JURONG PIONEER JUNIOR COLLEGE
JC2 Preliminary Examination 2019

PHYSICS
Higher 1

8867/01
27 September 2019

Paper 1 Multiple Choice

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

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

[Turn over

Data

speed of light in free space	$c = 3.00 \times 10^8\ \text{ms}^{-1}$
elementary charge	$e = 1.60 \times 10^{-19}\ \text{C}$
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	$m_p = 1.67 \times 10^{-27}\ \text{kg}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\ \text{mol}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11}\ \text{Nm}^2\text{kg}^{-2}$
acceleration of free fall	$g = 9.81\ \text{ms}^{-2}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$

1 Three of these quantities have the same units.

Which quantity has a different unit?

A $\dfrac{\text{kinetic energy}}{\text{displacement}}$

B impulse

C $\dfrac{\text{power}}{\text{velocity}}$

D rate of change of momentum

2 The speed of an airplane in still air is 200 km h^{-1}. The wind blows from the eastto west at a speed of 85 km h^{-1}.

In which direction must the pilot steer the airplane in order to fly due north?

A 23° east of north

B 23° west of north

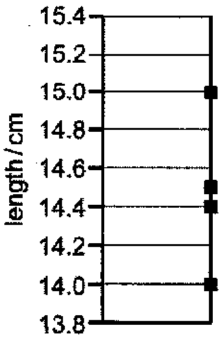
C 25° east of north

D 25° west of north

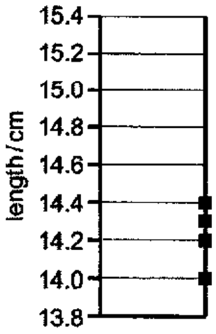
3 Four students use a ruler to measure the length of a 15.0 cm paper. Their measurements are recorded on four different charts.

Which chart shows measurements that are accurate but not precise?

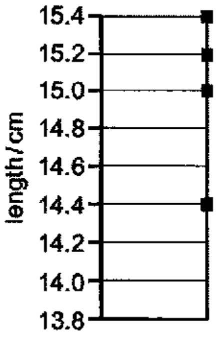
A



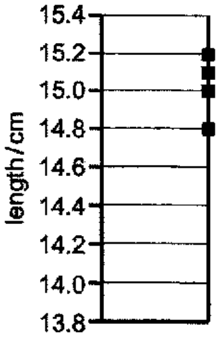
B



C



D



4 A man stands on the edge of a cliff. He throws a stone upwards with an initial velocity *u*. The stone reaches the top of its trajectory at 2.0 s and reaches the bottom of the cliff at 6.5 s. Air resistance is negligible.

What row shows the correct signs for displacement *s*, velocity *v* and acceleration *a* of the stone at the respective times *t*?

	t / s	*s*	*v*	*a*
A	1.5	+	+	+
B	2.5	+	+	–
C	3.5	–	–	–
D	4.5	–	–	–

5 The water surface in a deep well is 78 m below the top of the well. A person at the top of the well drops a stone into the well. The speed of sound in air is 330 m s^{-1}. Air resistance is negligible.

What is the time interval between the person dropping the stone and hearing it hitting the water?

A 3.9 s

B 4.0 s

C 4.1 s

D 4.2 s

6 A ball of mass 0.20 kg is launched with a speed of 5.0 m s^{-1} at an angle of 30° above the horizontal. Air resistance is negligible.

What is the kinetic energy of the ball at maximum height?

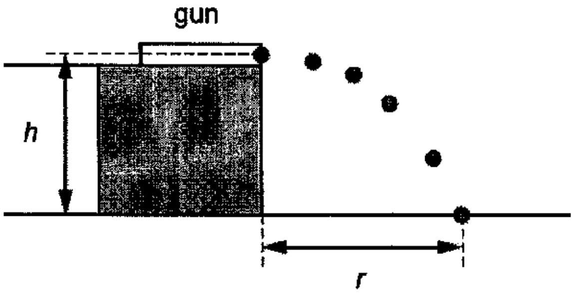
A 0 J

B 0.43 J

C 0.63 J

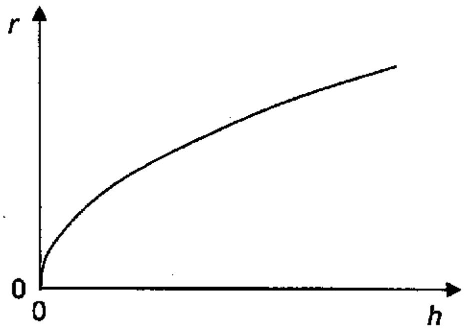
D 1.9 J

7 A spring gun is used to launch a steel ball with a constant horizontal velocity. The height *h* of the gun from the ground is varied and the horizontal displacement *r* of the ball when it hits the ground is measured.



Which graph shows the variation with height *h* of the horizontal displacement *r*?

A



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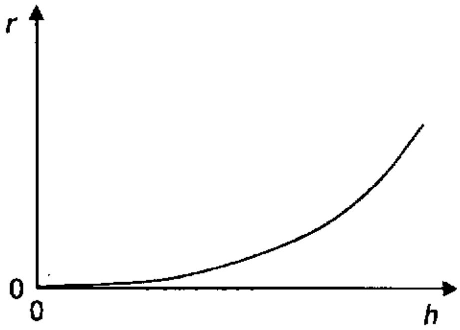

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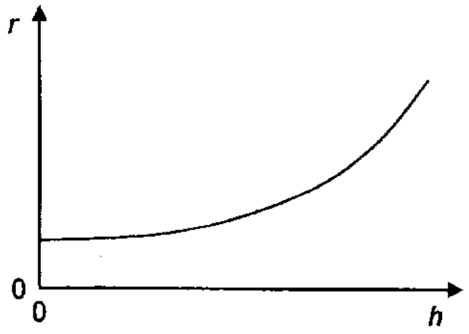
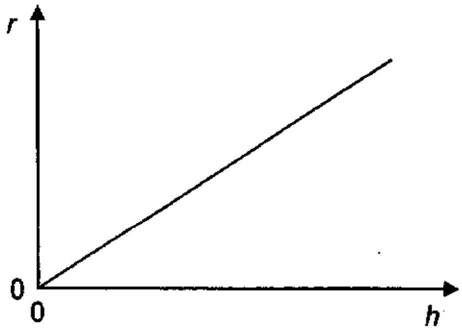


D



8 Which pair of forces is an example of action and reaction?

A The centripetal force keeping a satellite in orbit and the weight of the satellite.

B The air resistance acting on a falling rain drop and its weight.

C The normal reaction force from the table on a book and the weight of the book.

D The forces of repulsion experienced by two parallel current carrying wires.

9 A body of mass 5.0 kg is thrown vertically upwards through air.

What is the acceleration of the body when the magnitude of air resistance is 4.0 N?

A 1.8 m s^{-2}

B 9.0 m s^{-2}

C 9.8 m s^{-2}

D 11 m s^{-2}

10 Water is pumped through a hose-pipe at a rate of 90 kg per minute. Water emerges horizontally from the hose-pipe with a speed of 20m s^{-1}.

What is the minimum force applied by a person holding the hose-pipe to prevent it from moving backwards?

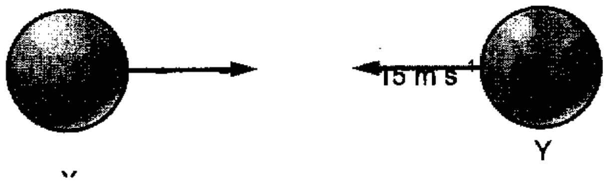
A 30 N

B 270 N

C 1800 N

D 110000 N

11 Two identicalballs X and Y are moving towards each other with speeds of 5 m s^{-1} and 15 m s^{-1} respectively as shown.



They make a head-on collision and ball Y moves to the left with a speed of 3 m s^{-1}.

What is the speed and direction of ball X after the collision?

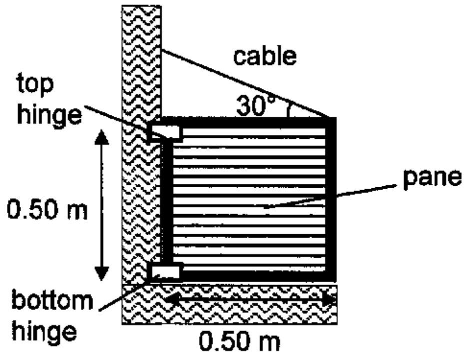
A 7 m s^{-1} to the left

B 17 m s^{-1} to the right

C 20 m s^{-1} to the left

D 23 m s^{-1} to the left

12 A door is made up of a uniform pane of mass 20 kg.The pane is 0.50 m wide and 0.50 m high and is freely hinged at the top and bottom as shown. A cable attached to the top right corner of the pane makes an angle of 30° with the top of the pane and has a tension of 150 N.



What is the magnitude and direction of the horizontal force exerted by the top hinge on the pane?

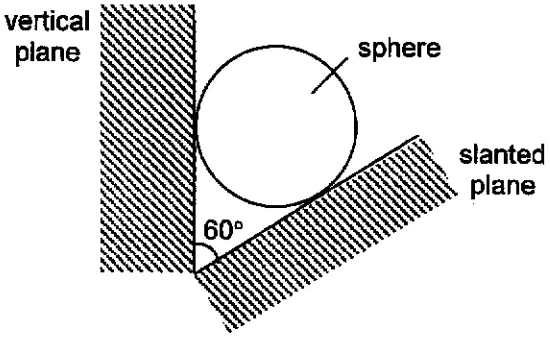
A 110 N to the left

B 300 N to the left

C 110 N to the right

D 300 N to the right

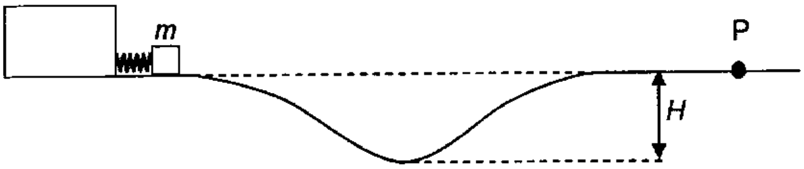
13 A uniform sphere of weight 15 N is placed in between two smooth planes as shown.



What is the magnitude of the force exerted by the vertical plane on the sphere?

A 0 N **B** 7.5 N **C** 8.7 N **D** 26 N

14 A small object of mass m is launched by a spring and travels along a rough track to a point P. The spring constant is k and the initial compression of the spring is x. As it travels to P it goes through a dip of depth H. The object experiences a constant force of friction f for the entire distance of d.



What is the kinetic energy of the object at point P?

A $\frac{1}{2}kx^2 + fd$

B $\frac{1}{2}kx^2 - fd$

C $\frac{1}{2}kx^2 + fd + mgH$

D $\frac{1}{2}kx^2 - fd - mgH$

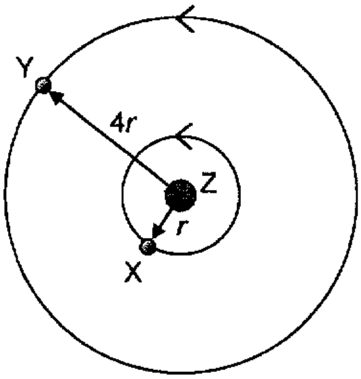
15 A space capsule of mass m re-enters the Earth's atmosphere at an angle θ to the horizontal. Due to air resistance, the vehicle travels at a constant speed v.

The heat-shield of the capsule dissipates heat at a rate P, such that the mean temperature of the capsule remains constant.

Taking g as the acceleration of free fall, which expression is equal to P?

A $\frac{1}{2}mv^2$ **B** $\frac{1}{2}mv^2 \sin^2 \theta$ **C** mgv **D** $mgv \sin\theta$

16 Two planets X and Yorbit around a star Z in the same direction, in circular orbits with orbital radii r and $4r$ respectively. X completes one revolution in time T.



How many revolutions does Y make in the same time T?

A $\frac{1}{8}$

B $\frac{1}{4}$

C 4

D 8

17 Which statement is correct for a particle moving in a horizontal circle with constant angular velocity?

A Thecentripetal force is constant.

B The kinetic energy is constant but the velocity varies.

C The speed and the linear momentum are both constant.

D The kinetic energy and the linear momentum both vary.

18 A circular disc of radius r has n metal studs uniformly spaced around its circumference. Each stud carries a charge q. The disc rotates about its axis with a frequency f.

What is the current due to the rotating charges?

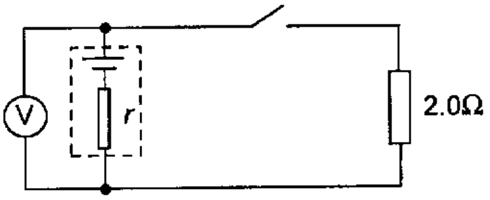
A $\frac{nq}{f}$

B nq

C nqf

D $\frac{nqf}{2\pi r}$

19 A battery with internal resistance r is connected in series with a 2.0 Ω resistor and a switch as shown.



A voltmeter connected across the battery reads 12 V when the switch is open but 8.0 V when it is closed.

What is the internal resistance r of the battery?

A 0.67 Ω

B 1.0 Ω

C 4.0 Ω

D 6.0 Ω

20 An electricity supply cable of length 120 m consists of 16 strands of copper wire each of cross-sectional area 5.0 mm^2. The resistivity of copper is 1.7×10^{-8}Ω m.

What is the resistance of the cable?

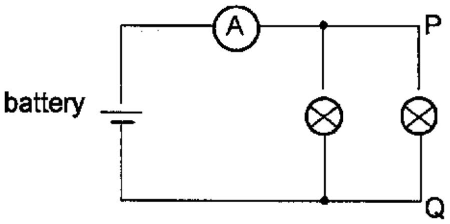
A 0.026 Ω

B 0.41 Ω

C 0.82 Ω

D 6.5 Ω

21 Two similar light bulbs are connected to a battery of negligible internal resistance. Each bulb operates at normal brightness and the ammeter registers a steady current.

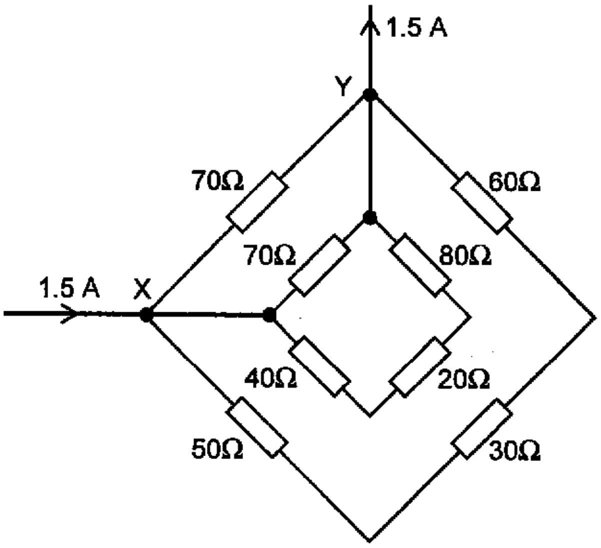


If a third identical bulb is connected across points P and Q, what happens to the ammeter reading and to the brightness of the first two bulbs?

	ammeter reading	brightness of bulbs
A	increases	increases
B	increases	unchanged
C	decreases	unchanged
D	decreases	decreases

22 Eight resistors are arranged as shown.

A current of 1.5 A enters the network at junction X and leaves through junction Y.



What is the current in the resistor of resistance 30Ω?

A 0.25 A

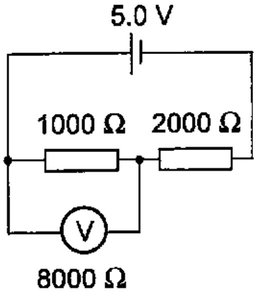
B 0.50 A

C 0.75 A

D 1.0 A

[Turn over

23 A 5.00 V battery of negligible internal resistance is connected across two resistors of resistance 1000 Ω and 2000 Ω. A voltmeter of resistance 8000 Ω is connected in parallel across one of the resistors.



What is the reading of the voltmeter?

A 1.54 V

B 1.67 V

C 2.50 V

D 4.09 V

24 A charged particle moves in a circular path in a uniform magnetic field.

Which statement is correct?

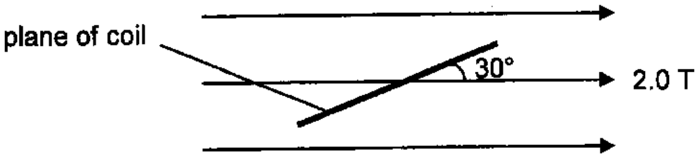
A The period of the circular motion is independent of the speed of the particle.

B The momentum of the particle is independent of its charge.

C The radius of the circular motion is directly proportional to its charge.

D The magnetic force on the particle is dependent on the mass of the particle.

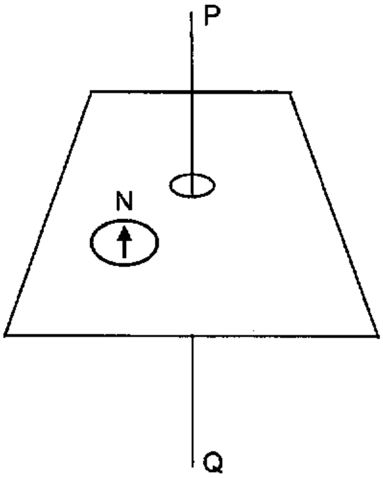
25 A 20-turns square coil of side 5.0 cm is placed so that the plane of the coil makes an angle of 30° with the direction of a uniform magnetic field of flux density 2.0 T. A current of
15 A is passed through the coil.



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

A0.75 Nm **B**1.3 Nm **C**15 Nm **D** 26 N m

26 A plotting compass is placed next to a vertical wire PQ. When there is no current in the wire, the compass points North (N) as shown in the figure below.



Which option below shows a possible direction for the compass to point when a current passes from Q to P?

A

B

C

D

27 It was once thought that the mass of an atom is spread uniformly through the volume of the atom. When α-particles are directed at a piece of gold foil, the results led scientists to believe instead that nearly all the mass of the gold atom is concentrated at a point inside the atom.

Which effect is possible only if nearly all the mass of the gold atom is concentrated at a point?

A A fewα-particles bounce back.

B Most α-particles are only slightly deflected.

C Some α-particles pass through without any deflection.

D Some α-particles are absorbed.

28 A different nucleus can be formed by bombarding a stable nucleus with an energetic α-particle.

$^{23}_{11}$Na is bombarded with an energetic α-particle.

What can be the products of this nuclear reaction?

A $^{25}_{10}$Ne + neutron

B $^{25}_{11}$Na + proton

C $^{26}_{12}$Mg + β

D $^{27}_{13}$Al + γ

29 A sample of a radioactive substance contains nuclide X and nuclide Y. After a period of time, $\frac{7}{8}$ of the nuclei of X and $\frac{3}{4}$ of the nuclei of Y have decayed.

What is the ratio $\frac{\text{half-life of X}}{\text{half-life of Y}}$?

A $\frac{2}{3}$

B $\frac{6}{7}$

C $\frac{7}{6}$

D $\frac{3}{2}$

30 The isotope $^{222}_{86}$Rn decays in a sequence of emissions to form the isotope $^{214}_{84}$Po . At each stage of the decay sequence, it emits either anα-particle or a β-particle.

What is the number of stages in the decay sequence?

A 3

B 4

C 5

D 6

End of paper

Name: ______________________________ Class: ____________

JURONG PIONEER JUNIOR COLLEGE

JC2 Preliminary Examination

PHYSICS
Higher 2

9749/02
20 September 2019

Paper 2 Structured Questions

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	/ 11
3	/ 10
4	/ 8
5	/ 8
6	/ 11
7	/ 22
Total	/ 80

This document consists of **19** printed pages. **[Turn over**

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	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

Answer **all** questions in the spaces provided

1 An aeroplane is at rest on a runway. It accelerates in a straight line along the runway and takes off after 55.0 s.

Fig. 1.1 shows the variation with time of the resultant force acting on the aeroplane while it is in contact with the runway.

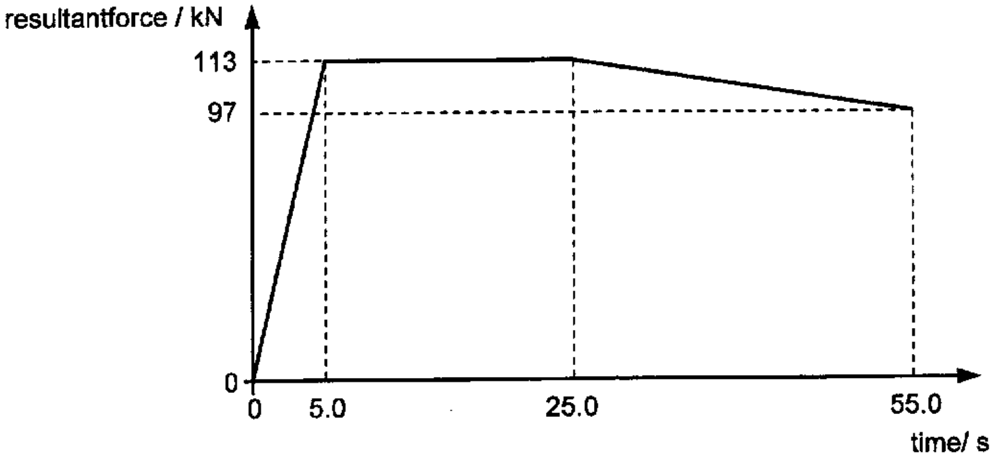


Fig. 1.1

(a) State two reasons why the resultant force on the aeroplane is not constant as it travels along the runway.

1. ....

....

2. ....

.... [2]

(b) Calculate the momentum of the aeroplane at take-off.

momentum = ... N s [3]

(c) The total mass of the aeroplane is 7.45×10^4 kg.

Calculate the velocity v_{max} of the aeroplane at take-off.

v_{max} = ... m s^{-1} [1]

(d) On Fig. 1.2, sketch a graph to show the variation with time of the velocity of the aeroplane as it travels along the runway.(Numerical values for the velocity are not required.)

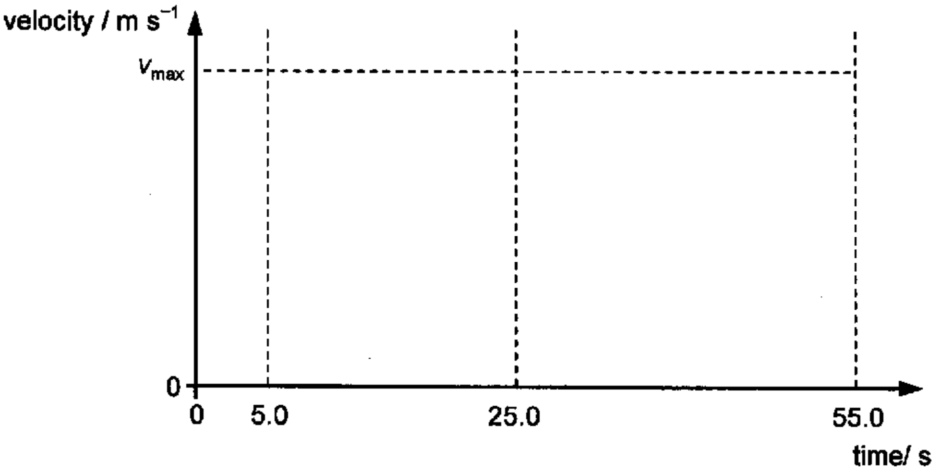


Fig. 1.2

[2]

(e) Estimate the distance the aeroplane travels along the runway.

distance = ... m [2]

2 A roller coaster car of mass 380 kg slides down a smooth slope and executes a loop of diameter *d*. After the loop, it experiences friction only in the area denoted as zone A, as shown in Fig. 2.1.

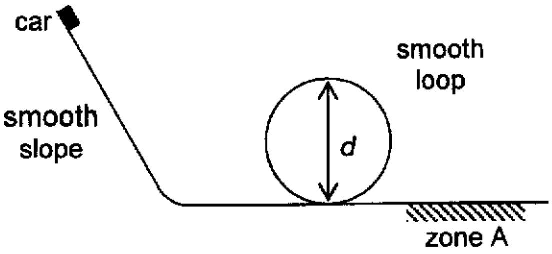


Fig. 2.1

The variationsof gravitational potential energy and kinetic energy of the car with time *t*are shown in Fig. 2.2.

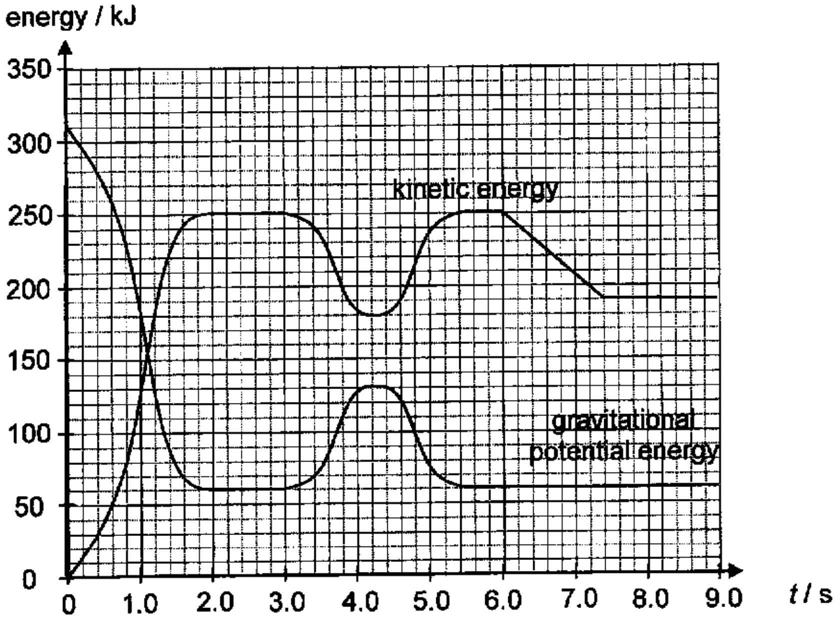


Fig. 2.2

(a) On Fig. 2.2, sketch the variation of total mechanical energy with time of the car, from $t = 0$ s to $t = 9.0$ s. [2]

(b) Between t = 3.0 s and t = 5.4 s, the car executes the loop.

Using Fig. 2.2, calculate d.

d = ... m [2]

(c) (i) State the start and end times at which the car is within zone A.

start time = ... s

end time = ... s [1]

(ii) Calculate the rate at which the car loses kinetic energy in zone A.

rate = ... W [2]

(iii) Calculate the speed of the carwhen it first enters zone A.

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

(iv) Hence, calculate the magnitude of the frictional forceacting on the car when it first enters zone A.

force = ... N [2]

3 **(a)** Explain what is meant by *internal energy* of a gas.

....

....

.... [1]

(b) The pressure p of an ideal gas of density ρ is related to the mean-square speed of its molecules by the expression

$$p = \frac{1}{3}\rho\langle c^2\rangle$$

Show that the average kinetic energy of a molecule of an ideal gas is proportional to its thermodynamic temperature T.

[2]

(c) An engine operates by using 0.024 mol of an ideal gas. The gas undergoes a cycle of changes as shown in Fig. 3.1.

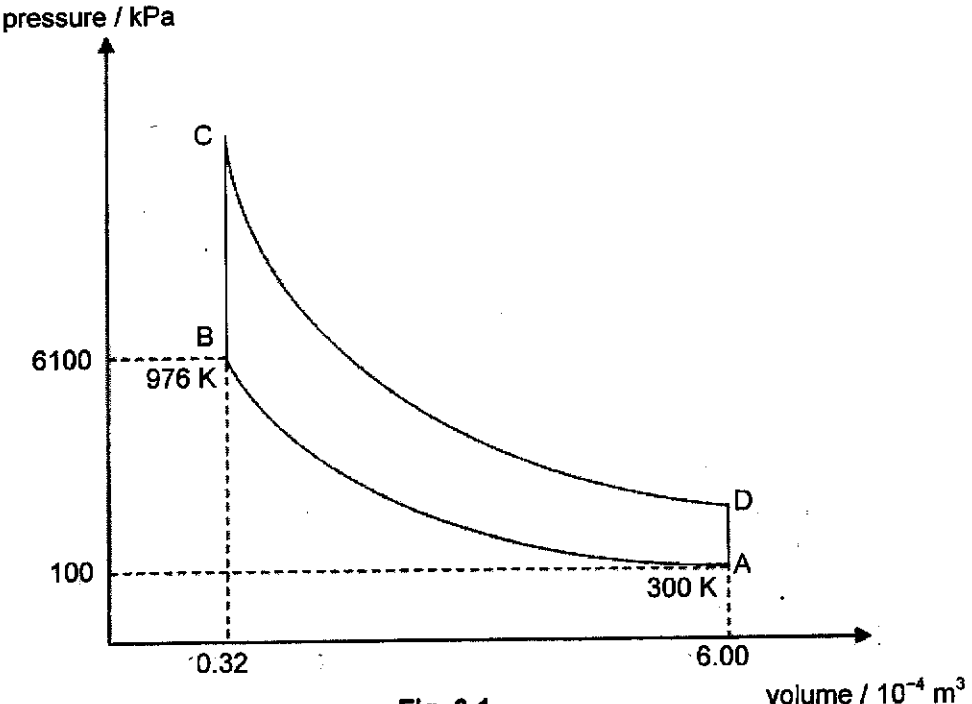


Fig. 3.1

The temperature of the gas at A and B are 300 K and 976 K respectively.

(i) Given that the gas gains 250J of heat during a heating process at constant volume from B to C, determine

1. the temperature at C,

temperature = ... K[3]

2. the pressure at C.

pressure = ... Pa [1]

(ii) Fig. 3.2 shows some of the values of changes in Fig. 3.1.

Complete Fig. 3.2.

change	heat supplied to gas/ J	work done by gas/ J	increase in internal energy/ J
A to B	0	–200	
B to C	250		
C to D	0		
D to A	–100		

Fig. 3.2

[3]

4 Fig. 4.1 shows two identical solenoids with their axes aligned and the two opposite faces at a distance of 0.20 m apart.

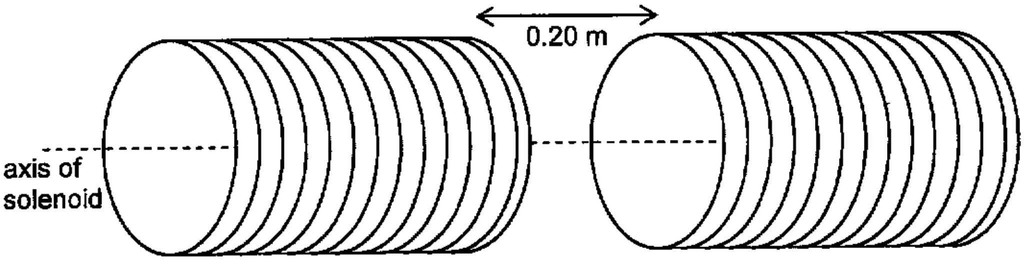


Fig. 4.1

The space between the solenoids is a vacuum with a uniform magnetic flux density of 1.2×10^{-3} T.

An electron moving with speed 5.0×10^{7} m s^{-1} normal to the magnetic field between the solenoids traces an arc of a circular path.

(a) **(i)** Determine the radius of the circular path.

radius = ... m [2]

(ii) State and explain whether the electron will collide with any of the solenoids.

....

....

.... [2]

(b) In another similar experiment described above, the electron is found to spiral inwards with decreasing radius even though the magnetic field remains constant.

With reference to the speed of the electron, suggest a reason for this motion.

....

....

.... [2]

(c) A uniform electric field is applied in the region of the magnetic field so that the electron continues undeflected through the two fields.

Determine the magnitude of the electric field strength E.

E = ... N C^{-1} [2]

5 **(a)** When monochromatic radiation is incident on a clean cadmium surface, electrons with a range of kinetic energies up to a maximum of 3.65×10^{-20} J are released. The work function of cadmium is 4.07 eV.

(i) Explain what is meant by *work function*.

....

.... [1]

(ii) Explain why the emitted electrons have a range of kinetic energies up to a maximum.

....

....

....

.... [2]

(iii) Calculate the wavelength of the radiation.

wavelength= .... m [2]

(b) In the wave model of electromagnetic radiation, electrons near the surface of a metal absorb energy from the wave.

(i) The radiation incident on the cadmium surface in **(a)** delivers energy at a rate of 3.0×10^{-22} J s^{-1}.

Calculate the minimum time it would take an electron to absorb sufficient amount of energy to be emitted from the metal surface.

time= .... s [1]

(ii) In the actual experiment conducted,photoelectrons are observed to be emitted without any time lag.

Explain how this observation provides evidence for the particulate nature of electromagnetic radiation.

....

....

....

.... [2]

6 Tritium is an isotope of hydrogen and is represented by the symbol ^3_1H.

(a) Explain the term *isotope*.

....

.... [1]

(b) Tritium has a binding energy per nucleon of 2.83 MeV.

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

....

.... [1]

(ii) Given that the mass of a proton is 1.00783u and the mass of a neutron is 1.00867u, calculate, to five decimal places, the mass of a tritium nucleus.

mass = ... u[3]

(c) In a fusion power reactor, two deuterium nuclei fuse together to form a tritium nucleus.

(i) Complete the nuclear equation below for the fusion of deuterium.

$$^{2}_{1}H + ^{2}_{1}H \rightarrow ^{3}_{1}H + \ldots\ldots\ldots\ldots$$

[1]

(ii) For the fusion of deuterium shown in **(i)**, 4.03 MeV of energy is released.

Calculate

1. the binding energy of a deuterium nucleus,

binding energy = ... MeV [2]

2. the mass of deuterium required per unit time to produce 2.86×10^{9} W of power.

mass = ... kg [3]

7 The decay of radioactive materials is a random process. On average, nuclides which decay rapidly exist for a shorter time than nuclides which decay slowly. It is common practice when making calculations on decay to make use of the half-life of a nuclide. One difficulty that arises with these calculations is when the radioactive material is a mixture of two or more nuclides.

This question considers the case when a mixture of two radioactive nuclides is present. In decommissioning a nuclear power station, this difficulty is compounded by the presence of about a hundred different radioactive nuclides in significant quantities.

(a) Explain what is meant by a *random* process.

....

....

.... [2]

(b) Define *half-life*.

....

....

.... [1]

(c) $^{131}_{52}\text{Te}$ decays by β emission to $^{131}_{53}\text{I}$. $^{131}_{53}\text{I}$ is not stable, and decays by β emission to the stable isotope Xe, but the half-life for this decay is very much longer than that for the decay of $^{131}_{52}\text{Te}$. A sample of pure $^{131}_{52}\text{Te}$ is prepared at time $t = 0$, and Fig. 7.1 shows the variation with time of the activity A of the whole sample. Background radiation can be ignored.

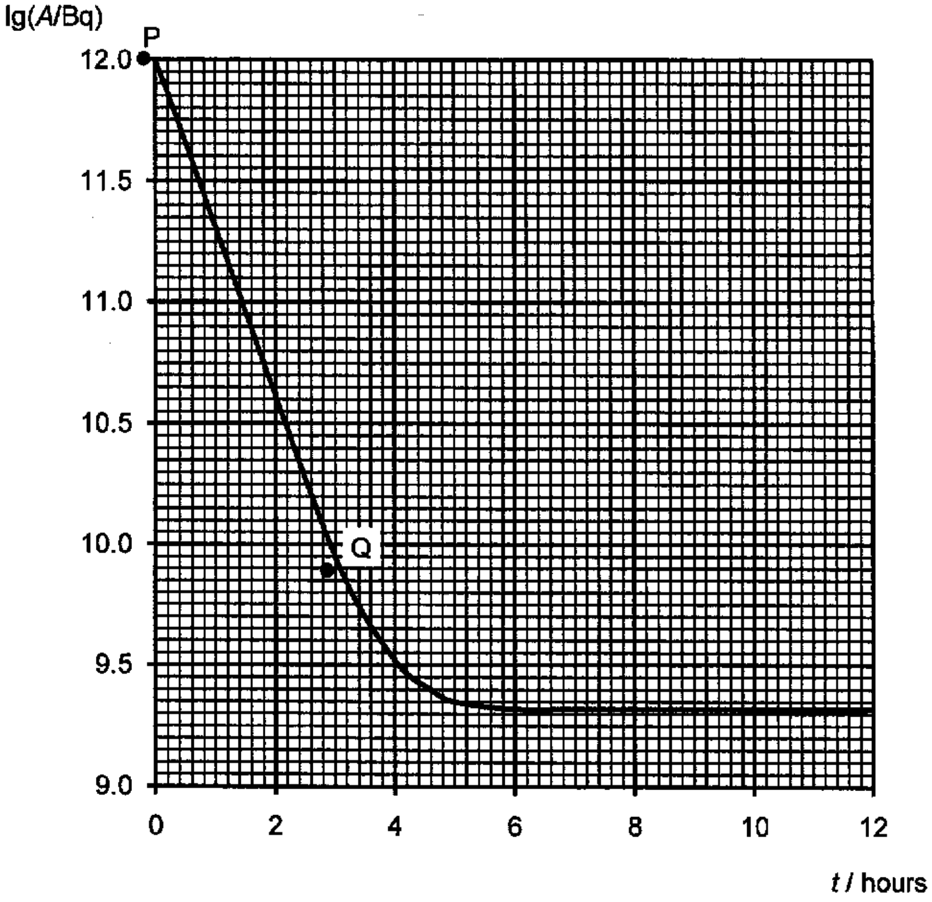


Fig. 7.1

(i) Write down the nuclear equation for the decay of $^{131}_{53}\mathrm{I}$ to Xe, showing the mass number and atomic number of the isotope Xe clearly.

.... [2]

(ii) Explain why the part PQ on the graph corresponds mainly to the decay of $^{131}_{52}\mathrm{Te}$.

....

....

.... [2]

(iii) Determine the gradient of PQ.

gradient= .... [2]

(iv) Hence, or otherwise,

1. show that the half-life of $^{131}_{52}\text{Te}$ is approximately 0.44 hours,

[3]

2. determine the initial number of $^{131}_{52}\text{Te}$ nuclides in the sample.

number of nuclides= .... [2]

(v) Explain why the graph seems flat after a time of 6 hours.

....

....

.... [2]

(vi) Hence, calculate the half-life of $^{131}_{53}\text{I}$.

half-life= .... hours [3]

(d) Suggest why background radiation can be ignored in this question.

....

....

.... [1]

(e) State and explain whether these two radioactive nuclides would pose any hazard if found when de-commissioning a nuclear reactor.

....

....

.... [2]

End of paper

Name: ______________________________ **Class:** _____________

JURONG PIONEER JUNIOR COLLEGE
JC2 Preliminary Examination

PHYSICS **9749/03**
Higher 2 **25 September 2019**

Paper 3 Longer Structured Questions **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	/ 8
2	/ 9
3	/ 8
4	/ 8
5	/ 10
6	/ 9
7	/ 8
8	/ 20
9	/ 20
Total	/ 80

This document consists of **27** printed pages. **[Turn over**

Data

speed of light in free space	$c = 3.00 \times 10^{8}\ \text{ms}^{-1}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\ \text{Hm}^{-1}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \text{Fm}^{-1}$
	$= (1/(36\pi)) \times 10^{-9}\ \text{Fm}^{-1}$
elementary charge	$e = 1.60 \times 10^{-19}\ \text{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\ \text{Js}$
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	$R = 8.31\ \text{JK}^{-1}\text{mol}^{-1}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\ \text{mol}^{-1}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\ \text{JK}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11}\ \text{Nm}^2\text{kg}^{-2}$
acceleration of free fall	$g = 9.81\ \text{ms}^{-2}$

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	$p = \rho g h$
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	$R = R_1 + R_2 + \ldots$
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	$B = \frac{\mu_0 N I}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 n I$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

Section A

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

1 An experiment to determine the acceleration of free fall g is conducted by projecting a stone with speed u at an angle θ to the horizontal. The horizontal distance R travelled by the stone when it returns to the level of projection is measured. Air resistance is negligible.

(a) In determining the speed of the stone, a student defines speed as "distance travelled per second".

Explain why this definition is physically incorrect.

....

....

.... [2]

(b) Show that R is given by the expression

$$R = \frac{2u^2 \sin\theta \cos\theta}{g}.$$

[2]

(c) The above expression can be written as

$$R = \frac{u^2 \sin 2\theta}{g}.$$

The experiment is conducted to obtain the maximum range R_0.

Determine the value of θ to obtain R_0.

θ = ... ° [1]

(d) The values of u and R_0 are 12.6 m s^{-1} and 16.3 m, with associated percentage uncertainties of 3% and 4% respectively.

Calculate the value of g, and present the answer together with its uncertainty.

g = ...±..................... m s^{-2} [3]

2 A light helical spring is suspended vertically from a fixed point, as shown in Fig. 2.1.

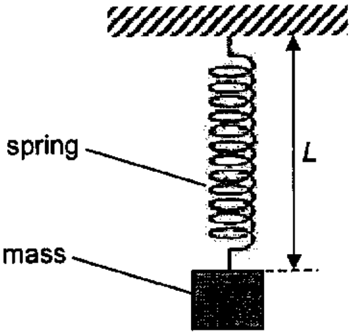


Fig. 2.1

Different masses are suspended from the spring. The weight *W* of the mass and the length *L* of the spring are recorded.

The variation with weight *W* of the length *L* is shown in Fig. 2.2.

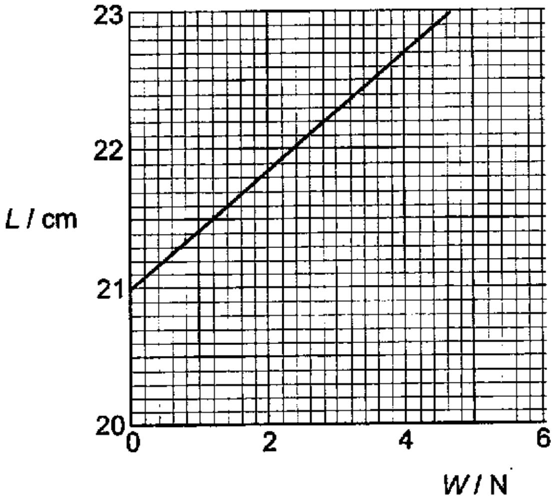


Fig. 2.2

(a) A mass of weight 2.6 N is suspended from the spring.

When the mass is stationary, it is then pulled downwards a distance of 0.60 cm and held stationary.

For the increase in extension of 0.60 cm, determine the magnitude of the change in

(i) the gravitational potential energy of the mass,

change = ... J [1]

(ii) the elastic potential energy of the spring.

change = ... J [2]

(b) The mass in **(a)** is now released. The mass performs simple harmonic motion.

(i) Use your answers in **(a)** to show that the total energy of oscillation of the mass is 0.0042 J.

[1]

(ii) Calculate the angular frequency of the oscillation.

angular frequency = ... rad s^{-1} [2]

(c) A light card is attached to the mass, as shown in Fig. 2.3. The mass is pulled downwards a distance of 0.60 cm, and released at $t = 0$.

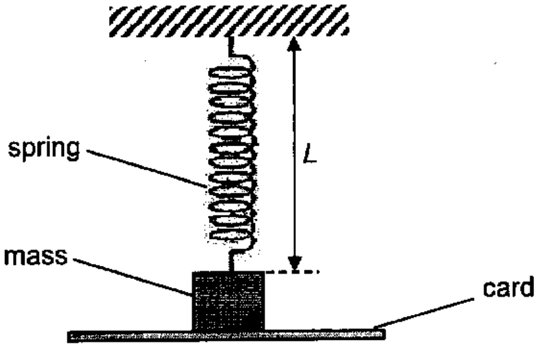


Fig. 2.3

The length of the spring is 21.7 cm after the first half of an oscillation.

Calculate the magnitude of the average force due to air resistance on the oscillating system.

force = ... N [3]

3 Two sources of sound S_1 and S_2 emit waves of frequency 220 Hz in phase as shown in Fig. 3.1.

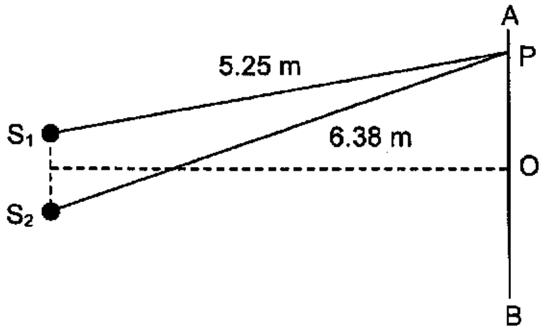


Fig. 3.1

(a) Sound wave is a longitudinal wave.

Explain what is meant by a longitudinal wave.

....

....

.... [1]

(b) At point P along the line AB, the waves are found to have a phase difference of $\frac{3}{2}\pi$ rad. S_1 and S_2 are 5.25 m and 6.38 m away from P respectively. For the sound waves emitted, determine

(i) the wavelength,

wavelength = ... m [2]

(ii) the speed.

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

(c) Point O is equidistant from S_1 and S_2. Sound waves from S_1 and S_2 arrive at O with intensities I and $3I$ respectively.

Determine the resultant intensity at O in terms of I.

resultant intensity = ... [3]

4 **(a)** Sound waves produced by a loudspeaker arrive at the microphone M via two different paths, LXM and LYM as shown in Fig.4.1. The left-tube is fixed in position, while the right-tube is a sliding-section.

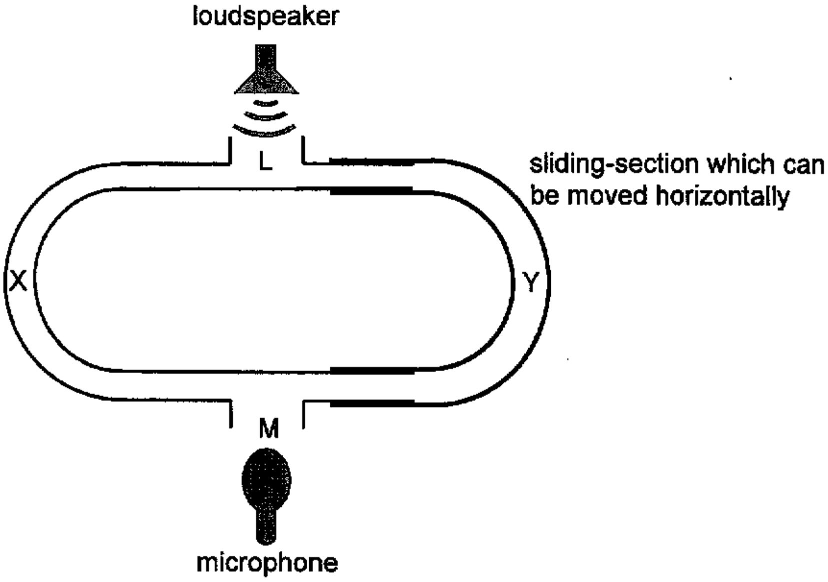


Fig. 4.1

Initially, the lengths of paths LXM and LYM are equal. The sliding-section is then pulled out horizontally to the right by a distance of 0.020 m, and the loudness detected at microphone M changes from a maximum to a minimum.

(i) Determine the wavelength of the sound waves.

wavelength = ... m **[2]**

(ii) When the opening at M is subsequently sealed, explain why a stationary (standing) wave can be set up in the tube.

....

....

....

....**[2]**

(b) Fig. 4.2 shows a monochromatic light of wavelength 600 nm passing through fine nylon threads. The threads act as a diffraction grating with lines in the horizontal direction. Part of the pattern of light showing the central bright fringe and its first two adjacent fringes on the screen is shown in Fig. 4.3.

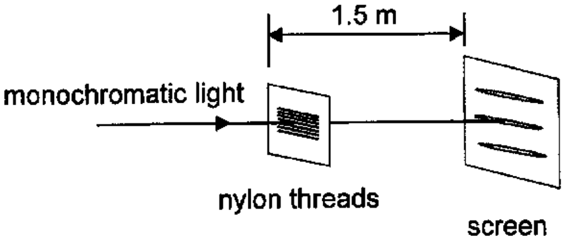


Fig. 4.2

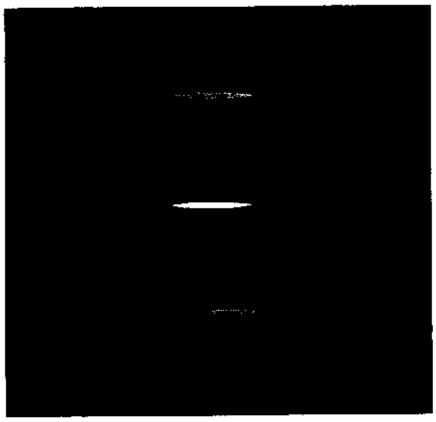


Fig. 4.3 (full size)

(i) Calculate the angle between the two first orders of the diffracted light.

angle = ... ° [2]

(ii) Using your answer to **(i)**, determine the number of nylon threads per millimetre.

number of threads per millimetre = ... [2]

5 Four point charges, each of magnitude q, are placed at the corners of a square ABCD of side a as shown in Fig. 5.1 below.

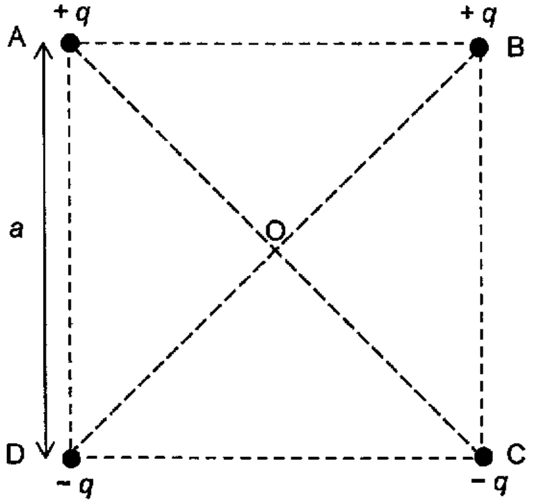


Fig. 5.1

Point O is the centre of the square.

(a) Define *electric field strength* at a point.

....

....

.... [1]

(b) (i) On Fig. 5.1, draw and label an arrow to show the resultant electric field strength E at O.

[1]

(ii) Show that the electric field strength at O is $\dfrac{\sqrt{2}q}{\pi\varepsilon_o a^2}$.

[3]

(c) A positively charged particle is projected into the square along a line that lies in the plane of the square as shown in Fig. 5.2. The line bisects the side AB.

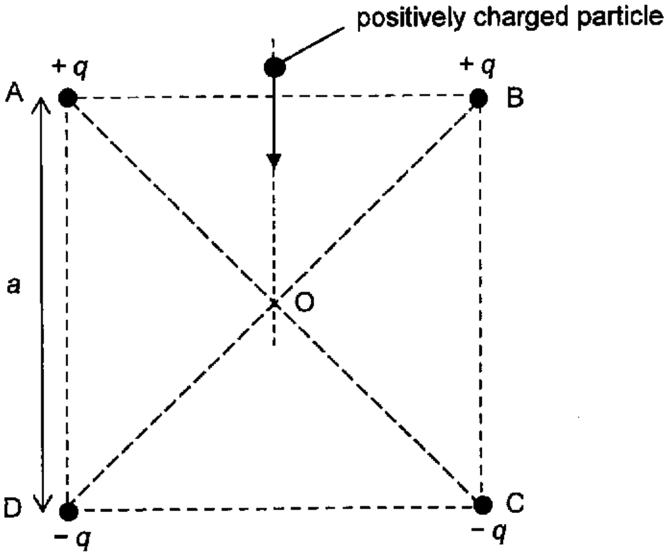


Fig. 5.2

Describe the motion of the particle after passing AB.

....

....

.... [2]

(d) Determine in terms of q, a and ε_o, the minimum kinetic energy required for the charge at C to move to infinity.

minimum kinetic energy = ... [3]

6 **(a)** A solenoid is connected to a variable d.c. supply as shown in Fig. 6.1.

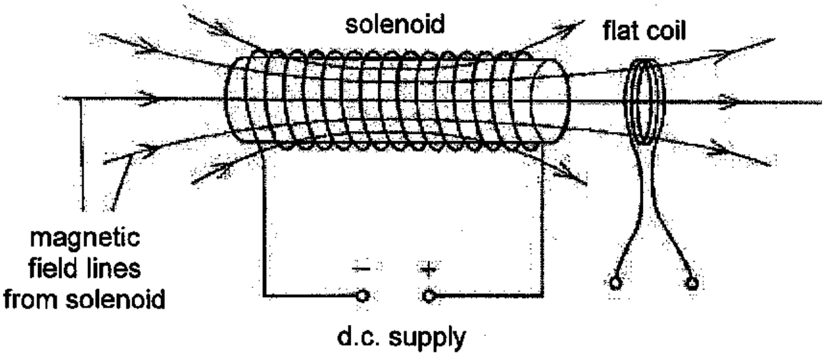


Fig. 6.1

A flat coil of diameter 6.4 cm and 180 turns is placed close to one end of the solenoid. The coil has a resistance of 1.5 Ω. The current in the solenoid is reduced. Fig. 6.2 shows the variation of the magnetic flux density B at right angles to the plane of the coil with time t.

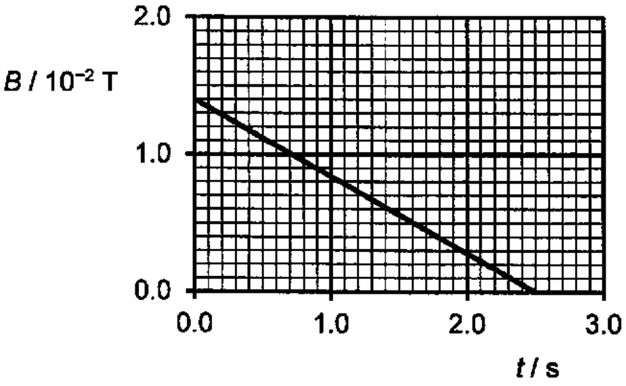


Fig. 6.2

(i) Use Fig. 6.2 to explain why the induced e.m.f. across the ends of the coil has a constant value from t = 0 s to t = 2.5 s.

....

....

....

.... [2]

(ii) Calculate the magnitude of the charge that flows through the coil from $t = 0$ s to $t = 2.5$ s.

charge = ... C [3]

(b) Fig. 6.3 shows a transformer circuit.

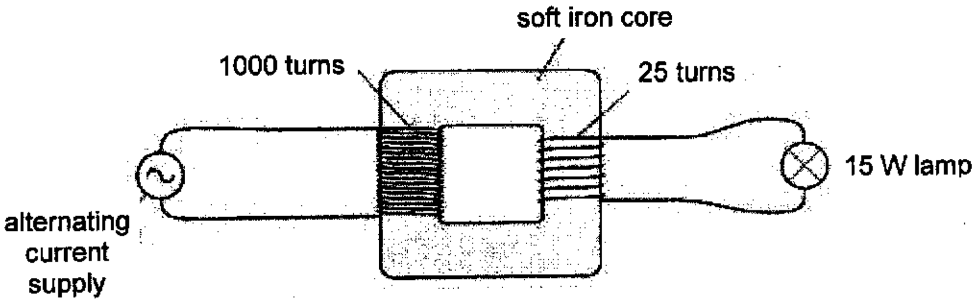


Fig. 6.3

The primary coil has 1000 turns and the secondary coil 25 turns. A lamp is connected to the output of the secondary coil. The potential difference across the lamp is 6.0 V and the lamp dissipates 15 W. The transformer has an efficiency of 100%.

(i) Calculate the current in the primary circuit.

current = ... A [2]

(ii) The alternating voltage supply is replaced by a battery.

Explain why the p.d. across the lamp increases but becomes zero some time after the battery is connected.

....

....

.... [2]

7 **(a)** Some of the energy levels of a particular atom X are shown in Fig. 7.1.

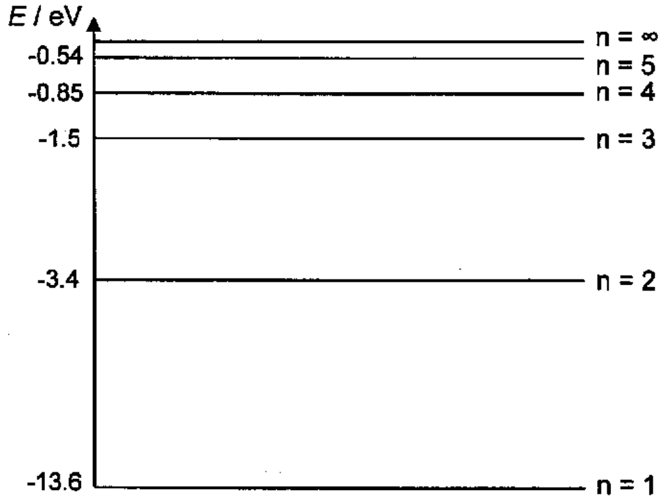


Fig. 7.1

(i) State the ionisation energy of atom X.

ionisation energy = ... eV [1]

(ii) Cool vapour of X at low pressure is bombarded with electrons of kinetic energy 2.00×10^{-18} J.

Determine the number of different wavelengths of radiation that will be emitted.

number of wavelengths = ... [2]

(iii) The electrons in **(ii)** were replaced with photons of the same energy to bombard the cool vapour of X.

Suggest the number of different wavelengths of radiation that will be emitted. Explain your answer.

....

....

.... [2]

(b) An X-ray spectrum is first produced by an X-ray tube with tungsten. Another X-ray spectrum is then produced using barium and both spectra are shown in Fig. 7.2.

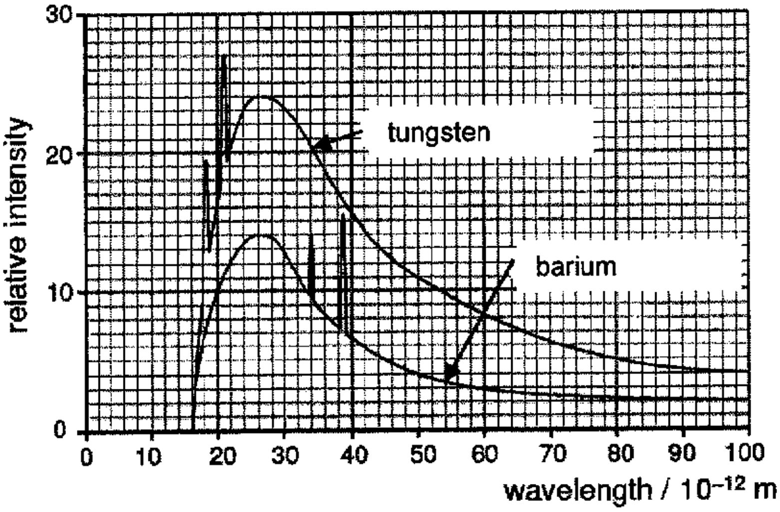


Fig. 7.2

(i) The accelerating potential used to produce the X-ray spectra using tungsten and barium are the same.

By reference to Fig. 7.2, state a feature how this can be deduced.

.... [1]

(ii) Hence, determine the accelerating potential.

accelerating potential = ... V [2]

Section B

Answer **one** question from this section.

8 **(a)** Explain why a body moving with uniform speed in a circle must experience a force towards the centre of the circle.

....

....

....

.... [2]

(b) A small ball of mass m is moving in a horizontal circle on the inside surface of a frictionless hemispherical bowl. The normal reaction force N makes an angle θ to the horizontal and is directed along QO, which is the radius of the bowl. The radius of the bowl is 8.0 cm and θ is 22°.

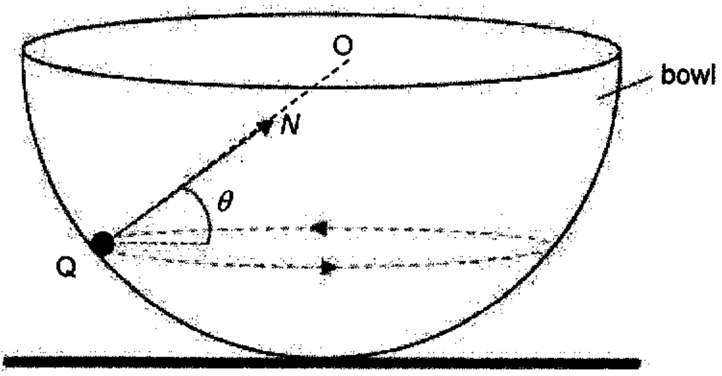


Fig. 8.1

(i) Determine the speed of the ball.

speed = ... m s^{-1} [4]

[Turn over

(ii) Explain whether this ball can move on a horizontal circular path of radius equal to the radius of the bowl.

....

....

.... [1]

(c) A planet has radius R. At a distance h above the surface of the planet, the gravitational field strength is g and the gravitational potential is ϕ.

(i) Define *gravitational potential* at a point.

....

....

....

.... [2]

(ii) Show that $\phi = -g(R+h)$.

[2]

(iii) A space probe moves past the planet with speed *u* as shown in Fig. 8.2.

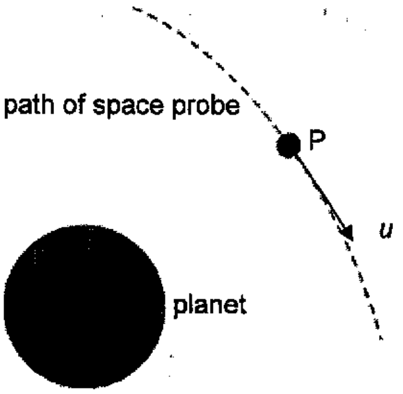


Fig. 8.2

The radius *R* of the planet is 3.3×10^6 m. A point P, located at 1.4×10^7 m above the surface of the planet, has a gravitational field strength of 0.15 N kg^{-1}.

Determine the minimum value of *u* such that the space probe at point P is just able to escape from the gravitational attraction of the planet.

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

(iv) The variation with distance r (in terms of radius R of the planet) from the centre of the planet of the gravitational potential ϕ is as shown in Fig. 8.3.

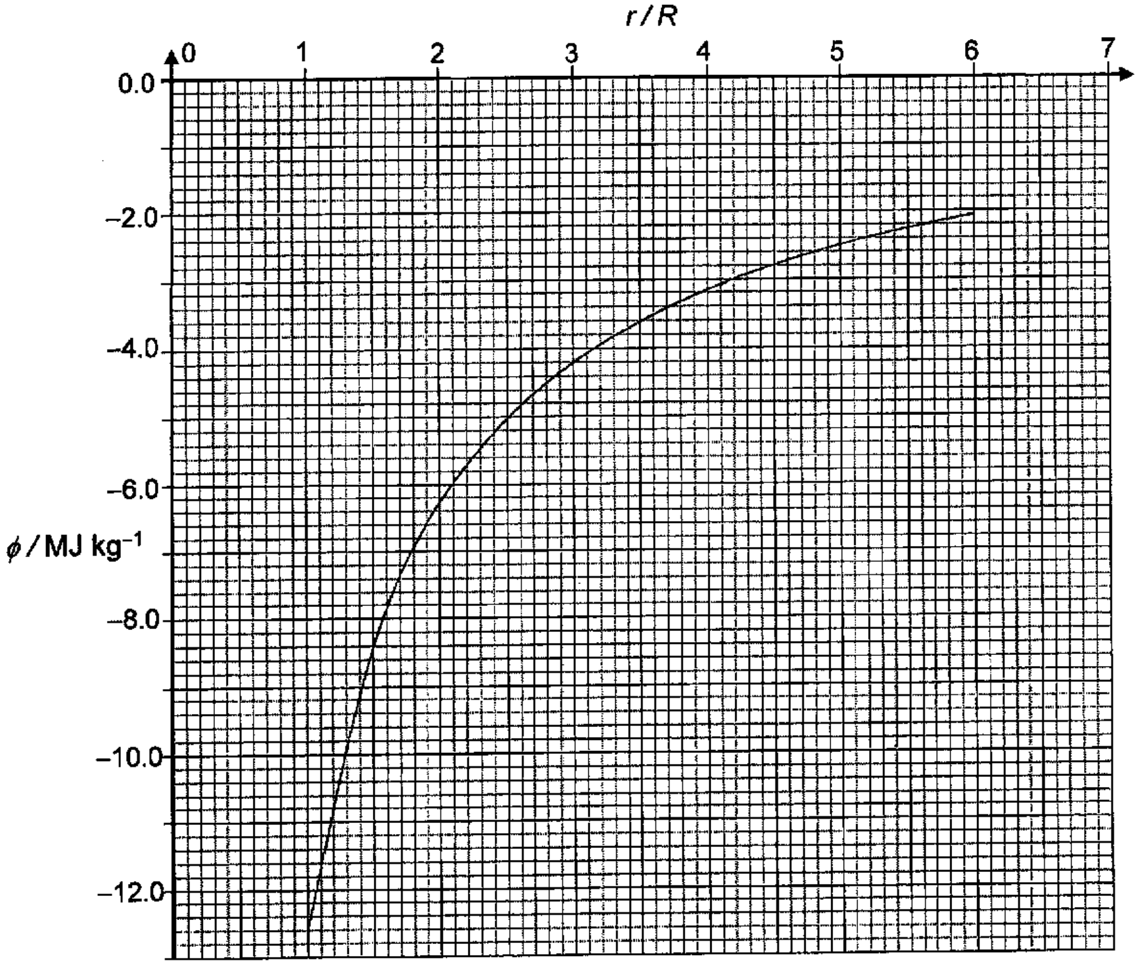


Fig. 8.3

A rocket of mass 1.2×10^4 kg lifts off from the surface of the planet.

1. Determine the change in gravitational potential energy of the rocket when it reaches a distance $4R$ from the centre of the planet.

change = ... J [2]

2. Determine the magnitude of the gravitational field strength at a distance 4*R* from the centre of the planet.

magnitude = ... N kg^{-1} [2]

3. Using the answer from **2.**, calculate the magnitude of the gravitational field strength at the surface of the planet.

magnitude = ... N kg^{-1} [2]

9 **(a)** Define the *volt*.

....

.... [1]

(b) By reference to energy transfers, distinguish between e.m.f. and p.d.

e.m.f. ....

....

p.d. ....

.... [2]

(c) The current flowing through a light bulb can be controlled by a potential divider as shown in Fig. 9.1.

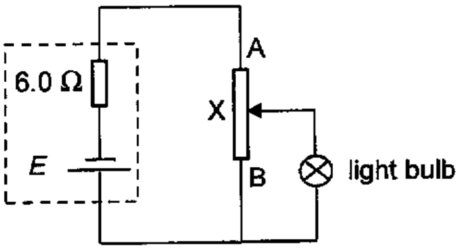


Fig. 9.1

AB is a potentiometer wire of uniform cross-sectional area with a total resistance of 16 Ω. It is connected to a battery of e.m.f. *E* and internal resistance 6.0 Ω and a light bulb. When the slider of the potentiometer wire is set at X, exactly mid-way along AB, the bulb has an operating power of 0.50 W and voltage of 2.0 V.

(i) Calculate the current through section XB of the potentiometer wire.

current = ... A [2]

(ii) Calculate the potential difference across section AX of the potentiometer wire.

potential difference = ... V [3]

(iii) Determine the e.m.f. *E* of the battery.

E = ... V [2]

(d) The current flowing through the light bulb can also be controlled using a variable resistor as shown in Fig. 9.2.

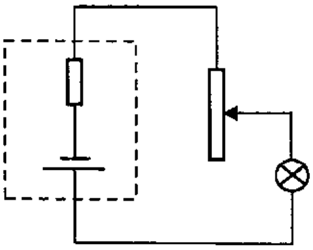


Fig. 9.2

State an advantage and disadvantage of using the variable resistor as compared to the potential divider in controlling the current through the light bulb.

....

....

....

.... [2]

(e) Fig. 9.3 shows two cells E_1 and E_2 of negligible internal resistances connected with a variable resistor R in a potentiometer circuit. AB is a uniform resistance wire.

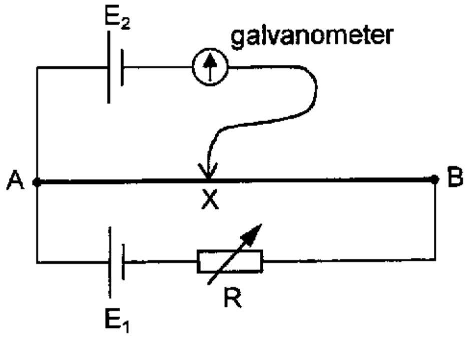


Fig. 9.3

(i) When the sliding contact is moved from A towards B, explain why a point X is found where the galvanometer gives zero deflection.

....

....

....

.... [2]

(ii) If the e.m.f. of E_1 is much larger than that of E_2, explain why this circuit is not suitable for comparison of the e.m.f. of the cells.

....

....

....

.... [2]

(f) Fig. 9.4 shows a potentiometer circuit with two cells E_1 and E_2 of negligible internal resistances for measuring a small e.m.f. produced by a thermocouple. Wire CD is 1.0 m long with a resistance of 2.0 Ω. Cell E_2 has an e.m.f. of 1.1 V and resistor R_1 has a resistance of 110 Ω. Both galvanometers show no deflection.

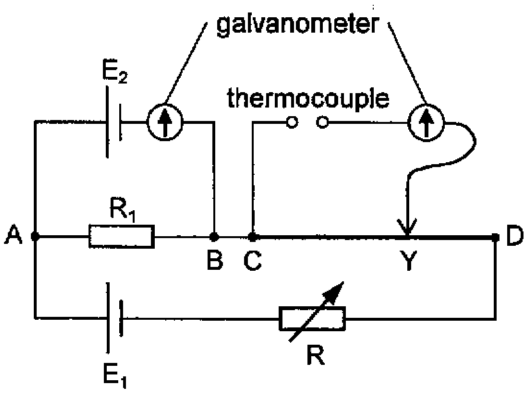


Fig. 9.4

(i) State the potential difference across AB.

potential difference = ... V [1]

(ii) The balance length CY is 72.5 cm.

Determine the e.m.f. of the thermocouple.

e.m.f. = ... V [3]

End of paper

Name	Class	Index Number

JURONG PIONEER JUNIOR COLLEGE
JC2 Preliminary Examination

PHYSICS **9749/04**
Higher 2

Paper 4 Practical

27 August 2019

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.

You will be allowed a maximum of one hour to work with the apparatus for Questions 1 and 2, and a maximum of one hour for Question 3. You are advised to spend approximately
30 minutes on Question 4.

Shift
Laboratory

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

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

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

For Examiner's Use	
1	/ 17
2	/ 5
3	/ 21
4	/ 12
Total	/ 55

This document consists of **19** printed pages.

[Turn over

1 In this experiment, you will investigate an electrical circuit.

(a) (i) You have been provided with a length of constantan wire attached to a metre rule, and a resistor Y of unknown resistance.

Connect the circuit as shown in Fig. 1.1.

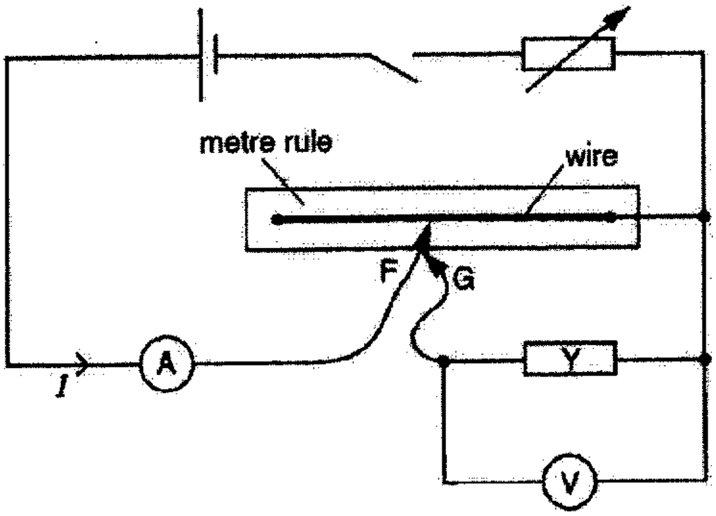


Fig. 1.1

F and G are crocodile clips.

(ii) Connect F to a point half-way along the wire. Connect G to F.

(iii) Place the slider of the rheostat at its mid-point.

(iv) Close the switch and record the voltmeter reading V_0 to the nearest 0.01 V.

V_0= ....[1]

(v) 1 Adjust the slider of the rheostat until the voltmeter reading just changes to (V_0 + 0.01) V.

Record the ammeter reading.

ammeter reading = ...

2 Adjust the slider of the rheostat until the voltmeter reading just changes to (V_0 – 0.01) V.

Record the ammeter reading.

ammeter reading = ...
[1]

(vi) Open the switch.

(b) The distance x between the end of the wire and F is shown in Fig. 1.2.

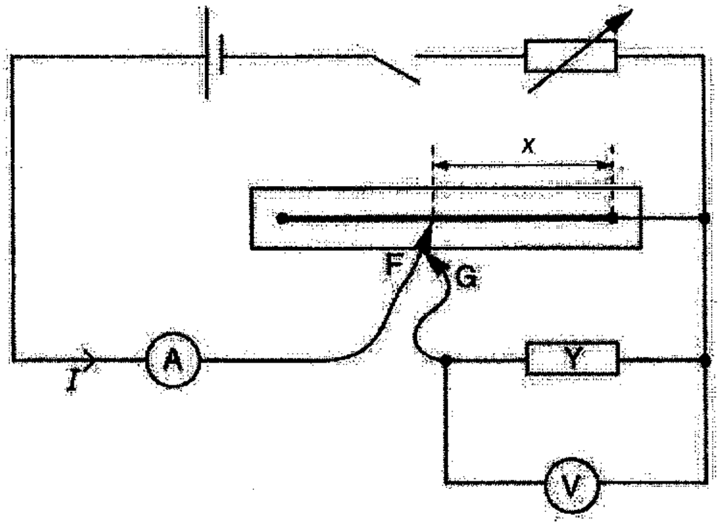


Fig. 1.2

(i) Move F so that x is approximately 30 cm.

(ii) Close the switch and adjust the slider of the rheostat until the voltmeter reading is equal to V_0.

(iii) Record x and the ammeter reading I.

x= ....

I= ....

[1]

(iv) Open the switch.

(c) Vary x and repeat **(b)(ii)**, **(b)(iii)** and **(b)(iv)** keeping the voltmeter reading equal to V_0 throughout.

[5]

(d) I and x are related by the expression

$$I = \frac{P}{x} + Q$$

where P and Q are constants.

Plot a suitable graph to determine the values of P and Q.

P = ...

Q = ...

[6]

(e) Theory suggests that

$$\frac{P}{Q} = L$$

where L is the length of wire that has the same resistance as resistor Y.

Calculate L.

L = ... [1]

(f) **(i)** Remove Y from the circuit and replace it with a wire of length L from the wire wound on the card. **Do not cut the wire**.

(ii) Connect F to a point half-way along the wire on the metre rule.

Repeat **(b)(ii)**, **(b)(iii)** and **(b)(iv)**.

x = ...

I = ...

(iii) Use your values in **(f)(ii)** to plot another point on your graph.

Label this point Z.

(iv) State whether this point agrees with the pattern of the other points on your graph.

Use your values in **(a)(v)** to justify your statement.

....

....

....

....

....

.... [2]

[Total: 17]

2 In this experiment, you will determine the spring constant of a spring.

(a) You have been provided with three identical springs, attached to a ring.

The length of an unstretched spring is S, as shown in Fig. 2.1.

Without disconnecting the springs, measure and record S for **one** of the springs.

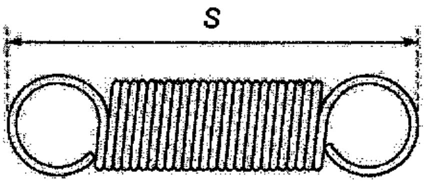


Fig. 2.1

S = ……………………………………

[Turn over

(b) (i) Set up the apparatus as shown in Fig. 2.2.

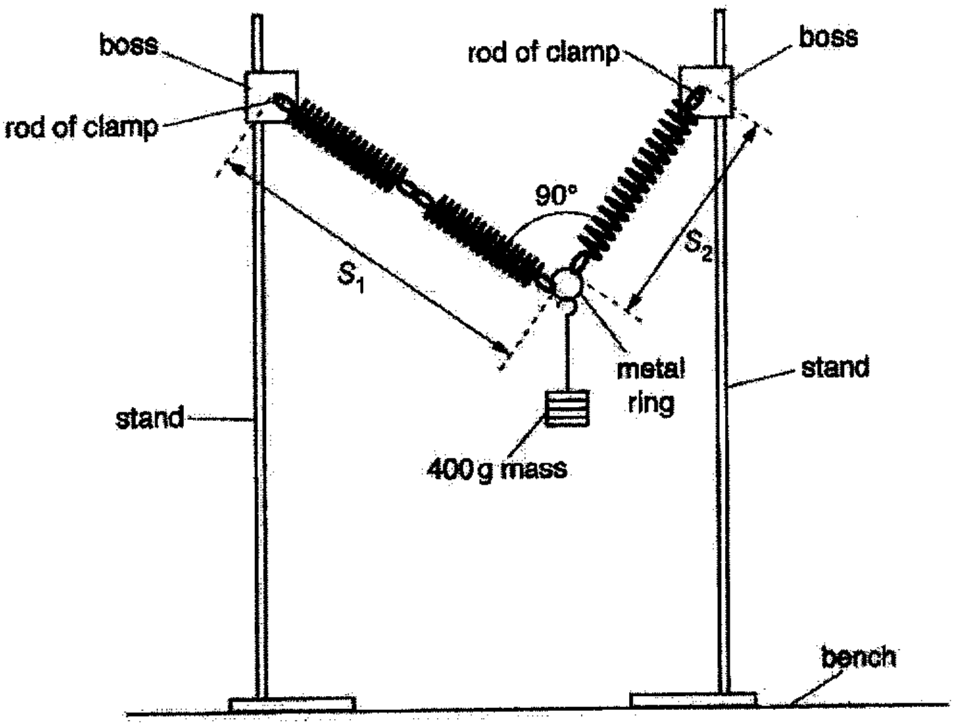


Fig. 2.2

Adjust the apparatus so that the angle between the springs is 90°.

The extended length of the double spring is S_1 and the extended length of the single spring is S_2.

Measure and record S_1 and S_2.

S_1 = ...

S_2 = ... [1]

(ii) The extensions are p and q where

$$p = S_1 - 2S \text{ and } q = S_2 - S.$$

Calculate p and q.

p = ...

q = ... [1]

(c) Theory suggests that

$$m^2g^2 = \frac{k^2p^2}{4} + k^2q^2$$

where m = 400 g, k is the spring constant of one of the springs and g = 9.81 m s^{-2}.

(i) Calculate$k$.

k = ... N m^{-1} [1]

(ii) If you were to repeat this experiment with other masses, describe the graph that you would plot to determine k.

....

....

....

....[2]

[Total: 5]

3 In this experiment, you will investigate the motion of an oscillating rule.

(a) **(i)** Balance the**metre rule** on the rod of the clamp, as shown in Fig. 3.1.

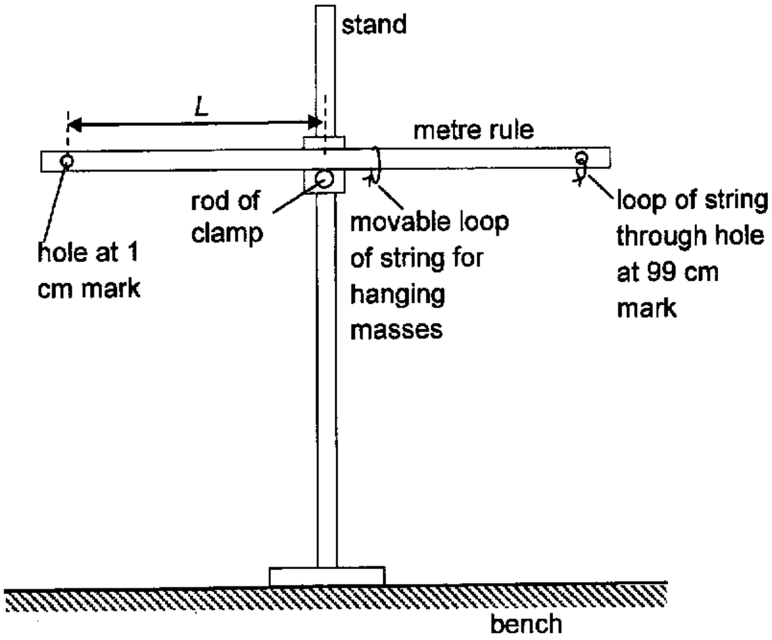


Fig. 3.1

(ii) Measure and record L, the distance from the hole at the 1 cm mark to the centre of gravity(c.g.) of the rule, as shown in Fig. 3.1.

L = ... [1]

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

percentage uncertainty in L = ... [1]

(iv) Measure and record M, the mass of the rule.

M = ... [1]

(b) Fig. 3.2 shows a spring attached to a loop of string with a paper clip at one end.

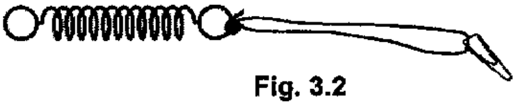


Fig. 3.2

(i) Set up the apparatus as shown in Fig. 3.3.

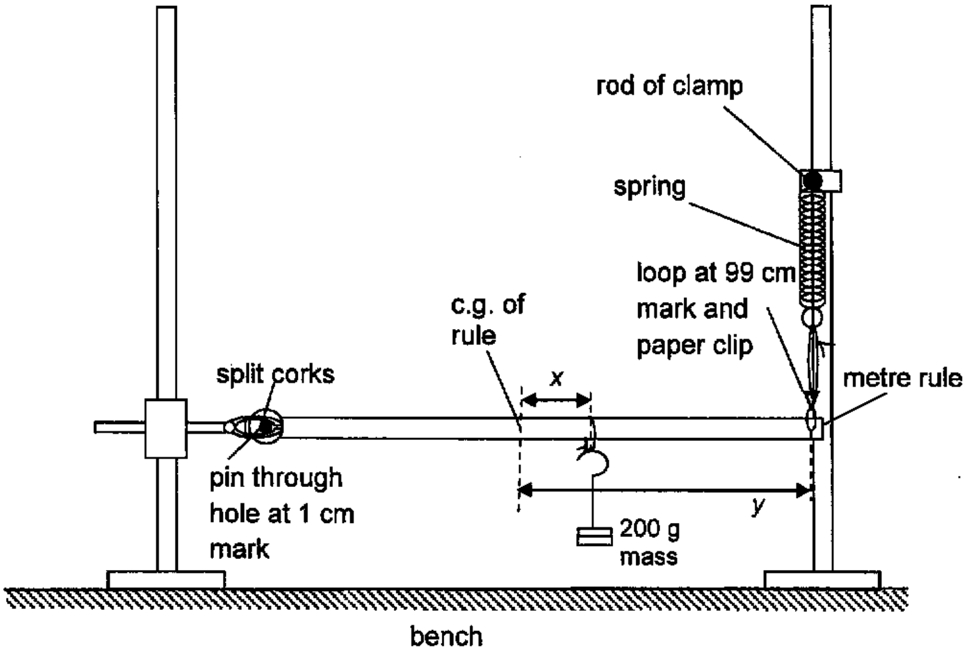


Fig. 3.3

(ii) Adjust the movable loop with the 200 g mass until x is around 15 cm. Adjust the apparatus until the spring and loop are vertical and the rule is horizontal. Ensure that the 200 g mass is further from the pin than the c.g. of the rule. The rule should be able to oscillate about the pin held by the split corks.

(iii) Measure and record$x$ and y.

x= ....

y= ....

[1]

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

percentage uncertainty in x= ....[1]

(c) Pull the 200 g mass down slightly and release. The rule will oscillate. Determine the period *T* of the oscillations.

T= ....[2]

(d) Increase *x* and repeat steps **(b)(iii)** and **(c)**.

x= ....

T= ....
[2]

(e) It is suggested that $x$and T are related by the expression

$$T = k\sqrt{M + \frac{x}{y}m}$$

where k is a constant and$m$ is the 200 g hanging mass.

(i) Use your values from **(a)(iv)**, **(b)(iii)**, **(c)**and **(d)** to determine two values of k.

Give your values of k to an appropriate number of significant figures.

first value of k = ...

second value of k = ...

[2]

(ii) State whether the results of your experiment support the suggested relationship in **(e)**.

Justify your conclusion by referring to your values in **(a)(iii)** and **(b)(iv)**.

....

....

....

....[1]

(f) **(i)** You will now determine two more values of *k* using:

- the**half metre rule** with a loop of string through a hole at the 49 cm mark as shown in Fig. 3.4
- the**metrerule** with a loop of string through a hole at the 49 cm mark as shown in Fig. 3.5.

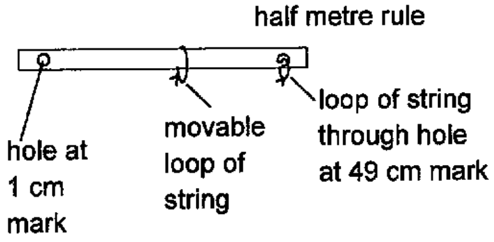


Fig. 3.4

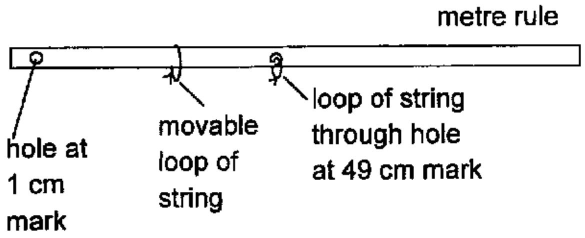


Fig. 3.5

x and y are measured from the 25 cm mark of both rules.

Ensure that the 200 g mass is further from the pin than the 25 cm mark of both the rules.

The value of x and y must be the **same** in both cases and the spring must be attached to the rule at the 49 cm mark.

You may take M, the mass of the **half metre rule** as 50.0 g.

Tabulate your results.

[3]

(ii) Comment on your values of k in **(e)(i)** and **(f)(i)**.

....

....

....

....

....

....[2]

(g) The behavior of the oscillating system depends on the location of the hole through which the loop is threaded.

It is suggested that the period T is inversely proportional to y, the distance between the c.g. of the rule and the hole which the loop is threaded through.

Explain how you would investigate this relationship using the half metre rule.

Your account should include:
- your experimental procedure
- control of variables
- how you would use your results to show inverse proportionality

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....**[4]**

[Total: 21]

4 Fig. 4.1 shows a copper rod and two steel bars.

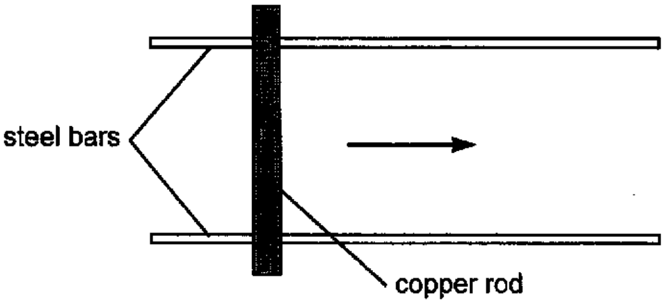

Fig. 4.1

When the rod moves at constant speed along the bars, a constant current is induced in the copper rod when the apparatus:

- forms part of a closed circuit
- is placed in a uniform magnetic field.

The value of the current I, using a copper rod of diameter d moving at speed v is

$$I = E d^p v^q$$

where E, p and q are constants.

Design an experiment to determine the values of p and q.

You are provided with some copper rods of different diameters.

Draw a diagram to show the arrangement of your apparatus. Pay particular attention to:

(a) the equipment you would use,

(b) the procedure to be followed,

(c) how you would produce a uniform magnetic field,

(d) the control of variables,

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

Diagram

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[12]

[Total: 12]

End of paper

2019 Physics Prelim Practical Exam Apparatus List

Question 1

1. One 1.5 V dry cell in holder
2. One switch
3. One resistor labelled Y
4. A length of resistance wire attached to a metre rule
5. A length of resistance wire coiled around a card (<u>to be coiled back after use</u>)
6. Nine connecting leads
7. One 0 – 200 mA digital ammeter
8. One 0 – 20 V digital voltmeter
9. One sliding rheostat

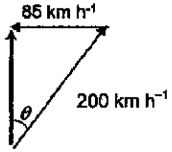
Question 2

1. Two stands
2. Two bosses
3. Two clamps
4. Three identical springs connected to a metal ring
5. One 100 g mass hanger
6. Three 100 g masses
7. One set square
8. One 30 cm ruler
9. Heavy weights

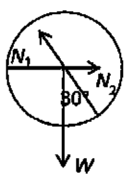
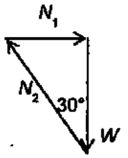
2019 Physics Prelim Practical Exam Apparatus List

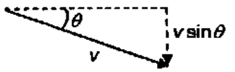
Question 3

1. One metre rule with three loops of thread (tied at 49 cm, 99 cm and a movable one)
2. One half metre rule with two loops of thread (tied at 49 cm and a movable one)
3. One spring attached to a loop of thread and a paper clip
4. One 100 g mass hanger
5. One 100 g mass
6. One pin
7. Two retort stands
8. Two sets of bosses and clamps
9. One stopwatch
10. Two split corks

Qn	Ans	Suggested Solution
1	B	Option A, C and D have the same units as force
2	C	$\theta = \sin^{-1}(\frac{85}{200}) \approx 25°$ 25°East of North 
3	C	The mean value for C is 15.0 cm; it is accurate. The measurements are not close; it is not precise.
4	D	Sign convention: upwards as positive Option A: Incorrect – acceleration should be negative Option B: Incorrect – velocity should be negative Option C: Incorrect – displacement should be positive Option D: Correct
5	D	$78 = \frac{1}{2}(9.81)t^2$ $t = 3.988$ s Time taken for sound to travel from water surface to person = $\frac{78}{330} = 0.236$ s Therefore time interval = 3.988 + 0.236 = 4.2 s
6	D	At maximum height, the velocity is horizontal. Kinetic energy $= \frac{1}{2}(0.20)(5.0\cos 30°)^2 = 1.9$J
7	A	Vertical: $h = \frac{1}{2}gt^2$ Horizontal: $r = u_x t$ Therefore $h = \frac{1}{2}g\left(\frac{r}{u_x}\right)^2$ $r = u_x\sqrt{\frac{2}{g}}\sqrt{h}$ A graph as shown in option A is obtained by sketching a graph of r against h.
8	D	By definition. The forces experienced by the wires are of the same nature, equal in magnitude, opposite in direction and acting on each other.
9	D	$\sum F = ma$ $4 + 5(9.81) = 5a$ $a = 10.6$ m s^{-1}

[Turn over

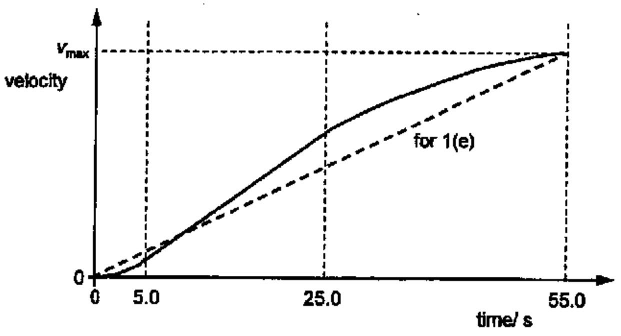
Qn	Ans	Suggested Solution
10	A	Assuming mass of water in 1s, Δp in 1s $= \frac{90}{60} \times 20 = 30$ kg m s^{-1} $\therefore F = \frac{\Delta p}{t} = 30$ N
11	A	By conservation of momentum, $p_i = p_f$ $5m - 15m = mv_2 - 3m$ $v_2 = -7$ m s^{-1}
12	C	Assume that the horizontal force at the top hinge is to the right, Taking moment about bottom hinge, $(T\sin\theta)d + (T\cos\theta)d = R_x(d) + W(0.5d)$ $(150\sin 30°)0.50 + (150\cos 30°)0.50 = R_x(0.50) + 20(9.81)(0.5)(0.50)$ $R_x = 107$ N (to the right)
13	C	  Resolving the forces, $N_2 \sin 30 = N_1$ (1) $N_2 \cos 30 = W$ (2) $\frac{(1)}{(2)}$: $\tan 30 = \frac{N_1}{W}$ $N_1 = W\tan 30 = 15\tan 30 = 8.66 = 8.7$ N (2s.f.) (Alternative: Using vector triangle) $N_1 = W\tan 30 = 15\tan 30 = 8.66 = 8.7$ N (2s.f.)
14	B	By conservation of energy, elastic potential energy is converted to kinetic energy and work done against friction. As height is the same at initial and final positions, gravitational potential energy is unchanged. $EPE_{loss} = KE_{gain} + WD_{friction}$ $\frac{1}{2}kx^2 = (KE_{final} - KE_{initial}) + fd$ $KE_{final} = \frac{1}{2}kx^2 - fd$ $(KE_{initial} = 0)$

Qn	Ans	Suggested Solution
15	D	 rate of heat dissipation P = rate of loss of GPE $P = mgv\sin\theta$
16	A	$\frac{GM_{star}m_{planet}}{R^2} = m_{planet}R\omega^2$ $\frac{GM_{star}}{R^3} = \left(\frac{2\pi}{T_{period}}\right)^2$ $\left(T_{period}\right)^2 \propto R^3$ $\frac{T^2}{r^3} = \frac{T_Y^2}{(4r)^3}$ $\therefore T_Y^2 = 64T^2$ $T_Y = 8T$ Thus Y completes only of $\frac{1}{8}$ an orbit for every 1 orbit of X.
17	B	For the particle moving with constant angular velocity, the speed is constant hence the KE is constant. However the direction keeps changing hence the velocity varies.
18	C	$I = \frac{Q}{t} = \frac{nq}{T} = \frac{nq}{1/f} = nqf$
19	B	The e.m.f. of the battery is 12 V and the terminal p.d. is 8.0 V. $I = \frac{8.0}{2.0} = 4.0$ A $E = V + Ir$ $12 = 8.0 + 4r$ $r = 1.0\ \Omega$
20	A	The wires in the cable are like resistors in parallel. $R_{wire} = \frac{(1.7\times10^{-8})(120)}{5.0\times10^{-6}} = 0.408$ $R_{cable} = \frac{0.408}{16} = 0.026\ \Omega$
21	B	When a third bulb is connected in parallel to the first two, there is no change in the p.d. across all the bulbs. Hence, the brightness remains the same based on $P = V^2 / R$. However, the effective resistance of the circuit decreases hence the current supplied by battery increases.
22	A	Between X and Y, the network is made of parallel resistors of resistance 70 Ω, 70 Ω, (40+20+80=140) Ω and (50+30+60=140) Ω. By proportionality, the 1.5 A current is divided into 6 parts, i.e. 0.25 A. Current of 0.50 A flows through each of the two 70 Ω resistors. Currents each of 0.25 A flow through the (40+20+80=140) Ω and (50+30+60=140) Ω. Resistors respectively. Hence, the current in 30 Ω resistor is 0.25 A.
23	A	Let R_{eff} be the effective resistance across 1000 Ω resistor and voltmeter. $\frac{1}{R_{eff}} = \frac{1}{1000} + \frac{1}{8000}$ $R_{eff} = 888.9\ \Omega$ $V = \frac{888.9}{888.9 + 2000} \times 5.0$ $= 1.54$ V
24	A	$Bqv = \frac{mv^2}{r}$ $Bq = \frac{mv}{r}$ $\frac{v}{r} = \frac{Bq}{m}$ $\frac{2\pi}{T} = \frac{Bq}{m}$ $T = \frac{2\pi m}{Bq}$ Period is independent of the speed of the particle.
25	B	Total torque, $\tau = F \times d$ $\tau = NBIL \times d$ $\tau = 20 \times 2.0 \times 15 \times \frac{5.0}{100} \times \frac{5.0}{100} \cos 30°$ $\tau \approx 1.3$ Nm
26	D	The magnetic field due to current flowing in the wire should add up vectorially with the Earth's magnetic field to produce the resultant field.
27	A	The deflection ofα-particles through very large angles imply that they have struck something heavy, indicating that most of the mass of the atom is concentrated there in the nucleus of the atom which is small relative to the size of the atom.
28	D	${}^{23}_{11}\text{Na} + {}^{4}_{2}\text{He} \rightarrow {}^{27}_{13}Al + \gamma$
29	A	When $\frac{7}{8}$ of the nuclei of X have decayed, 3 half-lives of X have passed. When $\frac{3}{4}$ of the nuclei of Y have decayed, 2 half-lives of Y have passed.

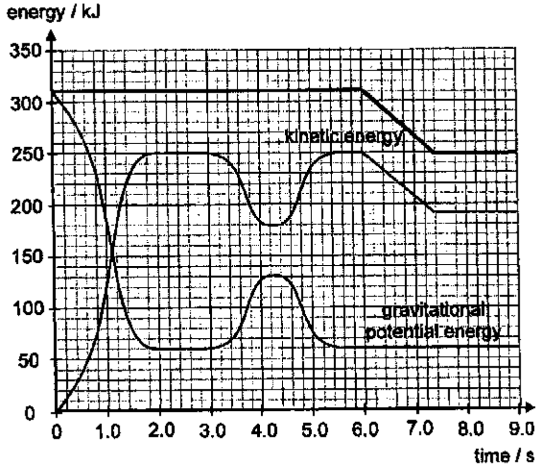
Qn	Ans	Suggested Solution
		Therefore $\dfrac{\text{half-life of X}}{\text{half-life of Y}} = \dfrac{2}{3}$
30	B	The decay sequence involves 2 α-decays and 2 β-decays. $^{222}_{86}\text{Rn} \rightarrow {}^{218}_{84}\text{Po} \rightarrow {}^{214}_{82}\text{Pb} \rightarrow {}^{214}_{83}\text{Bi} \rightarrow {}^{214}_{84}\text{Po}$

Answers to 2019 JC2 Preliminary Examination Paper 2 (H2 Physics)

Suggested Solutions:

No.	Solution	Remarks
1(a)	Any two: Air resistance varies with speed of aeroplane. Frictionrunway exerts on aeroplane varies. Mass of fuel in aeroplane decreases during take-off.	[2] 1 mark for each correct answer
1(b)	By Newton's 2nd law, Change in momentum of the aeroplane = area under the graph = final momentum – initial momentum = final momentum at take-off - 0 Momentum $=\left(\frac{1}{2}\times 5.0\times 1.13\times 10^5\right)+\left(20.0\times 1.13\times 10^5\right)+$ $\left[\frac{1}{2}(1.13+0.97)\times 10^5\times 30.0\right]$ $=5.693\times 10^6$ $\approx 5.69\times 10^6$ N s	[1] for using area under graph [1] for correct expression and numerical substitution [1] for correct answer
1(c)	Using $p=mv$, $v_{max}=\frac{p}{m}$ $=\frac{5.693\times 10^6}{7.45\times 10^4}$ $=76.42$ ≈ 76.4 m s^{-1}	[1] for correct answer
1(d)		

[Turn over

No.	Solution	Remarks
	Note: [1] Curve of increasing gradient from origin and line of constant gradient between 5.0 and 25.0 s. [1] Line of decreasing positive gradient after 25.0 s.	
1(e)	Distance = area under graph $= \frac{1}{2} \times 76.42 \times 55.0$ $= 2101$ ≈ 2200 m (Method is underestimation, refer to Fig. 3.2) Accept 2000 – 3000 m	[1] for correct estimation method [1] for correct answer
2(a)		[1] horizontal line from$t = 0$ s to $t = 6.0$ s, with mechanical energy at 310 kJ [1] straight line joiningpoints (6.0,310) and (7.4, 250), followed by horizontal line from $t =$ 7.4 s to$t =$ 9.0 s, with mechanical energy at 250 KJ
2(b)	From the Fig 2.2, t = 3.0 s to t = 4.3 s, the increase in gravitational potential energy is $\Delta GPE = 130 - 60$ $= 70$ kJ $mg\Delta h = 70000$ $\Delta h = \frac{70000}{380 \times 9.81}$ $= 18.778 \approx 19$ m The increase in height, and therefore the diameterdof loop, is 19 m.	[1] for correct substitution [1] for correct answer

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No.	Solution	Remarks
2(c)(i)	start time = 6.0 s end time = 7.4 s	[1] for correct start and end times.
2(c)(ii)	rate of loss of KE $= \frac{\text{loss of KE}}{\text{duration in zone A}}$ $= \frac{(250-190)\times 10^3}{7.4-6.0}$ $= 42857$ W ≈ 43000 W	[1] for correct substitution [1] for correct answer
2(c)(iii)	From Fig 2.2, the car enters zone A with a KE of 250 kJ, $\frac{1}{2}mv^2 = 250\ 000$ $v = \sqrt{\frac{2(250\ 000)}{380}}$ $= 36.274 \approx 36.3$ m s^{-1}	[1] for correct substitution [1] for correct answer
2(c)(iv)	Using $P = Fv$, $F = \frac{P}{v}$ $= \frac{42\ 857}{36.274}$ $= 1181.49$ ≈ 1200 N	[1] for correct substitution [1] for correct answer
3(a)	Internal energy is determined by the state of the system and it can be expressed as the sum of a random distribution of kinetic and potential energies associated with the molecules of the system.	[1] for correct answer
3(b)	$p = \frac{1}{3}\rho\langle c^2\rangle$ $= \frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$ $\Rightarrow pV = \frac{1}{3}Nm\langle c^2\rangle$..........(1) Subst $pV = nRT$ into (1) $\frac{1}{3}Nm\langle c^2\rangle = nRT$ $\Rightarrow \frac{1}{2}m\langle c^2\rangle = \frac{3}{2}\frac{n}{N}RT$.......... (2) $\Rightarrow E_k \propto T$ Hence, the average kinetic energy of a molecule of an ideal gas	[1] for showing the derivation of equation (1) [1] for equating ideal gas equation correctly and correct workings.

<table>
<tr><th>No.</th><th>Solution</th><th>Remarks</th></tr>
<tr><td></td><td>is proportional to its thermodynamic temperature T.</td><td></td></tr>
<tr><td>3(c)(i)1.</td><td>Using $\Delta U = Q + W_{on}$ and $U = \frac{3}{2}nRT$,
$\frac{3}{2}nR\Delta T = Q + (0)$ ($\because$ B $\rightarrow$ C constant volume)
$\frac{3}{2}(0.024)(8.31)\Delta T = 250$
$\Delta T = 835.67$ K
$\therefore T = 976 + 835.67 \approx 1810$ K</td><td>[1] for showing $\Delta U = Q + W_{on}$ $\frac{3}{2}nR\Delta T = Q + (0)$
[1] for correct substitution and ΔT
[1] for correct T</td></tr>
<tr><td>3(c)(i)2.</td><td>Using $pV = nRT$,
$p = \frac{nRT}{V}$
$= \frac{0.024 \times 8.31 \times 1811.67}{0.32 \times 10^{-4}}$
$= 11291233$
$\approx 1.13 \times 10^{7}$ Pa</td><td>[1] for correct answer</td></tr>
<tr><td>3(c)(ii)</td><td><table>
<tr><th>change</th><th>heat supplied to gas / J</th><th>work done by gas / J</th><th>increase in internal energy / J</th></tr>
<tr><td>A to B</td><td>0</td><td>–200</td><td>200</td></tr>
<tr><td>B to C</td><td>250</td><td>0</td><td>250</td></tr>
<tr><td>C to D</td><td>0</td><td>350</td><td>–350</td></tr>
<tr><td>D to A</td><td>–100</td><td>0</td><td>–100</td></tr>
</table></td><td>[3] for all correct answers
Deduct 1 mark for every 2 wrong answers</td></tr>
<tr><td>4(a)(i)</td><td>The magnetic force provides the centripetal force required to keep the particle in a circular path.
$Bqv = \frac{mv^2}{r}$
$r = \frac{mv}{Bq}$
$= \frac{(9.11 \times 10^{-31})(5.0 \times 10^{7})}{(1.2 \times 10^{-3})(1.60 \times 10^{-19})}$
$= 0.2372$
$= 0.24$ m</td><td>[1] for correct expression and numerical substitution
[1] for correct answer</td></tr>
<tr><td>4(a)(ii)</td><td>No.
The plane of the circular path is perpendicular to the axis of the solenoid.</td><td>[1] for correct answer
[1] for correct explanation</td></tr>
</table>

No.	Solution	Remarks
4(b)	As the radius decreases, the speed decreases too. The electron could be losing kinetic energy due to collision with air molecules (i.e. the space is not a perfect vacuum).	[1] for correct answer [1] for correct reason
4(c)	$F_B = F_E$ $Bqv = qE$ $E = Bv$ $= (1.2 \times 10^{-3})(5.0 \times 10^{7})$ $= 6.0 \times 10^{4}$ N C^{-1}	[1] for correct expression and numerical substitution [1] for correct answer
5(a)(i)	Work function energy is the minimum amount of energy needed to liberate an electron from the metal surface.	[1] for correct answer
5(a)(ii)	The photons each of same magnitude of energy (E=hf) are received by the electrons in the metal surface. The electrons nearest to the metal surface require the least amount of energy to be emitted as photoelectrons. Electrons deeper under the surface of the metal require more energy to be emitted. Hence, the emitted photoelectrons have a range of kinetic energies up to a maximum.	[1] for correct answer [1] for correct answer
5(a)(iii)	Using Einstein's photoelectric equation, $\frac{hc}{\lambda} = \Phi + \text{KE}_{max}$, $\lambda = \frac{hc}{\Phi + \text{KE}_{max}}$ $= \frac{6.63 \times 10^{-34} \times 3.00 \times 10^{8}}{\left(4.07 \times 1.60 \times 10^{-19}\right) + 3.65 \times 10^{-20}}$ $= 289.22 \times 10^{-9}$ m $\approx 2.89 \times 10^{-7}$ m	[1] for correct expression and numerical substitution [1] for correct answer
5(b)(i)	Time taken $= \frac{4.07 \times 1.60 \times 10^{-19}}{3.0 \times 10^{-22}}$ $= 2170.7$ ≈ 2170 s	[1] for correct answer
5(b)(ii)	Upon incident on the metal surface, the photons undergo 1 to 1 interaction with the electrons. The energy is transferred instantaneously to the electron which accounts for the instantaneous emission of electrons as photoelectrons without time lag. Hence, this interaction shows that electromagnetic radiation travels as photons which are discrete packets of energy.	[1] for correct answer [1] for correct answer

No.	Solution	Remarks
6(a)	Isotopes are nuclides with the same number of protons but different number of neutrons.	[1] for correct answer
6(b)(i)	The binding energy of a nucleus is the minimum amount of energy required to break the nucleus into its constituent particles. OR The binding energyof a nucleus is the energy released when a nucleus is formed from its constituent particles.	[1] for correct answer
6(b)(ii)	Binding energy of tritium $=3(2.83)=8.49$ MeV $8.49\times10^{6}\times1.60\times10^{-19}$ $=(1.00783u+2\times1.00867u-m)(3.00\times10^{8})^{2}$ $m=3.01608\ u$	[1] for BE of tritium [1] for correct substitution [1] for correct answer
6(c)(i)	${}^{2}_{1}\text{H} + {}^{2}_{1}\text{H} \rightarrow {}^{3}_{1}\text{H} + {}^{1}_{1}\text{H}$	[1] for correct answer
6(c)(ii)1.	BE of tritium – 2 × BE of deuterium = 4.03 MeV 8.49 – 2 × BE of deuterium = 4.03 MeV BE of deuterium = 2.23 MeV	[1] for correct substitution [1] for correct answer
6(c)(ii)2.	No. of reactions required per unit time $=\dfrac{2.86\times10^{9}}{4.03\times10^{6}(1.6\times10^{-19})}$ Mass of deuterium required per unit time $=\left[\dfrac{2.86\times10^{9}}{4.03\times10^{6}(1.60\times10^{-19})}\right](2\times2\times1.66\times10^{-27})$ $=2.95\times10^{-5}$ kg	[1] for no. of reactions [1] for correct substitution [1] for correct answer
7(a)	It is impossible to determine exactly which nucleus and exactly when a particular nucleus will disintegrate, although statistically, it is possible to predict the fraction of nuclei of a pure radioactive element that will decay after a certain length of time if its decay characteristics are known.	[1] for which nucleus [1] for when
7(b)	The half-life of a radioactive nuclide is the average time taken for a sample of the nuclide to decay to half its initial number of atoms/activity.	[1] for correct definition
7(c)(i)	${}^{131}_{53}\text{I} \rightarrow {}^{0}_{-1}e + {}^{131}_{54}\text{Xe}$	[1] for correct equation [1] for correct

No.	Solution	Remarks
		mass and atomic numbers of Xe
7(c)(ii)	At the start, Te-131 decays quickly toI-131 due to the short half-life as compared to the long half-life of decay of I-131. Hence, the activity decreases quickly as represented by PQ on the graph.	[1] for fast decay of Te-131 due to short half life [1] for quick decrease in activity
7(c)(iii)	$\text{gradient}=\dfrac{12.0-9.95}{0-3.0}$ $=-0.683$	[2] for correct gradient
7(c)(iv)1.	$A=A_0e^{-\lambda t}$ $\lg A=\lg A_0-(\lambda\lg e)t$ $\text{gradient}=-(\lambda\lg e)$ $=-0.683$ $\lambda=\dfrac{0.683}{\lg e}$ $=1.57\ \text{hr}^{-1}$ half-life, $t_{1/2}=\dfrac{\ln2}{\lambda}$ $=\dfrac{\ln2}{1.57}$ $=0.44$ hours (shown)	[1] for correct equation of graph [1] for correct decay constant [1] for correct half-life
7(c)(iv)2.	From the graph, $A_0=1.0\times10^{12}$ Bq $A_0=\lambda N_0$ $N_0=\dfrac{1.0\times10^{12}}{\dfrac{1.57}{60\times60}}$ $=2.29\times10^{15}$	[1] for correct expression and numerical substitution [1] for correct answer
7(c)(v)	The activity remains relatively constant after 6 hours. Almost all the Te must have decayed into I. The half-life of I is long, hence the activity remains constant for a long period of time as compared to Te.	[1] All Te decayed into I [1] The activity

No.	Solution	Remarks
		remains constant due to long half life
7(c)(vi)	$\lg A = 9.325$ $A = 2.11\times10^9$ Bq Since all Te decayed to I, $N_0 = 2.29\times10^{15}$ $A = \lambda N_0$ $2.11\times10^9 = \lambda\left(2.29\times10^{15}\right)$ $\lambda = 9.214\times10^{-7}\ \text{s}^{-1}$ $T_{1/2} = \dfrac{\ln 2}{9.214\times10^{-7}}$ $= 7.53\times10^5$ s $= 209$ hours	[1] for calculating activity of I [1] for correct decay constant of I [1] for correct half-life
7(d)	The activities of the radioactive nuclides in this question have very high values hence the background radiation would be negligible.	[1] for correct explanation
7(e)	No, although the nuclides have high activities which is dangerous but their half-lives are relatively short so they will decay into stable isotopes quickly.	[1] for correct answer [1] for relatively short half-lives

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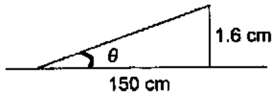
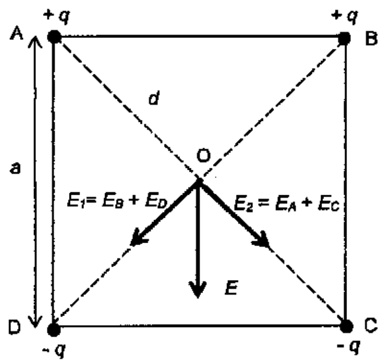
No.	Solution	Remarks
1(a)	Speed is a physical quantity and can only be defined in terms of other physical quantities. Distance is a physical quantity, but second is a unit for time which cannot be used to define speed. (A more appropriate definition for speed is distance travelled per unit time.)	[1] [1]
1(b)	Time to reach maximum height: $t = \dfrac{u\sin\theta}{g}$ $R = (u\cos\theta)(2t)$ $= (u\cos\theta)(2\dfrac{u\sin\theta}{g})$ $= \dfrac{2u^2\sin\theta\cos\theta}{g}$	[1] [1]
1(c)	Maximum R occurs when $\sin 2\theta = 1$. Hence $\theta = 45^\circ$	[1]
1(d)	$R_0 = \dfrac{u^2}{g}$ $g = \dfrac{u^2}{R_0}$ $= \dfrac{(12.6)^2}{16.3}$ $= 9.7399\ \text{m s}^{-2}$ $\dfrac{\Delta g}{g} = 2\dfrac{\Delta u}{u} + \dfrac{\Delta R_0}{R_0}$ $\dfrac{\Delta g}{9.7399} = \dfrac{2(3\%)+4\%}{100\%}$ $\Delta g = 0.97$ $= 1\ \text{m s}^{-2}$ Therefore, $g = (10 \pm 1)\ \text{m s}^{-2}$	[1] for calculating g [1] for calculating Δg [1]
2(a)(i)	Magnitude of change in GPE $= (2.6)(0.0060) = 0.0156$ J	[1] for correct substitution and correct answer
2(a)(ii)	Magnitude of change in EPE	[1] for correct substitution

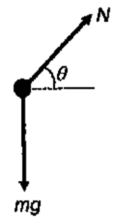
	$= \frac{1}{2}(0.0060)(2.6+4.0) = 0.0198$ J	[1] for correct answer
2(b)(i)	Total energy $= 0.0198 - 0.0156 = 0.0042$ J	[1] for correct substitution
2(b)(ii)	$0.0042 = \frac{1}{2}\left(\frac{2.6}{9.81}\right)\omega^2(0.60\times10^{-2})^2$ $\omega = 29.671$ rad s^{-1} $\omega \approx 30$ rad s^{-1}	[1] for correct substitution [1] for correct answer
2(c)	Loss in total energy = Work done against air resistance $\frac{1}{2}\left(\frac{2.6}{9.81}\right)(29.671)^2(0.0060^2 - 0.0040^2) = F_v(0.0060+0.0040)$ $F_v = 0.2333$ N $= 0.23$ N	[1] for correct application of conservation of energy [1] for correct substitution [1] for correct answer
3(a)	A longitudinal wave is a wave in which the oscillation of the particles is parallel to the propagation of the energy of the wave.	[1] for oscillations of particles
3(b)(i)	phase difference $= \frac{\text{path difference}}{\lambda}\times 2\pi$ $\frac{3}{2}\pi = \frac{6.38-5.25}{\lambda}\times 2\pi$ $\lambda = 1.51$ m	[1] for correct equation and substitution [1] for correct answer
3(b)(ii)	$v = f\lambda$ $= (220)(1.51)$ $= 331$ m s^{-1}	[1] for correct equation and substitution. [1] for correct answer
3(c)	$I = kA^2$ $3I = kA'^2$ $3kA^2 = kA'^2$ $A' = \sqrt{3}A$ resultant amplitude $= \sqrt{3}A + A = \left(\sqrt{3}+1\right)A$ resultant intensity $= k\left(\sqrt{3}+1\right)^2 A^2$ $= 7.46kA^2 = 7.46I$	[1] for amplitude of S_2 [1] for resultant amplitude [1] for resultant intensity
4(a)(i)	Path difference $= 2 \times 0.020$ $= 0.040$ m Path difference $= \frac{\lambda}{2}$	[1] for correct path difference

	$\lambda = 2 \times 0.040$ $= 0.080$ m	[1] for correct wavelength
4(a)(ii)	The sound waves from path LXM and LYM travel in opposite directions and meet. Since both waves are of equal amplitude, frequency and speed, they superpose to form a stationary wave.	[1] [1]
4(b)(i)	 $\theta = \tan^{-1}\left(\frac{1.6}{150}\right)$ $\theta = 0.61°$ angle between the two first orders $= 2\theta$ $= 2\tan^{-1}\left(\frac{1.6}{150}\right)$ $= 1.2°$	[1] for correct θ [1] for correct answer
4(b)(ii)	$d\sin\theta = n\lambda$ $d\sin 0.61° = 1(600\times10^{-9})$ $d = 5.6253\times10^{-5}$ m number of nylon threads per mm $= \frac{1\times10^{-3}}{d}$ $= \frac{1\times10^{-3}}{5.6253\times10^{-5}}$ $= 17.8$ ≈ 18	[1] for correct d [1] for correct answer
5(a)	Electric field strength at a point is the electric force per unit positive charge placed at that point.	[1]

5(b)(i) and (ii)	 Distance AO = BO = CO = DO = d, where $d = \frac{1}{2}\sqrt{a^2+a^2} = \frac{a}{\sqrt{2}}$ E_A, E_B, E_C and E_D are the electric field strength due to charges at A, B, C and D respectively. $E_A = E_B = E_C = E_D = \frac{q}{4\pi\varepsilon_o\left(\frac{a}{\sqrt{2}}\right)^2} = \frac{2q}{4\pi\varepsilon_o a^2}$ E_B and E_D are in the same direction while E_A and E_C are in the same direction. Thus $E_1 = E_B + E_D$ and $E_2 = E_A + E_C$ $E_1 = E_2 = \frac{4q}{4\pi\varepsilon_o a^2} = \frac{q}{\pi\varepsilon_o a^2}$ The resultant electric field strength at point O is $E = \sqrt{E_1^2 + E_2^2} = \frac{\sqrt{2}q}{\pi\varepsilon_o a^2}$	[1] draw E correctly [1] for $\frac{a}{\sqrt{2}}$ [1] for $\frac{2q}{4\pi\varepsilon_o a^2}$ [1]
(c)	The particle accelerates from AB towards CD along a straight path. Upon exiting CD, it decelerates.	[1] [1]
(d)	Potential at C is $V_C = V_A + V_B + V_D$ $= \frac{1}{4\pi\varepsilon_o}\left(\frac{q}{\sqrt{2}a} + \frac{q}{a} - \frac{q}{a}\right)$ $= \frac{q}{4\sqrt{2}\pi\varepsilon_o a}$ Minimum KE = change in p.e. as charge moves to infinity $= qV_C = \frac{q^2}{4\sqrt{2}\pi\varepsilon_o a}$	[1] for potential at C [1] for conservation of energy [1] for correct expression

6(a)(i)	From Fig. 6.2, there is <u>constant rate of decrease of magnetic flux density</u> at right angles to the plane of the coil. By Faraday's Law, <u>there is constant rate of decrease of magnetic flux linkage in the coil</u>. Hence, the induced e.m.f. across the ends of the coil is constant from $t = 0$ s to $t = 2.5$ s.	[1] for correct explanation [1] for correct explanation
6(a)(ii)	By Faraday's law, e.m.f. = rate of change of magnetic flux linkage $< E > = \frac{\Delta\Phi}{\Delta t} = \frac{\Delta(NBA)}{\Delta t}$ $< I > R = NA\frac{\Delta B}{\Delta t}$ $< I > \Delta t = \frac{NA\Delta B}{R}$ $\Delta Q = \frac{NA\Delta B}{R}\ \left(\because I\ \frac{\Delta Q}{\Delta t}\right)$ $= \frac{180\times\frac{\pi}{4}(6.4\times10^{-2})^2\times1.4\times10^{-2}}{1.5}$ $= 5.405\times10^{-3}$ $\approx 5.4\times10^{-3}$ C	[1] for $< E > = \frac{\Delta\Phi}{\Delta t}$ $= \frac{\Delta(NBA)}{\Delta t}$ [1] for correct expression and numerical substitution [1] for correct answer
6(b)(i)	Using $P = IV$, $I_s = \frac{P}{V} = \frac{15}{6.0} = 2.5$ A By $\frac{V_s}{V_p} = \frac{N_s}{N_p}$ and $V_sI_s = V_pI_p$, $I_p = \frac{N_s}{N_p}I_s$ $= \frac{25}{1000}\times2.5$ $= 0.0625$ $= 6.25\times10^{-2}$ A	[2]
6(b)(ii)	When the battery is first connected, <u>current increases instantaneously in the primary coil, giving rise to increase in magnetic flux linkage in secondary coil</u>. Hence, there is induced e.m.f. across the lamp. After some time, the <u>current in the primary coil is constant</u>. There is <u>no more change in magnetic flux density in secondary coil</u>. Hence, no e.m.f. across lamp.	[1] for correct explanation [1] for correct explanation

7(a)(i)	13.6 eV	[1] for correct answer
7(a)(ii)	KE of electrons $= \frac{2.00\times10^{-18}}{1.60\times10^{-19}}$ $=12.5$ eV Hence the highest state that the atom can be excited to is n=3.	[1] for correct highest state
	Only the following transitions are allowed From n =3 to n=2 From n =2 to n=1 From n =3 to n=1 Hence number of different wavelengths of radiation that can be emitted = 3	[1] for correct answer
7(a)(iii)	Zero.	[1]
	The energy of the photon does not match exactly any of the energies required for the atom to get excited from the ground state to higher excited state hence the photons incident will not be absorbed by the atom.	[1]
7(b)(i)	From the graph, minimum wavelength λ_{min} is the same for both spectra.	[1]
7(b)(ii)	KE lost by electron = energy of emitted X-ray photon $eV=\frac{hc}{\lambda_{min}}$ $\lambda_{min}=16\times10^{-12}$ m $V=\frac{hc}{e\lambda_{min}}=\frac{6.63\times10^{-34}\times3.00\times10^{8}}{1.60\times10^{-19}\times16\times10^{-12}}$ $=7.77\times10^{4}$ V	[1] for correct substitution [1] for correct answer
8(a)	The velocity changes as the direction of motion changes with time. So the motion is accelerated. By Newton's second law, a resultant force must be acting on it.	[1]
	Since there is no change in its speed, there is no component of resultant force tangential to the motion, resultant force must be perpendicular to its motion (i.e. towards the centre of the motion).	[1]

8(b)(i)	$r=0.08\cos(22^\circ)=0.074175$ $N\sin\theta=mg$.............(1) $N\cos\theta=\frac{mv^2}{r}$.............(2) (1)/(2): $\Rightarrow\tan\theta=\frac{gr}{v^2}$ $\Rightarrow v=\sqrt{\frac{9.81\times0.074175}{\tan(22^\circ)}}=1.3420\approx1.34\ \text{ms}^{-1}$  	[1] for correct r [1] for the 2 correct equations [1] for correct substitution [1] for correct answer
8(b)(ii)	No as there is no vertical component of the normal contact force to balance the weight.	[1] for correct answer
8(c)(i)	Gravitational potential at a point is the work done per unit mass in bringing a small test mass from infinity to that point.	[2]
8(c)(ii)	$g=\frac{GM}{(R+h)^2}\Rightarrow GM=g(R+h)^2$ $\phi=-\frac{GM}{(R+h)}=-\frac{g(R+h)^2}{(R+h)}=-g(R+h)$	[1] for correct expression [1] for correct manipulation
8(c)(iii)	$\phi=-g(\text{R+h})=-0.15(3.3\times10^{6}+1.4\times10^{7})=-2595000$ Gain in gravitational potential energy = Loss in kinetic energy $m\ (2595000)=\frac{1}{2}mv^2$ $\Rightarrow v=2278.2\approx2280\ \text{m s}^{-1}$	[1] for correct potential at P [1] for correct method/ substitution [1] for correct answer
8(c)(iv) 1.	$\Delta U=m(\Delta\phi)=12000\ \times[(-3.2)-(-12.6)]\times10^{6}\approx1.13\times10^{11}\text{J}$	[1] for correct substitution [1] for correct answer
8(c)(iv) 2.	$g=-\frac{d\phi}{dr}=-\frac{\Delta\phi}{\Delta r}=-\frac{(-1.0)-(-5.2)}{6.5-1.5}\times\frac{10^{6}}{3.3\times10^{6}}\approx0.255\ \text{N kg}^{-1}$	[1] for correct substitution [1] for correct answer
8(c)(iv) 3.	$g=\frac{\text{GM}}{(4\text{R})^2}=\frac{\text{GM}}{16\text{R}^2}=0.255\text{N kg}^{-1}$ $g_{surface}=\frac{\text{GM}}{(\text{R})^2}=0.255\times16=4.08\ \text{N kg}^{-1}$	[1] for correct method [1] for correct answer
9(a)	The volt is the potential difference between two points in a circuit in which one joule of electrical energy is converted to other forms of energy when one coulomb passes from one point to the other.	[1] for correct definition
9(b)	e.m.f. of a cell is the electrical potential energy converted from other forms of energy when unit charge flows through the cell. p.d. is the work done in converting electrical potential energy to other forms of energy when unit charge flows across two points in the circuit.	[1] for correct explanation for e.m.f. [1] for correct explanation for p.d.

9(c)(i)	$I = \frac{V}{R} = \frac{2.0}{8.0} = 0.25$ A	[1] for correct equation [1] for correct answer
9(c)(ii)	$P = IV$ $I = \frac{0.50}{2.0} = 0.25$ A Total current through AX $= 0.25 + 0.25 = 0.50$ A $V_{AX} = IR = (0.50)(8.0) = 4.0$ V	[1] for correct current through bulb [1] for correct total current [1] for correct final answer
9(c)(iii)	$E = Ir + V$ $E = (0.50)(6.0) + 6.0 = 9.0$ V	[1] for correct equation [1] for correct answer
9(d)	The advantage of using the variable resistor is that a larger current can pass through the bulb to achieve greater brightness. The disadvantage is that the range of voltage that can be applied across the bulb is smaller.	[1] for valid advantage [1] for valid disadvantage
9(e)(i)	As the sliding contact X is adjusted in the direction of B, the potential difference (p.d.) across AX increases. There will be a point along AB where the p.d. across AX is equal to the e.m.f. of cell E$_2$. When this happens, no current will flow through E$_2$, hence giving zero galvanometer reading.	[1] for balanced potentials [1] for no current
9(e)(ii)	The balance length AX will be too small to be reliable since the percentage uncertainty will be large as the value of the balance length approaches the value of the uncertainty of the measurement of the balance length.	[1] for stating small balance length [1] for correct explanation
9(f)(i)	1.10 V	[1] for correct answer
9(f)(ii)	Resistor across balance length CY $R_{CY} = \frac{0.725}{1.000} \times 2.0$ $= 1.45\ \Omega$ Total resistance across AD = R_{total} $V_{AB} = \frac{R_1}{R_{total}} \times V_{AD}$ — (1) $V_{CY} = \frac{R_{CY}}{R_{total}} \times V_{AD}$ — (2) $\frac{(2)}{(1)}$ $\frac{V_{CY}}{V_{AB}} = \frac{R_{CY}}{R_1}$	[1] for correct R_{CY} [1] for correct expression of V_{AB} and V_{CY}

	E.m.f. of thermocouple, $V_{CY} = \frac{R_{CY}}{R_1} \times V_{AB}$ $= \frac{1.45}{110} \times 1.10$ $= 0.0145$ V (14.5 mV)	[1] for correct answer

2019 JC2 Prelim Physics Practical Suggested Mark Scheme

Penalise for d.p. and unit once per question per instrument.
[redacted]
All range are inclusive of the end values.

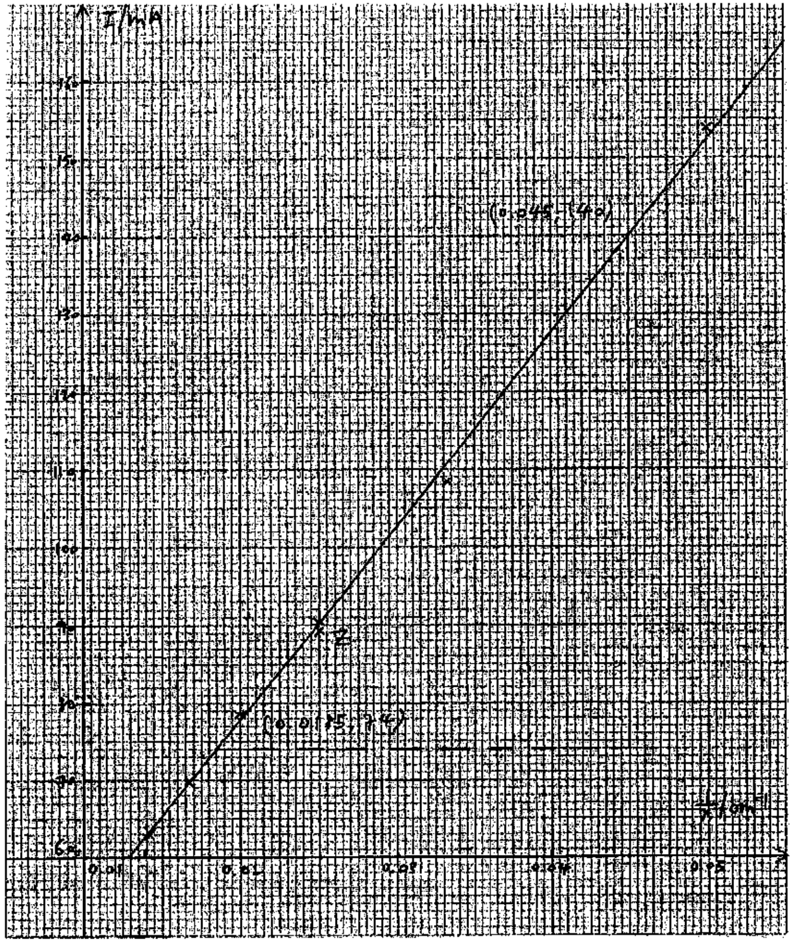
<table>
<tr><th>No.</th><th>Solution</th><th>Remark</th></tr>
<tr><td>1(a)(iv)</td><td>$V_0 = 0.27$ V</td><td>[1] for correct dp and units</td></tr>
<tr><td>1(a)(v)</td><td>first ammeter reading = 92.8 mA
second ammeter reading = 87.1 mA</td><td>[1] for correct dp and units</td></tr>
<tr><td>1(b)(iii)</td><td>$x = 30.0$ cm
$I = 108.2$ mA</td><td>[1] for correct dp and units
29 cm to 31 cm range for x.</td></tr>
<tr><td>1(c)</td><td><table>
<tr><th>x / cm</th><th>I / mA</th><th>$\frac{1}{x}$ / cm^{-1}</th></tr>
<tr><td>20.0</td><td>153.8</td><td>0.0500</td></tr>
<tr><td>30.0</td><td>108.2</td><td>0.0333</td></tr>
<tr><td>40.0</td><td>90.4</td><td>0.0250</td></tr>
<tr><td>50.0</td><td>78.4</td><td>0.0200</td></tr>
<tr><td>60.0</td><td>69.9</td><td>0.0167</td></tr>
<tr><td>70.0</td><td>62.9</td><td>0.0143</td></tr>
</table>
Note:
Range for x minimum of 50 cm
Penalise if not significant range of I
Trend of change: as x increase, I decreases.</td><td>[1] for 6 sets of readings(see note)
[1] for correct d.p. for raw data
[1] for correct sf for processed data
[1] for correct calculation
[1] for correct headings and units</td></tr>
<tr><td>1(d)</td><td>Refer to attached graph.</td><td>[1] correct axes and units, scale
[1] correct plotting of points to half the smallest division
[1] best fit line (penalize for big scatter and curve)</td></tr>
<tr><td>1(d)</td><td>$gradient = P = \dfrac{140-74}{0.045-0.0185} = 2490$ mA cm
Substitute $(0.045, 140)$ into the equation,
$140 = (2490)(0.045) + Q$
$Q = 27.9$ mA</td><td>[1] correct labelling of gradient coordinates of triangle and correct size of triangle, correct substitution of the gradient
[1] for correct determination and units of P
[1] correct calculation and units for Q</td></tr>
<tr><td>1(e)</td><td>$L = \dfrac{2490}{27.9} = 89.2$ cm</td><td>[1] for correct calculation and units
Range:
0 m < L < 2 m</td></tr>
</table>

1(f)(ii)	$x = 40.0$ cm $I = 89.3$ mA	39 cm < x < 41cm
1(f)(iv)	The point agrees with the pattern set by the other points on the graph as it is very close to the best fit line. Comparing with (a)(v), error in values of $I = \dfrac{92.8-97.1}{2} = 3$ mA Z is well within the error range of ±3 mA.	[1] for (f)(ii), f(iii) and statement based on scatter of Z from best fit line [1] for valid justification using (a)(v). Accept any logical reasoning.
2(a)	$S = 5.0$ cm	
2(b)(i)	$S_1 = 27.8$ cm $S_2 = 17.6$ cm	[1] for correct measurements with units [redacted]
2(b)(ii)	$p = 17.8$ cm $q = 12.6$ cm	[1] for correct calculation with units
2(c)(i)	$k = 25.4$ N m^{-1}	[1] for correct calculation
2(c)(ii)	$m^2g^2 = \dfrac{k^2p^2}{4} + k^2q^2$ $\left(\dfrac{p^2}{4}+q^2\right) = \dfrac{g^2}{k^2}m^2$ Plot $\left(\dfrac{p^2}{4}+q^2\right)$ vs m^2, gradient is $\dfrac{g^2}{k^2}$ so k can be determined.	[1] for correct linearization [1] for correct gradient
3(a)(ii)	$L = \dfrac{L_1+L_2}{2}$ $= \dfrac{0.490+0.490}{2}$ $= 0.490$ m	[1] - repeated - nearest mm - unit [redacted]

3(a)(iii)	percentage uncertainty $= \frac{\Delta L}{L} \times 100\%$ $= \frac{0.005}{0.490} \times 100\%$ $= 1\%$	[1] - ΔL between [redacted] to 5 mm - answer 1 or2 s.f.
3(a)(iv)	$M = 0.10811$ kg	[1] - [redacted]
3(b)(iii)	$x = 0.150$ m $y = 0.490$ m	[1]– nearest mm Range of ±0.5cm for x and y: [redacted] [redacted]
3(b)(iv)	percentage uncertainty $= \frac{\Delta x}{x} \times 100\%$ $= \frac{0.002}{0.150} \times 100\%$ $= 1\%$	[1] Δx = 2or3 mm - answer 1 or2 s.f.
3(c)	$N = 47$ $t_1 = 21.6$ s $t_2 = 21.6$ s $T = \frac{t_1 + t_2}{2N} = \frac{21.6 + 21.6}{2(47)} = 0.460\text{s}$ [redacted]	[1] for t - 1 d.p. in s - more than 20s - repeated readings [1] for T calculated correctly and in 3 s.f.
3(d)	$x = 0.380$ m $N = 40$ $t_1 = 22.9$ s $t_2 = 22.8$ s $T = \frac{t_1 + t_2}{2N} = \frac{22.9 + 22.8}{2(40)} = 0.571\text{s}$	[1] x in nearest mm [1] T calculated correctly and in 3 s.f.
3(e)(i)	First value : $T = k\sqrt{M + \frac{x}{y}m}$ $0.460 = k\sqrt{0.10811 + \frac{0.150}{0.490}(0.200)}$ $k = 1.11785$ $= 1.12 \text{ s kg}^{-0.5}$	[1] for first k

	Second value : $T = k\sqrt{M + \frac{x}{y}m}$ $0.571 = k\sqrt{0.10811 + \frac{0.380}{0.490}(0.200)}$ $k = 1.11297$ $= 1.11 \text{ s kg}^{-0.5}$	[1] for second k [redacted]
3(e)(ii)	Percentage difference in values of k $= \frac{1.12 - 1.11}{1.11} \times 100\%$ $= 0.9\%$ Percentage difference in values of $k$is comparable to the percentage uncertainties of x([redacted]) Hence, the experimental resultssupport the suggested relationship. [redacted]	[1] - valid conclusion by comparing the percentage difference of k. [redacted]
3(f)(i)	see table below [1] – table heading with symbols and units. [redacted] [1] – all raw data in correct d.p. [1] – all processed data calculated correctly. [redacted]	
3(f)(ii)	[redacted]	[redacted]
3(g)(i)	- Drill 6 small hole at equal intervals between 28cm to 48cm of the half metre rule. Tie a small loop of thread	[1] [redacted]

M / kg	x / m	y / m	N	t_1 /s	t_2 /s	T /s	k / s kg$^{-0.5}$
0.0500	0.050	0.240	55	21.1	21.3	0.385	1.27
0.10811	0.050	0.240	35	21.2	21.1	0.604	1.56


I/mA
160
150
140
130
120
110
100
90
80
70
60
0.01
0.02
0.03
0.04
0.05
(0.045, 140)
Z
(0.0175, 74)
$\frac{1}{x}$/cm^{-1}