Name	Class	Index Number

PIONEER JUNIOR COLLEGE
JC2 Preliminary Examination

PHYSICS **9749/01**
Higher 2

Paper 1 Multiple Choice

22 September 2017

1 hour

Additional Material: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

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 document consists of **18** printed pages.

Data

speed of light in free space	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ 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	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\varphi = -\frac{GM}{r}$
temperature	$T / \text{K} = T / {}^\circ\text{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$
	$= \pm\omega\sqrt{x_0^{\ 2} - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + ...$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + ...$
electric potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 N I}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 n I$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

1 When a constant braking force is exerted on a train travelling at speed v, the distance s moved by the train in coming to a stop is given by the expression

$$s = kv^2$$

where k is a constant.

When v is measured in metres per second and s is measured in metres, the constant has a value of k_1.

What is the value of the constant when the speed is measured in kilometres per hour, and the distance is measured in kilometres?

A $7.72 \times 10^{-5}\ k_1$

B $2.78 \times 10^{-4}\ k_1$

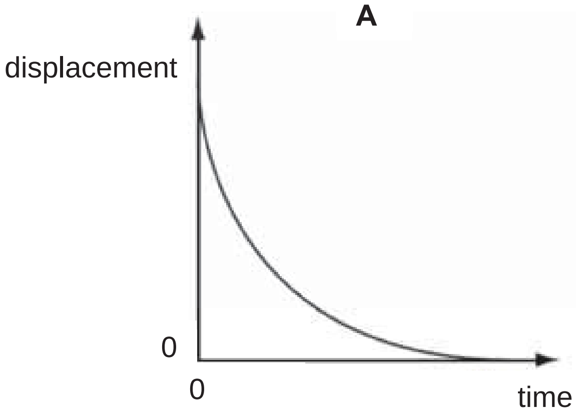
C $3.60 \times 10^{-3}\ k_1$

D $1.30 \times 10^{-2}\ k_1$

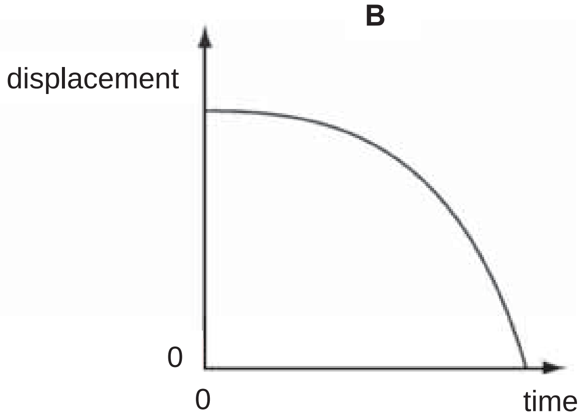
2 An object is released from rest and falls vertically. Its initial acceleration decreases until it eventually reaches terminal velocity.

Which graph best represents how the displacement of the object varies with time?

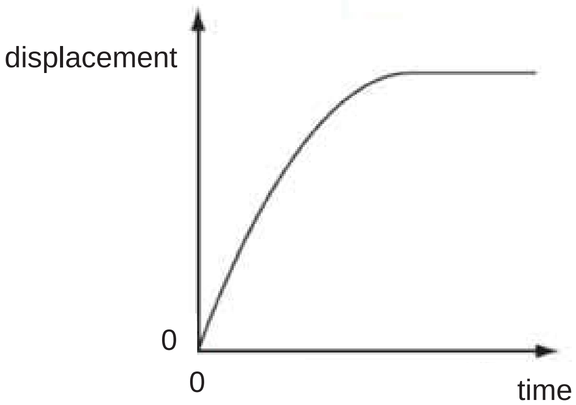
A



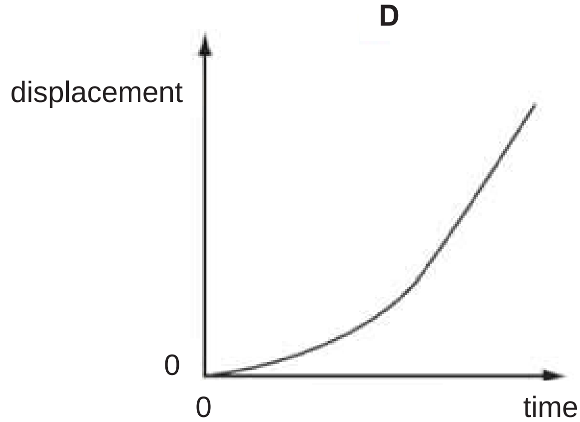
B



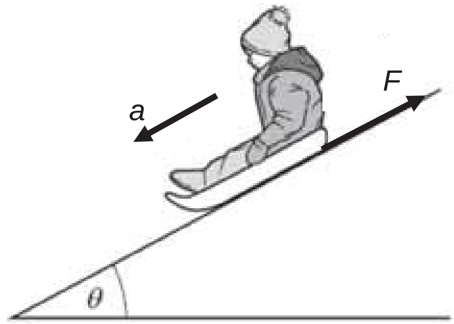
C



D



3 A child on a sledge slides down a slope with acceleration *a*. The slope is inclined at an angle θ above the horizontal.



The mass of the child is *m* and the mass of the sledge is *M*. The acceleration of free fall is *g*. Ignore the effects of air resistance.

What is the frictional force *F*?

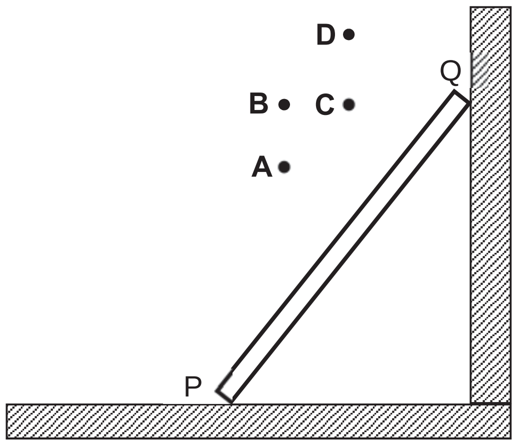
A $m(g\sin\theta - a)$

B $m(g\cos\theta + a)$

C $(m+M)(g\sin\theta - a)$

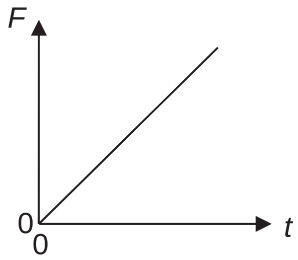
D $(m+M)(g\cos\theta - a)$

4 The diagram shows a non-uniform plank PQ resting against a wall. The resultant forces at P and Q are F_P and F_Q respectively.



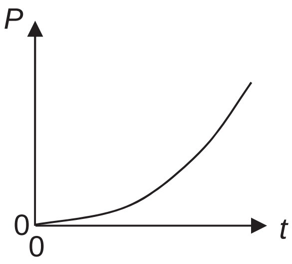
If the plank is in equilibrium, which point must F_P and F_Q act through?

5 The graph shows the variation with time t of the driving force F exerted by the engine on a vehicle.

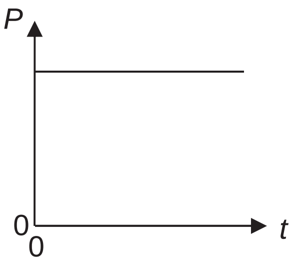


Which graph shows the variation with time t of the power P delivered by the engine?

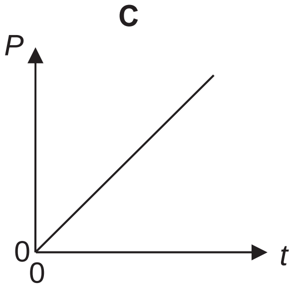
A



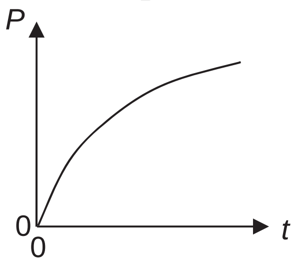
B



C



D



6 Astronomical observations show that the length of the day increased by approximately 6×10^{-3} s from the years 1870 to 1900.

What is the corresponding percentage change in the Earth's angular velocity?

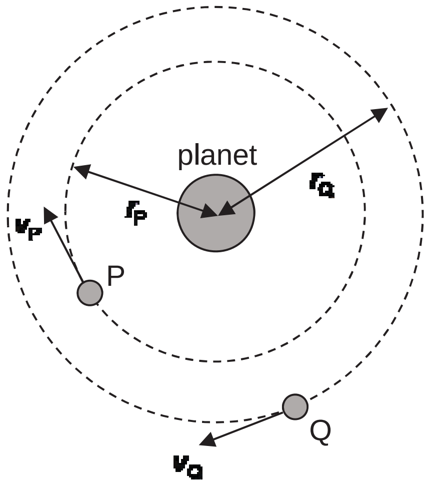
A -1.9×10^{-8} %

B -6.9×10^{-6} %

C 1.9×10^{-8} %

D 6.9×10^{-6} %

7 Two moons P and Q have circular orbits about a planet as shown below.



(not to scale)

Moon P has an orbital radius r_P of 1.4×10^8 m and linear speed v_P. Moon Q has an orbital radius r_Q of 2.3×10^{10} m and linear speed v_Q.

What is the ratio $\frac{v_P}{v_Q}$?

A 6.1×10^{-3}

B 7.8×10^{-2}

C 13

D 160

8 A satellite of mass 80 kg moves from a point where its gravitational potential energy due to Earth is −4800 MJ, to another point where its gravitational potential energy is −1600 MJ.

In which direction does the satellite move and what is its change in gravitational potential?

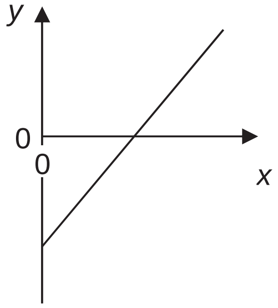
A closer to the Earth and a loss of 40 MJ kg^{-1} of potential.

B closer to the Earth and a loss of 3200 MJ kg^{-1} of potential.

C further from the Earth and a gain of 40 MJ kg^{-1} of potential.

D further from the Earth and a gain of 3200 MJ kg^{-1} of potential.

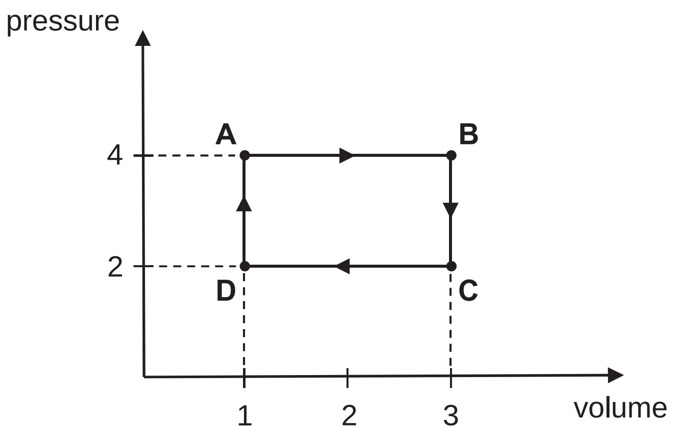
9 The graph shows the relationship between the volume and temperature of a fixed mass of an ideal gas at constant pressure.



What is the quantity and appropriate unit on each axis for this graph?

	y-axis	x-axis
A	temperature / K	volume / m^3
B	temperature / °C	volume / m^3
C	volume / m^3	temperature / K
D	volume / m^3	temperature / °C

10 A fixed mass of ideal gas undergoes a cycle of changes as shown.



At which point on the graph do the gas molecules have the lowest root-mean-square speed?

11 An ideal gas exerts a pressure of 60 Pa when its temperature is 400 K and the number of molecules present per unit volume is N. Another sample of the same gas exerts a pressure of 30 Pa when its temperature is 300 K.

How many molecules are present per unit volume of this second sample?

A $\frac{3N}{2}$

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

C $\frac{3N}{4}$

D $\frac{2N}{3}$

12 Which of the following statements about a simple harmonic oscillator is correct?

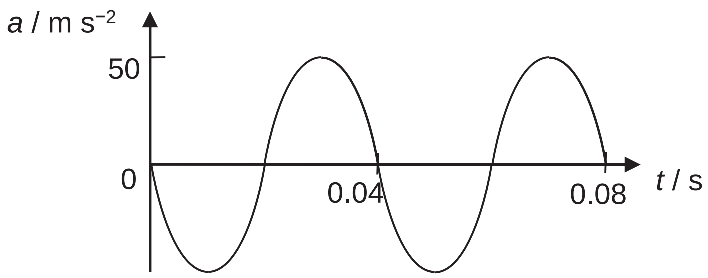
A The kinetic energy of the oscillator is proportional to the frequency of its motion.

B The potential energy of the oscillator is minimum when the oscillator is momentarily at rest.

C The kinetic energy of the oscillator is zero when the oscillator is at the equilibrium position.

D When the kinetic energy of the oscillator is equal to its potential energy, the oscillator is neither at the rest position nor at the maximum displacement positions.

13 A body performs simple harmonic motion with period T. The graph shows the variation with time t of its acceleration a.



What is the ratio of the body's displacement to its amplitude at time $t = \frac{5T}{8}$?

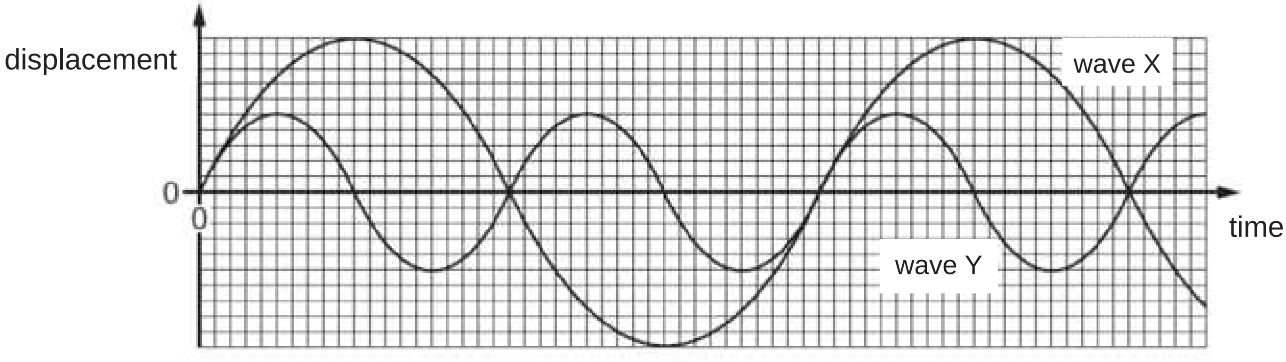
A −0.71

B 0.71

C −0.87

D 0.87

14 The graph shows the variation with time of the displacement of two separate waves X and Y.



Wave X has frequency *f* and amplitude *A*.

What is the frequency and amplitude of wave Y?

	frequency	amplitude
A	2*f*	2*A*
B	2*f*	0.5*A*
C	0.5*f*	2*A*
D	0.5*f*	0.5*A*

15 A wave of frequency 20 Hz travels at 32 m s^{-1} through a medium.

What is the phase difference between two points 2.8 m apart?

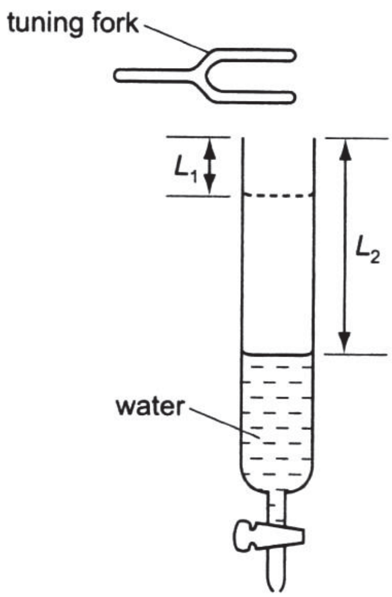
A There is no phase difference.

B They are out of phase by half a cycle.

C They are out of phase by two thirds of a cycle.

D They are out of phase by three quarters of a cycle.

16 A tuning fork is made to vibrate above a burette filled with water. The water is allowed to run out of the tube.



A loud sound is heard when the length of the air column is 0.18 m and again when the length is 0.45 m.

What is the wavelength of the sound in the tube?

A 0.27 m

B 0.36 m

C 0.54 m

D 1.1 m

17 Two coherent waves, of intensities I and $4I$, meet in anti-phase at a point.

What is the resultant intensity at that point?

A 0

B I

C $3I$

D $5I$

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

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

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

C The electric field strength due to a point charge varies as $\frac{1}{r^2}$ where r is the distance from the charge.

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

19 A proton and an alpha particle are accelerated from rest through a potential difference of V.

If the final momentum of the proton is p, what is the final momentum of the alpha particle?

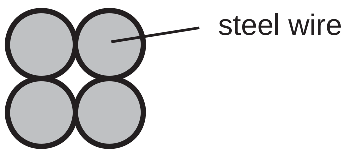
A $\sqrt{2}p$

B $2p$

C $2\sqrt{2}p$

D $4p$

20 An electrical supply cable consists of four identical steel wires arranged next to one another. Each wire has a cross-sectional area of 50 mm^2 and a resistivity of 9.0×10^{-8} Ω m. The cross-section of the cable is as shown.



What is the resistance of 100 m length of the cable?

A 4.5×10^{-8} Ω

B 7.2×10^{-7} Ω

C 0.045 Ω

D 0.72 Ω

21 A uniform copper rod of cross-sectional area 8.0×10^{-6} m^2 has 8.5×10^{28} conduction electrons per cubic metre. A current flows through the rod when a potential difference is applied across it.

Given that the drift velocity of electrons in the rod is 2.3×10^{-5} m s^{-1}, what is the current in the rod?

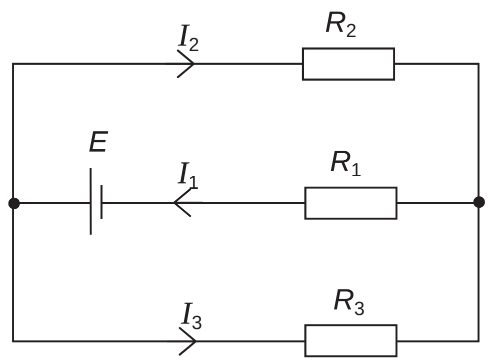
A 0.25 A

B 0.40 A

C 2.5 A

D 4.0 A

22 A cell of e.m.f. E and negligible internal resistance is connected in a circuit causing currents I_1, I_2 and I_3 in the three resistors of resistance R_1, R_2 and R_3 respectively.



Which equation relating to this circuit is correct?

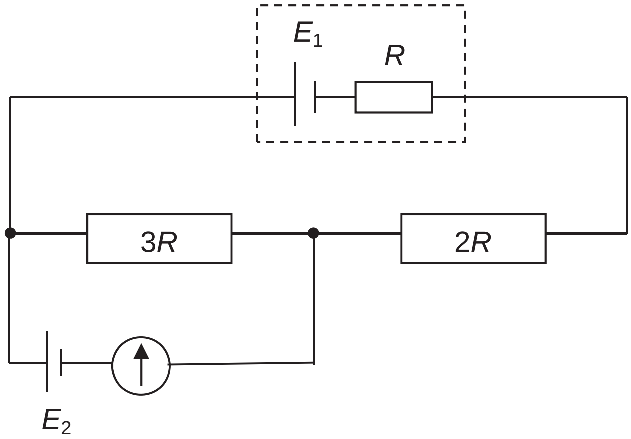
A $E + I_3R_3 = I_1R_1$

B $E - I_2R_2 = I_1R_1$

C $E + I_1R_1 = \dfrac{I_1R_2R_3}{(R_2 + R_3)}$

D $E - I_1R_1 = I_2R_2 + I_3R_3$

23 Two cells of e.m.f. E_1 and E_2 have internal resistances R and zero respectively. The cells are connected to resistors of resistances 3R and 2R, as shown below.



If the galvanometer shows no deflection, what is the ratio $\frac{E_1}{E_2}$?

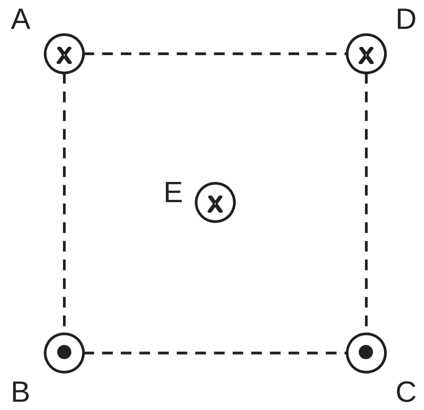
A 0.60

B 1.0

C 1.7

D 2.0

24 Four parallel conductors A, B, C and D carrying equal currents, pass vertically through the four corners of a square. In conductors A and D, the current is flowing into the page, and in conductors B and C, current is flowing out of the page.



Which of the following **incorrectly** describes the resultant force on conductor E, with current flowing into the page, at the centre of the square?

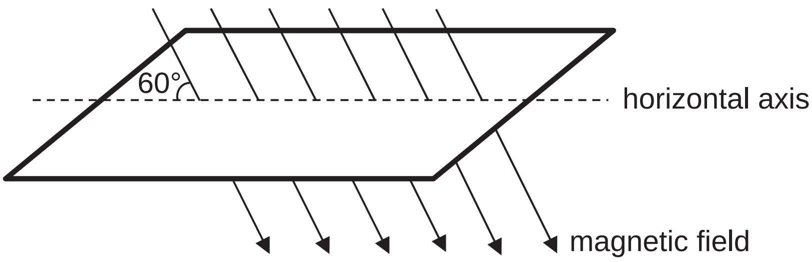
A The resultant force due to wires B and D points towards line AD, perpendicular to AD.

B The resultant force due to wires B and C points towards line AD, perpendicular to AD.

C The resultant force due to wires A and D points towards line AD, perpendicular to AD.

D The resultant force due to wires A, B, C and D points towards line AD, perpendicular to AD.

25 A magnetic field of flux density 4.0×10^{-4} T passes through a coil of wire of 50 turns and an area of 30 cm^2. The field makes an angle of 60° with the horizontal plane of the coil.



What is the e.m.f. induced in the coil when it is turned over once about its horizontal axis in a time of 0.60 s?

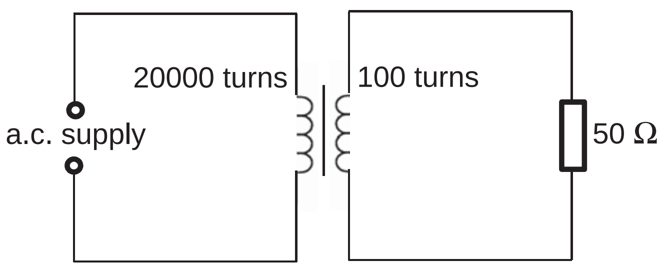
A 5.0×10^{-5} V

B 8.7×10^{-5} V

C 1.0×10^{-4} V

D 1.7×10^{-4} V

26 The primary of a non-ideal transformer has 20000 turns and is connected to an a.c. supply. The secondary has 100 turns and is connected to a resistor of resistance 50 Ω. The r.m.s. secondary voltage is 210 V. The transformer is 60% efficient.



What is the r.m.s. primary current?

A 0.013 A

B 0.021 A

C 0.035 A

D 4.2 A

27 When electrons with velocity v travel through a vacuum and are incident on a thin carbon film, they produce a pattern of concentric circles on the fluorescent screen.

What causes the pattern and how would the pattern change when the velocity v is decreased?

	cause	change to pattern
A	refraction	diameters of circles decrease
B	refraction	diameters of circles increase
C	diffraction	diameters of circles decrease
D	diffraction	diameters of circles increase

28 The line spectrum of hydrogen includes no X-ray frequencies.

The reason for this is

A the ionisation energy is too low.

B the work function energy is too high.

C there is only one electron in a hydrogen atom.

D there are too few electronic energy levels in the hydrogen atom.

29 Nucleus P decays in two stages to produce nucleus Q.

Which decay sequence will result in the highest number of neutrons in nucleus Q?

A a β-particle followed by a γ-ray

B an α-particle followed by a γ-ray

C an α-particle followed by a β-particle

D a β-particle followed by another β-particle

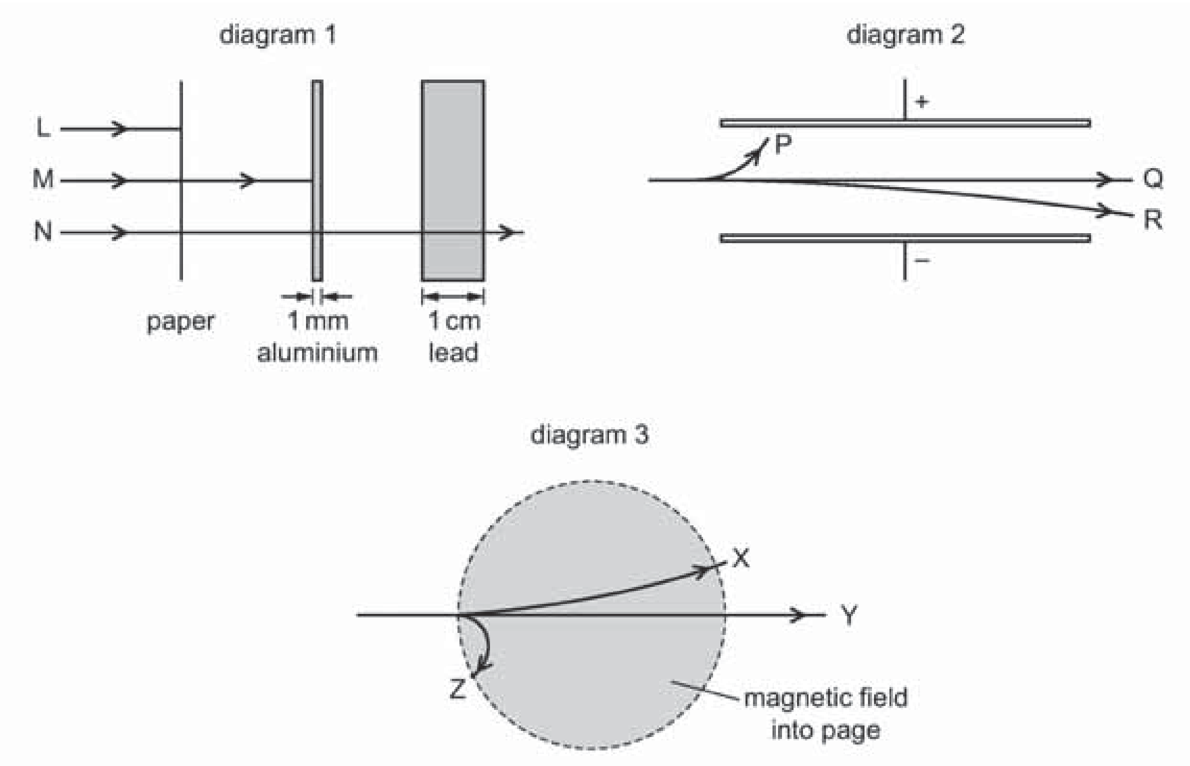
30 Alpha, beta and gamma radiations

1 are absorbed to different extents in solids,

2 behave differently in an electric field,

3 behave differently in a magnetic field.

The diagrams illustrate these behaviours.



Which three labels on these diagrams refer to the same kind of radiation?

A L, P, X **B** M, P, Z **C** M, R, X **D** N, Q, X

End of paper

Name	Class	Index Number

PIONEER JUNIOR COLLEGE
JC2 Preliminary Examination

PHYSICS **9749/02**
Higher 2

Paper 2 Structured Questions

15 September 2017

2 hours

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

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, 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	/ 10
2	/ 9
3	/ 12
4	/ 11
5	/ 10
6	/ 9
7	/ 19
Total	/ 80

This document consists of **22** printed pages.

Data

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	$= (1/(36\pi)) \times 10^{-9}$ F m^{-1}
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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
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molar gas constant	$R = 8.31$ J K^{-1} mol^{-1}
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gravitational constant	$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}
acceleration of free fall	$g = 9.81$ m s^{-2}

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work done on/by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\varphi = -\frac{GM}{r}$
temperature	$T / \text{K} = T / {}^\circ\text{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$
	$= \pm\omega\sqrt{x_0{}^2 - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + ...$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + ...$
electric potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 N I}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 n I$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

[Turn over

1 **(a)** A ball of mass 0.050 kg is dropped from rest onto a hard floor and bounces vertically repeatedly. The height from which the ball is dropped is measured to be 2.000 ± 0.001 m. Assume air resistance is negligible.

(i) Determine the speed of the ball, with its associated uncertainty, just before the first impact.

speed = ……..................... ± .... m s^{-1} [3]

(ii) The speed of the ball decreases by 30 % just after the first bounce.

1. Determine the corresponding momentum of the ball.

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

2. Given that the duration of the first impact is 0.10 s, calculate the magnitude of the average force exerted on the ball by the floor.

force = ... N [2]

(b) A rock climber is stranded on a ledge. The rescuer on the ground shoots a rescue kit to him. The rescue kit is directed at an initial angle of 60° above the horizontal and has a launch speed of 17 m s^{-1}. Assume air resistance is negligible.

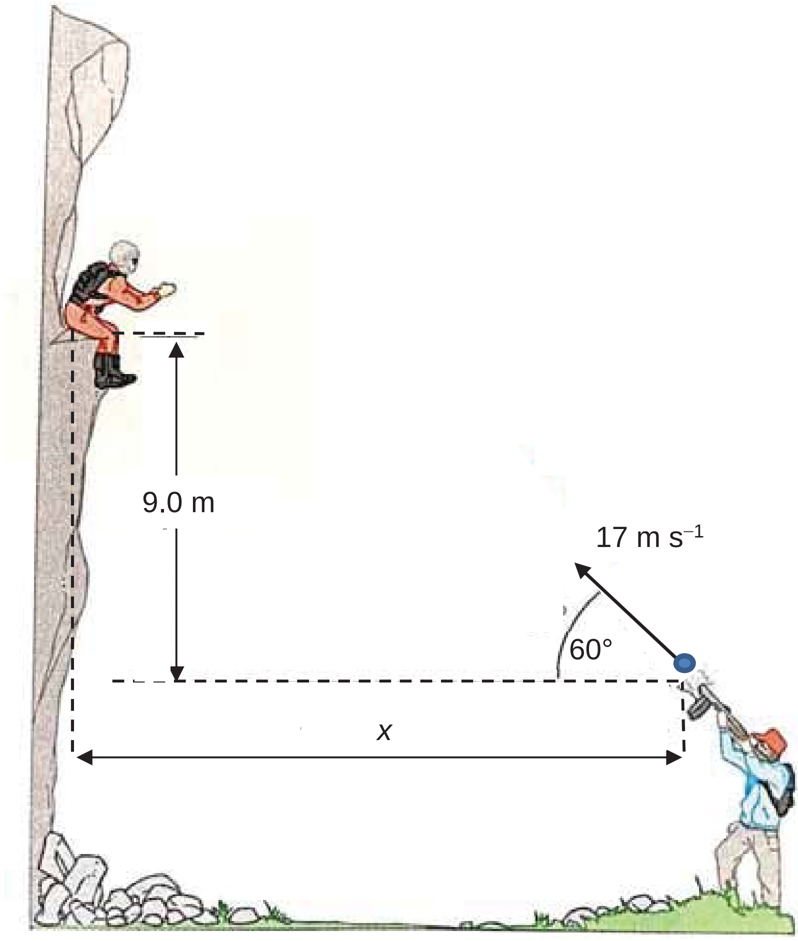


Fig. 1.1 (not drawn to scale)

(i) The kit reaches the top of its trajectory and then falls towards the climber.

Determine the time the kit takes to reach the climber.

time = ... s [2]

(ii) Hence, determine the horizontal distance x travelled by the kit.

x = ... m [1]

2 **(a)** State what is meant by an *ideal gas*.

....

.... [1]

(b) **(i)** A tyre is filled with air at a temperature of 15 °C and a pressure of 220 kPa.

If the tyre reaches a temperature of 38 °C, calculate the fraction of the original amount of air that must be removed to maintain the original pressure of 220 kPa. Assume the air to be ideal.

fraction = ... [3]

(ii) If the pressure of the air in a sealed tyre is doubled while its volume is held constant, calculate the ratio of the new root-mean-square speed to the original root-mean-square speed of the air molecules.

ratio = ... [2]

(c) Explain how molecular movement causes the pressure exerted by a gas.

....

....

....

....

.... [3]

3 **(a)** The wavelength of the monochromatic light from a source can be determined using the experimental setup as shown in Fig. 3.1. The slit separation *a* is 0.030 mm and the distance between the double slits and the screen *D* is 1.2 m.

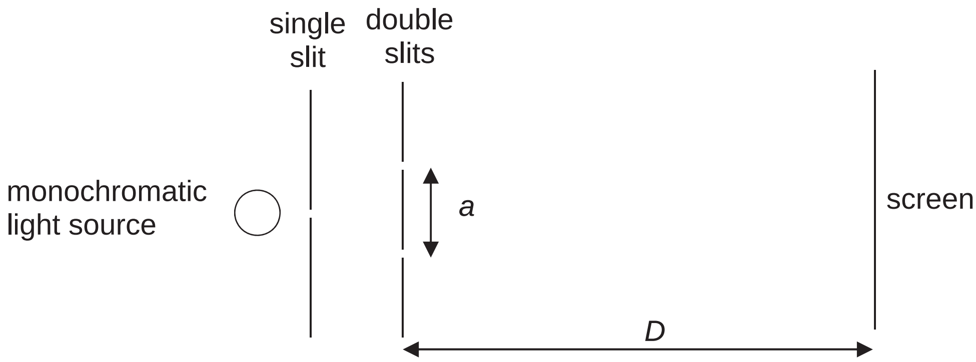


Fig. 3.1

When the monochromatic light is incident on the slits, the separation of the bright fringes on the screen is 1.7 cm.

(i) Calculate the wavelength of the monochromatic light source.

wavelength = ... m [2]

(ii) The following changes are made independently. Describe, in each case, the effect on the fringe separation and on the contrast between dark and bright fringes.

1. The distance *D* is increased to 2*D*, keeping *a* and λ constant.

....

.... [2]

2. The monochromatic light source is changed to red light, keeping *a* and *D* constant.

....

.... [2]

3. A polariser is placed between the single slit and the double slits.

....

.... [2]

(b) A diffraction grating with 450 lines per millimetre is placed in front of a white light source. The first order violet light emerges at an angle of 11.6° and the first order red light at an angle of 15.8°.

(i) Calculate the wavelength of these two colours.

wavelength of violet light = ... m

wavelength of red light = ... m [2]

(ii) Determine if any overlap of the spectrum can be observed.

[2]

4 A charged metal sphere is isolated in space. Measurements of the electric potential *V* are made for different distances *x* from the centre of the sphere. The variation with distance *x* of the electric potential *V* is shown in Fig. 4.1.

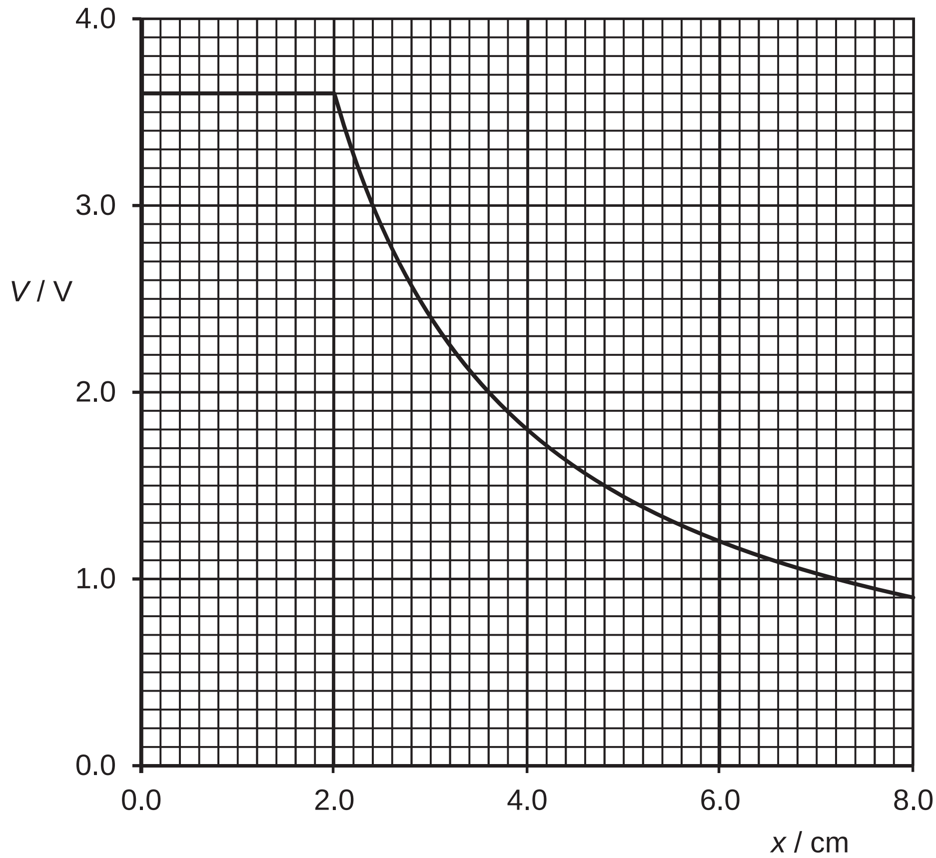


Fig. 4.1

(a) By making reference to electric fields, explain why the electric potential is constant for distances between $x = 0$ and $x = 2.0$ cm.

....

....

.... [2]

(b) Calculate the charge on the sphere.

charge = ... C [2]

(c) Calculate the total electric potential at x = 4.0 cm if a particle of charge −7.2 × 10^{-12} C is placed at x = 6.0 cm.

electric potential = ... V [3]

(d) The particle of charge −7.2 × 10^{-12} C accelerates upon release from rest at x = 6.0 cm.

(i) Without any calculations, describe the acceleration of the particle in terms of its magnitude and direction.

....

....

.... [2]

(ii) Calculate the kinetic energy of the particle after moving a distance of 2.0 cm.

kinetic energy = ... J [2]

5 A battery of e.m.f. *E* and internal resistance of 3.0 Ω is connected to a variable resistor of resistance *R*, as shown in Fig. 5.1.

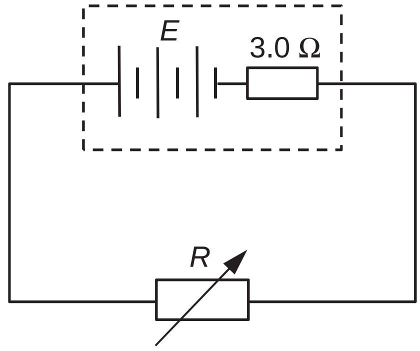


Fig. 5.1

The resistance *R* in the circuit is varied. The variation with *R* of the power *P* dissipated in the variable resistor is shown in Fig. 5.2.

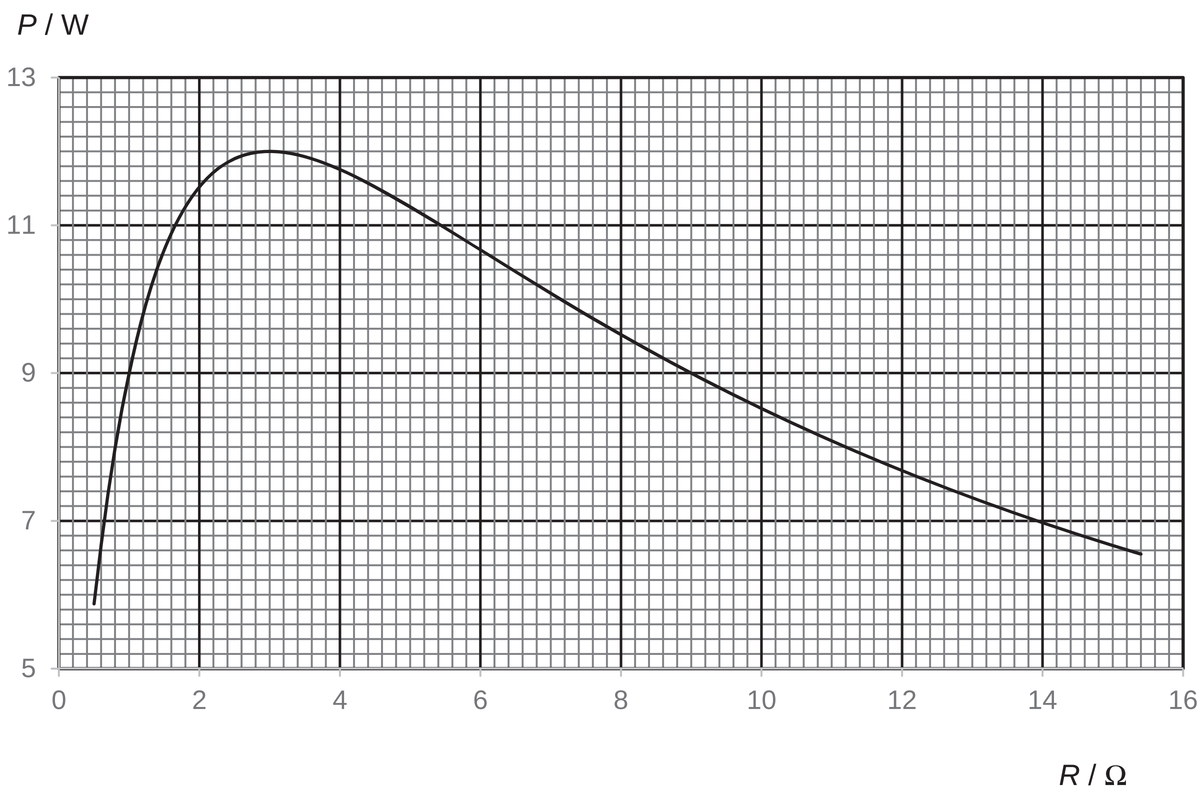


Fig. 5.2

(a) When R = 14.0 Ω, calculate

(i) the current in the circuit,

current = ... A [2]

(ii) the e.m.f. E of the battery,

E = ... V [2]

(iii) the total energy supplied by the battery in 10 minutes.

energy = ... J [2]

(b) State the value of R at which the power dissipated in the variable resistor is a maximum.

R = ... Ω [1]

(c) With reference to Fig. 5.2, explain why the graph has a maximum value.

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

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

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

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

(d) If the battery has negligible internal resistance, sketch the variation with *R* of the power *P* dissipated in the variable resistor on Fig. 5.3.

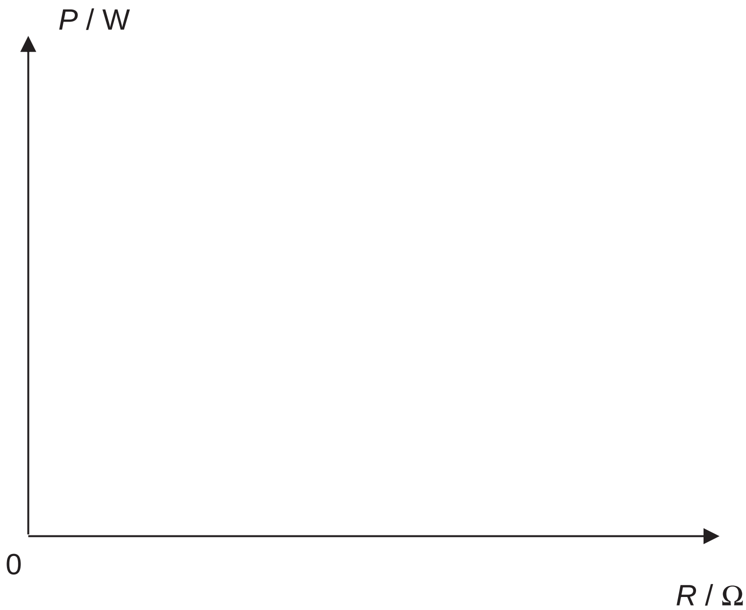


Fig. 5.3

[1]

6 Fig. 6.1 shows the cross-section of a long straight wire. Current in the wire is flowing out of the plane of the paper.

Fig. 6.1

(a) On Fig. 6.1, sketch the magnetic flux pattern due to the current in the wire. [2]

(b) An electron is projected with a speed of 1.5×10^7 m s^{-1} towards the wire, at a perpendicular distance of 2.0 cm from the wire, as shown in Fig. 6.2. A current of 3.0 A is flowing in the wire.

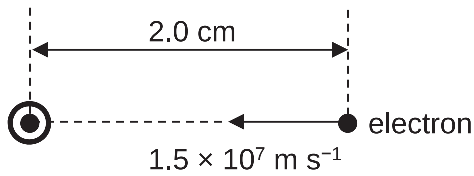


Fig. 6.2

(i) Show that the magnitude of the magnetic flux density at a perpendicular distance of 2.0 cm from the wire is 3.0×10^{-5} T.

[1]

(ii) A magnetic force acts on the electron the moment it is projected towards the wire.

1. State the direction of the magnetic force.

.... [1]

2. Calculate the magnitude of the magnetic force.

magnetic force = ... N [2]

(c) A flat circular coil of radius 1.3 cm is placed near the straight wire, with its centre at a perpendicular distance of 2.0 cm from the wire, as shown in Fig. 6.3. A current of 3.0 A flows through the circular coil.

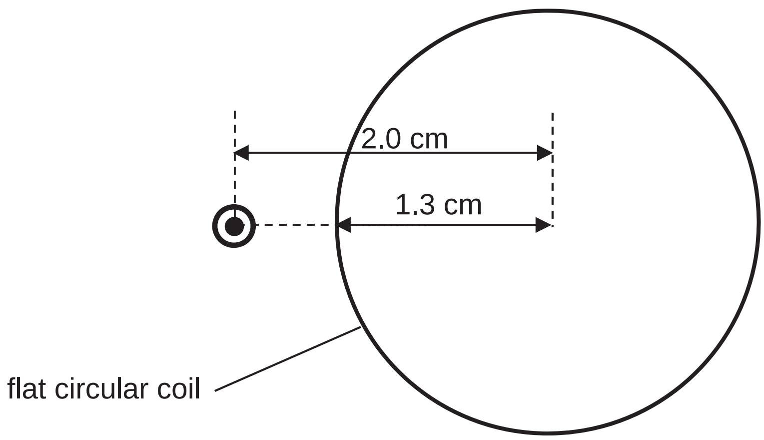


Fig. 6.3

Calculate the magnitude of the resultant magnetic flux density at the centre of the circular coil.

magnetic flux density = ... T [3]

7 A piston of mass m is fixed to a light spring in a frictionless cylinder of air as shown in Fig. 7.1. The cylinder is clamped tightly in place. At equilibrium position, the spring has an extension x_0. The piston is then displaced downwards by a vertical displacement x from the equilibrium position and released. The piston-spring system starts to oscillate.

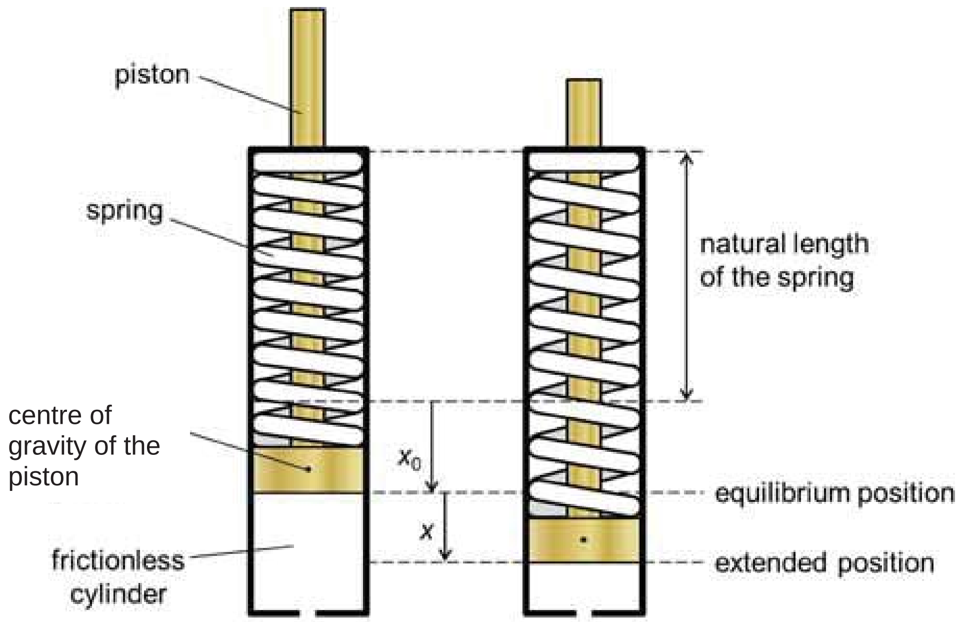


Fig. 7.1

(a) (i) On Fig. 7.2, draw and label the forces acting on the piston when the piston is displaced a vertical displacement x below the equilibrium position.

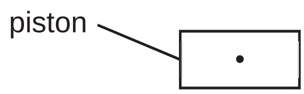


Fig. 7.2

[1]

(ii) Taking downwards as positive, use Newton's second law of motion to derive an equation for the acceleration a of the piston in terms of its mass m, the spring constant of the spring k and its displacement x from the equilibrium position. Show your working clearly.

[2]

(iii) Explain how the equation in **(ii)** shows that the piston oscillates with simple harmonic motion.

....

....

....

.... [2]

(b) The piston-spring system is now fixed in a large reserve cylinder that is filled with oil as shown in Fig. 7.3. The reserve cylinder is clamped tightly in place.

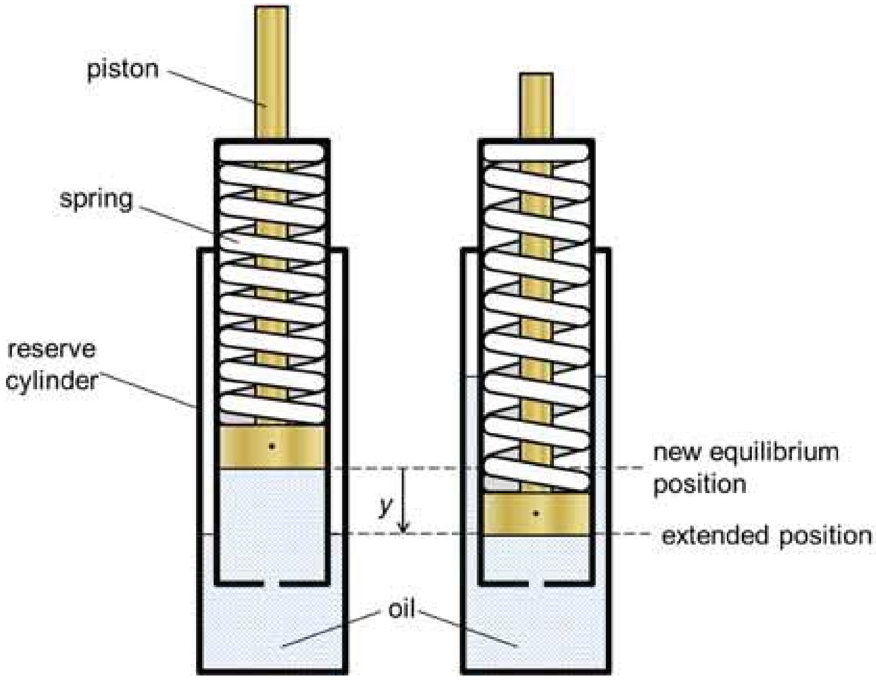


Fig. 7.3

The piston is displaced downwards with an initial displacement of y = 4.0 cm and released. Fig. 7.4 shows the variation with time t of the displacement y of the oscillations of the piston.

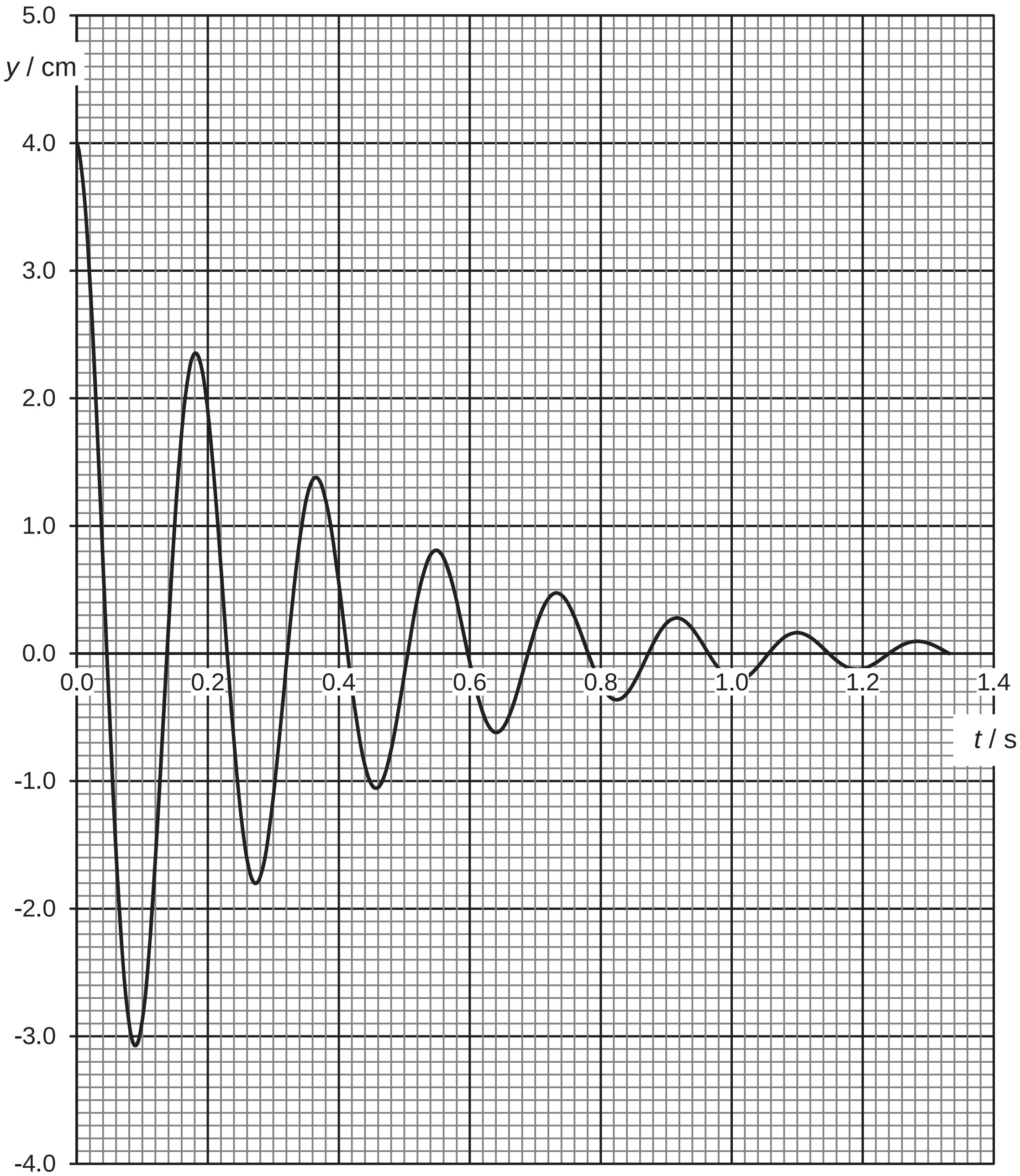


Fig. 7.4

(i) State and explain whether the damping of the piston is light, heavy or critical.

....

....

.... [2]

(ii) Use Fig. 7.4 to deduce the amplitude of the oscillation of the piston at t = 0.50 s.

amplitude = ... cm [1]

(c) It is suggested that the amplitude of the oscillation decreases exponentially with time according to the relationship

$$A = A_0 e^{-2\pi f_n \gamma t}$$

where A_0 is the amplitude at t = 0 and A is the amplitude at t. The constant γ is dependent on the fluid that produces the damping of the oscillating piston. The constant f_n is the natural frequency of the oscillating piston.

An experiment is carried out to determine γ. Fig. 7.5 shows some data obtained from Fig. 7.4.

t / s	A / cm	ln(A / cm)
0	4.00	1.386
0.18	2.35	0.854
0.37		
0.55	0.81	−0.21
0.73	0.47	−0.76
0.92	0.28	−1.27
1.10	0.16	−1.83

Fig. 7.5

(i) Use Fig. 7.4 to complete Fig. 7.5 for t = 0.37 s. [1]

(ii) Fig. 7.6 is a graph of some of the data of Fig. 7.5.

On Fig. 7.6,

1. plot the point corresponding to t = 0.37 s,

2. draw the line of best fit for all points.

[2]

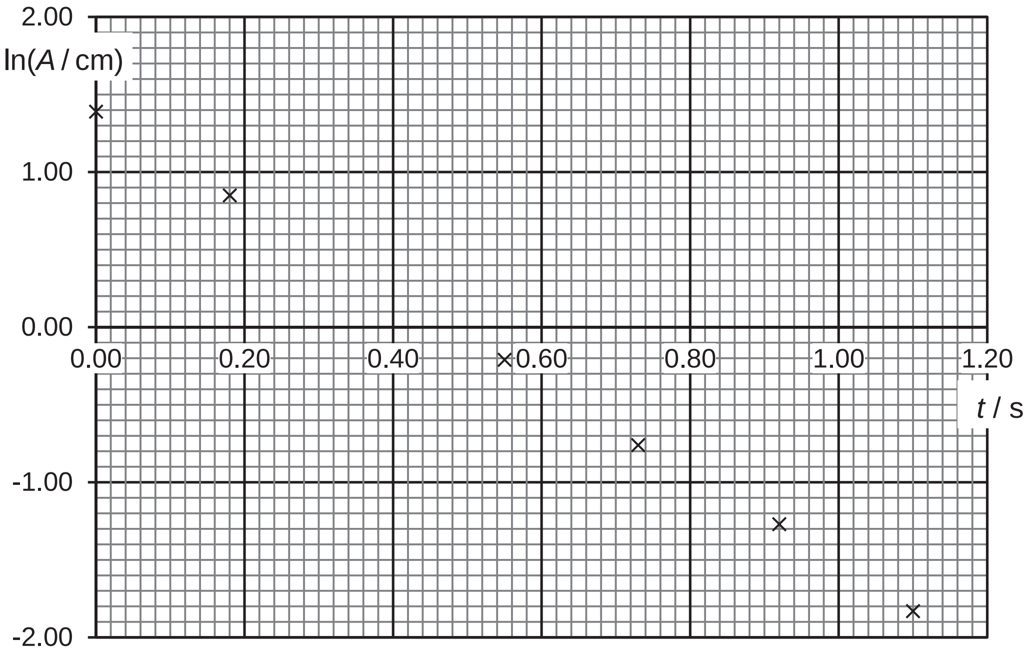


Fig. 7.6

(iii) Determine the gradient of the line drawn in **(ii)**.

gradient = ... [2]

(iv) Explain why the graph in Fig. 7.6 supports the expression given in **(c)**.

....

....

....

.... [2]

(v) Use Fig. 7.4 to determine the constant f_n.

f_n = ... Hz [1]

(vi) Determine the constant γ.

γ = ... [1]

(d) Damping systems like these are often used in motor vehicle suspension systems.

If the damping coefficient γ is a measure of damping of the vehicle suspension system, suggest with a reason whether the magnitude of γ is likely to be higher or lower than that in **(c)(vi)**.

....

....

....

.... [2]

End of paper

Name	Class	Index Number

PIONEER JUNIOR COLLEGE
JC2 Preliminary Examination

PHYSICS **9749/03**
Higher 2

Paper 3 Longer Structured Questions

19 September 2017

2 hours

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

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer any **one** question only.

You are advised to spend about one and half hours on Section A and half an hour on Section B.

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		/	9
2		/	9
3		/	8
4		/	7
5		/	7
6		/	9
7		/	11
8		/	20
9			20
Total		/	80

This document consists of **25** printed pages.

Data

speed of light in free space	$c = 3.00 \times 10^{8}\ \text{m s}^{-1}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\ \text{H m}^{-1}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \text{F m}^{-1}$
	$= (1/(36\pi)) \times 10^{-9}\ \text{F m}^{-1}$
elementary charge	$e = 1.60 \times 10^{-19}\ \text{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\ \text{J s}$
unified atomic mass constant	$u = 1.66 \times 10^{-27}\ \text{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\ \text{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\ \text{kg}$
molar gas constant	$R = 8.31\ \text{J K}^{-1}\ \text{mol}^{-1}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\ \text{mol}^{-1}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\ \text{J K}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11}\ \text{N m}^{2}\ \text{kg}^{-2}$
acceleration of free fall	$g = 9.81\ \text{m s}^{-2}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -\frac{Gm}{r}$
temperature	$T / \text{K} = T / {}^\circ\text{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$
	$= \pm\omega\sqrt{x_0{}^2 - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

Section A

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

1 **(a)** Distinguish between *gravitational potential energy* and *elastic potential energy*.

gravitational potential energy: ……………………………………………………………………

……………………………………………………………………………………………………

elastic potential energy: ……………………………………………………………………………

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

(b) A spring is attached horizontally to a movable light slider at point A and a fixed support at point B, as shown in Fig. 1.1.

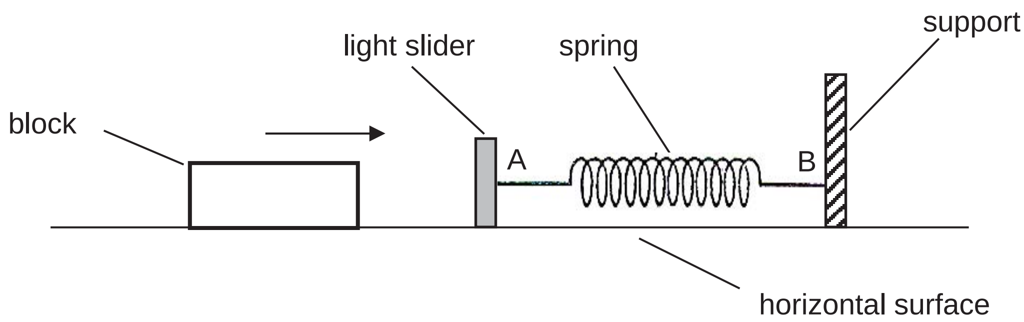


Fig. 1.1

A block of mass 1.7 kg moves towards the slider and collides with the slider, compressing the spring. The variation with force F exerted on the spring of the compression x of the spring is shown in Fig. 1.2. The block comes to a rest momentarily when F is 4.5 N.

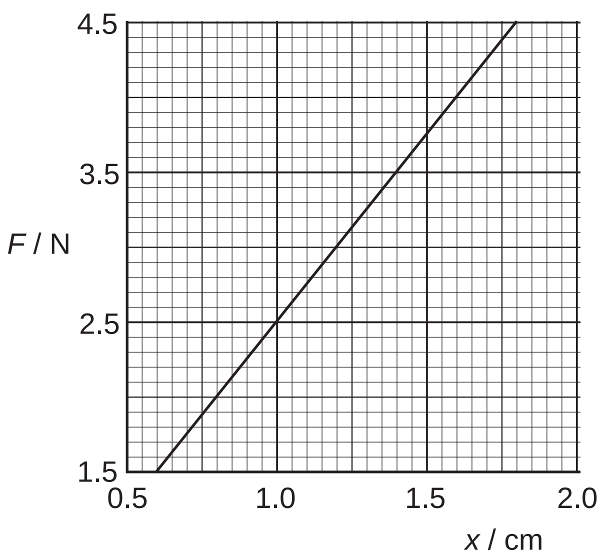


Fig. 1.2

(i) Calculate the spring constant of the spring.

spring constant = ... N m^{-1} [2]

(ii) Calculate the elastic potential energy stored in the spring when the block is at rest momentarily.

elastic potential energy = ... J [2]

(iii) The frictional force between the block and the horizontal surface is 1.2 N.

Calculate the speed of the block when it first makes contact with the slider.

speed = ... m s^{-1} [3]

2 **(a)** Define *gravitational field strength* and state an appropriate unit for it.

....

.... [2]

(b) The Earth may be considered to be a uniform sphere of radius 6380 km with its mass of 5.97×10^{24} kg concentrated at its centre, as shown in Fig. 2.1.

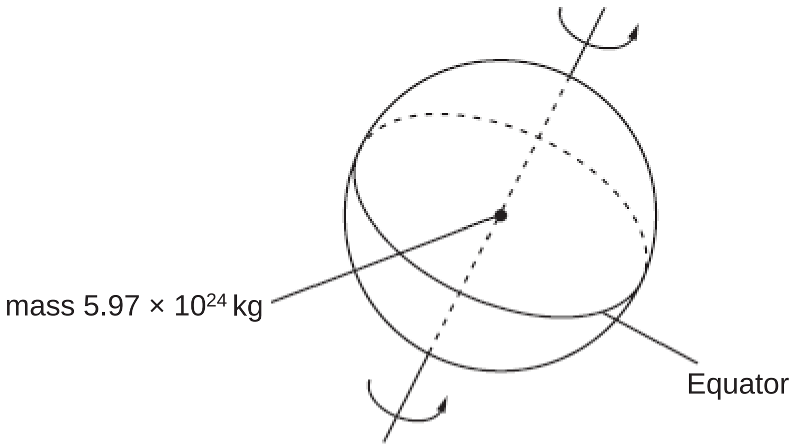


Fig. 2.1

A mass of 1.00 kg on the Equator rotates about the axis of the Earth with a period of 8.65×10^4 s.

(i) Use Newton's law of gravitation to calculate the gravitational force of attraction between the 1.00 kg mass and the Earth.

gravitational force= .... N [2]

(ii) Determine the centripetal force on the 1.00 kg mass.

centripetal force = ... N [2]

(iii) Hence, determine the acceleration of free fall at the Equator

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

(iv) The acceleration of free fall at the Equator is not equal to the acceleration of free fall at the poles.

Explain why they are different.

....

.... [1]

3 **(a)** State what is meant by *specific latent heat of fusion*.

....

....

.... [2]

(b) 30 g of ice at −15 °C is taken from a freezer and placed in a Styrofoam cup containing 200 g of water at 28 °C. Data for ice and for water are given below.

Specific heat capacity of ice = 2.1×10^{3} J kg^{-1} K^{-1}
Specific heat capacity of water = 4.2×10^{3} J kg^{-1} K^{-1}
Specific latent heat of fusion of ice = 3.3×10^{5} J kg^{-1}

Calculate the final temperature of the water in the Styrofoam cup. Assume negligible heat transfer to the surroundings.

temperature = ...°C [3]

(c) **(i)** State the *first law of thermodynamics*.

....

....

.... [1]

(ii) A gas of volume 1.5×10^{-3} m^3 and at a pressure of 1.0×10^5 Pa is supplied with 50 J of thermal energy. Its volume increases to 1.7×10^{-3} m^3 with the pressure remaining constant.

Calculate the change in the internal energy of the gas.

change in internal energy = ... J [2]

4 A microwaves transmitter is located a distance directly opposite an aerial, which is connected to a meter as shown in Fig. 4.1. Microwaves polarised in the vertical plane is incident on the aerial which is initially positioned vertically to give a maximum reading on the meter.

The aerial can subsequently be made to rotate through an angle θ in the vertical plane.

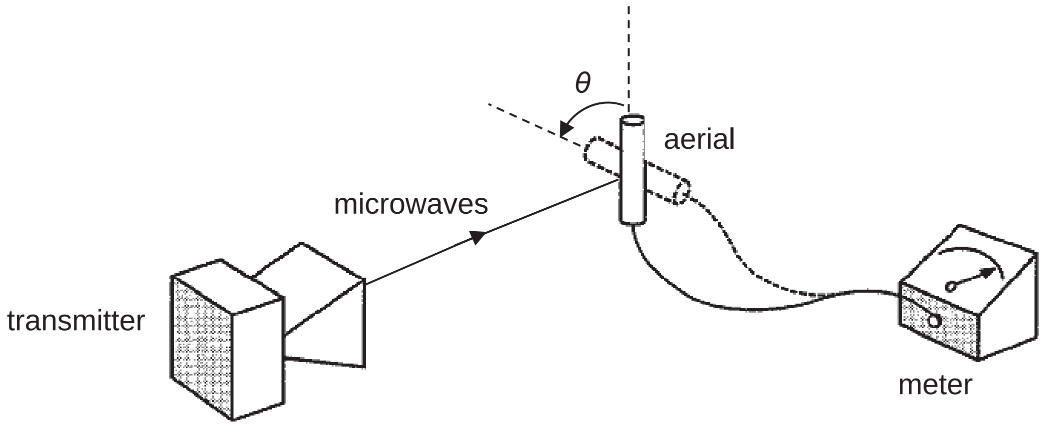


Fig. 4.1

(a) **(i)** When the angle θ through which the aerial is rotated is increased from 0° to 90°, describe and explain the variation, if any, in the meter reading.

....

....

.... [2]

(ii) State what the variation in meter reading, if any, suggest about the nature of microwaves.

.... [1]

(b) When the aerial is positioned vertically, the amplitude and intensity of the signal received is A and I respectively.

(i) Determine the smallest angle θ through which the aerial must be rotated so that the amplitude of the signal received is $\frac{A}{2}$.

θ = ... ° [2]

(ii) When the aerial is rotated such that the amplitude of the signal received is $\frac{A}{2}$, determine the intensity of the signal received in terms of I.

intensity = ... I [2]

5 (a) State what is meant by *diffraction*.

....

....

.... [2]

(b) (i) A ripple tank is used to show the diffraction of water waves. On Fig. 5.1, plane wavefronts are shown approaching a single slit.

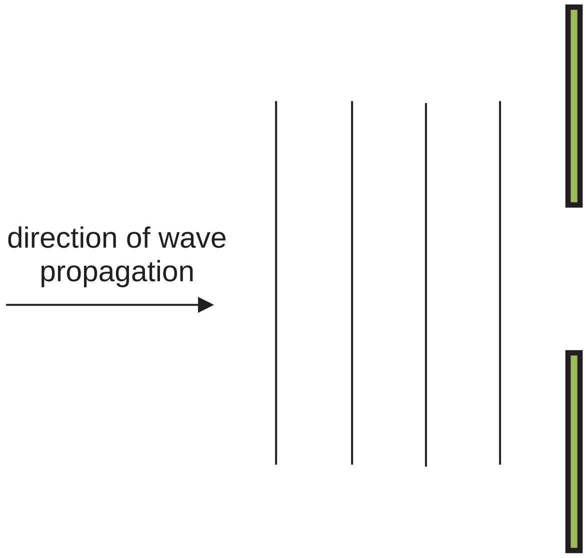


Fig. 5.1

On Fig 5.1, draw four wavefronts to show the waves after they have passed through the slit. [2]

(ii) The list is now made narrower as shown in Fig. 5.2.

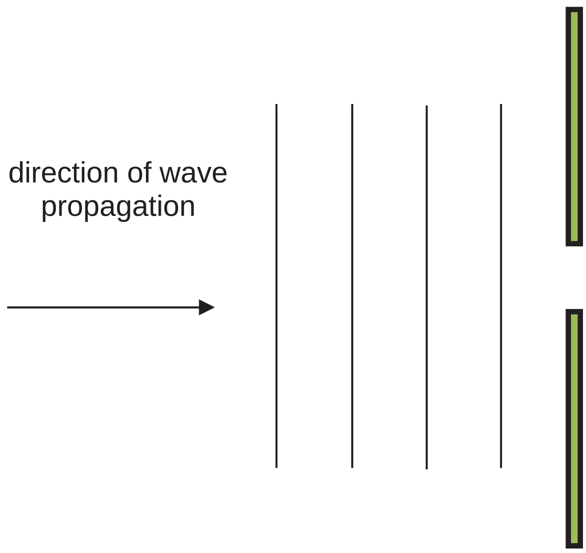


Fig. 5.2

On Fig. 5.2, draw four wavefronts to show the waves after they have passed through the narrower slit. [1]

(c) The headlights of a car are 1.4 m apart. If the diameter of the pupil of the eye is 2.5 mm, calculate the distance at which the images of the two headlights are just resolved. (Assume the headlights are point sources of wavelength of 500 nm.)

distance = ... m [2]

6 **(a)** An ammeter whose internal resistance is 63 Ω reads 5.25 mA when connected in a circuit containing a battery and two resistors in series. The two resistors have resistances 750 Ω and 480 Ω respectively.

Calculate the current in the circuit when the ammeter is absent.

current = ... mA [2]

(b) Fig. 6.1 shows a cell of e.m.f. 2.0 V and internal resistance 0.20 Ω connected in parallel to two identical lamps L_1 and L_2. The ammeters A_1 and A_2 in the circuit have negligible resistance and A_2 reads 0.50 A.

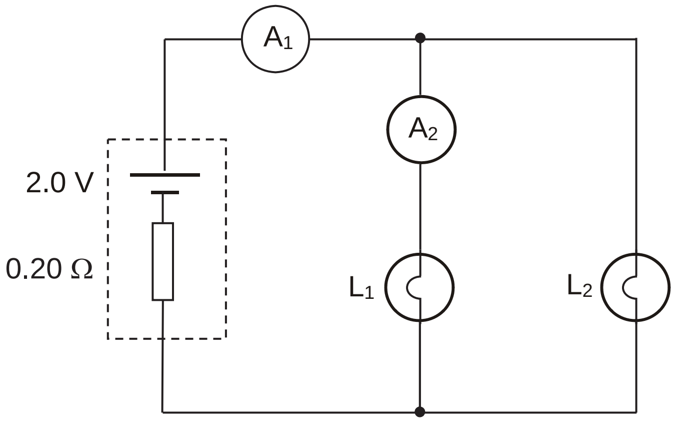


Fig. 6.1

(i) Calculate the potential difference across L_1.

potential difference = ... V [2]

(ii) If another identical lamp L_3 is connected in parallel with L_1 and L_2, explain whether the current in ammeter A_1 remains the same, increases or decreases.

....

....

.... [2]

(c) A new circuit is set up as shown in Fig. 6.2. A 1.0 m potentiometer wire AB of resistance 3.0 Ω is connected across the 2.0 V cell. Another cell of e.m.f 0.50 V and negligible internal resistance is included in the circuit. A resistor X is connected in series to the 2.0 V cell and balance length of 0.80 m is obtained.

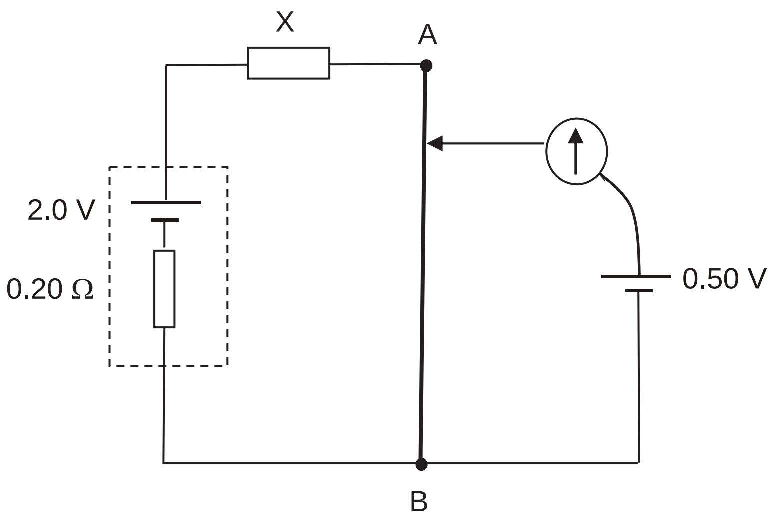


Fig. 6.2

Calculate the resistance of resistor X.

resistance = ... Ω [3]

7 **(a)** Explain what is meant by a *photon*.

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

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

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

(b) Light of wavelength 350 nm is incident on a metal surface. The work function energy of the metal is 2.46 eV.

(i) Show that electrons are emitted with a maximum speed of 6.2×10^5 m s^{-1}.

[2]

(ii) Determine the de Broglie wavelength of an electron at this speed.

de Broglie wavelength = …………………………… m [2]

(c) The metal surface is replaced with zinc. Zinc has a work function energy of 4.31 eV.

(i) Determine whether electrons will be emitted.

[2]

(ii) Explain whether your conclusion in **(i)** is affected by the intensity of light.

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

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

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

(d) Explain how the line spectra provide evidence for discrete energy levels in isolated atoms.

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

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

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

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

Section B

Answer **one** question in this section in the spaces provided.

8 **(a)** A square coil of wire of side *s* falls vertically through a uniform magnetic field of flux density *B* with speed *v*. The wire has uniform cross-sectional area *A* and resistivity *ρ*. The field is directed normally into the plane of the coil, as shown in Fig. 8.1.

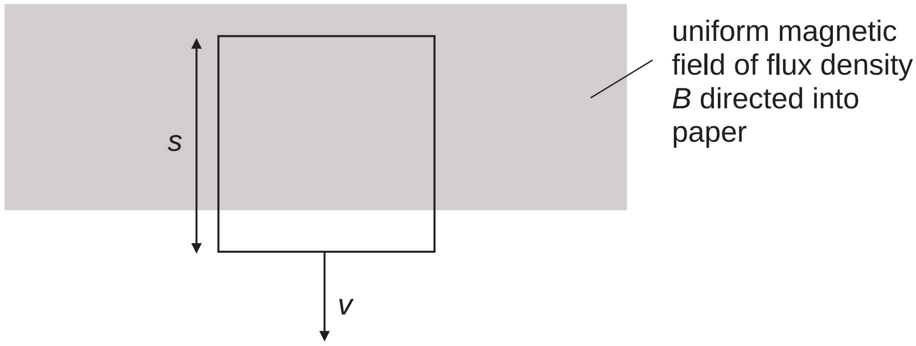


Fig. 8.1

As the coil leaves the region of uniform magnetic field, a current flows in the coil.

(i) Explain why a current flows in the coil as it leaves the region of uniform magnetic field.

....

....

.... [2]

(ii) On Fig. 8.1, indicate the direction of the current in the coil. [1]

(iii) Show that the current I in the coil is given by the expression

$$I = \frac{BvA}{4\rho}$$

.

[2]

(iv) After some time, before it completely leaves the region of magnetic field, the coil falls with a constant speed.

Explain why the coil falls with a constant speed.

....

....

....

....

.... [3]

(v) Calculate the constant speed for the coil given that *B* has a magnitude of 2.0 T and the coil is made of a metal of resistivity 1.5×10^{-6} Ω m and density 8400 kg m^{-3}.

speed = ... $m\ s^{-1}$ [3]

(b) Another square coil of side 20 cm made from the same metal wire is now rotated about an axis PQ at a uniform rate of 5 revolutions per second in the same uniform magnetic field as shown in Fig. 8.2. The wire has a diameter of 0.10 cm. An e.m.f. is generated in the coil when it rotates

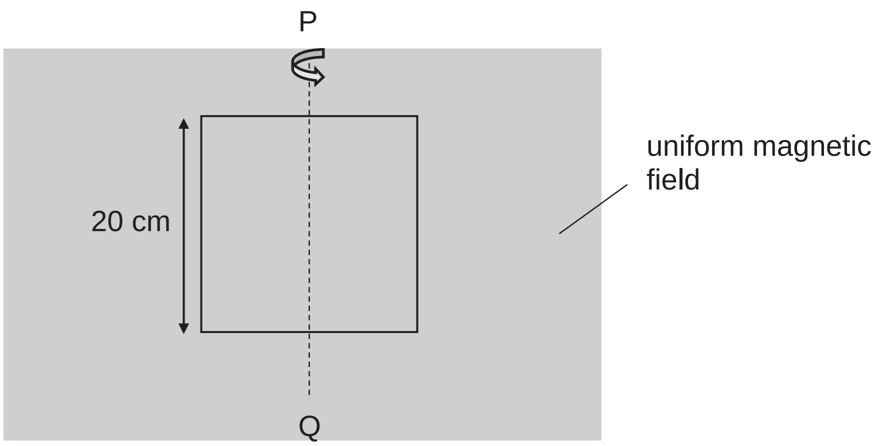


Fig. 8.2

(i) Explain why the e.m.f. is sinusoidal.

....

....

.... [2]

(ii) At time t = 0, the area of the coil is perpendicular to the magnetic field.

1. On Fig. 8.3, sketch a graph, with appropriate values, to show the variation with time of the magnetic flux Φ through the coil for at least two cycles.

Fig. 8.3

[3]

2. On Fig. 8.4, sketch a corresponding graph, with appropriate values, to show the variation with time of the induced e.m.f. generated in the coil.

Fig. 8.4

(iii) Calculate the root-mean-square current in the coil.

current = ... A [2]

9 (a) Nuclear fusion is a nuclear reaction in which two or more atomic nuclei collide at very high speed and fuse to form a larger nucleus. Fusion of light nuclei yields considerable amount of energy and can serve as potential energy sources for the Earth. One of the most promising is the fusion of deuterium and tritium, which results in the formation of a stable helium nuclide. Each deuterium-tritium fusion reaction yields 17.59 MeV of energy, accompanied by the release of a single neutron.

Deuterium ($^{2}_{1}H$) and tritium ($^{3}_{1}H$) are isotopes of hydrogen.

(i) State what is meant by *binding energy* of a nucleus.

....

.... [1]

(ii) On Fig. 9.1, sketch the variation with nucleon number A of the binding energy per nucleon B_E. Indicate the maximum value of B_E and the corresponding value of A.

Fig. 9.1

[2]

(iii) Explain why fusion of nuclei having high nucleon numbers is not associated with a release of energy.

....

....

....

.... [2]

(iv) Complete the nuclear equation for the deuterium-tritium fusion reaction below.

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

[1]

(v) Some data for the reaction in **(iv)** are given.

binding energy per nucleon of ${}^{2}_{1}H$ = 1.112 MeV
binding energy per nucleon of ${}^{3}_{1}H$ = 2.827 MeV
rest mass of proton = 1.00728 u
rest mass of neutron = 1.00866 u

1. Show that the binding energy of the helium nucleus in **(iv)** is 28.295 MeV.

[2]

2. Hence, calculate the mass of the helium nucleus.

mass = ... kg [3]

(b) The radioactive decay of the isotope bismuth-210 is both spontaneous and random.

(i) Explain what is meant by *spontaneous* decay.

....

.... [1]

(ii) Bismuth-210 ($^{210}_{84}Bi$) undergoes β^--decay to form polonium (Po). When the velocities of the β^--particles are measured, it is found that there is a continuous distribution of velocities up to a maximum. Fig. 9.2 shows the variation with energy of the number of β^--particles.

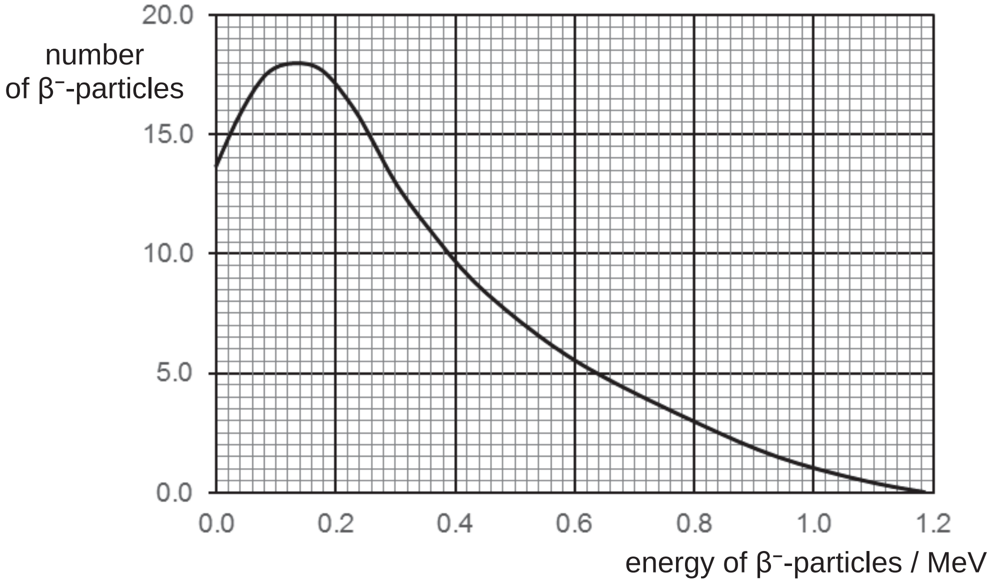


Fig. 9.2

Explain why there is a continuous distribution of energy among the β^--particles.

....

....

....

....

....

.... [3]

(iii) The isotope bismuth-212 ($^{212}_{83}Bi$) undergoes spontaneous α-particle decay. The energy of the α-particles emitted is 6.42 MeV.

Suggest, with a reason, which of the two isotopes, bismuth-210 or bismuth-212, has the larger decay constant.

....

....

....

.... [3]

(c) Polonium itself is radioactive and decays by the emission of α-particles. The polonium decays to form lead (Pb) which is stable. The half-life of polonium is 138 days.

A sample of bismuth-210 is stored for a time of 150 days in a lead container. The half-life of bismuth-210 is 5.0 days.

The number of polonium nuclei is almost equal to the number of lead nuclei.

By reference to the half-lives, explain this observation.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

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

End of paper

Name	Class	Index Number

PIONEER JUNIOR COLLEGE
JC2 Preliminary Examination

PHYSICS **9749/04**
Higher 2

Paper 4 Practical Paper

29 August 2017

2 hours 30 minutes

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams, 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.

Shift
Laboratory

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	/ 9
2	/ 14
3	/ 20
4	/ 12
Total	/ 55

This document consists of **14** printed pages.

[Turn over

1 In this experiment, you will investigate the extension of a rubber band.

(a) Set up the retort stand as shown in Fig. 1.1. Hang the rubber band from the rod and the mass hanger on the lower end of the rubber band.

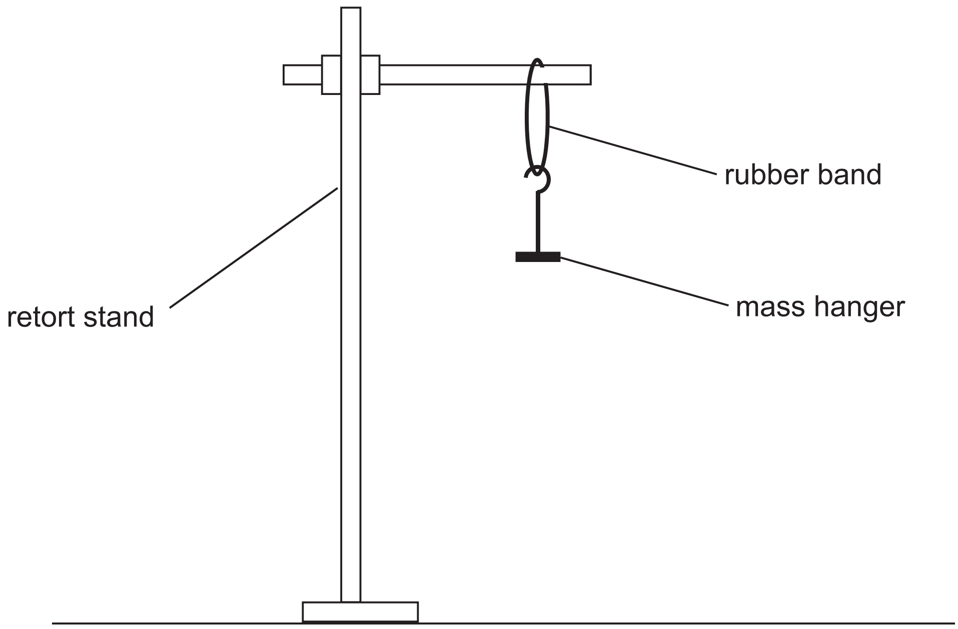


Fig. 1.1

(b) (i) Measure and record the length l of the rubber band.

l = ... [1]

(ii) Estimate the percentage uncertainty in this value of l.

percentage uncertainty = ... [2]

(c) Record five more readings of *l* and mass *m* up to a value of *m* = 300 g.
When increasing the mass, ensure that the rubber band is not allowed to slacken.

[2]

(d) Plot your values from **(c)** on Fig. 1.2. The graph obtained should be a curve.

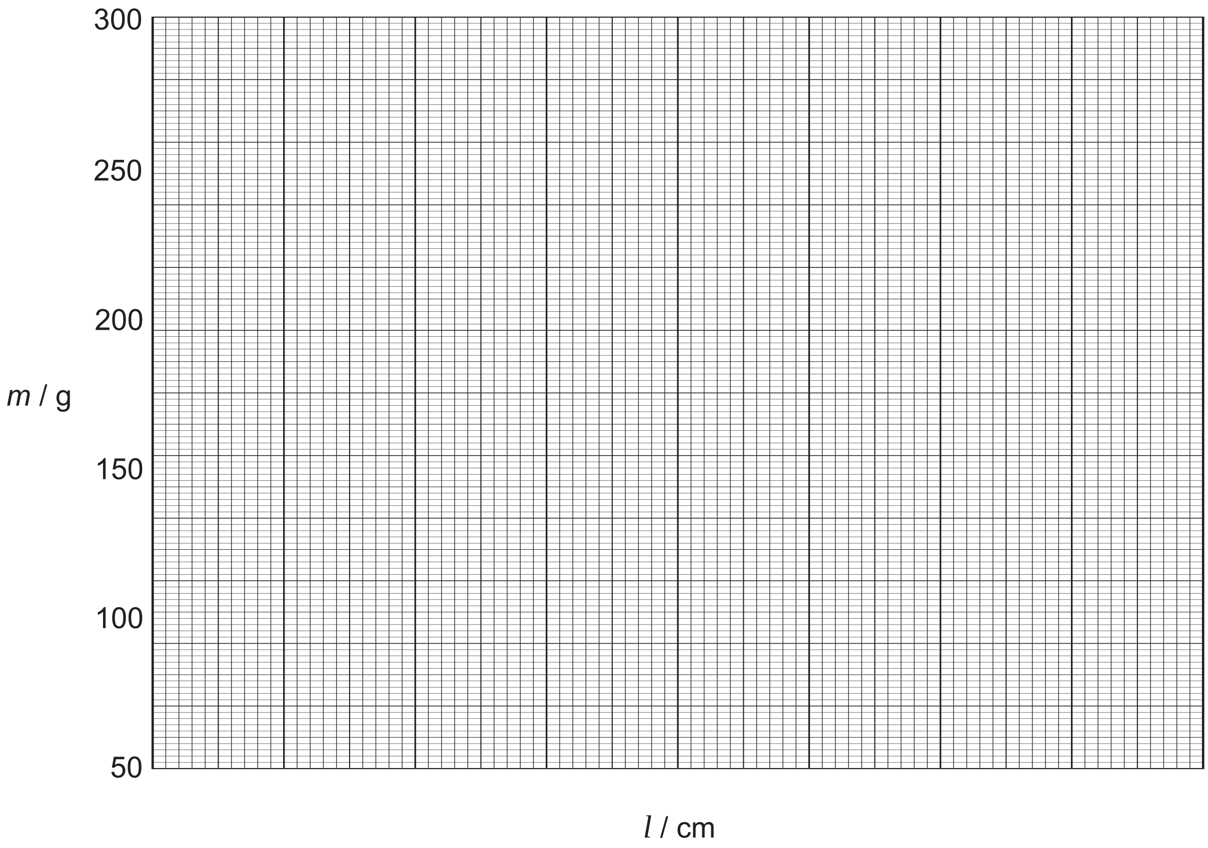


Fig. 1.2

[2]

(e) Based on your graph in Fig. 1.2, comment on the spring constant of the rubber band.

....

....

....

.... [2]

[Total: 9 marks]

2 In this experiment, you will investigate how the potential difference across a current-carrying wire depends on its diameter.

(a) Measure and record the diameter *d* of wire A.

d = ... [1]

(b) Connect the circuit shown in Fig. 2.1. The wire A should be connected into the circuit using crocodile clips placed close to the ends of the wire.

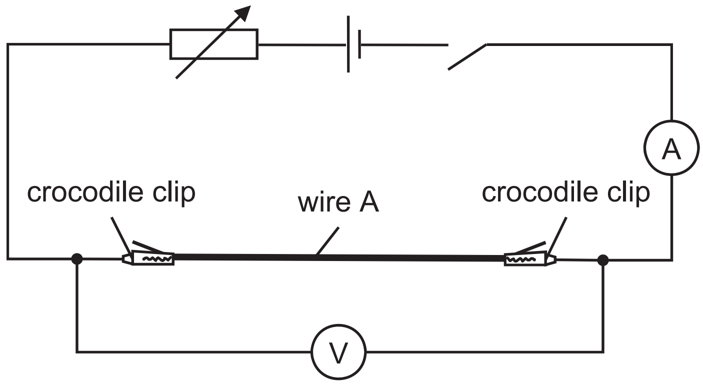


Fig. 2.1

(c) (i) Measure and record the length *L* of wire between the crocodile clips.

L = ... [1]

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

percentage uncertainty = ... [1]

(d) (i) Close the switch. Adjust the variable resistor until the current is close to 90 mA. Record this current *I*.

I = ...

(ii) Record the voltmeter reading V and then open the switch.

V = ... [1]

(e) Measure and record the diameter d of wire B.

d = ... [1]

(f) **(i)** In the circuit, replace wire A with wire B, maintaining the same length L of the wire between the crocodile clips as in **(c)(i)**.

(ii) Close the switch. Adjust I to the same value as in **(d)(i)**. Record V and then open the switch.

V = ... [1]

(g) It is suggested that the relationship between V, L and d is

$$V = \frac{kL}{d^2}$$

where k is a constant.

(i) Using your data, calculate two values of k.

value of k for wire A = ...

value of k for wire B = ... [2]

(ii) Justify the number of significant figures that you have given for your values of k.

....

....

.... [1]

(iii) Explain whether your results support the suggested relationship.

....

....

....

....

.... [1]

(h) **(i)** Describe two sources of uncertainty or limitations of the procedure in this experiment.

1. ....

....

2. ....

.... [2]

(ii) Describe two improvements that could be made to this experiment. You may suggest the use of other apparatus or different procedures.

1. ....

....

2. ....

.... [2]

[Total: 14 marks]

3 In this experiment, you will investigate how the period of a spring pendulum varies with load.

(a) Set up the apparatus as shown in Fig. 3.1.

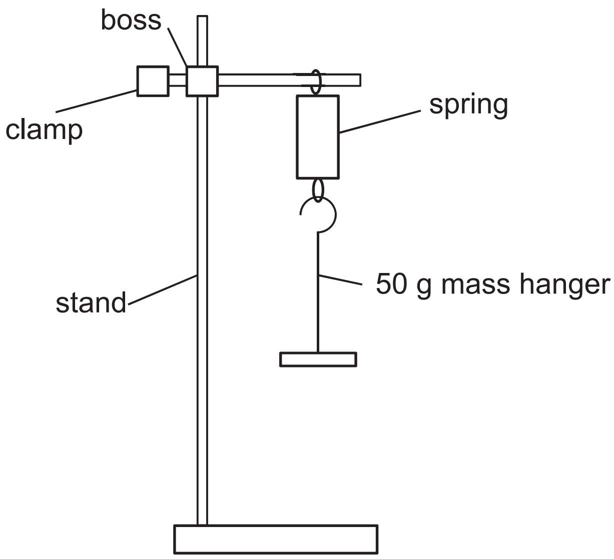


Fig. 3.1

(b) Pull the mass **horizontally**.

Release the mass and allow it to oscillate.

Take measurements to determine the period *T* of these oscillations.

T = ... [1]

(c) Vary the mass m suspended from the spring and repeat **(b)** for further values of m.

Record values of m, T, lg m and lg T.

[6]

(d) It is suggested that T and m are related by the expression

$$T = am^b$$

where a and b are constants.

(i) Plot a graph of lg T against lg m.

(ii) Determine the gradient of the line.

gradient = ... [2]

(iii) Determine the y-intercept of the line.

y-intercept = ... [2]

[3]

(e) Use values from **(d)(ii)** and **(d)(iii)** to determine values for a and b.

a = ... [1]

b = ... [1]

(f) Identify any anomalous observation.

Suggest a cause for the anomaly identified.

....

....

....

.... [2]

(g) (i) Calculate the value of T when m = 1500 g.

T = ... [1]

(ii) Identify a problem with determining an experimental value of T when m = 1500 g.

....

....

.... [1]

[Total: 20 marks]

4 A student is investigating the characteristics of different light-emitting diodes (LEDs). Fig. 4.1 shows examples of LEDs and the circuit symbol for an LED.

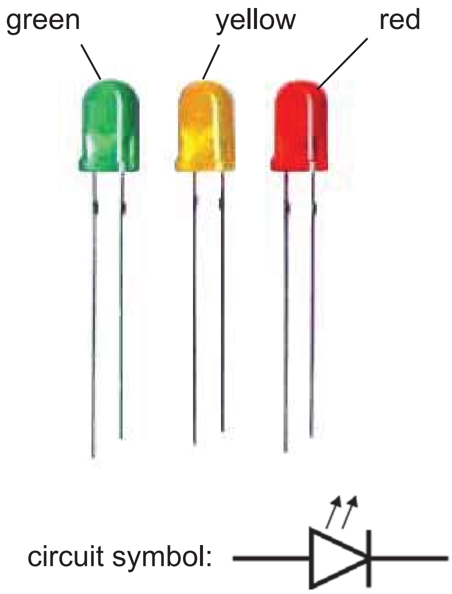


Fig. 4.1

Each LED needs a minimum potential difference V across it to emit light. The student is investigating the relationship between V and the wavelength λ of the light emitted by the LED for several different LEDs.

It is suggested that the relationship is

$$V = k\lambda^n$$

where k and n are constants.

You are provided with a number of LEDs of different wavelengths. You may use any of the other equipment usually found in a Physics laboratory.

Design an experiment to determine the relationship between V and λ.

You should draw a labelled diagram to show the arrangement of your apparatus. In your account you should pay particular attention to

(a) the identification and control of variables,

(b) the equipment you would use,

(c) the procedure to be followed,

(d) how the relationship between V and λ is determined from your readings and how measurements of λ are to be determined,

(e) any precautions that would be taken to improve the accuracy and safety of the experiment.

Diagram

[12]

End of paper

PJC Answers to JC2 Preliminary Examination Paper 1 (H2 Physics)

1 A	6 B	11 D	16 C	21 C	26 C
2 D	7 C	12 D	17 B	22 B	27 D
3 C	8 C	13 A	18 A	23 D	28 A
4 B	9 B	14 B	19 C	24 A	29 A
5 A	10 D	15 D	20 C	25 D	30 B

Suggested Solutions:

1 1 m s^{-1} = 3.6 km h^{-1}
1 m = 0.001 km

$$k = \frac{s}{v^2}$$

Since speed is measured in kilometres per hour, and the distance is measured in kilometres,

$$\text{value of constant} = \frac{0.001}{3.6^2} k_1$$
$$= 7.72 \times 10^{-5} k_1$$

Answer: A

2 Gradient of graph gives the velocity. Graph D shows the speed of the object increasing from zero to a constant maximum value.

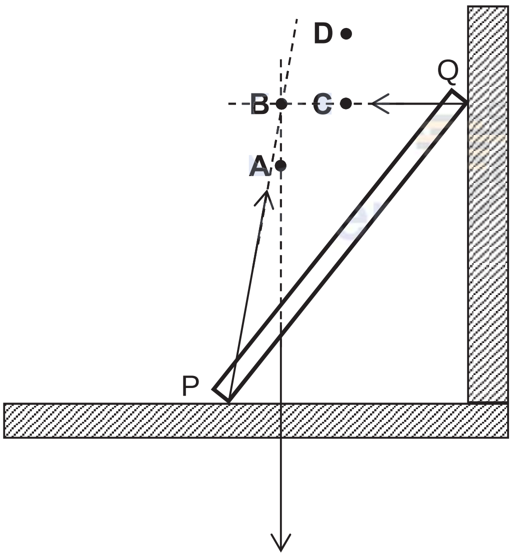
Answer: D

3 Resultant force $= (m+M)a$

$$(m+M)a = (m+M)g\sin\theta - F$$
$$F = (m+M)g\sin\theta - (m+M)a$$
$$= (m+M)(g\sin\theta - a)$$

Answer: C

4



Answer: B

5 $P = Fv$

Since both F and v increases with time, P increases at an increasing rate.

Answer: A

6 Let new angular velocity be ω' and original angular velocity be ω.

$$\text{period} = 24 \times 60 \times 60$$
$$= 8.64 \times 10^4 \text{ s}$$

$$\text{percentage change} = \frac{\omega' - \omega}{\omega} \times 100\%$$
$$= \frac{\frac{2\pi}{8.64 \times 10^4 + 6 \times 10^{-3}} - \frac{2\pi}{8.64 \times 10^4}}{\frac{2\pi}{8.64 \times 10^4}} \times 100\%$$
$$= -6.9 \times 10^{-6}\ \%$$

Answer: B

7 Gravitational force provides the centripetal force. Let mass of planet be M, mass of moon P be m_P and mass of moon Q be m_Q.

For P:

$$\frac{GMm_P}{(r_P)^2} = \frac{m_P (v_P)^2}{r_P}$$
$$GM = (v_P)^2 r_P \quad ---(1)$$

For Q:

$$\frac{GMm_Q}{(r_Q)^2} = \frac{m_Q (v_Q)^2}{r_Q}$$
$$GM = (v_Q)^2 r_Q \quad ---(2)$$

Solving (1) and (2):

$$\frac{v_P}{v_Q} = \left(\frac{r_Q}{r_P}\right)^{0.5}$$
$$= \left(\frac{2.3 \times 10^{10}}{1.4 \times 10^8}\right)^{0.5}$$
$$= 13$$

Answer: C

8 Since gravitational potential energy of satellite becomes less negative, there is an increase in potential energy and the satellite is moved further from the Earth.

$$\text{Increase in gravitational potential} = \frac{-1600-(-4800)}{80}$$
$$= 40 \text{ MJ kg}^{-1}$$

Answer: C

9 Using $PV = nRT$. Since pressure is constant, $T \propto V$.
The values of T are measured in Kelvins and the graph cuts the origin.
Hence, if the values of T are measure in degree Celsius, the graph would shift downwards by −271.15.

Answer: B

10 For ideal gas, $pV = nRT$, $pV \propto T$,
The gas at lowest temperature has lowest internal energy and hence lowest root-mean-square speed.

At point A, pV = 4 units
At point B, pV = 12 units
At point C, pV = 6 units
At point D, pV = 2 units

Hence, point D has the lowest temperature and lowest root-mean-square speed.

Answer: D

11 Using $pV = NkT$,

$$p = \frac{N}{V}kT$$

$$N_v = \frac{N}{V} = \frac{p}{kT} \Rightarrow N_v \propto \frac{p}{T}$$

$$\frac{N_v'}{N_v} = \frac{p'}{T'}\left(\frac{T}{p}\right) = \frac{30}{300}\left(\frac{400}{60}\right)$$

$$N_v' = \frac{2N}{3}$$

Answer: D

12 Option A: The kinetic energy of the oscillator is proportional to **square of the frequency** of its motion. Incorrect.

Option B: The potential energy of the oscillator is **maximum** when the oscillator is momentarily at rest. Incorrect.

Option C: The kinetic energy of the oscillator is **maximum** when the oscillator is at the equilibrium position. Incorrect.

Option D: When the kinetic energy of the oscillator is equal to its potential energy, the oscillator is neither at the rest position nor at the maximum displacement positions. Correct.

Answer: D

13 Acceleration of SHM given by
$a = -a_0 \sin(\omega t)$

Displacement of SHM given by
$x = x_0 \sin(\omega t)$

Ratio

$$\frac{x_{t=\frac{5T}{8}}}{x_0} = \frac{x_0 \sin(\frac{2\pi}{T} \times \frac{5T}{8})}{x_0}$$

$$= x_0 \sin(\frac{5\pi}{4})$$

$$= -0.71$$

Answer: A

14 In the same time duration when wave X completes one cycle of oscillations, wave Y completes two cycles. Hence frequency of wave Y is 2*f*.

Magnitude of maximum displacement of wave Y is half that of wave X. Hence, amplitude of wave Y is 0.5*A*.

Answer: B

15 Using $v = f\lambda$,
$30 = 20\lambda$
$\lambda = 1.6\,\text{m}$

$$\Delta\phi = \left(\frac{\Delta x}{\lambda}\right)2\pi$$

$$= \left(\frac{1.2}{1.6}\right)2\pi$$

$$= \left(\frac{3}{4}\right)2\pi$$

Hence the two points are out of phase by three quarters of a cycle.

Answer: D

16 First resonance is $\frac{1}{4}\lambda$, while second resonance is $\frac{3}{4}\lambda$.

Difference in the length = 0.45 – 0.18 = $\frac{1}{2}\lambda$

Therefore, wavelength of the sound wave is 0.54 m.

Answer: C

17 $I \propto A^2$

Since waves are in anti-phase → resultant amplitude is A. Therefore intensity is I.

Answer: B

18 If the electric field strength is zero at a point, it only means that the electric potential gradient is zero at that point. The value of the electric potential at that point need not be zero.

Answer: A

19 For proton, $p = \sqrt{2meV}$

For alpha particle, $p' = \sqrt{2(4m)(2e)V} = 2\sqrt{2}p$

Answer: C

20

$$R_{wire} = \frac{(9.0\times10^{-8})(100)}{(50\times10^{-6})} = 0.18\ \Omega$$

Wires are in parallel,

$$R_{cable} = \frac{0.18}{4} = 0.045\ \Omega$$

Answer: C

21 $I = nqvA$

$= (8.5\times10^{28})(1.60\times10^{-19})(2.3\times10^{-5})(8.6\times10^{-6})$

$= 2.5$ A

Answer: C

22 p.d. across parallel branch = $E - I_1R_1$

$E - I_1R_1 = I_2R_2$

Answer: B

23 At null point, $E_2 = \frac{3R}{3R+2R+R}E_1$

Hence $\frac{E_1}{E_2} = 2.0$

Answer: D

24 For option A, the resultant force points towards conductor D.

Answer: A

25

$$\varepsilon = \frac{(2)(50)\left(30\times10^{-4}\right)\left(4.0\times10^{-4}\right)\sin 60^{0}}{0.60}$$

$$= 1.7\times10^{-4}\ \text{V}$$

Answer: D

26

$$I_S = \frac{V_S}{R} = \frac{210}{50} = 4.2\ \text{A}$$

The transformer is 60% efficient, so

$$I_S V_S = 0.6 I_P V_P$$

$$I_P = \frac{I_S V_S}{0.6 V_P} = \frac{I_S N_S}{0.6 N_P}$$

$$= \frac{(4.2)(100)}{0.6(20000)} = 0.035\ \text{A}$$

Answer: C

27 Velocity decreases → de Broglie's wavelength increases → more diffracted → larger diameter of circles

Answer: D

28 The energy of a photon of X-ray is much higher than the ionisation energy of hydrogen (13.6 eV).

Answer: A

29 Let R be the nucleus formed after the first stage decay.

Option A:

$$^{A}_{Z}\text{P} \rightarrow {}^{A}_{Z+1}\text{R} + {}^{0}_{-1}e$$

$$^{A}_{Z+1}\text{R} \rightarrow {}^{A}_{Z+1}\text{Q} + \gamma$$

Number of neutrons in nucleus Q $= A - (Z+1) = A - Z - 1$

Option B:

$$^{A}_{Z}\text{P} \rightarrow {}^{A-4}_{Z-2}\text{R} + {}^{4}_{2}\text{H}e$$

$$^{A-4}_{Z-2}\text{R} \rightarrow {}^{A-4}_{Z-2}\text{Q} + \gamma$$

Number of neutrons in nucleus Q $= A - 4 - (Z-2) = A - Z - 2$

Option C:

$$^{A}_{Z}\text{P} \rightarrow {}^{A-4}_{Z-2}\text{R} + {}^{4}_{2}\text{H}e$$

$^{A-4}_{Z-2}\text{R} \rightarrow ^{A-4}_{Z-1}\text{Q} + ^{0}_{-1}e$

Number of neutrons in nucleus $\text{Q} = A - 4 - (Z - 1) = A - Z - 3$

Option D:

$^{A}_{Z}\text{P} \rightarrow ^{A}_{Z+1}\text{R} + ^{0}_{-1}e$

$^{A}_{Z+1}\text{R} \rightarrow ^{A}_{Z+2}\text{Q} + ^{0}_{-1}e$

Number of neutrons in nucleus $\text{Q} = A - (Z + 2) = A - Z - 2$

Answer: A

30 Beta radiation can be stopped by 1 mm of aluminium (diagram 1), deflects towards the positively charged plate (diagram 2) and traces an anti-clockwise circular arc in a magnetic field into the page (diagram 3).

Answer: B

PJC Answers to 2017 JC2 Prelim P2 (H2 Physics)

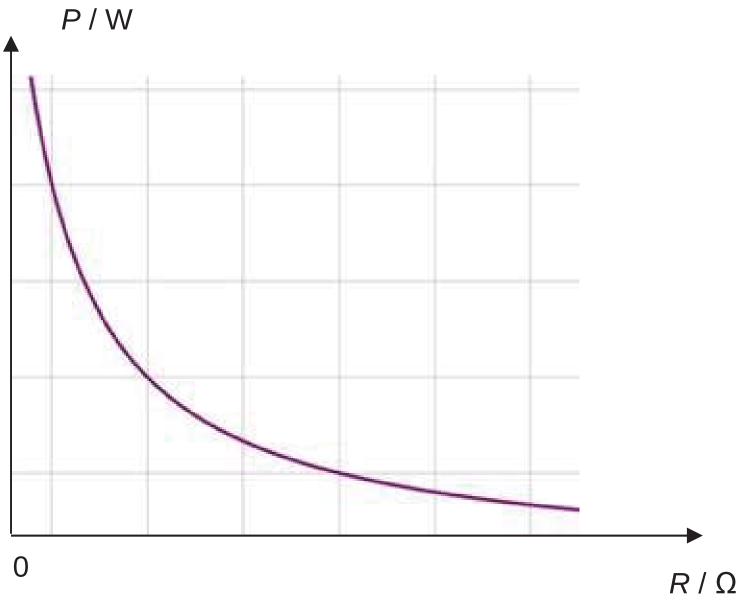
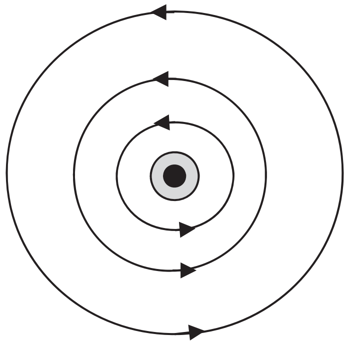
Suggested Solutions:

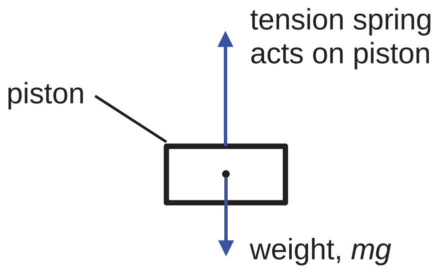
No.	Solution	Remarks
1(a)(i)	$v^2 = u^2 + 2as$ $= 2as$ $= 2(9.81)(2.000)$ $= 39.24 \text{ m}^2 \text{ s}^{-2}$ $v = 6.264 \text{ m s}^{-1}$ $\frac{\Delta v}{v} = \frac{1}{2}\frac{\Delta s}{s}$ $\Delta v = \frac{1}{2}\left(\frac{\Delta s}{s}\right)v$ $= \frac{1}{2}\left(\frac{0.001}{2.000}\right)6.264$ $= 0.002 \text{ m s}^{-1}$ $v = (6.264 \pm 0.002) \text{ m s}^{-1}$	[1] for correct substitution and correct v [1] for correct substitution and correct Δv (no rounding off required at this stage) [1] for correct answer
1(a)(ii) 1.	$p_{\text{final}} = 0.050(0.70)(6.264)$ $= 0.22 \text{ kg ms}^{-1}$	[1] for substitution [1] for answer
1(a)(ii) 2.	Take upwards as positive $\lvert\text{average resultant force}\rvert = \frac{\lvert\Delta p\rvert}{\Delta t}$ $= \frac{0.050(0.70)(6.264) - [-(0.05)6.264]}{0.1}$ $= 5.3246 \text{ N}$ $N - mg = 5.3246$ $N = 5.3246 + 0.05(9.81)$ $= 5.82 \text{ N}$	[1] for correct resultant force [1] for correct contact force
1(b)(i)	Take upwards as positive. $s_y = u_y t + \frac{1}{2}a_y t^2$ $9.0 = (17\sin 60°)t + \frac{1}{2}(-9.81)t^2$ $t = 0.855$ s (rejected) or $t = 2.1468$ s $= 2.1 \text{ s (2 s.f.)}$	[1] for correct substitution [1] for correct answer

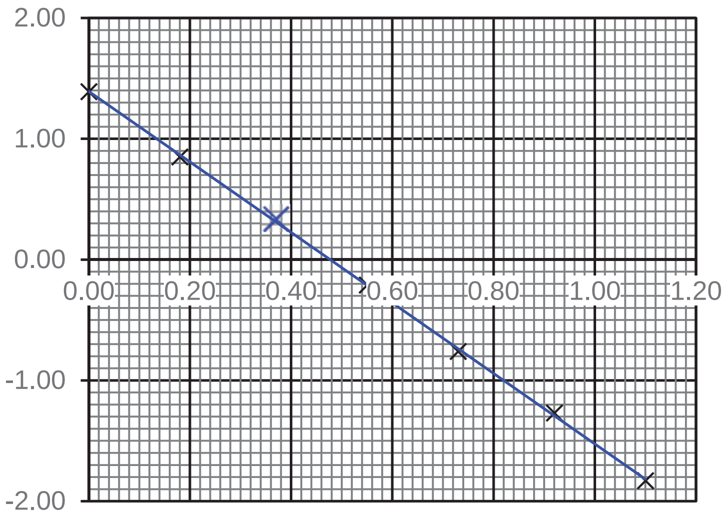
2(a)	An ideal gas is a gas which obeys the equation of state, $PV = nRT$ for all pressure, volume and temperature.	[1]
2(b)(i)	$PV = nRT$ $n = \frac{PV}{RT}$ Since P, V and R are constant, $n \propto \frac{1}{T}$ $\frac{n_1}{n_2} = \frac{T_2}{T_1} = \frac{15+273.15}{38+273.15} = 0.926$ Fraction that must be removed = 1 – 0.926 = 0.074	[1] Correct use of equation of state to obtain $n \propto \frac{1}{T}$ [1] Correct substitution into equation to obtain ratio [1] Correct final answer
2(b)(ii)	$PV = nRT$ Since $P \propto T$, temperature doubles when pressure doubles. $\frac{1}{2}m<c^2>=\frac{3}{2}kT$ $\sqrt{<c^2>} = \sqrt{\frac{3kT}{m}}$ $\sqrt{<c^2>} \propto \sqrt{T}$ $\frac{c_{rms1}}{c_{rms}} = \sqrt{\frac{T_1}{T}} = \sqrt{2} = 1.41$	[1] Temperature doubles [1] Correct final answer
2(c)	A gas is made of molecules that are constantly in random motion, colliding with each other and the walls of the container. When a molecule strikes and rebounds from a wall, it undergoes a change of momentum. According to Newton's Second Law, a force would be exerted by the wall on the molecule, to cause the change in momentum. According to Newton's Third Law, the molecules would also exert an equal but opposite force on the wall (action-reaction pair of forces). Pressure is force exerted per unit area of contact. The pressure on the walls of the container is therefore the result of the force on the walls by the molecules, as the molecules strike and rebound from the walls.	[1] Explanation using Newton's 2nd law [1] Explanation using Newton's 3rd law [1] Relate pressure to force per unit area
3(a)(i)	$\Delta x = \frac{\lambda D}{a}$ $1.7\times10^{-2} = \frac{\lambda(1.2)}{(0.030\times10^{-3})}$ $\lambda = 4.25\times10^{-7}$ m	[1] for correct substitution (conversion) [1] correct answer
3(a)(ii) 1.	The fringe separation will increase (by a factor of two), and the brightness will decrease, contrast will decrease.	[1] for fringe separation [1] for contrast

3(a)(ii) 2.	In comparision, red light as a longer wavelength, therefore the <u>fringe separation will increase</u>, but there will be no change in brightness, hence <u>contrast remains the same</u>.	[1] for fringe separation [1] for contrast
3(a)(ii) 3.	The light source is initially unpolarised. With the polariser, the light that passes through will be polarised in a single plane, hence the brightness of the fringe will be lower hence <u>contrast will decrease</u>, no change in fringe separation.	[1] for fringe separation [1] for contrast
3(b)(i)	$d\sin\theta = n\lambda$ $\frac{1}{450\times10^{3}}\sin 11.6 = (1)\lambda_V$ $\lambda_V = 4.47\times10^{-7}$ m $d\sin\theta = n\lambda$ $\frac{1}{450\times10^{3}}\sin 15.8 = (1)\lambda_r$ $\lambda_r = 6.05\times10^{-7}$ m	[1] for violet light [1] for red light
3(b)(ii)	For overlap, $(n+1)\lambda_V \le (n)\lambda_r$ $n \ge 2.80$ n = 3	[1] for condition [1] for correct answer Allow trial and error method
4(a)	There is no electric field within the charged metal sphere. Since electric field strength is equal in magnitude to the electric potential gradient, the electric potential gradient will be zero between *x* = 0 and *x* = 2.0 cm, which means the electric potential is constant between *x* = 0 and *x* = 2.0 cm.	[1] [1]
4(b)	$V = \frac{Q}{4\pi\varepsilon_0 r}$ $3.6 = \frac{Q}{4\pi(8.85\times10^{-12})(2.0\times10^{-2})}$ $Q = 8.0\times10^{-12}$ C	[1] for correct substitution [1] for correct answer
4(c)	Electric potential at *x* = 4.0 cm due to -7.2×10^{-12} C $= \frac{-7.2\times10^{-12}}{4\pi(8.85\times10^{-12})(2.0\times10^{-2})} = -3.24$ V Electric potential at *x* = 4.0 cm due to charged metal sphere = 1.8 V Total electric potential at *x* = 4.0 cm = 1.8 – 3.24 = −1.4 V	[1] for correct electric potential due to -7.2×10^{-12} C [1] for correct substitution [1] for correct answer

4(d)(i)	The direction of the acceleration of the particle is towards the centre of the metal sphere. The magnitude of the acceleration is larger when the particle is nearer the metal sphere.	[1] [1]
4(d)(ii)	Particle moves from x = 6.0 cm to x = 4.0 cm. Change in electric potential = 1.8 – 1.2 = 0.6 V Loss in electric potential energy = Gain in kinetic energy Kinetic energy $= (7.2 \times 10^{-12})(1.8 - 1.2)$ $= 4.32 \times 10^{-12}$ J $\approx 4.3 \times 10^{-12}$ J	[1] for correct substitution [1] for correct answer
5(a)(i)	$P = I^2 R$ $7.0 = I^2 (14.0)$ $I = 0.71$ A	[1] for correct use of equation [1] for correct answer
5(a)(ii)	$E = I(R + r)$ $= 0.71(14.0 + 3.0)$ $= 12.1$ V	[1] for correct use of equation [1] for correct answer
5(a)(iii)	$Q = IEt$ $= (0.71)(12.1)(60 \times 10)$ $= 5150$ J	[1] for correct use of equation [1] for correct answer
5(b)	$R = 3.0\ \Omega$	[1] for correct answer
5(c)	When R is smaller than r, a higher percentage of the power supplied by the battery is dissipated in the internal resistance. As R increases, the power dissipated in the variable resistor increases. However, the current decreases and this results in decreasing power dissipated in the variable resistor when R exceeds the value of r.	[1] for explanation of power dissipated when R is lower than r [1] for explanation of power dissipated when R is higher than r
5(d)	When $r = 0$, $P = \frac{V^2}{R}$	[1] for correct shape of graph

		
6(a)		[1] for series of circular field lines centered on the wire and for correct direction of arrows [1] for non-uniform field
6(b)(i)	$B = \frac{\mu_0 I}{2\pi d} = \frac{4\pi \times 10^{-7}(3.0)}{2\pi(2.0 \times 10^{-2})}$ $B = 3.0 \times 10^{-5}$ T	[1] for correct substitution
6(b)(ii) 1.	Out of the plane of the paper.	[1]
6(b)(ii) 2.	$F = Bqv \sin 90° = (3.0 \times 10^{-5})(1.60 \times 10^{-19})(1.5 \times 10^{7})$ $F = 7.2 \times 10^{-17}$ N	[1] for correct substitution [1] for correct answer
6(c)	For the flat circular coil, the magnetic flux density at the centre of the coil: $B = \frac{\mu_0 NI}{2r} = \frac{4\pi \times 10^{-7}(1)(3.0)}{2(1.3 \times 10^{-2})}$ Magnitude of the resultant magnetic flux density at the centre of the coil	[1] for correct substitution in $B = \frac{\mu_0 NI}{2r}$

	$=\sqrt{\left[\frac{4\pi\times10^{-7}(1)(3.0)}{2(1.3\times10^{-2})}\right]^2+\left(3.0\times10^{-5}\right)^2}$ $=1.48\times10^{-4}$ T $\approx1.5\times10^{-4}$ T	[1] for correct substitution [1] for correct answer
7(a)(i)		[1] for correct forces and clear label
7(a)(ii)	Taking downwards as positive, and by Newton's second law, $mg-\text{tension}=ma$ $mg-k(x_0+x)=ma$ (where x_0 is extension of spring at equilibrim) $-kx=ma$ (since $kx_0=mg$) $a=-\frac{k}{m}x$	[1] for correct expression [1] for correct answer with correct sign
7(a)(iii)	Since <u>$\frac{k}{m}$ is a constant</u>, <u>$a\propto -x$</u>. This indicates that the <u>acceleration of the piston is directly proportional to its displacement from the equilibrium position and the negative sign indicates that its acceleration is always opposite to its displacement and towards the equilibrium position</u>. Hence, consistent with the definition of simple harmonic motion where $a=-\omega^2x$.	[1] for $\frac{k}{m}$ being a constant [1] for correct condition for SHM
7(b)(i)	The damping of the piston is <u>light</u> because the <u>oscillation of the piston continues to overshoot the equilibrium position with its amplitude decreasing by a small amount as time progresses. The period of the oscillation remains constant.</u> For critical and heavy damping, the oscillation of the piston does not overshoot its equilibrium position.	[1] for light damping [1] for correct explanation Award no marks if no explanation
7(b)(ii)	0.85 cm to 1.00 cm	[1] for correct answer
7(c)(i)	<table><tr><td>*t* / s</td><td>*A* / cm</td><td>ln(*A* / cm)</td></tr><tr><td>0.37</td><td>1.40</td><td>0.336</td></tr></table>	[1] for correct answer

7(c)(ii) 1. & 2.		[1] for correct plotted point for t = 0.37 s [1] for line of best fit
7(c)(iii)	Using gradient coordinates (0.10, 1.10) and (1.06, −1.70), Gradient $= \dfrac{-1.70 - 1.10}{1.06 - 0.10}$ $= \dfrac{-2.80}{0.96}$ $= -2.92$	[1] for correct gradient coordinates (read to half smallest square) and calculation [1] for correct answer
7(c)(iv)	Taking natural log of both sides, $A = A_0 e^{-2\pi f_n \gamma t}$ $\ln A = \ln A_0 - 2\pi f_n \gamma t$ $= -2\pi f_n \gamma t + \ln A_0$ The graph of ln A against t shows a straight line graph with negative gradient $-2\pi f_n \gamma$ and positive vertical intercept ln A_0. Hence, the graph in Fig. 7.6 supports the given expression.	[1] for correct linearisation [1] for correct link to the positive intercept and minus sign in the gradient
7(c)(v)	6 complete cycles take 1.10 s $f_n = \dfrac{1}{\text{period}} = \dfrac{1}{\frac{1.10}{6}} = 5.45\text{ Hz}$	[1] for correct calculation
7(c)(vi)	Using $2\pi f_n \gamma = \lvert\text{gradient}\rvert$,	[1] for correct calculation and answer

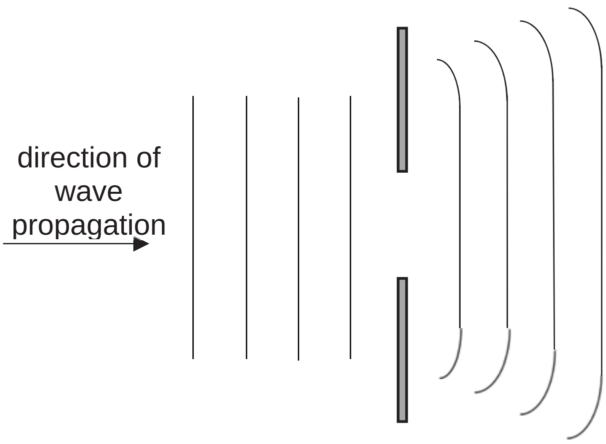
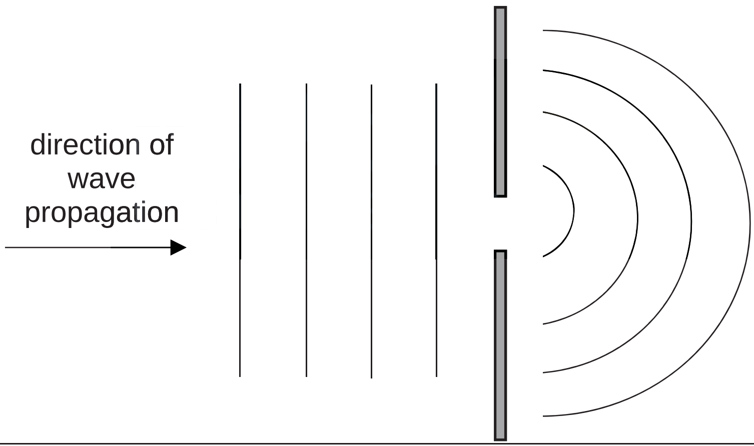
	$\gamma = \dfrac{2.92}{2\pi f_n}$ $= \dfrac{2.92}{2\pi(5.45)}$ $= 0.08527$ ≈ 0.0853	
7(d)	The damping coefficient is likely to be higher so that the vehicle suspension system approaches critical damping, i.e. the piston returns to its equilibrium position in the shortest possible time, hence preventing the vehicle from bouncing (oscillating) continuously after going over a hump or pothole	[1] for correct answer [1] for correct explanation Award no marks if no explanation

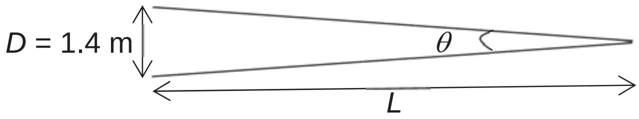
PJC Answers to JC2 Preliminary Examination Paper 3 (H2 Physics)

Suggested Solutions:

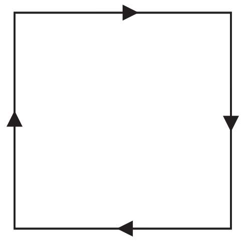
1(a)	Gravitational potential energy - Energy possessed by a mass due to its position in a gravitational field Elastic potential energy - Energy stored as a result of deformation of a solid (extension and compression of an object)	[1] [1]
1(b)(i)	$F = kx$ $k =$ gradient of graph $= \frac{4.5 - 1.5}{1.8 \times 10^{-2} - 0.6 \times 10^{-2}} = 250 \text{ N m}^{-1}$	[1] for correct substitution [1] for correct answer (can accept answer if student uses one point in the graph to calculate)
1(b)(ii)	Elastic potential energy $= \frac{1}{2}Fx = \frac{1}{2}(4.5)(1.8 \times 10^{-2})$ or $\frac{1}{2}kx^2 = \frac{1}{2}(250)(1.8 \times 10^{-2})^2$ $= 0.0405 \text{ J}$ $\approx 0.041 \text{ J}$	[1] for correct substitution [1] for correct answer
1(b)(iii)	Loss in KE = Gain in EPE + Work done against friction $\frac{1}{2}(1.7)v^2 = 0.0405 + (1.2)(1.8 \times 10^{-2})$ $v \approx 0.27 \text{ m s}^{-1}$	[1] for correct equation of conservation of energy [1] for correct substitution [1] for correct answer
2(a)	Gravitational field strength at a point is defined as the gravitational force per unit mass acting at that point. Unit: N kg^{-1}.	[1] for correct definition and [1] for correct unit
2(b)(i)	gravitational force $= \frac{GMm}{R^2}$ $= \frac{6.67 \times 10^{-11}(5.97 \times 10^{24})(1.00)}{(6380 \times 10^3)^2}$ $= 9.78 \text{ N}$	[1] for correct substitution [1] for correct answer

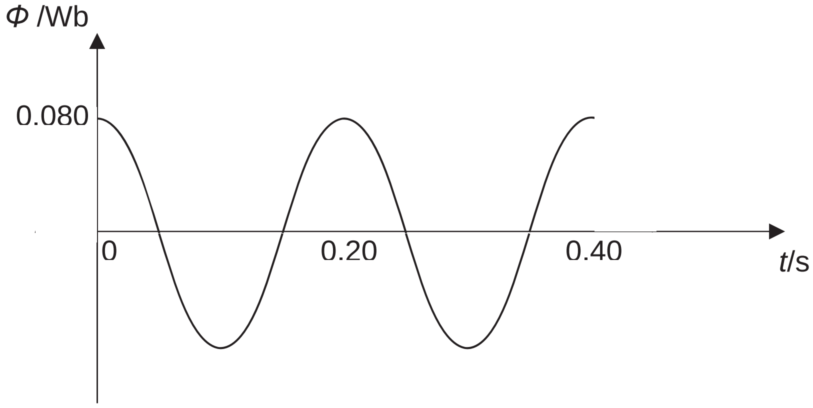
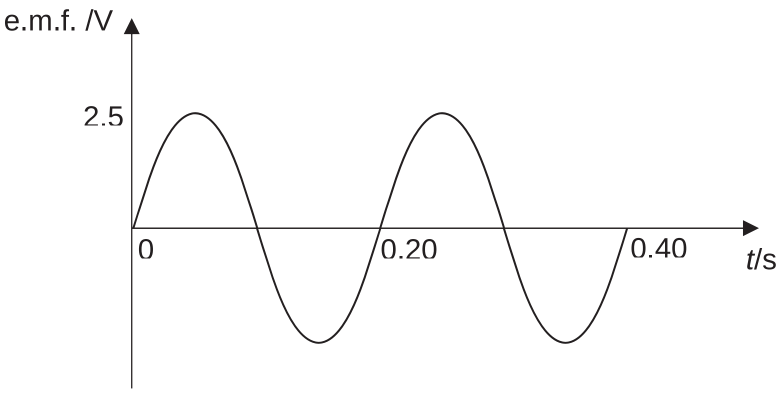
2(b)(ii)	centripetal force $= mR\omega^2$ $= mR\left(\frac{2\pi}{T}\right)^2$ $= (1.00)(6380\times10^3)\left(\frac{4\pi^2}{(8.65\times10^4)^2}\right)$ $= 0.0337\,\text{N}$	[1] for correct substitution [1] for correct answer
2(b)(iii)	acceleration of free fall $= \frac{\text{gravitational force} - \text{centripetal force}}{\text{mass}}$ $= \frac{9.78 - 0.0337}{1.00}$ $= 9.75\ \text{m s}^{-2}$	[1] for correct substitution [1] for correct answer
2(b)(iv)	At the equator part of the acceleration due to free fall has to provide the centripetal acceleration. Hence the acceleration of free fall is lower than that at the poles. Or: Earth is not spherical. It bulges at the Equator. Distance from the poles to the centre of Earth is smaller than distance from Equator to centre of Earth. Hence the acceleration of free fall at Equator is lower than that at the poles.	[1] for correct answer
3(a)	Specific latent heat of fusion is the amount of heat (thermal energy) required to convert a unit mass of the solid, at its melting point, into liquid at the same temperature.	[2]
3(b)	Let the final temperature of water be T Heat loss by water = Heat gained by ice $m_w c_w (28 - T) = m_i l_i + m_i c_i (15 - 0) + m_i c_w (T - 0)$ $(0.2)(4.2\times10^3)(28 - T) =$ $(0.03)(3.3\times10^5) + (0.03)(2.1\times10^3)(15) + (0.03)(4.2\times10^3)T$ $23520 - 840\,T = 9900 + 945 + 126\,T$ $T = 13\ ^\circ\text{C}$	[1] Correct statement [1] Correct substitution into equation [1] Correct final answer
3(c)(i)	The first law of thermodynamics states that the increase in internal energy of a system is the sum of the heat supplied to the system and work done on the system.	[1]
3(c)(ii)	Work done on the gas, $W = -p\,\Delta V$ $= -(1.0\times10^5)(1.7\times10^{-3} - 1.5\times10^{-3})$ $= -20\ \text{J}$ By the first law of thermodynamics, the change in internal energy is given by $\Delta U = Q + W$ $= +50 + (-20)$ $= +30\ \text{J}$	[1] Correct work done and substitution into equation [1] Correct final answer

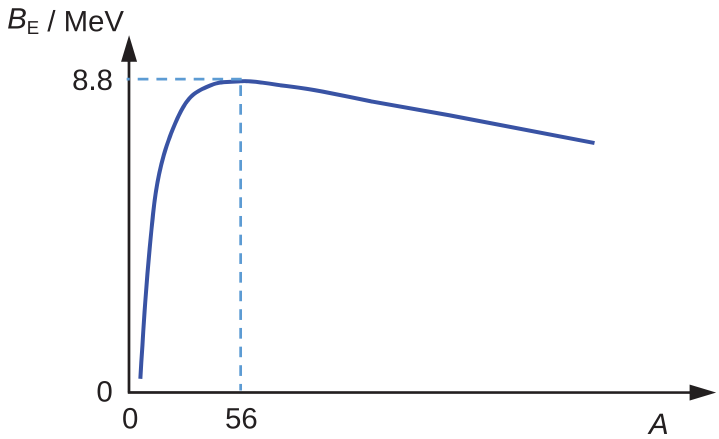
4(a)(i)	The meter reading decreases from a maximum to zero. The aerial detects microwaves that are polarised parallel to it. Hence the reading drops to zero when the plane of polarisation of the microwaves is perpendicular to the aerial.	[1] [1]
4(a)(ii)	Microwaves are transverse waves.	[1]
4(b)(i)	$\frac{A}{2} = A\cos\theta$ $\theta = 60^\circ$	[1] for correct substitution [1] for correct answer
4(b)(ii)	$I \propto A^2$ $\frac{I_1}{(0.5A)^2} = \frac{I}{A^2}$ $I_1 = 0.25I$	[1] for correct substitution [1] for correct answer
5(a)	It is the bending of waves when it passes through an aperture or round an obstacle.	[1] [1]
5(b)(i)		[1] constant wavelength (i.e. equal spacing before and after) [1] only slight diffraction
5(b)(ii)		[1] shows greater diffraction

5(c)	 $\theta = \frac{\lambda}{a}$ $= \frac{500\times10^{-9}}{2.5\times10^{-3}}$ $= 2.0\times10^{-4}$ rad $\tan\theta \approx \theta$ $\frac{1.4}{L} \approx 2.0\times10^{-4}$ $L \approx 7.0\times10^{3}$ m	[1] correct use of Rayleigh criterion [1] correct answer for *L*. (Allow sin θ or $\frac{0.7}{L}$)
6(a)	$E = IR$ $= (5.25 \times 10^{-3})(63 + 750 + 480)$ $= 6.788$ V $I = \frac{E}{R} = \frac{6.788}{(750+480)} = 5.52\times10^{-3}$ A	[1] Calculating e.m.f [1] Correct final answer
6(b)(i)	Current through A_1, $I_1 = 0.50 + 0.50 = 1.0$ A $E = V + I_1 r$ $2.0 = V + 1.0\ (0.20)$ $V = 1.80$ V	[1] Correct substitution into equation [1] Correct final answer
6(b)(ii)	Connecting L_3 parallel to L_1 and L_2 will <u>lower the effective resistance of the circuit</u>. Hence, current in A_1 <u>increases</u>	[1] Correct explanation [1] Correct conclusion based on correct explanation
6(c)	P.d across AB = $\frac{0.5}{0.8}(1) = 0.625$ V $\left(\frac{3}{3+0.2+R_x}\right)2 = 0.625$ $\left(\frac{6}{3.2+X}\right) = 0.625$ $3.2 + X = 9.6$ X = 6.4 Ω	[1] p.d across AB [1] Correct substitution [1] Correct final answer

7(a)	It is a quantum of energy of an electromagnetic radiation, and is given by *hf*, where *h* is the Planck's constant and *f* is the frequency of the radiation.	[1] [1] need to explain *h* and *f*
7(b)(i)	$hf = \Phi + \frac{1}{2}mv^2$ $\frac{(6.63\times10^{-34})(3.0\times10^{8})}{(350\times10^{-9})} = 2.46(1.6\times10^{-19}) + \frac{1}{2}(9.11\times10^{-31})v^2$ $v = 6.2\times10^{5}\ \text{m s}^{-1}$	[1] photon energy [1] work function
7(b)(ii)	$p = \frac{h}{\lambda}$ $mv = \frac{h}{\lambda}$ $(9.11\times10^{-31})(6.1\times10^{5}) = \frac{(6.63\times10^{-34})}{\lambda}$ $\lambda = 1.2\times10^{-9}\ \text{m}$	[1] correct substitution [1] correct answer
7(c)(i)	$hf = 5.7\times10^{-19}\ \text{J}$ $= 3.6\ \text{eV}$ Since the energy of a photon is less than the work function energy, no electrons will be emitted.	[1] Evidence of photon energy less than work function energy, or equivalent [1] correct conclusion
7(c)(ii)	The energy of light is quantised where each photon transfers its energy completely to an electron. If the photon energy is lower than the work function, no electron will be emitted. Increase in intensity only increases the number of photons incident on metal per unit time.	[1] correct explanation
7(d)	When electrons transit from a higher energy level to a lower energy level, a photon corresponding to the energy level difference is emitted. Since only photons of certain energies are emitted, only transitions between certain energy levels are allowed, hence the energy levels must be discrete.	[1] [1]
8(a)(i)	As the coil leaves the region of uniform magnetic field, it experiences a changing magnetic flux linkage. According to Faraday's law, this induces an e.m.f in the coil and a current flows in the coil as it is a closed circuit.	[1] for stating changing flux linkage [1] for e.m.f. and current induced

8(a)(ii)		[1] for correct current direction
8(a)(iii)	$\varepsilon = Bsv$ .... (1) $I = \frac{\varepsilon}{R}$ .... (2) Sub (2) into (1): $I = \frac{Bsv}{\frac{\rho 4s}{A}} = \frac{BsvA}{4\rho s} = \frac{BvA}{4\rho}$	[1] for correct induced e.m.f. expression [1] for correct current expression and substitution
8(a)(iv)	An upward magnetic force acts on the coil due to interaction between the induced current and magnetic field. As the coil accelerates downwards due to its weight, the induced current increases due to the greater rate of change of magnetic flux through the coil. Hence, the magnetic force increases until it is equal to the weight of the coil. Acceleration drops to zero and the coil falls with constant speed.	[1] for stating upward magnetic force on coil [1] for increasing rate of change of magnetic flux [1] for magnetic force increases until equal to weight
8(a)(v)	$F = mg$ $BIs = Vdg$ $B\left(\frac{BvA}{4\rho}\right)s = 4sAdg$ $v = \frac{4dg(4\rho)}{B^2}$ $= \frac{16(8400)(9.81)(1.5 \times 10^{-6})}{4}$ $= 0.49 \text{ m s}^{-1}$	[1] for equating magnetic force to weight [1] for correct substitution [1] for correct answer
8(b)(i)	The coil rotates with a constant angular frequency hence the angle between the normal of the coil and the direction of the magnetic field varies at a constant rate. This gives rise to a sinusoidal change in magnetic flux (since $\Phi = BA\cos\omega t$) and hence induced e.m.f. with time (since $\varepsilon = -\frac{d\Phi}{dt}$).	[1] for constant angular frequency [1] for sinusoidal change in flux and e.m.f.

8(b)(ii)1.	$T = \frac{1}{f} = 0.20$ s $\Phi = \Phi_0 \cos \omega t = Bs^2 \cos \omega t$ $\Phi_0 = Bs^2 = (2.0)(0.20)^2 = 0.080$ Wb 	[1] for correct period [1] for correct maximum flux value [1] for correct shape
8(b)(ii)2.	$\varepsilon = -\frac{d\Phi}{dt} = Bs^2 \omega \sin \omega t$ $\varepsilon_0 = (2.0)(0.20)^2\, 2\pi(5) = 2.5$ V 	[1] for correct shape [1] for correct maximum e.m.f. value
8(b)(iii)	$I_{rms} = \frac{I_0}{\sqrt{2}} = \frac{\frac{\varepsilon_0}{R}}{\sqrt{2}}$ $= \frac{\varepsilon_0}{\left(\frac{4s\rho}{A}\right)\sqrt{2}}$ $= \frac{2.513}{\frac{4(0.20)(1.5 \times 10^{-6})}{\pi (0.00050)^2}\sqrt{2}} = 1.2$ A	[1] for correct equations [1] for correct substitution and final answer
9(a)(i)	The binding energy of a nucleus <u>is the minimum amount of energy required to break the nucleus into its constituent particles</u>.	[1] for correct explanation (or alternative)

9(a)(ii)		[1] for correct shape [1] for correct values
9(a)(iii)	For nuclei having high nucleon numbers, the binding energy per nucleon decreases with larger nucleon numbers. When two such nuclei fuse together, they will produce a daughter nucleus which has an even larger nucleon number and smaller binding energy per nucleon. This means that the daughter nucleus is less stable than the parent nuclei. OR The total binding energy of the products is less than that of the initial nuclei, hence there is an increase in the total mass of the system, and energy has to be supplied for such a reaction to take place. No energy will be released.	[1] for correct answer [1] for correct answer
9(a)(iv)	${}^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + {}^{1}_{0}n$	[1] for correct answer
9(a)(v)1.	17.59 MeV of energy released $BE_{He} = BE_{Deuterium} + BE_{Tritium} + 17.59\text{ MeV}$ $BE_{He} = (2\times1.112)+(3\times2.827)+17.59\text{ MeV}$ $= 28.295\text{ MeV (shown)}$	[2] for correct answer
9(a)(v)2.	Using the definition of binding energy of a nuclei $BE_{He} = \left(\sum m_{constituents} - m_{He}\right)c^2$ $m_{He} = \sum m_{constituents} - \frac{BE_{He}}{c^2}$ $= (2\times1.00728+2\times1.00866)(1.66\times10^{-27}) - \frac{(28.295\times10^{6})(1.60\times10^{-19})}{(3.00\times10^{8})^2}$ $= 6.6426\times10^{-27}$ $\approx 6.643\times10^{-27}$ kg	[1] for correct mathematical definition [1] for correct expression and numerical substitution [1] for correct answer

9(b)(i)	Spontaneous decay means the decay process is not affected by external factors such as chemical composition and physical conditions such as temperature, pressure, electric fields, magnetic fields, luminosity, etc.	[1] for correct answer
9(b)(ii)	In beta decay, there are three products – the β^--particle (electron), the daughter nucleus and the neutrino. The neutrino is a neutral particle with negligible mass in comparison with that of an electron. By the principle of conservation of energy, the total energy is shared by the daughter nucleus, the electron and the neutrino. Since there are many ways that the energy can be divided among the three particles to satisfy the conservation principle. If the electron is emitted with a large amount of energy, the neutrino is emitted with a small amount of energy and vice versa. Hence, the electrons in beta decay are emitted over a continuous range of energies.	[1] for identification of presence of neutrino [1] for principle of conservation of energy [1] for correct explanation
9(b)(iii)	Using the data of Fig. 9.2, the energy of the α-particles emitted is greater compared to that of the β^--particles. The parent nucleus bismuth-212 is less stable compared to bismuth-210, and hence more likely to undergo decay. Hence, bismuth-212 has a larger decay constant. Note: Half-life of bismuth-212 (60.6 min), decay constant (1.91×10^{-4} s^{-1}) Half-life of bismuth-210 (5.0 days), decay constant (1.60×10^{-6} s^{-1})	[1] for comparing energy of α- and β^--particles [1] for correctly identifying bismuth-212 less stable [1] for correct larger decay constant of bismuth-212
9(c)	This is because the half-life of bismuth-210 (5.0 days) is 27 times smaller than that of polonium (138 days). Therefore, the rate of decay of bismuth-210 into polonium far exceeds that of polonium to lead. In 150 days, almost all the bismuth-210 has decayed to form polonium. About half the polonium nuclei have undergone decay to form lead nuclei (1 decay).	[1] for correct comparison of half-lives [1] for correct explanation

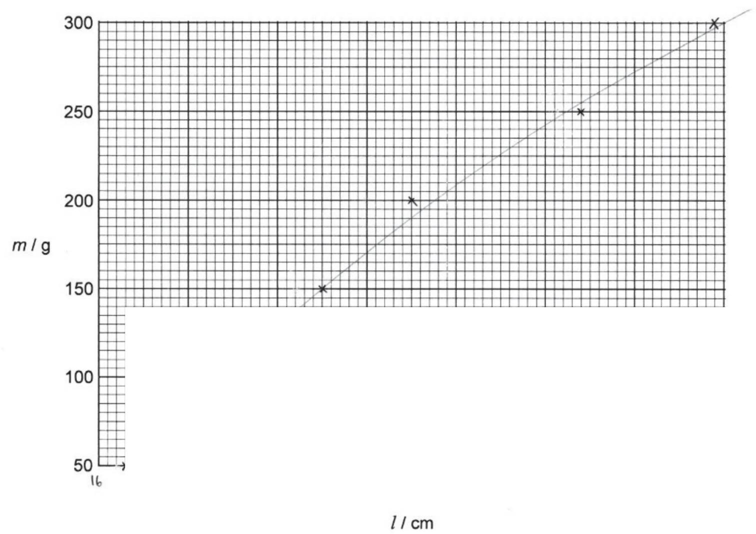
PJC 2017 JC2 Physics Preliminary Practical Examination Suggested Mark Scheme

<table>
<tr><th>No.</th><th>Solution</th><th>Remarks</th></tr>
<tr><td>1(b)(i)</td><td>l = 16.3 cm</td><td>[1]
- l recorded to nearest 0.1 cm
- do not accept if l is obviously too large or too small.</td></tr>
<tr><td>1(b)(ii)</td><td>$\text{percentage uncertainty} = \frac{\Delta l}{l} \times 100\%$
$= \frac{0.2}{16.3} \times 100\%$
$= 1.2\%$</td><td>[1]
- $\Delta l = 0.2$ cm (accept up to $\Delta l = 0.4$ cm)

[1]
- correct calculation
- 1 or 2 s.f.</td></tr>
<tr><td>1(c)</td><td>
<table>
<tr><th>m / g</th><th>l / cm</th></tr>
<tr><td>50</td><td>16.2</td></tr>
<tr><td>100</td><td>17.1</td></tr>
<tr><td>150</td><td>18.2</td></tr>
<tr><td>200</td><td>19.0</td></tr>
<tr><td>250</td><td>21.1</td></tr>
<tr><td>300</td><td>22.9</td></tr>
</table>
</td><td>[1]
- headings with units

[1]
- 6 sets of data with correct trend

Do not penalise for precision of readings.

Repeating and non-repeating of readings are both acceptable.</td></tr>
<tr><td>1(d)</td><td>
</td><td>[1]
- correct plotting of points

[1]
- curve with correct shape drawn based on data points

- Do not allow straight line</td></tr>
<tr><td>1(e)</td><td>As the mass increases, the increase in extension is larger.

Spring constant decreases with increasing mass.</td><td>[1] correct identification of trend

[1] correct conclusion</td></tr>
</table>

2(a)	$d_1 = 0.31$ mm $d_2 = 0.33$ mm $d = 0.32$ mm	[1] - d measured to the nearest 0.01 mm with consistent unit - evidence of repeated measurements of d [or in (e)] - accept $0.20\text{ mm} \le d \le 0.40\text{ mm}$
2(c)(i)	$L = 0.990$ m	[1] - L recorded to nearest mm with consistent unit - L at least 0.900 m
2(c)(ii)	Percentage uncertainty $= \frac{\Delta L}{L} \times 100\%$ $= \frac{0.002}{0.990} \times 100\%$ $= 0.2\%$	[1] - absolute uncertainty in L is 2 mm - 6 mm - correct method of calculation to get percentage uncertainty. - percentage uncertainty expressed to 1 or 2 s.f.
2 (d)(i) and (d)(ii)	$I = 90.7$ mA $V = 1.398$ V	[1] - I recorded to the nearest 0.1 mA with consistent unit. -accept $85.0\text{ mA} \le I \le 95.0\text{ mA}$ - V recorded to the nearest 0.001 V with consistent unit. - accept $1.300\text{ V} \le V \le 1.500\text{ V}$
2(e)	$d_1 = 0.36$ mm $d_2 = 0.38$ mm $d = 0.37$ mm	[1] - d measured to the nearest 0.01 mm with consistent unit - accept $0.30\text{ mm} \le d \le 0.50\text{ mm}$ - $d_B > d_A$
2(f)(ii)	$V = 1.038$ V	[1] - accept $0.950\text{ V} \le V \le 1.150\text{ V}$ - $V_B < V_A$ - Do not penalise d.p.
2(g)(i)	From $V = \frac{kL}{d^2}$, $k = \frac{Vd^2}{L}$	

<table>
<tr><td></td><td>For wire A:
$k_A = \frac{(1.398)(0.32\times10^{-3})^2}{0.990} = 1.4\times10^{-7}$ V m

For wire B:
$k_B = \frac{(1.038)(0.37\times10^{-3})^2}{0.990} = 1.4\times10^{-7}$ V m</td><td>[1]
Values of k calculated correctly
[1] with correct unit.</td></tr>
<tr><td>2(g)(ii)</td><td>The values of k were expressed to 2 significant figures because in the calculation of k, the values of d are expressed to the least number of significant figures (i.e. 2 significant figures) compared to L and V.</td><td>[1]
- Justification of s.f. linked to L <u>and</u> d <u>and</u> V. (must identify quantity with least s.f.)</td></tr>
<tr><td>2(g)(iii)</td><td>Percentage difference in values of k
$= \frac{(1.446 - 1.435)10^{-7}}{1.435\times10^{-7}} \times 100\%$
$= 0.7\%$

Since the values of k_A and k_B differ by less than 10%, they are relatively close to each other, suggesting that k is a constant. Hence, my experimental results support the suggested relationship $V = \frac{kL}{d^2}$.</td><td>[1]
- valid conclusion based on the calculated values of k, using percentage difference
- candidate must test against a stated criterion: the difference in the values of k is no more than e.g. 10%.</td></tr>
<tr><td>2(h)(i)</td><td>1. Two readings are not enough to draw a conclusion in supporting the suggested relationship.

2. Wires are kinked / not straight, hence making it difficult to measure L accurately.

3. It is difficult to measure the ammeter and/or voltmeter readings due to fluctuating ammeter and/or voltmeter readings with the presence of contact resistance.</td><td>[2]
- Accept appropriate sources of uncertainty.
- Ignore reference to parallax error, heating effects on wire and battery runs down.
-Ignore non-uniform wire and take average diameter.</td></tr>
<tr><td>2(h)(ii)</td><td>1. Take more readings and plot a graph/calculate more values of k.

2. Suitable method to keep wire straight, e.g. hang weights off ends of wire.

3. Clean the electrical contacts before the experiment e.g. Sand-paper the crocodile clips and wire contacts, and check that the crocodile clips are tightened at the circuit contact.</td><td>[2]
- 2 relevant suggested improvements.
- Do not credit: take more readings and average them.</td></tr>
<tr><td>3(b)</td><td>$T = \frac{24.2 + 24.2}{2(30)} = 0.807$ s</td><td>[1] for repeated readings and NT at least 20 s.</td></tr>
<tr><td>3(c)</td><td><table><tr><td>N</td><td>m/g</td><td>t_1/s</td><td>t_2/s</td><td>T/s</td><td>lg(m/g)</td><td>lg(T/s)</td></tr><tr><td>30</td><td>50</td><td>24.2</td><td>24.2</td><td>0.807</td><td>1.70</td><td>−0.093</td></tr><tr><td>30</td><td>100</td><td>26.6</td><td>26.8</td><td>0.890</td><td>2.000</td><td>−0.051</td></tr></table></td><td>[2] - 6 sets of data. 1 mark for 5 sets of data.</td></tr>
</table>

<table>
<tr>
<td></td>
<td>
<table>
<tr><td>40</td><td>150</td><td>36.3</td><td>35.9</td><td>0.903</td><td>2.176</td><td>−0.044</td></tr>
<tr><td>40</td><td>200</td><td>37.8</td><td>37.9</td><td>0.946</td><td>2.301</td><td>−0.024</td></tr>
<tr><td>40</td><td>250</td><td>39.7</td><td>39.6</td><td>0.991</td><td>2.398</td><td>−0.004</td></tr>
<tr><td>40</td><td>300</td><td>41.3</td><td>41.3</td><td>1.03</td><td>2.477</td><td>0.013</td></tr>
</table>
</td>
<td>No marks for less than 5 sets of data.
- Penalise 2 marks for no t values
- Penalise 2 marks for wrong mode of oscillation
[1] headings with units (N must be stated clearly or included in table)
[1] t recorded to nearest 0.1 s (at least 4 sets more than 20 s). m is recorded to the nearest gram.
[1] correct calculations for T/s, lg(m/g), lg(T/s)
[1] correct s.f. for T/s, lg(m/g), lg(T/s)</td>
</tr>
<tr>
<td>3(d)(i)</td>
<td>See separate graph below</td>
<td>[1]
- axes labelled with correct directions
- correct scale
[1]
- correct plotting of points
[1]
- best fit line drawn based on student’s data (penalise if best fit line is forced out)</td>
</tr>
<tr>
<td>3(d)(ii)</td>
<td>Use (1.980, −0.0820) and (2.310, −0.0200)
$\text{gradient} = \dfrac{-0.0200-(-0.0820)}{2.310-1.980}$
$= 0.188$</td>
<td>[1]
- correct substitution for gradient
- gradient coordinates labelled on graph
-coordinates read to half a small square accuracy

[1]
- correct calculation</td>
</tr>
<tr>
<td>3(d)(iii)</td>
<td>Use (1.980, −0.0820)
$-0.0820 = (0.188)(1.980) + c$
$c = -0.454$</td>
<td>[1]
- correct substitution for y-intercept
-coordinates read to half a small square accuracy (e.c.f.)
[1]
- correct calculation</td>
</tr>
</table>

3(e)	$b = 0.188$ $\lg a = -0.454$ $a = 0.352 \text{ s g}^{-0.188}$	[1] - correct *a* value - correct unit [1] - correct *b* value - correct unit
3(f)	There are two anomalous points (1.700, −0.093) and (2.000, −0.051). When the **<u>oscillating mass is small</u>**, it exhibits unintended modes of oscillations. This introduces significant counting errors and it is difficult to determine the start and stop positions of the mass accurately.	[1] - identify the anomalous points (no need to provide coordinates) [1] - correct cause for anomalies Award zero if no anomaly identified.
3(g)(i)	$T = (0.352)(1500)^{0.188}$ $= 1.39 \text{ s}$	[1] -correct calculation of *T* - allow e.c.f.
3(g)(ii)	The large value of *m* may stretch the spring beyond its elastic limit. (accept beyond proportionality limit and damaged spring)	[1] for correct problem
4	**<u>Aim</u>**: To determine the relationship between *V* and λ. **<u>Independent variable</u>**: Wavelength emitted by the LED, λ. **<u>Dependent variable</u>**: Minimum potential difference across LED, *V*. **<u>Controlled variable</u>**: - Keep distance between the LED and light detector constant.	 [1] for stating wavelength, λ [1] for stating potential difference, *V* [1] for controlled variable

Diagram:

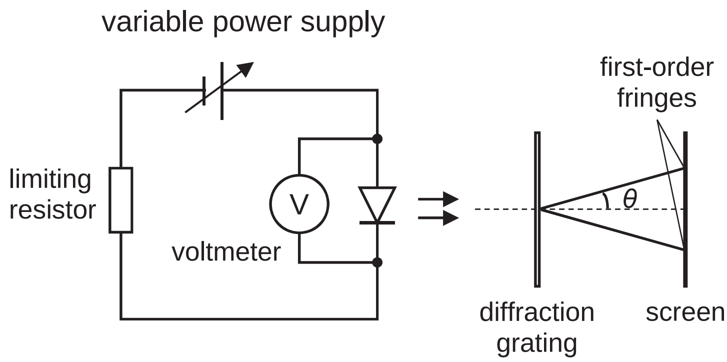


Fig. 4a

[1] for correct circuit
[1] for light sensor/probe/detector/spectrometer

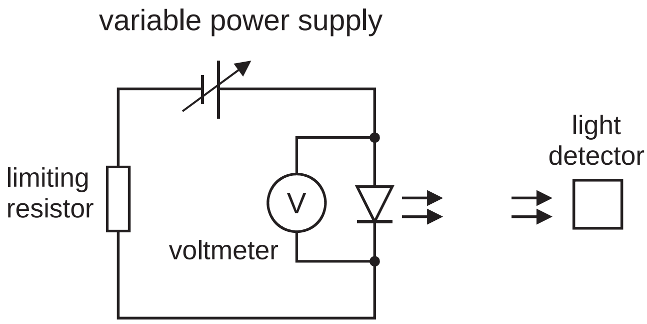


Fig. 4b

Procedure:

a. Set up the apparatus as shown above.

b. Switch on the variable power supply in Fig. 4a to obtain maximum intensity from the LED. Incident the light emitted from the LED through a diffraction grating of known grating constant *d* (distance between adjacent slits) and upon the screen.

c. Measure the angle between first-order fringe and grating normal θ using a protractor.

d. Using the diffraction grating expression $d\sin\theta = n\lambda$ to determine the wavelength λ of light emitted by LED.

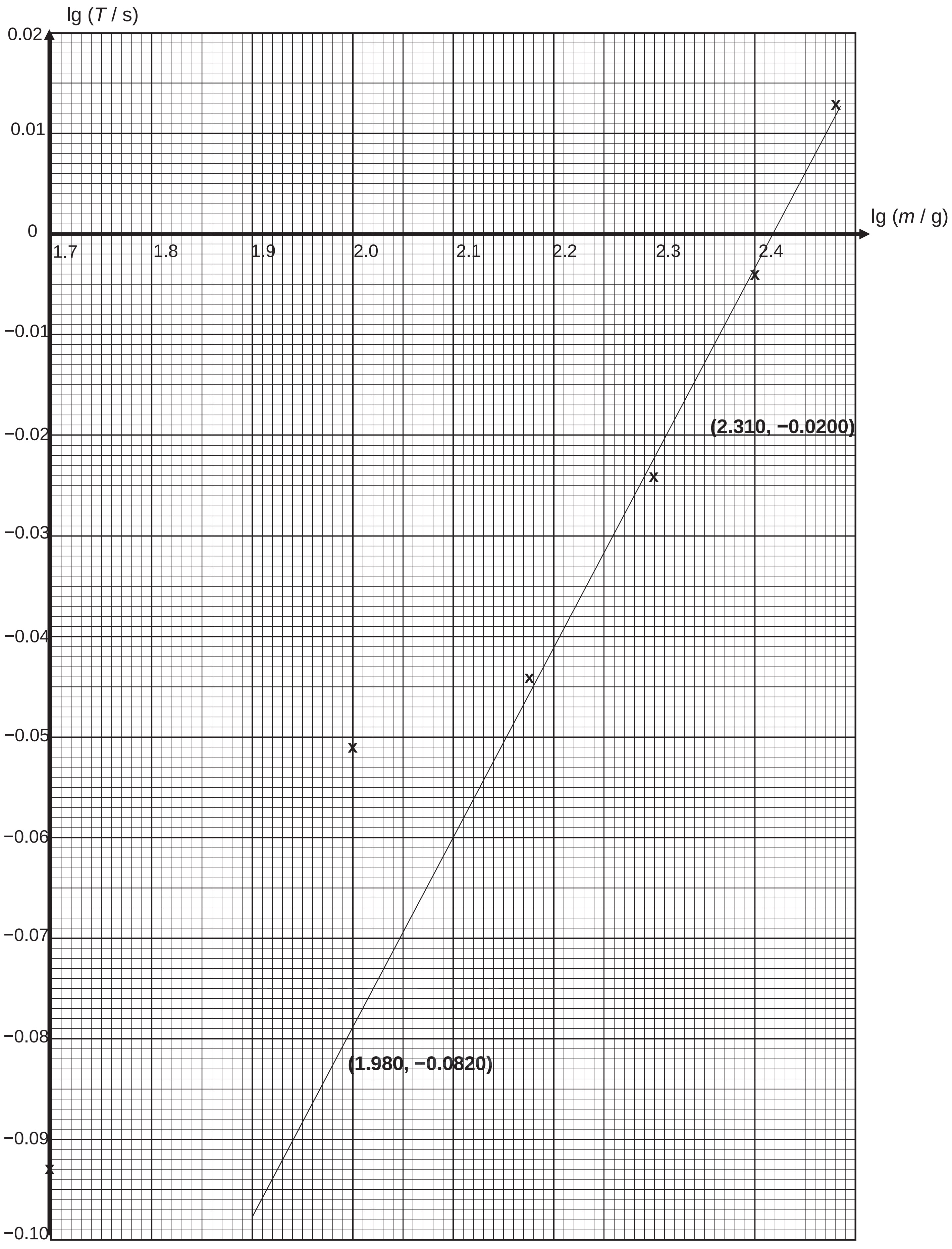
[1] for using methods of diffraction grating/Young's double slits/single slit to determine λ (Accept use of LED spec chart or spectrometer to obtain λ)

e. Switch off the variable power supply and adjust power supply output to minimum.

f. Switch on the variable power supply (See Fig. 4b) and slowly increase the power supply output such that the potential difference across the LED is gradually increased until <u>the LED (just) emits light</u> by using the light detector. Measure and record the potential difference *V* using the voltmeter.

[1] for method to change p.d. across LED, e.g. variable power supply / potential divider / variable resistor / rheostat
[1] for (slowly) increase the p.d. across LED until LED (just) emits light

	g. Repeat steps (b) to (f) to obtain 6 sets of readings for V and λ using different coloured LEDs.	[1] for 6 sets. [1] for how to vary independent variables.
	h. Using the suggested relationship $V = k\lambda^n$, and linearising it to obtain $\ln V = n\ln\lambda + \ln k$, plot a graph of $\ln V$ against $\ln\lambda$, where gradient of the graph is n and vertical intercept of graph is $\ln k$	[1] for plotting a graph of of $\ln V$ against $\ln\lambda$ (Accept $\lg V$ against $\lg\lambda$) [1] for determination of both constants (gradient and vertical intercepts).
	i. If suggested relationship $V = k\lambda^n$ is valid, the graph of $\ln V$ against $\ln\lambda$ will follow a linear trend / straight line with gradient n and vertical intercept $\ln k$.	Teaching point: [relationship is valid if plotted graph is a straight line]
	<u>Further details</u>: ***Precautions to improve accuracy*****:** - Take more than one reading of the potential difference V and find the average of the readings for the same λ or LED. - Carry out the experiment in a dark room or with the LED in a tube so as to minimize ambient lighting. - Readings on the voltmeter should be taken quickly so as to keep the temperature of the LED (circuit) constant. - Use a light meter / lux meter / detector (LDR) to determine the point when the LED just emits light up so as to random errors due to visual inspection by human eye. - Point the light meter / lux meter / detector (LDR) at the top of the LED as the emitted light appears to be the brightest at the top of the LED.	[1] for one appropriate precaution to improve accuracy Do not accept wire heats up
	Safety precautions**:** - Use a protective/current-limiting resistor in the circuit set-up to prevent LEDs from burning out. - Connect the polarity of the LED correctly in the circuit to prevent LED from being damaged. - Gently wipe off any moisture or let the LED device dry before using it to prevent short-circuiting the LED. - Gently wipe off dust or dirt particles from the LED with a soft lint-free cloth before using it to prevent short-circuiting the LED.	[1] for one appropriate safety precaution Do not accept electrocution.


lg (T / s)
0.02
0.01
0
−0.01
−0.02
−0.03
−0.04
−0.05
−0.06
−0.07
−0.08
−0.09
−0.10
lg (m / g)
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4
(2.310, −0.0200)
(1.980, −0.0820)