3$ $r = 54232 \approx 54200$ km	**[1] for any correct method** **[1] for answer Accept answer even if student does not take average**

Qn	Suggested solutions	Remarks
(b)(i)	Useful intensity of light received = $0.16 \times 1500 = 240$ $I = \frac{P}{Area} \Rightarrow Area = \frac{P}{I} = \frac{360}{240} = 1.5\ m^2$	**[1] for correct method** **[1] for correct answer**
(ii)	The satellite will sometimes be in the shadow cast be Earth/ no direct sunlight The electrical circuits/ batteries are not 100% efficient Satellites required extra power for position control or other stated function Panels may not be perpendicular to sunlight. Radiation damage (from cosmic rays) reduces number of useful cells	**[2]** **Any two of the following.**
(iii)	The intensity of sunlight is too small. The rea of panel would be too large or massive to be launched	**[1]** **Any one of the following**
9(a)(i)	For diameter = 6.0 m and v = 3.0 m s-1, P = 150 W. lg P = 2.18	**[1]**
(ii)	1. correct point plotted. 2. suitable best-fit line	**[1]** **[1]**
(iii)	$\text{Gradient} = \frac{3.45 - 1.90}{0.91 - 0.38}$ n = 2.93 (to 3 s.f) (Accept n = 2.95 $\pm$ 0.05) Sub (0.38, 1.90) and gradient = 2.93, 1.90 = (2.93) (0.38) + y-intercept y-intercept = 0.7866 lg k = 0.7866 k = 6.12	**[1] for correct method** **[1] for correct n** **[1] for correct k**
(b)(i)	Volume of air in 1s $= \pi r^2 v = \pi (\frac{6}{2})^2 (8.0) = 226.2 \approx 226\ m^3$	**[1]**
(ii)	Kinetic energy $= \frac{1}{2} m v^2 = \frac{1}{2} (\rho V) v^2$ $= \frac{1}{2}(1.3)(226.2)(8.0)^2 = 9409 \approx 9410$ J	**[1] for correct method** **[1] for correct answer**
(c)	efficiency $= \frac{\text{useful power output}}{\text{total power output}} = \frac{2750}{9409} = 0.292$	**[1]**
(d)	• Type of material used for the blades. A lighter material has smaller inertia in rotating and hence the power output will be higher. • Shape of the blades. An aerodynamic shape will cause the power output to be higher. • Surface area of the blade. A larger surface area implies that more wind is in contact with the blade and the power output will be higher. • Friction between the wheel and the axle. A higher friction would mean that more energy is lost through heat, causing the power output to be less	**[1] for any of the following reasons**

Qn	Suggested solutions	Remarks
(e)	• The wheel of diameter 30 m may be too heavy to mount during construction. • The wheel produces a very large torque, hence may be unstable. • To provide a strong frame to support it, it may be costly. • There may be space constraints to construct long blades as they extend 30m high up.	**[1] for any of the following reasons**

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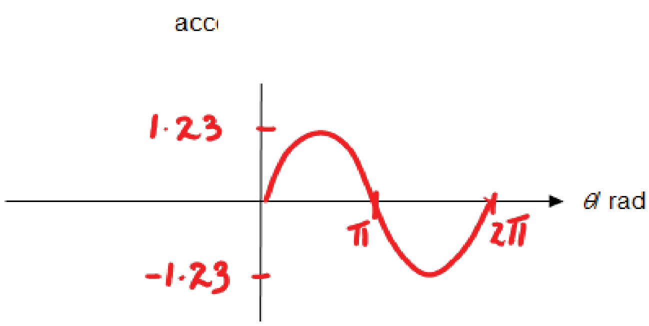
Qn	Suggested solutions	Remarks
1 (a)(i)	The principle of conservation of linear momentum states that the total momentum of a system of interacting bodies is constant provided no external resultant force acts on it.	**[1]**
(ii)	Total final momentum = total initial momentum $1.5v_A + 5v_B = (1.5)(4) = 6$ Relative speed of separation = relative speed of approach $v_B - v_A = 4$ Solving simultaneously, $v_A = -2.154 = -2.2$ m s^{-1} $v_B = 1.846 = 1.8$ m s^{-1}	**[1] eqn** **[1] eqn (also accept eqn of KE conservation)** **[1] v_A ans (must be –ve)** **[1] v_B ans**
(b)	Consider the vertical motion to determine time of flight: $s = ut + \frac{1}{2}at^2$ $0.6 = \frac{1}{2}(9.81)t^2$ $t = 0.350$ s Consider the horizontal motion to determine horizontal distance travelled: $s = (1.2)(0.350) = 0.420$ m	**[1] sub** **[1] ans** **[1] ans**
(c)	The GPE gained during free fall is dissipated by this vertical retarding force. $mgh = Fd$ $(5)(9.81)(0.6+0.08) = F(0.080)$ $F = 417$ N	**[1] sub** **[1] ans**
2(a)	The gas molecules are in continuous random motion. When they collide with the walls of the container, they experience change in momentum. <u>Rate of change of momentum is force</u> acting on the gas. <u>Force per unit area is pressure</u>. Using <u>Newton's Third Law of Motion</u>, since there is pressure exerted on the gas by the container, there must be pressure exerted by the gas on the container.	**[1]** **[1]** **[1]**
(b)(i)	$pV = nRT$ $(1.0 \times 10^5)V = (1)(8.31)(300)$ $V = 0.02493 = 0.025$ m^3	**[1] sub**
(ii)	Density $= \dfrac{\text{mass}}{\text{volume}} \rightarrow \rho = \dfrac{0.032}{0.025} = 1.28$ kg m^{-3}	**[1] ans**
(iii)	$p = \frac{1}{3}\rho c_{rms}^2 \rightarrow 1.0 \times 10^5 = \frac{1}{3}(1.28)c_{rms}^2$ $c_{rms} = 484$ m s^{-1}	**[1] sub** **[1] ans**
(iv)	average KE of molecule $= \frac{3}{2}kT = \frac{3}{2}(1.38 \times 10^{-23})(300)$ $= 6.21 \times 10^{-21}$ J	**[1] sub** **[1] ans**
3(a)	Using $x = \dfrac{\lambda D}{a} = \dfrac{690 \times 10^{-9} \times 2.5}{0.800 \times 10^{-3}} = 2.16 \times 10^{-3} m$	**[1] formula** **[1] sub** **[1] ans**
(b)(i)	There is <u>no change in the spacing</u>. The <u>maxima is the brighter</u> and thus the <u>contrast is higher</u>.	**[1]** **[1]**

Qn	Suggested solutions	Remarks
(ii)	Since D is larger, x will be larger. The separation will increase. The maxima is dimmer due to the longer distance, thus the contrast is lower.	**[1]** **[2]**
(iii)	Since wavelength of green light is shorter, x will be smaller. The separation will decrease. The contrast remains unchanged.	**[1]** **[1]**
4(a)(i)	From the graph, at 2.0 V, I = 2.0 A → R = 1.00 Ω From the graph, at 10.0 V, I = 5.1 A → R = 1.96 Ω	**[1]** **[1] read off values correctly** **[1] ans**
(a)(ii)	Lattice ions in the metal to vibrate more vigorously, causing an increased rate of collision with the moving electrons. The increased rate of collision reduces the rate of flow of electrons, hence, lowering the current flow.	**[1]** **[1]**
(b)(i)	$R = \frac{\rho\ell}{A} = \frac{4\rho\ell}{\pi d^2}$ $0.50 = \frac{4(5.5\times10^{-8})\ell}{\pi(0.084\times10^{-3})^2} \Rightarrow \ell = 0.0503$ m	**[1] Value of A** **[1] Eqn** **[1] sub** **[1] ans**
(b)(ii)	The length of the filament wire is too long to be placed inside the filament lamp.	**[1]**
5(a)	Electric field strength at a point in an electric field is defined as the electric force exerted per unit positive charge placed at that point.	**[1]**
(b)(i) 1.	B is positively charged because the electric field lines point to the left away from sphere B, and electric field lines point away from positive charges.	**[1]**
(b)(i) 2.	Electric potential is constant inside each sphere, because zero electric field strength within a sphere implies zero potential gradient.	**[1]** **[1]**
(b)(ii)	$Q_A = 4Q_B$ -------------- (1) At x = 4.0 cm, $E_A - E_B = 1.25 \times 10^7$ $Q_A/[4\pi\varepsilon_0(0.04)^2] - Q_B/[4\pi\varepsilon_0(0.08)^2] = 1.25 \times 10^7$ ----------------- (2) Substituting (1) into (2), $4Q_B/[4\pi\varepsilon_0(0.04)^2] - Q_B/[4\pi\varepsilon_0(0.08)^2] = 1.25 \times 10^7$ Solving, $Q_B = 5.93 \times 10^{-7}$ C	 **[1] eqn (2)** **[1] working** **[1]**

Qn	Suggested solutions	Remarks
(b)(iii)	Gain in electric potential = area under graph between x = 1.4 cm and x = 3.0 cm Estimated area between x = 1.4 cm and x = 3.0 cm = ½ $(0.6 \times 10^{-2})(10.0 \times 10^{7})$ + ½ $(0.6 \times 10^{-2})(1.5 \times 10^{7})$ + ½ $(1.6 \times 10^{-2})(6.0 + 2.5)10^{7} + (0.2 \times 10^{-2})(0.5 \times 10^{7})(3.5)$ = 1060 kV Or by counting squares under graph. Acceptable range for either method is between 800 kV and 1100 kV. Energy gained by proton = $(1060 \times 10^{3})(1.60 \times 10^{-19})$ = 1.70×10^{-13} J	**[1] area under graph** **[1] area within range** **[1] sub** **[1] ans**
6(a)	Work function is the <u>minimum energy required to liberate/emit an electron</u> from the surface.	**[1]**
(b)(i)	$hc/\lambda = \phi + E_{MAX}$	**[1]**
(b)(ii)	From (b)(i), $hc/\lambda = hf_0 + E_{MAX}$ when $E_{MAX} = 0$, $1/\lambda_0 = 1.95 \times 10^{6}$ m^{-1} (allow $\pm 0.05 \times 10^{6}$ m^{-1}) (<u>evidence</u> of use of y-intercept from graph) $f_0 = c(1/\lambda_0) = (3.00 \times 10^{8})(1.95 \times 10^{6})$ $= 5.85 \times 10^{14}$ Hz OR chooses point on the line and substitutes values of $1/\lambda$ and E_{MAX} into $hc/\lambda = \Phi + E_{MAX}$	**[1] method** **[1] sub** **[1] ans**
(b)(iii)	Same gradient, towards left of original graph (implying larger y-intercept)	**[1]**
(c)(i)	($I = \frac{Nhf}{tA} \Rightarrow$ when I increases, it can mean $\frac{N}{t}$ increases or f increases.) <u>Number of electrons emitted per unit time increases</u> because there are now <u>more photons striking the metal surface per unit time</u>.	**[1]**
(c)(ii)	<u>E_{MAX}</u> of emitted photoelectron is the <u>same</u> as <u>photon-electron interaction is 1 to 1</u>, and since f is fixed, <u>energy of photon</u> absorbed by electron <u>is constant</u> and for same surface with same work function.	**[1]** **[1]** **[1]**
7(a)	Angular velocity is the <u>rate of change of angular displacement</u>.	**[1]**

Qn	Suggested solutions	Remarks
(b)(i)	Since gravitational force (on satellite due to Earth) provides the centripetal force for each satellite to orbit around Earth, $\frac{GM_E m}{r^2} = mr\omega^2$ $\omega = \sqrt{\frac{GM_E}{r^3}}$ $\omega_A = \sqrt{\frac{(6.67x10^{-11})(6.0x10^{24})}{(1.0x10^4 x10^3)^3}} = 6.33x10^{-4} rads^{-1}$ $\omega_B = \sqrt{\frac{(6.67x10^{-11})(6.0x10^{24})}{(2.0x10^4 x10^3)^3}} = 2.24x10^{-4} rads^{-1}$	**[1] - statement** **[1] - expression** **[1] – ans** **[1] - ans**
(b)(ii)	When satellites are diametrically opposite to each other, the difference in their angular displacement = 180° = π rad. Since $\omega = d\theta/dt$, => $\Delta\theta = \Delta\omega\Delta t$ => $\pi = (\omega_A - \omega_B)\,\Delta t$ $= (6.33 \times 10^{-4} – 2.24 \times 10^{-4})\Delta t$ $\Delta t = 7.68 \times 10^3$ s	**[1]- $\Delta\theta = \pi$ rad** **[1] – sub.** (accept ecf) **[1] - ans**
(c)	The gravitational potential at a point is defined as the work done per unit mass in bringing a small test mass from infinity to that point.	**[1]**
(d)(i)	Gravitational potential $\phi = -\frac{GM}{r}$ $\Delta\phi = -\frac{GM_E}{r_A} - (-\frac{GM_E}{r_B})$ $\Delta\phi = GM_E(-\frac{1}{r_A} + \frac{1}{r_B})$ $\Delta\phi = (6.67x10^{-11})(6.0x10^{24})(-\frac{1}{1.0x10^4 x10^3} + \frac{1}{2.0x10^4 x10^3})$ $= - 2.00 \times 10^7$ J kg^{-1}	**[1] – sub** **[1] - ans**
(d)(ii)	ΔGPE = $m_B\Delta\phi$ = (100)(-2.00 x 10^7) = - 2.00 x 10^9 J	**[1] – ans** (accept ecf)
(d)(iii)	Change in KE = $\frac{GM_E m_B}{2r_A} - \frac{GM_E m_B}{2r_B}$ $= \frac{(6.67x10^{-11})(6.0x10^{24})(100)}{2}(\frac{1}{1.0x10^7} - \frac{1}{2.0x10^7})$ = 1.00 x 10^9 J	**[1] – subst** **[1] - ans**
(d)(iv)	Change in total energy = ΔGPE + ΔKE = - 2.00 x 10^9 + 1.00 x 10^9 = -1.00 x 10^9 J	**[1] – ans** (accept ecf)

Qn	Suggested solutions	Remarks
(e)	As the satellite loses energy, its orbital radius decreases and its kinetic energy will increase and it will move faster. As the work done against resistive forces by the satellite increases, it will 'burn up' as its potential energy is increasingly converted to thermal energy.	**[1]** **[1]** **[1]**
(f)	Escape velocity = $\sqrt{\dfrac{2GM_E}{r_E}}$ $= \sqrt{\dfrac{2(6.67x10^{-11})(6.0x10^{24})}{(6.4x10^3 x10^3)}}$ = 1.12×10^4 m s^{-1}	**[1] – sub** **[1] - ans**
8(a)(i)	$\theta = \omega t$	**[1]**
(ii)	Distance GH = r $\sin\theta =$ r $\sin\omega t$	**[1]**
(iii)	Let GH $= y$ $y = -r\sin\omega t$ $v = -r\omega\cos\omega t$ $a = r\omega^2 \sin\omega t = -\omega^2 y$ Since it is periodic motion in which acceleration is proportional and opposite of its displacement from the equilibrium position, It is SHM.	**[2] for manipulation (Accept $y = r\sin\omega t$)** **[1] for explaining/ defining SHM**
(iv)1.	$v = -r\omega\cos(\omega t) = -(0.10)(3.5)\cos(30^o) = -0.303$ ms^{-1} speed = 0.303 ms^{-1}	**[1] for substitution** **[1] for correct answer** **Accept other method.**
2.	$a = r\omega^2 \sin\omega t = (0.10)(3.5^2)\sin(30^0) = 0.613$ ms^{-2}	**[1] for substitution** **[1] for correct answer** **Accept other method.**
(v)	 **Fig. 7.2**	**[1] for correct shape** **Accept - sinθ.** **[1] for correct labelling**

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Qn	Suggested solutions	Remarks
(b)(i)	The narrow strip of the metal disc between C and R acts as a straight conductor. When the disc rotates, this strip will be cutting magnetic flux with time. By Faraday's law, there will be an e.m.f induced.	[1] [1]
(ii)	$\varepsilon = \dfrac{d\phi}{dt} = \dfrac{d(BA)}{dT}$ $= B\left(\dfrac{dA}{dt}\right) = \dfrac{B(\pi r^2)}{T} = \dfrac{\dfrac{B(\pi r^2)}{2\pi}}{\omega} = \dfrac{1}{2}B\omega r^2$	[1] [1]
(iii)	$\omega = \dfrac{15(2\pi)}{1} = 30\pi$ e.m.f $= \dfrac{1}{2}B\omega r^2 = \dfrac{1}{2}(0.25)(30\pi)(0.10)^2 = 0.118$ V	[1] for calculating ω [1] for correct answer
(iv)	Current flow from C to R. According to Lenz's law, the direction of the induced current along CR would be such as to produce a force acting to the right, to oppose the change. In order that the force acting on CR would be to the right, the induced current must be flowing from C to R (centre to rim) along CR by Fleming's left hand rule.	[1] [1] [1]

Suggested marking scheme for 2017 Prelim Examination Paper 4

Qn	Answer	Marks
1(a)(i)	**MMO** x measured to the correct precision with unit	1
(ii)	**ACE** Sensible value in Δx (allow 2 to 5mm) and hence corresponding percentage uncertainty of x (to a maximum of 2 s.f.)	1
(b)(i)(ii)(iii)	**MMO** h_o, h_1 *and* H_1 are measured to the correct precision with unit	1
(c)(i)	**MMO** t are measured to the correct precision with unit and there is evidence of repeated reading.	1
(ii)	**MMO** x_1 are measured to the correct precision with unit and there is evidence of repeated reading.	1
(iii)	**ACE** Estimation of m_1 using ratio of x *and* x_1 values and 200 g with correct unit.	1
(iv)	**ACE** Flow rate R_1 with appropriate number of significant figures with units	1
(d)	**MMO** Measurement of h_2, H_2, t_2, x_2 and m_2 for lower marking, **ACE** Calculation of R_2. **PDO** Values of h_2, H_2, t_2, x_2 and m_2 to appropriate precision **PDO** Flow rate R_2 with appropriate number of significant figures with units, e.g. g s^{-1} **ACE** Determination of a constant of proportionality. **ACE** Draw conclusion based on stated criterion e.g. not obeyed because more than 20% difference in values of k.	6
(e)	**P** Use holes of different size with the same depth **P** Calculation of exit velocity by dividing the mass flow rate with density and area of hole	2
2(a)	**MMO** d are measured to the correct precision with unit and there is evidence of repeated reading.	1
(b)(i)	**MMO** I *and* V are measured to the correct precision with unit	1
(iii)	**MMO** Take three readings showing correct trend. Allow tables with three readings. **MMO** I *and* V are measured to the correct precision with unit	2
(c)	**PDO** Points are correctly plotted. **PDO** Line of best fit.	2

(d)	**ACE** Calculation of gradient **ACE** Determination of length L with appropriate number of significant figures with units,	**2**
3(b)(i)(ii)	**MMO** Value of L to the nearest mm with unit Value of θ to the nearest degree with unit	**1**
(iii)	**ACE** Percentage uncertainty in θ correctly calculated. $\Delta\theta \geq 2°$.	**1**
(c)(ii)	**MMO** Repeated timings for each value of θ with the number of oscillations n taken such that $nT \geq 10$ s.	**1**
(d)	**MMO** • Award 2 marks if candidate <u>has successfully collected 6 or more sets</u> of data (x, T) without assistance / intervention and <u>there is evidence of repeat readings</u> • Award 1 mark if candidate has successfully collected 5 sets of data (x, T) without assistance/intervention. • Award zero mark if candidate has successfully collected 4 or fewer sets of data (x, T) without assistance/intervention. • Deduct 1 mark if candidate requires some assistance /intervention but has been able to do most of the work independently. • Deduct 2 marks if candidate has been unable to collect data without assistance/ intervention.	**2**
	PDO Layout: column headings (raw data and calculated quantities: θ, t, T, $T^2$and cosθ). Each column heading must contain a quantity and unit.	**1**
	PDO All values of e.g. θ, t to the correct precision.	**1**
	PDO For each calculated value of e.g. T, $T^2$and cosθ, the number of s.f. should be the same or one more than the number of s.f, in the raw data.	**1**
	ACE Correctly calculated values of calculated quantity.	**1**
(e)	**ACE** Linearising equation.	**1**
	ACE y-intercept must be read off to the nearest half small square or determined from y = mx + c using a point on the line.	**1**
	ACE Gradient - the hypotenuse of the gradient triangle must be greater than half the length of the drawn line. Read-offs must be accurate to half a small square	**1**
	ACE Values of A and B calculated correctly with units.	**1**
	PDO	**1**

	• Sensible scales must be used. Awkward scales (e.g. 3:10) are not allowed. • Scales must be chosen so that plotted points occupy at least half the graph grid in both x and y directions. • Axes must be labelled with the quantity and units which is being plotted.	
	PDO All observations must be plotted. Work to an accuracy of half a small square.	**1**
	PDO Straight line of best fit - judge by scatter of points about the candidate's line. There must be a fair scatter of points either side of the line.	**1**
(f)	**MMO** Anomalous data/results, if any, must be identified" Appropriate justification must be given" Otherwise comment on absence of anomalous data. (only 2 anomalous data allowed)	**1**
(g)	**ACE** Relevant points (with appropriate elaboration) might include:	**2**
(h)	**ACE** Relevant points (with appropriate elaboration) might include:	**1**

Suggested solutions

1(a)(i)	x = 65 mm
(ii)	Percentage uncertainty$=\dfrac{3}{65}\times 100\% = 4.6\%$ (Allow a maximum of 2 s.f.)
(b)(i)	h_0= 17 mm
(ii)	h_1= 60 mm
(iii)	H_1 = 43 mm
(c)(i)	$t_1=\dfrac{t_a+t_b}{2}=\dfrac{29.4+29.8}{2}=29.6$ s
(ii)	$x_1=\dfrac{x_a+x_b}{2}=\dfrac{27+29}{2}=28$ mm
(iii)	$\dfrac{x}{x_1}=\dfrac{m}{m_1}\Rightarrow\dfrac{65}{28}=\dfrac{200}{m_1}\Rightarrow m_1\approx 86$ g
(iv)	$R_1=\dfrac{86}{29.6}\approx 2.9$ g s^{-1}
(d)	h_2 = 40 mm H_2 = 23 mm $t_2=\dfrac{t_a+t_b}{2}=\dfrac{13.2+13.6}{2}=13.4$ s $x_2=\dfrac{x_a+x_b}{2}=\dfrac{12+12}{2}=12$ mm $\dfrac{x}{x_2}=\dfrac{m}{m_2}\Rightarrow\dfrac{65}{12}=\dfrac{200}{m_2}\Rightarrow m_2\approx 37$ g $R_2=\dfrac{37}{13.4}\approx 2.8$ g s^{-1} $R\propto\sqrt{H}\Rightarrow R=k\sqrt{H}$ when H_1 = 43 mm, R_1= 2.9 g s^{-1}, $k_1=\dfrac{R_1}{\sqrt{H_1}}=\dfrac{2.9}{\sqrt{43}}=\ 0.44$ when H_1 = 23 mm, R_1= 2.8 g s^{-1}, $k_1=\dfrac{R_1}{\sqrt{H_1}}=\dfrac{2.8}{\sqrt{23}}=\ 0.58$ <u>Comparing the different values of *k*</u> $k_{mean}=\dfrac{0.44+0.58}{2}=0.51$ $\because\ \Delta k=0.58-0.44=0.14$ Percentage difference $=\dfrac{\Delta k}{k_{mean}}\times 100\%=\dfrac{0.14}{0.51}\times 100\%=27\%$ <u>Draw conclusion based on stated criterion:</u> The relationship is not true because there is more than 20% difference in values of k.

2(a) d_{ave} = (0.28+0.28+0.28) /3 = <u>0.28 mm</u>

(b)(i) I = 60.0 mA
V = 0.752 V

(iii)

I / mA	V / V
66.9	0.839
72.6	0.909
78.0	0.975

(c)

(d)

3(b)(i) L = 50.1 cm

(ii) θ = 55°

(iii) Estimate $\Delta\theta \approx 3°$

Hence, percentage uncertainty = $\frac{\Delta\theta}{\theta} x100\% = \frac{3}{55} x100\%$ = **<u>5.5%</u>** (max of 2 s.f.)

(c)(ii)

Time for 10 oscillations	
t_1 /s	**t_2 /s**
18.7	18.8

Period, $T = \frac{t_1 + t_2}{20} = \frac{18.7 + 18.8}{20}$ = **<u>1.88 s</u>**

(d)

θ / °	**Time for 10 oscillations**		**Period T / s**	**T^2 / s^2**	**cos (θ / °)**
	t_1 /s	**t_2 /s**			
55	18.7	18.8	1.88	3.52	0.57
44	16.5	16.7	1.66	2.76	0.72
61	20.3	20.8	2.06	4.22	0.48
68	22.7	23.0	2.29	5.22	0.37
65	21.8	22.1	2.20	4.82	0.42
59	19.6	20.0	1.98	3.92	0.52

(e) Given: $T^2 = A(\cos\theta) + B$

Graph of is T^2 vs cos θ *is* plotted, gradient = A, the y-intercept = B

gradient , m = $\frac{4.90 - 3.175}{0.40 - 0.65} = -\ 6.90$

$A \approx -\ 6.90\ s^{-1}$

Sub (0.40, 4.90) into the equation

$4.90 = (-6.90)(0.4) + B$

$B \approx 7.66\ s^{-1}$

(g) There are no anomalous data points. All the data points are reasonably close to the best-fit straight line.

OR

There are no anomalous data points. All the data points are on the best-fit straight line.

OR

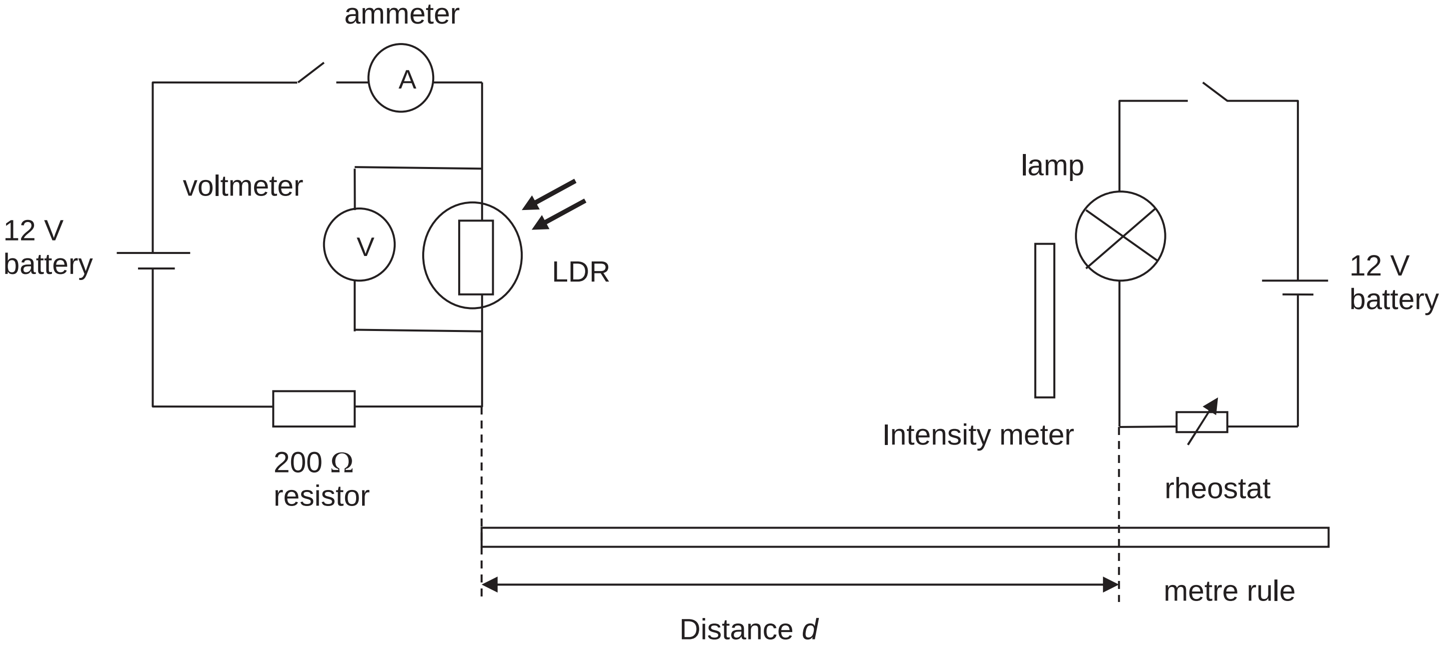
Point (x,y) is an anomalous data point as it is too far from the line of best fit.

(h) 1. There is difficulty in holding protractor stationary and vertically and hence there is difficulty in measuring the angle.

	2. Difficulty in estimating the extreme or equilibrium positions for the measurement of time for n oscillations
(i)	1. Use trigonometric function to determine θ (with suitable elaboration). 2. Set up fiducial line by e.g. suspending a pendulum close to oscillating ruler but not in contact with the set-up) to provide accurate indication of extreme or equilibrium positions.

Suggested solution to Planning

Diagram



Objective:

To investigate how the resistance, *R* of the LDR depends on the distance *d* from the lamp.

Independent variable	**:**	Distance *d* from the lamp
Dependent variable	**:**	Resistance *R* of the LDR
Controlled variable	**:**	**1.** Alignment of the lamp with the LDR
		2. Brightness/Intensity of the lamp/Keep output of the lamp constant
		3. Ambience light intensity

Apparatus:

1. Measure the distance *d* between the lamp and the LDR using a metre rule. Set d = 10.0 cm
2. Measure the voltage, *V* across the LDR using a voltmeter in series. Measure the current, I through the LDR using a ammeter in series. Calculate the resistance of LDR using $R = V/I$.
3. The orientation of the LDR with respect to the lamp must be kept constant i.e the lamp must be pointing at the LDR in the same direction. The lamp and the LDR can be fixed at a particular position using adhesive tape.
4. An intensity meter is used to check whether the output of the lamp is constant during the experiment. Use a rheostat in series with the voltage supply to the lamp and adjusting the rheostat to maintain a constant current (i.e. constant intensity of light) through the lamp.
5. The experiment should be performed in a dark room so that the intensity of other light sources would not interfere with the variation of the resistance of the LDR.

Procedure

1 Set up the apparatus as shown in the diagram above.

2 Measure the distance *d* between the lamp and the LDR

3 Close the circuits.

4 Measure the potential difference across the LDR and the current flowing LDR.

5 Record the voltmeter and the ammeter readings and calculate the resistance of the LDR.

6 Open the circuits

7 Increase the distance *d* and repeat step (2) to (6) until you have 6 sets of readings of *d*, *V, I and R.*

Analysis

1 Assume that the resistance *R* is related to the distance *d* by the equation

$$R = kd^n$$

where k and n are constants.

2 Taking lg on both sides, $\lg(R) = n\lg(d) + \lg(k)$.

3 Plot a graph of lg (*R*) against lg (*d*)

4 If the above relationship is true, a straight line graph will be obtained where the gradient is equal to n and the y-intercept is equal to lg(k).

Safety considerations

1 Do not look directly at the lamp. Wear sun glasses if the intensity of the lamp is too high.

2 Do not touch the lamp with bare hands. Wear gloves when handling the lamp after use.

3 Electric circuit set up must be away from sink and kept dry at all times.

4 Do not handle the electrical circuits with wet hand.

5 Ensure all the connecting wires are properly insulated to prevent any cases of electric shock.

Additional details

1 The orientation of the LDR with respect to the lamp must be kept constant i.e the lamp must be pointing at the LDR in the same direction. The lamp and the LDR can be fixed at a particular position using adhesive tape.

2 The resistance of the LDR is high and hence the current flowing in the circuit will be small. The ammeter is set to 200 mA to measure the current flowing in the circuit.

3 Take average readings of *V* and *I* by repeating the experiment with increasing and decreasing *d*.

4 The intensity meter, lamp and the LDR can be placed in a black cardboard tube/container to minimize the light from the surroundings from reaching the LDR or intensity meter.

5 The distance between the intensity meter and the lamp should also be kept constant by placing markers at their locations. The alignment/orientation of the lamp and the intensity meter is to be kept constant.

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Suggested mark scheme to Planning Question

Diagram		**[2]**
Good choice of apparatus and a clearly labeled diagram.		
- correct circuit diagram e.g voltmeter // to LDR, ammeter in series with LDR, orientation of lamp and LDR, diagram showing ruler measuring distance *d*, LDR using conventional circuit symbol, correct circuit diagram for the lamp	**D1,** **D2**	
Procedure		**[4]**
- The procedure is outlined in a clear and logical manner such that it can be followed by another person carrying out the experiment. - $R = \frac{V}{I}$	**P1** **P2**	
Mention of apparatus used for different measurement - **voltmeter** to measure **potential difference**, **ammeter** to measure the **current**. - **ruler** to measure **distance** *d*, **intensity meter** to measure **intensity** of lamp.	**P3** **P4**	
Control of variables		**[2]**
- Alignment of the lamp with the LDR	**C1,** **C2**	
- Brightness/intensity of the lamp/ Keep output of the lamp constant		
- Ambience light intensity		
Note: **minus [1]** if dependent or independent variable is stated wrongly		
Analysis		**[1]**
- details of derived quantities to be calculated. Plot lg *R* vs lg *d*, y-intercept = lg k , gradient = n must be included to be awarded [1] mark	**A1**	
Safety Precaution		**[1]**
- Do not look directly at the lamp. Wear sun glasses if the intensity of the lamp is too high.		
- Do not touch the lamp with bare hands. Wear gloves when handling the lamp	**S1**	

after use.		
- Electric circuit set up must be away from sink and kept dry at all times.		
- Do not handle the electrical circuits with wet hand.		
- Ensure all connecting wires are properly insulated to prevent any cases of electrocution.		
Any additional details		**[max 2]**
- The orientation of the LDR with respect to the lamp must be kept constant i.e the lamp must be pointing at the LDR in the same direction. The lamp and the LDR can be fixed at a particular position using adhesive tape.	**AD1**	
- A intensity meter is used to check whether the output of the lamp is constant during the experiment. The alignment/orientation of distance of the lamp and the intensity meter and the distance between the intensity metre and the lamp should be kept constant by placing markers at their locations.	**AD2**	
- The experiment should be performed in a dark room so that the intensity of other light sources would not interfere with the variation of the resistance of the LDR.		
- The resistance of the LDR is high and hence the current flowing in the circuit will be small. The ammeter is set to 200 mA to measure the current flowing in the circuit.		
- Taking average of V and I by repeating experiment with increasing d and decreasing d.		
- The intensity meter, lamp and the LDR can be placed in a black cardboard tube/container to minimize the light from the surroundings from reaching the LDR or intensity meter.		