Class Adm No

Candidate Name: ______________________________

Class	Adm No

millennia institute

2017 Preliminary Examination II

Pre-University 3

H2 PHYSICS **9646/01**

Paper 1 Multiple Choices

Thursday **21 Sep 2016** **1 hour 15 minutes**

Additional Materials: OMR 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, admission number and NRIC number on the OMR Answer Sheet in the spaces provided.

There are **forty** 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 OMR Answer Sheet.

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 approved scientific calculator is expected, where appropriate.

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
molar gas constant,	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion,	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas,	W	=	$p\Delta V$
hydrostatic pressure,	p	=	$\rho g h$
gravitational potential,	ϕ	=	$-\frac{Gm}{r}$
displacement of particle in s.h.m.	x	=	$x_o \sin \omega t$
velocity of particle in s.h.m.,	v	=	$v_o \cos \omega t$
		=	$\pm \omega\sqrt{(x_o^2 - x^2)}$
mean kinetic energy of a molecule of an ideal gas	E	=	$\frac{3}{2}kT$
resistors in series,	R	=	$R_1 + R_2 + \ldots$
resistors in parallel,	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + \ldots$
electric potential,	V	=	$\frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage,	x	=	$x_o \sin \omega t$
transmission coefficient	T	=	$\exp(-2kd)$
	where k	=	$\sqrt{\frac{8\pi^2 m(U-E)}{h^2}}$
radioactive decay,	x	=	$x_0 \exp(-\lambda t)$
decay constant,	λ	=	$\frac{0.693}{t_{\frac{1}{2}}}$

1 What is the approximate power of a light bulb at home?

A 0.1 W **B** 10 W **C** 1000 W **D** 10000 W

2 In the determination of the amount of charge, *Q*, moving across a conductor *I* is the current reading from an ammeter and *t* is the time recorded on a stop watch.

$I \pm \Delta I$ = (2.00 ± 0.05) A
$t \pm \Delta t$ = (6.00 ± 0.01) s

What is the percentage uncertainty of the value of Q calculated from these readings?

A 2.5% **B** 2.7% **C** 3.0% **D** 4.2%

3 While sitting on a tree branch 12.0 m above the ground, a monkey drops a chestnut. When the chestnut has fallen 2.0 m, the monkey throws a second chestnut vertically downwards.

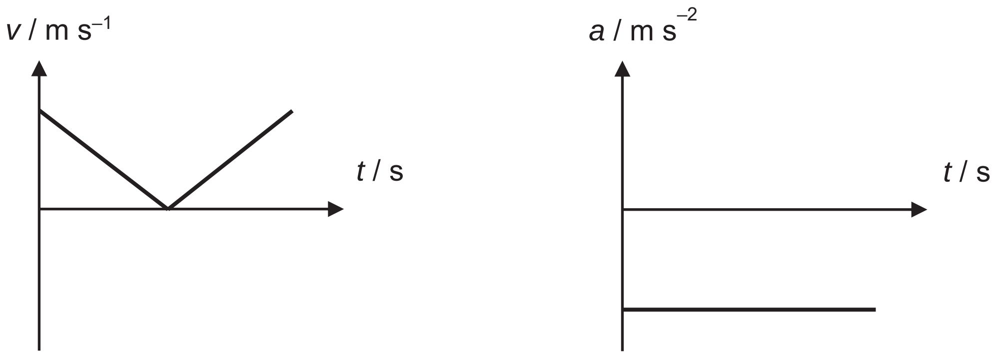
What is the initial speed of the second chestnut if both chestnuts were to land at the same time?

A 2.5 ms^{-1}
B 4.1 ms^{-1}
C 8.4 ms^{-1}
D 14.5 ms^{-1}

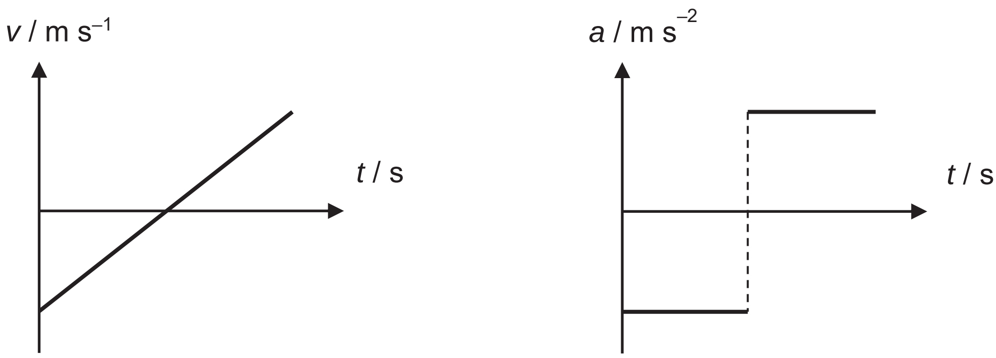
4 An electron decelerates uniformly in an electric field, comes to a stop, and accelerates at the same rate that it decelerated earlier.

Which of the following velocity-time and acceleration-time graphs best represent the above motion?

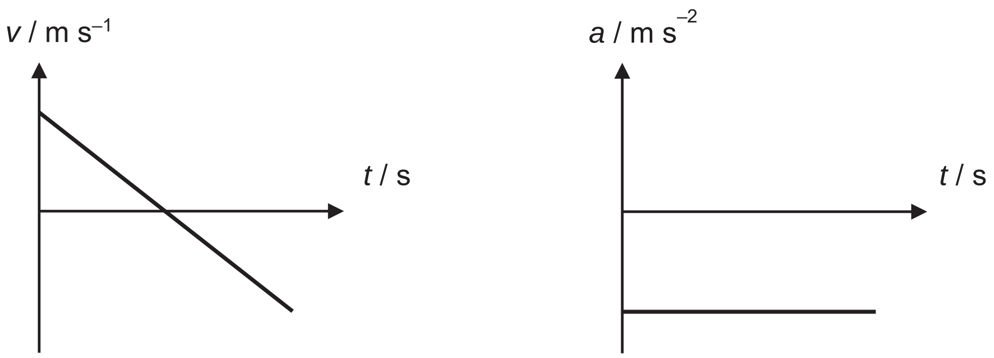
A



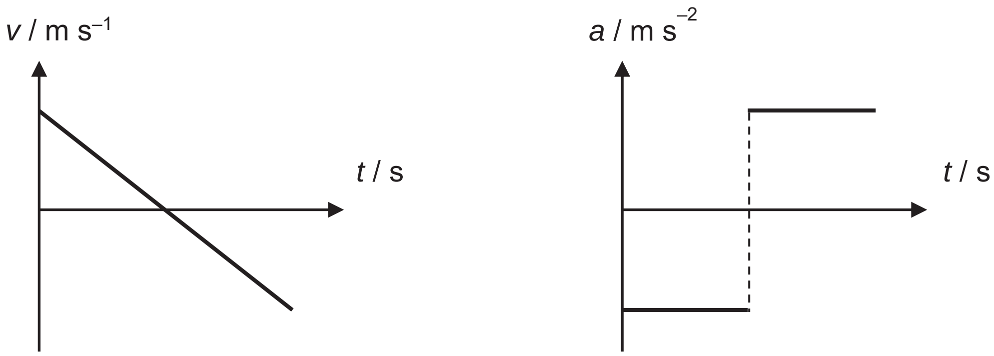
B



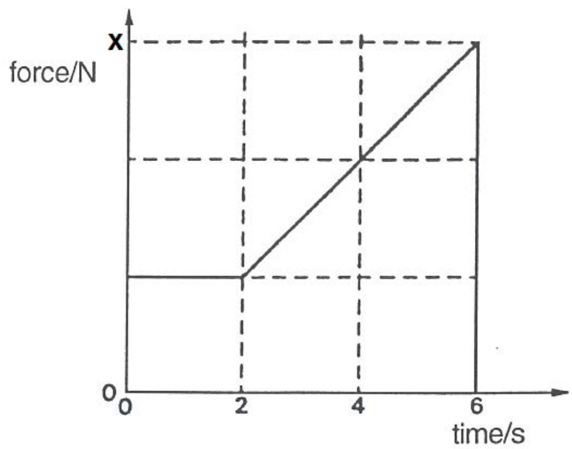
C



D



5 A force which varies with time as shown in the figure acts on a body.



Assuming that the body is moving in a straight line, and given that the body gained momentum of 20 kg ms^{-1} at the end of 6 seconds, what is the value of x?

A 2 N

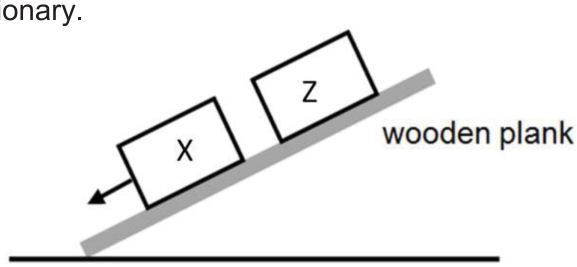
B 3 N

C 6 N

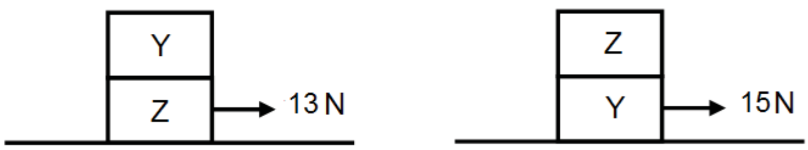
D 10 N

6 Blocks X, Y and Z have the same dimensions but are made of different materials.

Blocks X and Z are placed on a wooden plank. When the plank is tilted, block X slides down while block Z remains stationary.



When block X is put on top of block Y, the force required to maintain constant velocity is 13 N.
When block Y is put on top of block X, the force required to maintain constant velocity is 15 N.



Which of the following gives the roughness of the blocks in decreasing order?

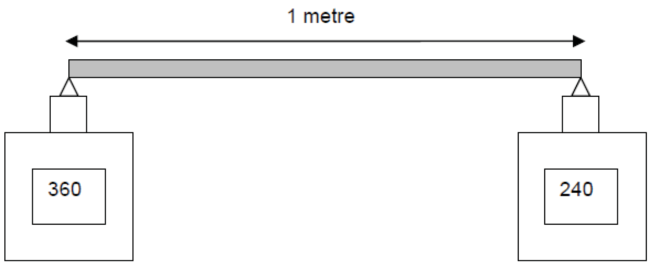
A YZX

B ZXY

C XZY

D ZYX

7 A rod of length 1 m has non-uniform composition, so that the centre of gravity is not at its geometrical centre. The rod is laid on supports across two top-pan balances as shown in the diagram. The balances (with no zero error) give readings of 360 g and 240 g.



Where is the centre of gravity of the rod *relative to its geometrical centre*?

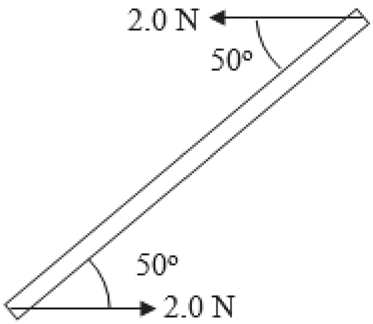
A 0.10 m to the left

B 0.10 m to the right

C 0.25 m to the left

D 0.25 m to the right

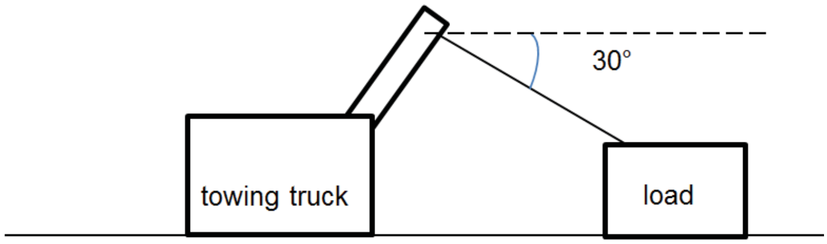
8 A ruler of length 0.30 m is pivoted at its centre. Equal and opposite forces of 2.0 N are applied to the ends of the ruler creating a couple as shown below.



What is the magnitude of the torque of the couple on the ruler when it is in the position shown?

A 0.19 N m **B** 0.23 N m **C** 0.38 N m **D** 0.46 N m

9 The diagram below shows a tow truck pulling a load at constant velocity horizontally to the left. The cable makes an angle of 30° with the horizontal and the tension in the cable is found to be 2500 N.



What is the work done by the cable when it has travelled 15 m?

A zero

B 18800 J

C 32500 J

D 37500 J

10 The top end of a spring is attached to a fixed point and a mass of 4.2 kg is attached to its lower end. The mass is released and after bouncing up and down several times it comes to rest at a distance 0.29 m below its starting point.

Which option gives the gain in the gravitational potential energy of the mass E_p and the gain in the elastic potential energy of the spring E_s?

	E_p / J	E_s / J
A	-12	-12
B	-12	+6
C	+12	-12
D	+12	+6

11 An artificial satellite travels in a circular orbit about the Earth in a uniform circular motion.

Which of the following statement is **not true**?

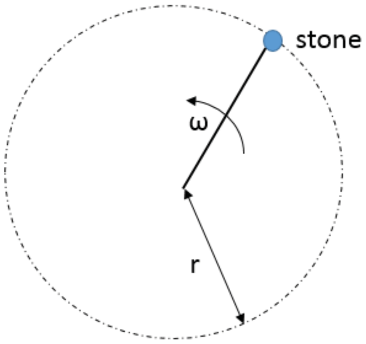
A The velocity of the satellite is constant throughout the motion.

B The period of the motion is constant.

C There is zero work done by the satellite during the orbit.

D The acceleration of the satellite is always directed towards the centre of the orbit.

12 A stone of mass m is attached to a string. The stone is rotating in a vertical circle of radius r with a constant angular speed ω as shown.



The acceleration of free fall is g.

What is the minimum magnitude of the tension in the string during one revolution of the stone?

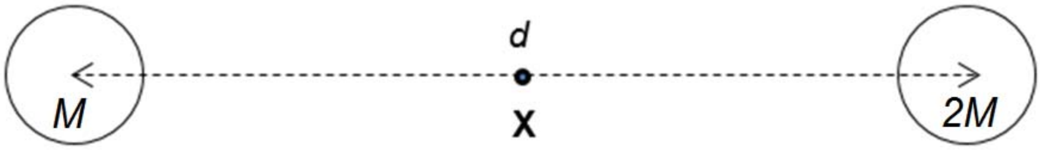
A $m\,(r\,\omega^2 - g)$

B $m\,r\,\omega^2$

C $m\,g$

D $m\,(g - r\,\omega^2)$

13 The centers of two isolated spherical stars each of radius *R* are separated by a distance *d* as shown. One star has mass M, and the other has mass 2M.



Point **X** is mid-way between the stars.

Which expression gives the net gravitational force due to the two stars that acts on a mass *m* placed at point **X**?

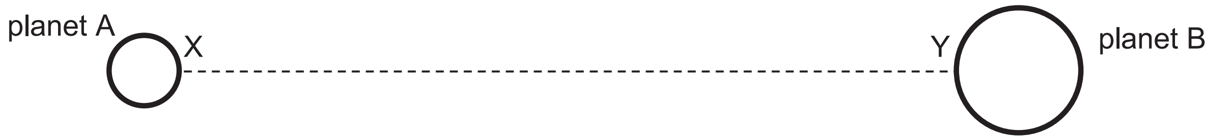
A zero

B $\frac{2GMm}{d^2}$ to the right

C $\frac{4GMm}{d^2}$ to the left

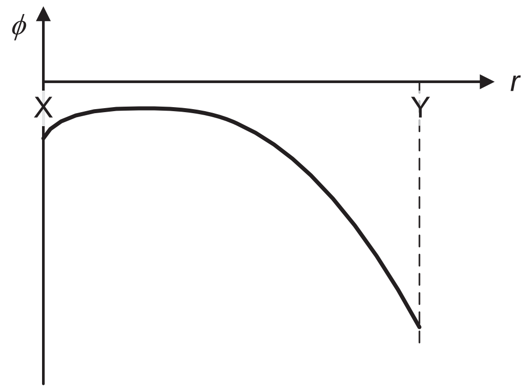
D $\frac{4GMm}{d^2}$ to the right

14 The mass of planet A is 8 times smaller than that of planet B, while the radius of planet A is half that of planet B. Line XY joins the surface of planet A to the surface of planet B.

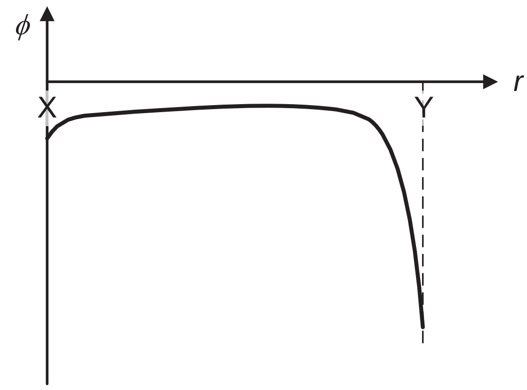


Which of the following graphs represents the variation of gravitational potential ϕ with distance r from the surface of planet A?

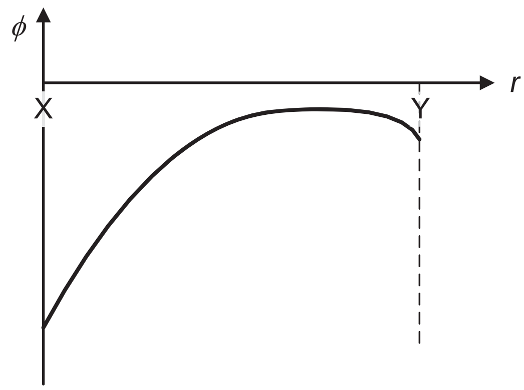
A



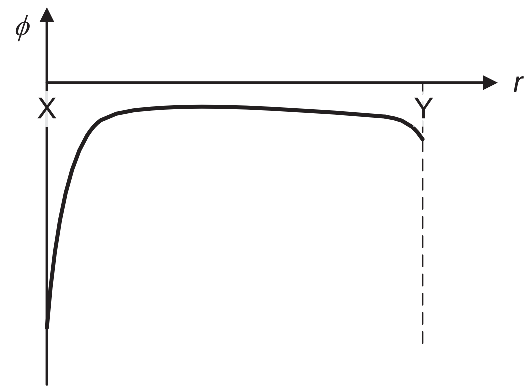
B



C



D



15 A body in simple harmonic motion makes n complete oscillations in one second.

Which of the following expression represents the angular frequency of the motion?

A n rad s^{-1} **B** πn rad s^{-1} **C** $2\pi n$ rad s^{-1} **D** $1/n$ rad s^{-1}

16 An object of mass 150 g executes simple harmonic motion with amplitude of 2.5 cm. At a displacement of 1.0 cm from the equilibrium, its kinetic energy is 0.62 J.

What is the natural frequency of the oscillation?

A 18 Hz **B** 20 Hz **C** 22 Hz **D** 24 Hz

17 The table gives the results from an experiment to determine the specific heat capacity of a liquid by an electrical method.

mass of liquid heated	1.5 kg
initial liquid temperature	300 K
final liquid temperature	357 K
electrical power of heater	1.0 kW
duration of heating	200 s

Which of the following is the specific heat capacity of the liquid?

A 2.4 J kg^{-1} K^{-1}

B 2400 J kg^{-1} K^{-1}

C 2.0 J kg^{-1} K^{-1}

D 2000 J kg^{-1} K^{-1}

18 The kinetic theory of gases may be used to derive the following expression relating the pressure P and the volume V of a gas to the root-mean-square speed of its molecules:

$$P = \frac{1}{3}\frac{Nm}{V} < c^2 >.$$

What does the term $\frac{Nm}{V}$ represent in this expression?

A The density of the gas

B The mass of the all the gas molecules

C The total number of molecules in one mole of gas

D The total number of molecule present in volume V

19 A transverse wave of speed 0.50 m s^{-1} travels in a stretched string. The displacement *y* of particles along the stretched string with time is given by the expression.

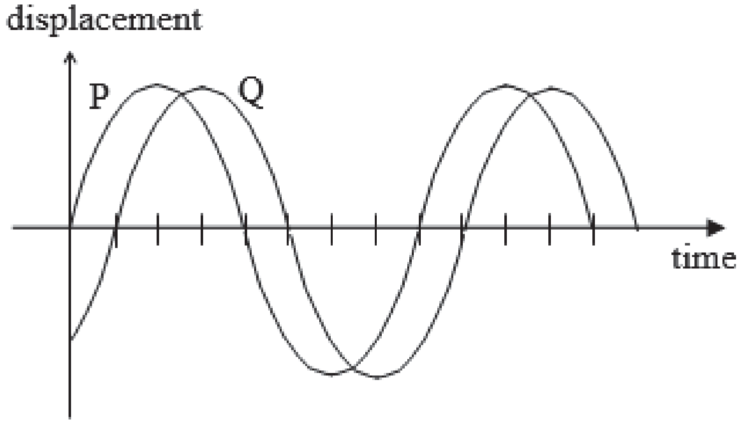
$$y = 30\cos 0.35\, t$$

Given that *t* is in second (s) and *y* in metre (m), what is the wavelength of the wave?

A 1.7 m **B** 7.3 m **C** 9.0 m **D** 11.4 m

20 The diagram shows two waves P and Q.

What is the phase difference between the two waves?



A $\pi/8$ rad **B** $\pi/4$ rad **C** $\pi/2$ rad **D** π rad

21 When a two-slit arrangement is set up to produce interference fringes on a screen using monochromatic source of green light, the fringes are found to be too close together for convenient observation.

In which of the following ways would it be possible to increase the separation of the fringes?

A Decrease the distance between the screen and the slits.

B Increase width of each slit.

C Have a larger distance between the two slits.

D Replace the light source with a monochromatic source of red light

22 A diffraction grating ruled with 5000 lines per cm is illuminated with white light.

If the wavelength for yellow light and violet light are 600 nm and 400 nm respectively, which one of the following statements is NOT correct?

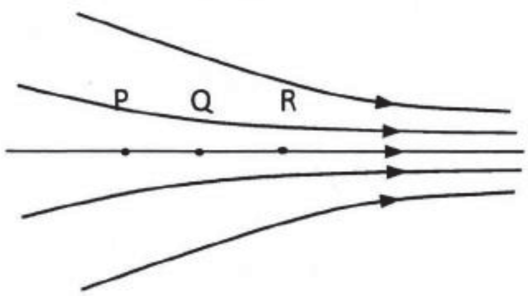
A The central image is white.

B The second-order image of the yellow light coincides with the third-order image of violet light.

C There is no fourth-order image for yellow light.

D The red end of the first-order spectrum is closer to the central image than the violet end of the first-order spectrum.

23 The figure below shows electric field lines with points PQR on one of the field lines. The distance PQ = QR.



Which of the following statement is *not true*?

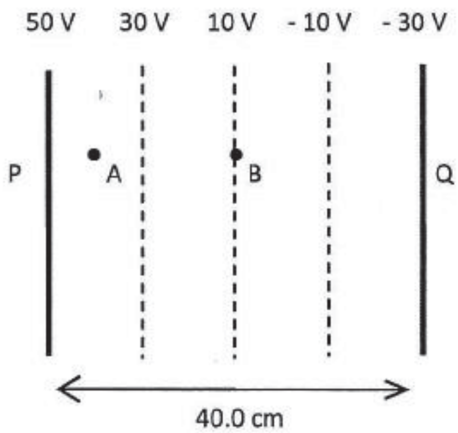
A P has a higher potential than R.

B A negative charge placed at Q will experience an electric force acting towards P.

C The field strength at P is larger than R.

D A proton will experience electric force of the same magnitude as an electron when placed at Q.

24 An electron is released at point B and it moves towards point A.



Determine the speed of the electron when it reaches point A.

A 1.26×10^6 ms^{-1}

B 3.25×10^6 ms^{-1}

C 5.43×10^6 ms^{-1}

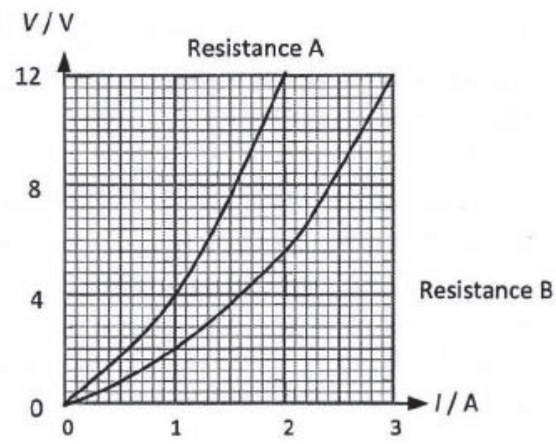
D 7.58×10^6 ms^{-1}

25 The total energy dissipated in a circuit when a charge of 5.0 C flows from the battery is 20 J.

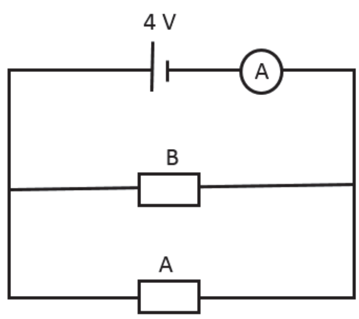
What is the e.m.f. of the battery?

A 4.0 V
B 10 V
C 50 V
D 100 V

26 Resistor A and B have the following V-I characteristic.



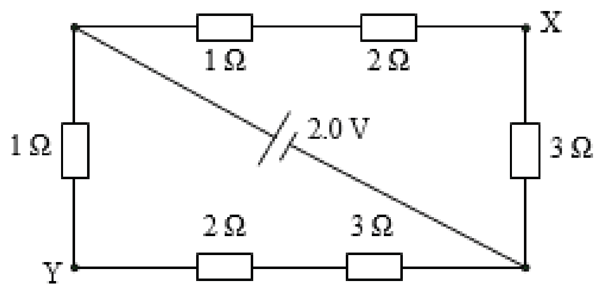
What is the current reading on the ammeter if resistor A and B are connected in the circuit as shown below?



A 1.0 A **B** 1.6 A **C** 2.6 A **D** 3.0 A

27 Six resistors are connected to a 2.0 V cell of negligible internal resistance as shown in the figure below.

What is the potential difference between X and Y?



A 0.67 V

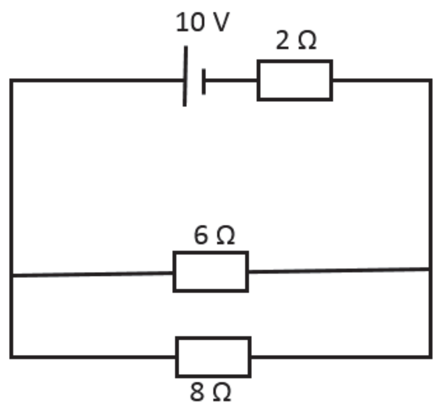
B 0.89 V

C 1.33 V

D 1.67 V

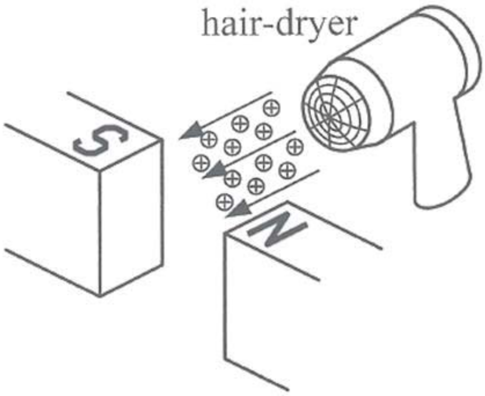
28 In the circuit below, the battery has negligible internal resistance.

What is the magnitude of the current passing through the 6.0 Ω resistor?



A 0.62 A **B** 0.88 A **C** 1.1 A **D** 1.7 A

29 A hair dryer discharges hot air that contains many positively charged ions, and the motion of these ions constitutes an electric current. The diagram below illustrates the hot air being directed between the poles of a strong magnet.



In which direction will the ions be deflected?

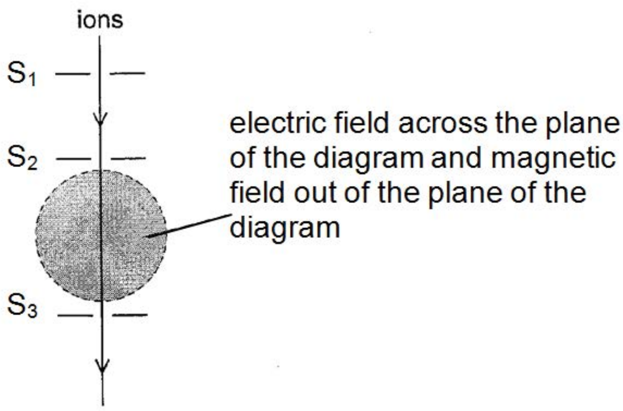
A Vertically downwards

B Vertically upwards

C Towards the north pole N

D Towards the south pole S

30 The diagram shows part of an apparatus in which positive ions pass through slits S_1, S_2 and S_3.



Between S_2 and S_3, they pass through mutually perpendicular magnetic and electric fields, the intensities of which may be varied.

What is the function of the mutually perpendicular fields between S_2 and S_3?

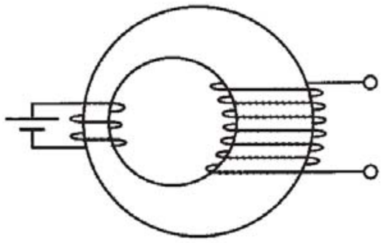
A To accelerate the ions to high velocity

B To select ions of a particular charge

C To select ions of a particular mass

D To select ions of a particular velocity

31 Two coils are wound around a soft iron ring of variable cross-section. One coil has 3 turns and is connected to a d.c. supply. The other coil has 7 turns.



Which of the following is the same inside each coil?

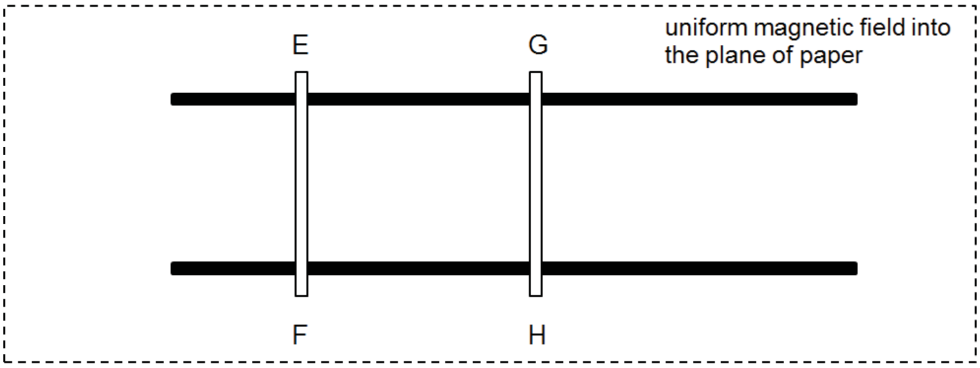
A magnetic flux density

B magnetic flux

C magnetic flux linkage

D magnetic field

32 Two light metal rods EF and GH are initially at rest on two smooth horizontal conducting rails of negligible resistance. A uniform magnetic field B is directed perpendicularly into the paper.



Rod EF is given a nudge so that it slides to the left.

In which direction would rod GH move?

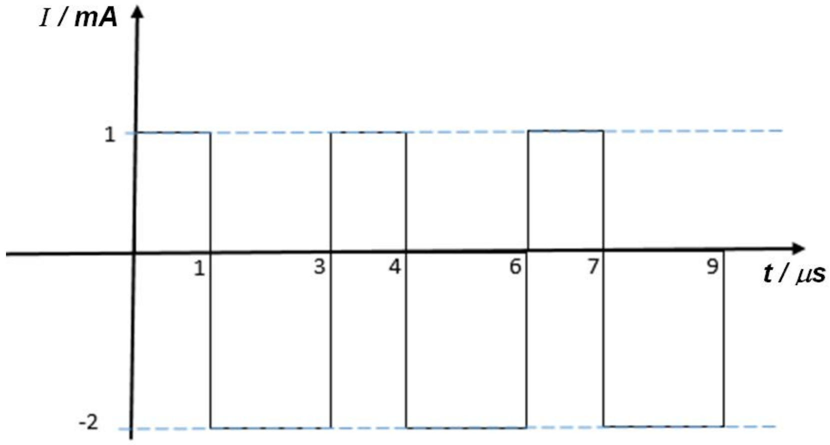
A To the left

B To the right

C To the left, then to the right

D To the right, then to the left

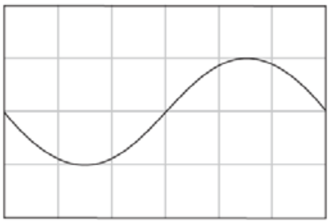
33 Figure below shows an a.c. current.



What is the root-mean-square value for this current?

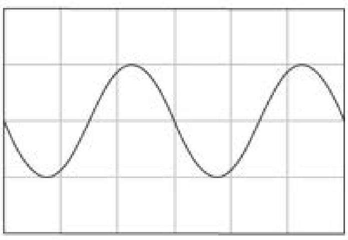
A 1.25 mA **B** 1.73 mA **C** 3.32 mA **D** 5.48 mA

34 An a.c generator is rotating at an angular frequency of ω. The waveform produced on the screen of a cathode-ray oscilloscope (c.r.o.), when the c.r.o. is connected to measure the e.m.f. generated, is shown below.

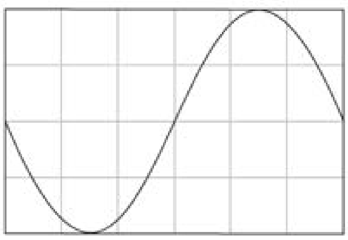


Which of the following diagrams shows the waveform displayed on the c.r.o. when the generator rotates at an angular frequency of 2ω?

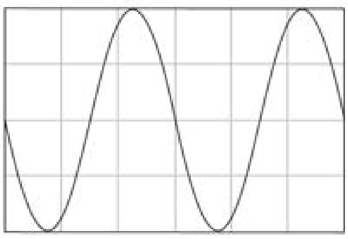
A



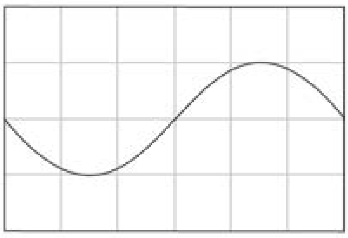
B



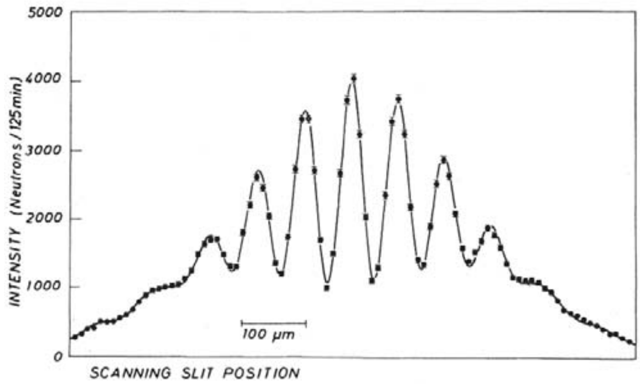
C



D



35 Figure below shows the experimental results of a double-slit experiment done using neutrons.



Double-slit interference pattern made with neutrons.

(A. Zeilinger, R. Gähler, C.G. Shull, W. Treimer, and W. Mampe, Reviews of Modern Physics,

C_{60} molecules (each of mass 720 times that of a neutron) with the same kinetic energies of the neutrons are used to do the experiment in the same experimental condition.

What will happen to the fringe spacing?

A increase by 720 times.

B increase by $\sqrt{720}$ times.

C decrease by 720 times.

D decrease by $\sqrt{720}$ times.

36 An electron and a proton approach a potential barrier of height *U* and thickness *d*. The transmission coefficient *T* is given in the relation below:

$$T \ \alpha \ e^{-2kd} \quad \text{where } k = \sqrt{\frac{8\pi^2 m(U-E)}{h^2}}$$

The value of e^{-2kd} for the electron is in the order of 10^{-5}, and that for the proton is in the order of 10^{-186}.

Which statement best describes the electron and proton?

A The electron will never reach the other side of the barrier.

B The electron has a higher chance of reaching the other side of the barrier.

C The proton has a higher chance of reaching the other side of the barrier.

D The proton will never reach the other side of the barrier.

37 Which of the following statements about intrinsic semiconductors is true?

A It can behave like an insulator at low temperature.

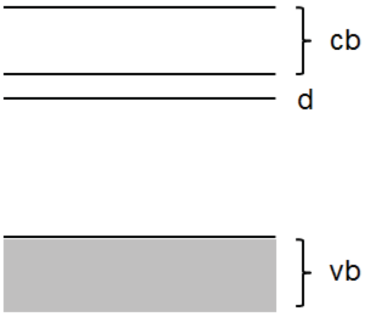
B The donor energy level lies just below the conduction band.

C The valence band and conduction band overlap.

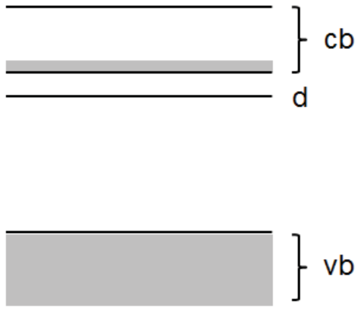
D There is an energy gap of 5 eV to 10 eV between the valence and conduction band.

38 Which diagram illustrates the valence band vb, the conduction band cb, and the dopant level d in an intrinsic semiconductor doped with electron-deficient impurity atoms that is at zero Kelvin? (Electrons are represented by the shaded region.)

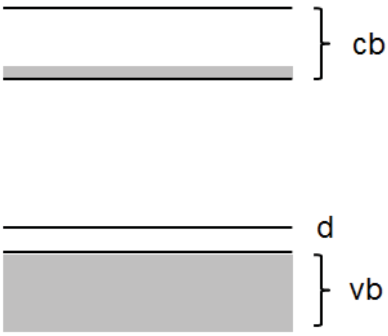
A



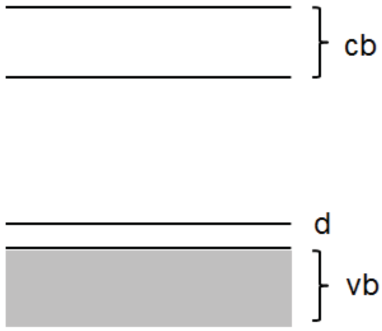
B



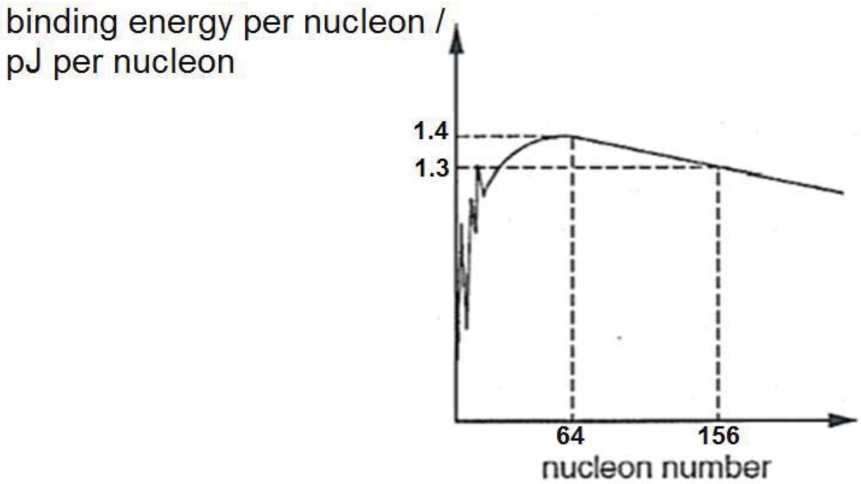
C



D



39 The sketch graph shows how the binding energy per nucleon varies with the nucleon number of naturally occurring nuclides.



What is the total binding energy of the nuclide $^{156}_{64}Gd$?

A 83 pJ

B 90 pJ

C 203 pJ

D 218 pJ

40 Samples of two radioactive nuclides, X and Y, each have equal activity A_o at time t = 0. X has a half-life of 20 years and Y a half-life of 15 years.

The samples are mixed together.

What will be the total activity of the mixture at t = 30 years?

A $0.10A_o$ **B** $0.25A_o$ **C** $0.30A_o$ **D** $0.60A_o$

End of Paper

Class	Adm No

Candidate Name: ______________________________

2017 Preliminary Examination II
Pre-university 3

H2 Physics **9646/02**
Paper 2 Structured Questions

Monday **11 Sep 2017** **1 hour 45 minutes**

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and admission number in the spaces at the top of this page.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use 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	
2	
3	
4	
5	
6	
7	
Total	

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
molar gas constant,	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion,	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas,	W	=	$p\Delta V$
hydrostatic pressure,	p	=	$\rho g h$
gravitational potential,	ϕ	=	$-\frac{Gm}{r}$
displacement of particle in s.h.m.	x	=	$x_o \sin \omega t$
velocity of particle in s.h.m.,	v	=	$v_o \cos \omega t$
		=	$\pm \omega\sqrt{(x_o^2 - x^2)}$
mean kinetic energy of a molecule of an ideal gas	E	=	$\frac{3}{2}kT$
resistors in series,	R	=	$R_1 + R_2 + \ldots$
resistors in parallel,	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + \ldots$
electric potential,	V	=	$\frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage,	x	=	$x_o \sin \omega t$
transmission coefficient	T	=	$\exp(-2kd)$
	where k	=	$\sqrt{\frac{8\pi^2 m(U-E)}{h^2}}$
radioactive decay,	x	=	$x_0 \exp(-\lambda t)$
decay constant,	λ	=	$\frac{0.693}{t_{\frac{1}{2}}}$

Section A (60 Marks)

Answer **all** questions

It is recommended that you spend about 1 hour 15 minutes on this section.

1 A 4.00 kg mass is attached to a vertical rod by means of two cords. When the system rotates about the axis of the rod, the cords are extended as shown in Fig. 1.1 and the tension in the upper cord is 70.0 N.

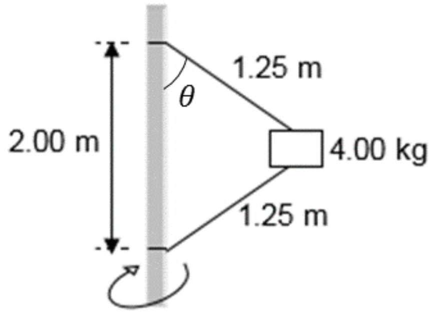


Fig. 1.1

(a) Draw a clearly labelled free body diagram of the 4.00 kg mass.

[1]

(b) Show that the tension in the lower cord is 21.0 N.

[2]

(c) Show that the system makes around 41 revolutions in one minute.

[3]

(d) Find the number of revolutions per minute at which the lower cord just goes slack.

number of revolutions per minute = …………………………. min^{-1} [3]

(e) Explain quantitatively what happens to angle θ if the number of revolutions per minute is less than that calculated in **(c)**.

………

………

………

………[2]

2 In Fig. 2.1, S_1 and S_2 are two small loudspeakers that emit sound waves of the same intensity and wavelength. A microphone for detecting sound intensity is placed at point P such that $S_1P = S_2P$

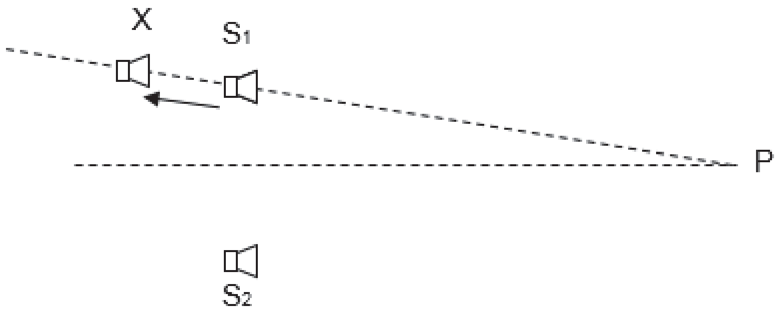


Fig. 2.1

(a) One of the conditions required for the formation of a well-defined interference pattern is that the two sources are coherent.

State what is meant by *coherent sources* and suggest how coherence of S_1 and S_2 can be achieved in this case.

……

……

……

……[2]

(b) S_1 and S_2 are in phase. The speaker S_1 is moved slowly away from P along the line PS_1. As S_1 is moved, the sound detected at P fluctuates in intensity.

Explain this observation.

……

……

……

……[2]

(c) In moving the source from S_1 to point X as shown in Fig. 2.1, the intensity of the sound at P changes from a maximum to a minimum. The distance S_1X = 0.082 m.

Calculate the wavelength of the sound emitted by the sources.

wavelength = ………………….. m [1]

[Turn Over

(d) S_1 remains at the point X and the frequency f of the sound emitted from both S_1 and S_2 is gradually increased until a maximum sound intensity is first detected at point P. This occurs when f = 4100 Hz.

(i) Estimate a value for the speed of sound.

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

(ii) Explain why the maximum sound intensity detected at P when S_1 is at point X differs from that detected at P if S_1 is at its original position (i.e. when $S_1P = S_2P$).

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………[1]

(e) S_1 has an intensity of I and S_2 has an intensity of 3 I. Determine the intensity at point P in terms of I when S_1 is at its original position.

intensity = …………………… I [3]

3 (a) Define *electric field strength.*

………

………[1]

(b) Time-of-flight mass spectroscopy uses the arrangement shown in Fig. 3.1 to measure the mass of molecules. A laser pulse knocks an electron out of a molecule in a sample placed midway between the parallel charged plates, leaving it as a positively charged ion. The positively charged ion accelerates towards the detector due to the presence of an E-field as shown in Fig. 3.1.

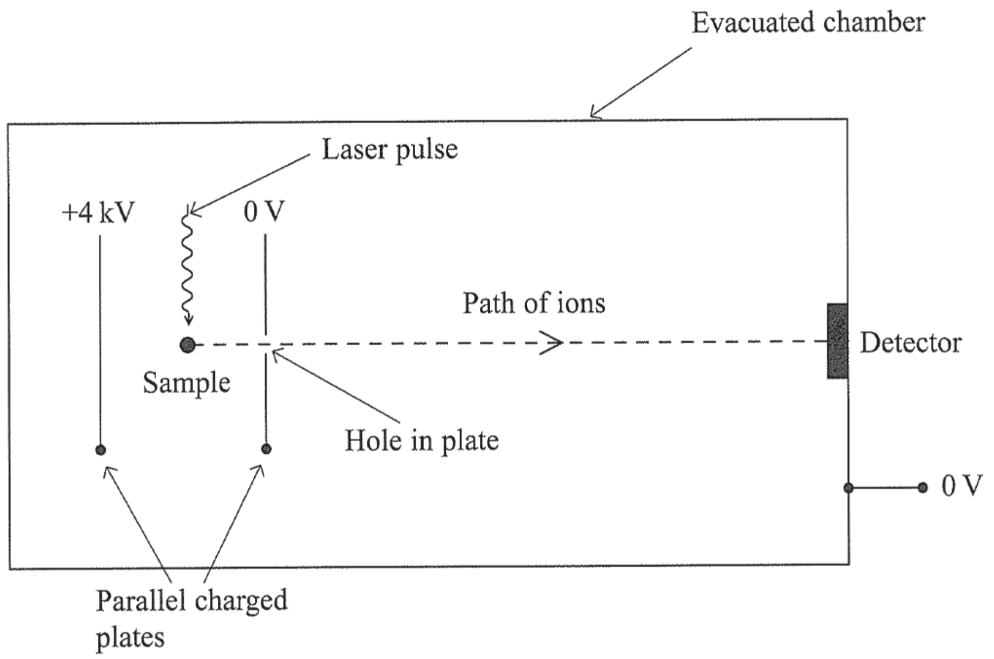


Fig. 3.1

(i) Draw the electric field lines between the two plates in Fig. 3.1. [1]

(ii) The parallel charged plates are placed 5.00 cm apart. Determine the electric field strength, *E* at the centre of the parallel charged plates.

electric field strength = ………………….. V m^{-1} [1]

(iii) State the amount of charge on each of the ion created.

charge = …………………….. C [1]

[Turn Over

(iv) Show that the speed, *v*, of a positively charged ion as it reaches the hole in the plate is given by

$$v = \sqrt{\frac{6.4 \times 10^{-16}}{m}}\ ,$$

where *m* is the mass of the ion in kg. It can be assumed that the ions were at rest initially.

[2]

(v) The distance between the hole in the plate and the detector is 1.5 m. The time taken for an ion to cover this distance is 2.3 μs. Calculate the mass of this ion.

mass of ion = ……………………….. kg [2]

4 A student had a lamp rated at 3.0 V, 0.20 A. He had only a battery of 12 V with negligible internal resistance. In order to obtain a voltage of about 3.0 V, he connected a circuit as shown in Fig. 4.1. He used a voltmeter to check the voltage before connecting the lamp between terminals A and B. The resistance wire CD has a length of 1 m and a total resistance of 1000 Ω.

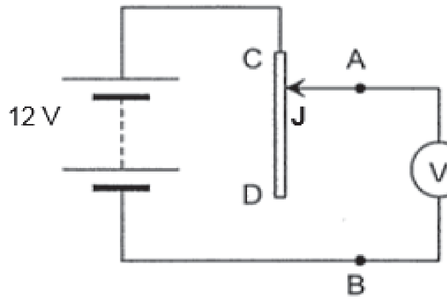


Fig. 4.1

When the sliding contact J was moved from C to D in Fig 4.1, the voltmeter reading fell from 12 V to 11 V.

(a) Show that the resistance of the voltmeter is 11.0 kΩ.

[2]

(b) The student then modified the circuit to that shown in Fig. 4.2. He is now able to adjust the sliding contact J to obtain a voltmeter reading of 3.0 V.

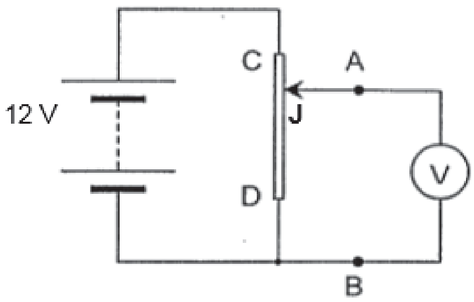


Fig. 4.2

(i) Calculate the current flowing through the voltmeter when it gives a reading of 3.0 V.

current = ………………….. A [1]

(ii) Assuming this current is negligible compared with the current flowing through the resistance wire, determine the distance from C that the sliding contact J would be at.

distance from C = ………………….. m [1]

(iii) Calculate the power dissipated in the resistance wire length CJ calculated in **(b)(ii)**.

power = ……………….. W [2]

(c) The student then replaced the voltmeter with the lamp across AB. Explain why the lamp did not light up assuming the lamp is not defective.

………

………

………

……[2]

5 A simple transformer with an iron core is illustrated in Fig. 5.1.

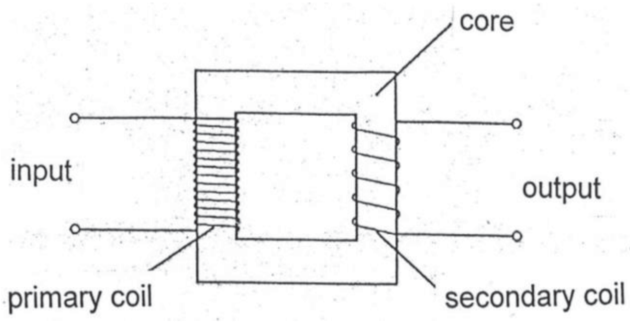


Fig. 5.1

(a) Explain how the transformer works.

……

……

……

……

……

……[3]

(b) A transformer has 500 turns in the primary coil and 10 turns in the secondary coil. The root-mean-square (r.m.s.) value of the alternating voltage and current in the primary coil are 240 V and 2.0 A respectively.

(i) Explain what is meant by the root-mean-square (r.m.s.) value of an alternating current.

…………………………………………………………………………………………………

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

(ii) Determine the r.m.s. values of the voltage and current in the secondary coil. State an assumption made.

voltage in the secondary coil = …………..………... V [1]

current in the secondary coil = ………………………A [1]

Assumption:

…………………………………………………………………………………………………

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

6 Parachutes have been used by the military for various purposes. The material for the parachute changed from silk to nylon since World War 2. Most armies operate parachute troops for one role or another. In this context, the term *rate of descent* refers to the terminal velocity achieved by the paratrooper during an operation. The recommended rate of descent for a paratrooper is 5.8 m $s^{-1.}$

There are two basic types of jumps from an aircraft: *LALO* (Low Altitude Low Opening) and *HALO* (High Altitude Low Opening).

LALO Operation

In a *LALO* Operation, a large number of troops is dropped into an area quickly and they spend little time in the air. A large Drop Zone (DZ) is usually required for such operation. For mass combat drops, troops are normally dropped below 300 m. The disadvantage is that the low flying aircraft are much more vulnerable to anti-aircraft fire. Modern parachutes specially designed for low altitude jumps can allow jumps at the extremely low altitude of 76 m.

HALO Operation

HALO is most commonly used by troopers for covert operations behind enemy lines. The high altitude - usually above 8200m - is well above the visual and auditory range of enemy ground troops and also at a safe distance from most anti-aircraft fire. The disadvantage of *HALO* jump is that the high altitude requires special equipment due to the environmental pressure and temperatures. The troopers have to bring oxygen above 4250 m, respirators and protective clothing in order to survive. The advantage is that the paratroopers should be able to land on smaller Drop Zones (DZs).

Fig 6.1 presents the two types of parachutes (MC1 and MC6) used by US Army.

Parachute Model	**MC1**	**MC6**
Effective area of parachute	90.0 m^2	75.4 m^2
Length of suspension line	6.7 m	6.5 m
Tensile strength of line	1780 N	1780 N
Time for 360° turn	9 second	5 second
Assembled weight	13 kg	13 kg
Minimum exit altitude	152 m	152 m
Maximum exit velocity (1 Knot = 1.85 km h^{-1})	150 Knots	150 Knots

Fig. 6.1

Fig. 6.2 shows the descent rate and exit weight data from test drops of the 2 parachutes at different heights. (Sea level refers to altitude very close to the Earth's surface.)

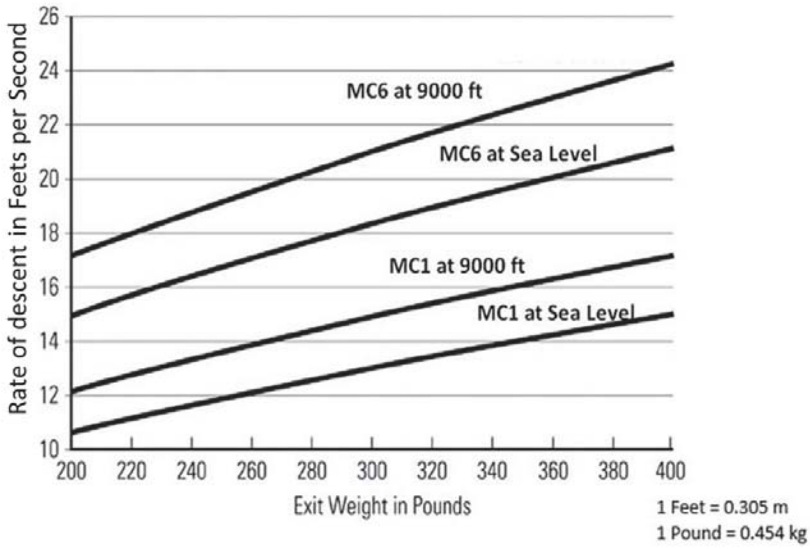


Fig 6.2

(a) Suggest a reason why nylon is a better choice of material for parachute as compared to silk.

………...

………...[1]

(b) Draw a clearly labelled free body diagram of a trooper when his parachute opens fully during a jump. [1]

(c) With reference to Fig 6.1, state and suggest a reason which parachute gives a higher rate of descent?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

[Turn Over

(d) Suggest a suitable reason why the same parachute will produce two different rate of descent as shown in Fig. 6.2?

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

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

(e) The formula for air drag is $F_{drag} = ½ \rho C_D A v^2$, where ρ is the density of the air, C_D is the drag coefficient, A is the effective area of the parachute and v is the velocity of the paratrooper.

Experiments were carried with one of the parachute from Fig. 6.1 to determine the relationship between the air drag and velocity of the jumper. The data obtained from the experiment is plotted into a graph as shown in Fig. 6.3.

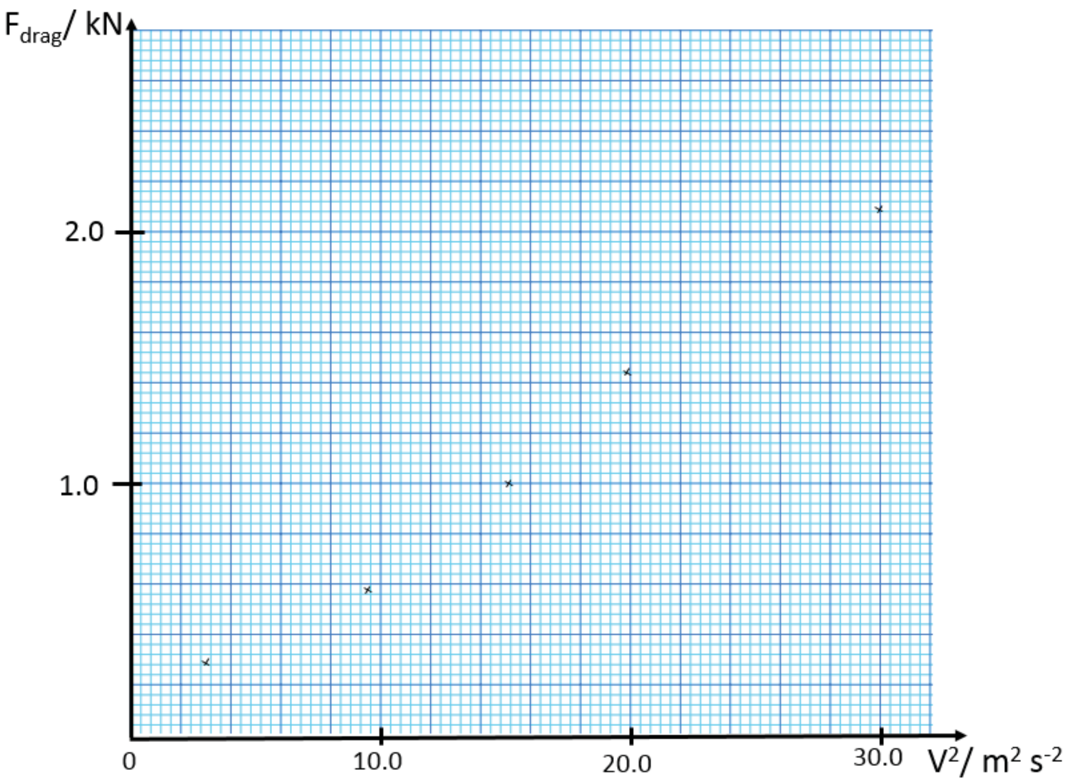


Fig. 6.3

(i) Draw the line of best fit using the data points provided in Fig. 6.3. [2]

(ii) Determine the drag force that acts on the trooper when his speed is 4.0 m s^{-1}.

drag force = …………………… N [1]

(iii) Given that the density of air, ρ is 1.23 kg m^{-3} and drag coefficient, C_D of parachute is 1.50, determine the effective area of the parachute.

effective area = ………………. m^2 [3]

(iv) State the model of parachute used for this experiment.

parachute model = ………………….. [1]

(f) **(i)** In a mission, a helicopter hovers at a fixed position above a target. Determine the speed of a paratrooper who falls for 2 seconds after dropping out of the helicopter. (Assume air resistance is negligible during the fall)

speed = ……………………. m s^{-1} [1]

(ii) Using the answer from **(i)**, sketch the velocity-time graph of the trooper from the moment he made the jump until he reaches terminal velocity. You may assume that the parachute opened two seconds after he made the jump and the terminal velocity is 5.8 m s^{-1}. [2]

Section B (12 Marks)

It is recommended that you spend about 30 minutes on this section.

7 A blowgun is a simple weapon consisting of a narrow, long tube for firing light darts. The weapon is used by inserting the dart into the pipe of the blowgun and using the force created by the user's breath to give the projectile momentum. Its propulsive power is limited by the user's respiratory muscles.

When an absorbent material is placed some distance from the blowgun, the darts fired from the blowgun are observed to create a hole with diameter of 10 mm and penetrate a depth of one to two centimeters.

Design a laboratory experiment to investigate how the depth of penetration varies with the speed of the dart. In your account you should pay particular attention to

a) how the speed of the dart may be measured,

b) how the depth of penetration of the dart into the absorbent material is to be measured,

c) how the speed of the dart is to be changed,

d) the analysis of the data,

e) the precautions to be taken to improve the safety of the experiment.

You may assume that all of the following equipment is available, together with any other standard laboratory apparatus that would be found in a school science laboratory.

Blowgun	Measuring Tape
Darts	Air Pump
Stopwatch	Sheets of absorbent material (cork)
Photogates	Aluminium foils
Metrerule	Microphone
Vernier Calipers	Video Camera
A pail of water	Cathode Ray Oscillocope

DIAGRAM

………

………

………

………

………

………

………

………

………

………

………

………

....[12]

END OF PAPER

Blank Page

Class	Adm No

Candidate Name: ______________________________

H

millennia institute

2017 Preliminary Examination II
Pre-university 3

H2 Physics **9646/03**

Paper 3 Longer Structured Questions

Wednesday **13 Sep 2016** **2 hours**

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and admission number in the spaces at the top of this page.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, and glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer any **two** questions.

You are advised to spend about one hour on each section.

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	/ 10
3	/ 10
4	/ 12
Sect B	
5	/ 20
6	/ 20
7	/ 20
Total	

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
molar gas constant,	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion,	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas,	W	=	$p\Delta V$
hydrostatic pressure,	p	=	$\rho g h$
gravitational potential,	ϕ	=	$-\frac{Gm}{r}$
displacement of particle in s.h.m.	x	=	$x_o \sin \omega t$
velocity of particle in s.h.m.,	v	=	$v_o \cos \omega t$
		=	$\pm \omega\sqrt{(x_o^2 - x^2)}$
mean kinetic energy of a molecule of an ideal gas	E	=	$\frac{3}{2}kT$
resistors in series,	R	=	$R_1 + R_2 + \ldots$
resistors in parallel,	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + \ldots$
electric potential,	V	=	$\frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage,	x	=	$x_o \sin \omega t$
transmission coefficient	T	=	$\exp(-2kd)$
	where k	=	$\sqrt{\frac{8\pi^2 m(U-E)}{h^2}}$
radioactive decay,	x	=	$x_0 \exp(-\lambda t)$
decay constant,	λ	=	$\frac{0.693}{t_{\frac{1}{2}}}$

Section A
Answer **all** the questions in this section

This page is intentionally blank.

1 Two stars with masses M_1 and M_2 are separated by a distance R of 1.2×10^{10} m as shown in Fig.1.1.

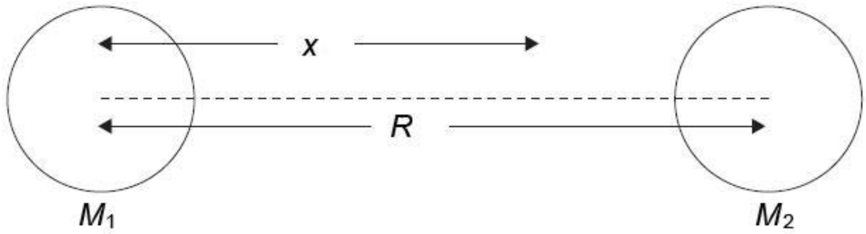


Fig. 1.1

The total gravitational potential due to the stars at any point along a line joining their centres is V. The graph in Fig. 1.2 shows how V varies with the distance x from the centre of star M_1.

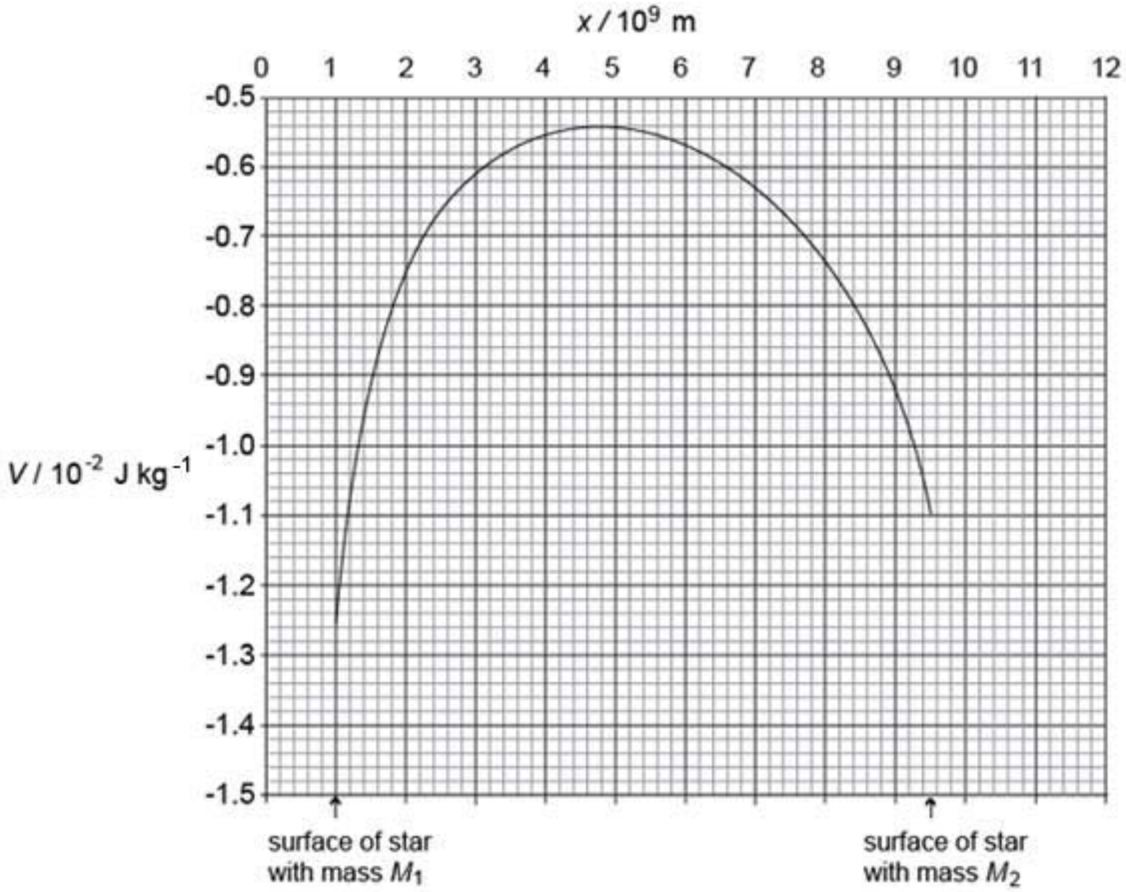


Fig. 1.2

A particle is launched with kinetic energy E_K from the surface of star with mass M_1.

The particle arrives at the surface of the star of mass M_2.

(a) **(i)** Explain what is meant by the term *gravitational potential*.

…………………………………………………………………………………………………

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

(ii) Explain why all values of gravitational potential are negative.

…………………………………………………………………………………………………

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

(b) Use the graph to explain whether the kinetic energy of the particle when it arrives at the surface of M_2 is less than, equal to, or larger than its initial kinetic energy E_K.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

(c) Determine the distance x from the centre of star M_1 at which the gravitational field strength due to the two stars is zero. Show clear explanation of how you arrive at the answer.

distance x = ……………………….. m [2]

(d) Determine the ratio $\frac{M_1}{M_2}$.

ratio = ……………………….. [2]

2 A heat pump is a device that extracts heat from one place and transfers it to another. Refrigerators and air conditioners are both common examples of this technology. Heat pumps work by changing the state of a refrigerant gas through a cycle of evaporation and condensation.

Fig 2.1 shows that in a heat pump, a compressor pumps the refrigerant between two heat exchanger coils.

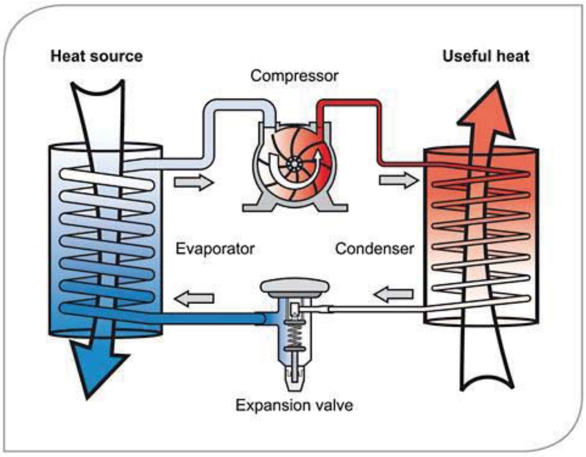


Fig. 2.1

In one coil, the refrigerant is evaporated at low pressure and absorbs heat from its surroundings. The refrigerant is then compressed as it moves to the other coil, where it condenses at high pressure. At this point, it releases the heat it absorbed earlier in the cycle. The heat pump cycle is fully reversible by reversing the direction of movement of the refrigerant. Thus heat pumps can provide year-round climate control – heating in winter and cooling in summer

In a particular heat pump, a fixed mass of gas undergoes a cycle of changes in pressure, volume and temperature as illustrated in Fig. 2.2. Between **A** and **B**, the gas absorbs heat from the atmosphere (gas heats up), and between **C** and **D** it delivers heat to the inside of a building (gas cools down).

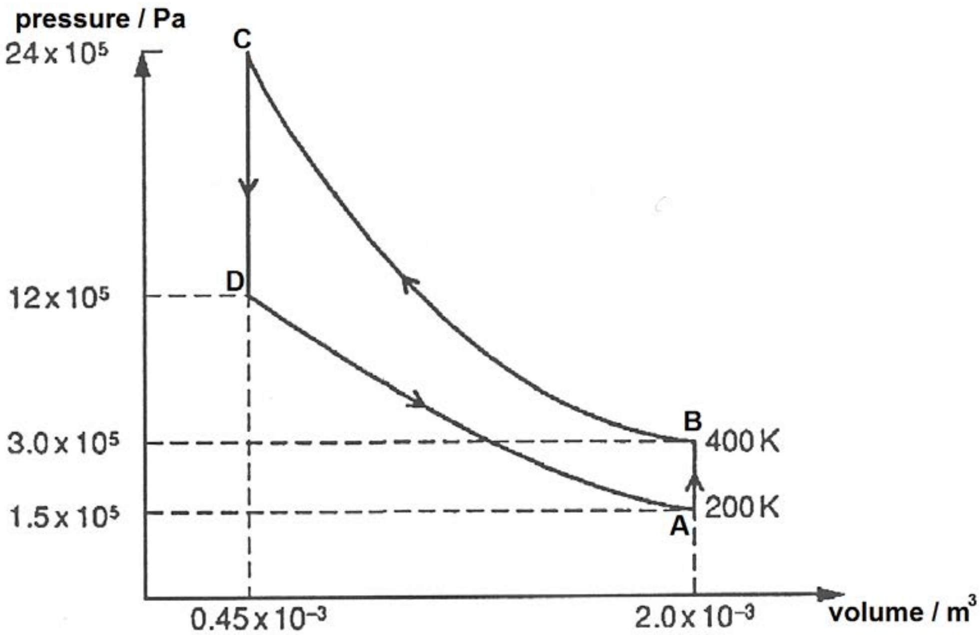


Fig. 2.2

(a) The table below shows the increase in internal energy which takes place during each of the changes **A** to **B**, **B** to **C** and **C** to **D**. It also shows that in both of sections **B** to **C** and **D** to **A**, no heat is supplied to the gas.

	increase in internal energy / J	heat supplied to gas / J	work done on gas /J
A to **B**			
B to **C**	1200	0	
C to **D**	-1350		
D to **A**	-600	0	

Fig. 2.3

(i) Using the first law of thermodynamics and necessary data from the graph, complete the table in Fig 2.3. You will find it helpful to proceed in the following order:

1. work done on gas
2. heat supplied to gas for **C** to **D**
3. increase in internal energy **A** to **B**
4. heat supplied to gas for **A** to **B** [4]

(ii) **1.** With reference to values in Fig 2.3, and given that the cycle is completed 20 times per second, show that the minimum average power of the motor required to run the pump is 12 000 W.

[2]

2. Determine the average rate of supply of heat by the gas to the building.

rate of supply of heat = ……………………….. W [1]

(b) Given that the gas can be assumed to be ideal, determine the change in temperature in the process **C** to **D**.

change in temperature = ……………………….. K [3]

[Turn over

3 **(a)** State the laws of electromagnetic induction.

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

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

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

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

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

…………………………………………………………………………………………………… [4]

(b) Fig. 3.1 shows a circular coil of wire placed in a uniform magnetic field of flux density 5.0×10^{-5} T. The coil has 400 turns, a resistance of 4.0 Ω and an area of 25 cm^2.

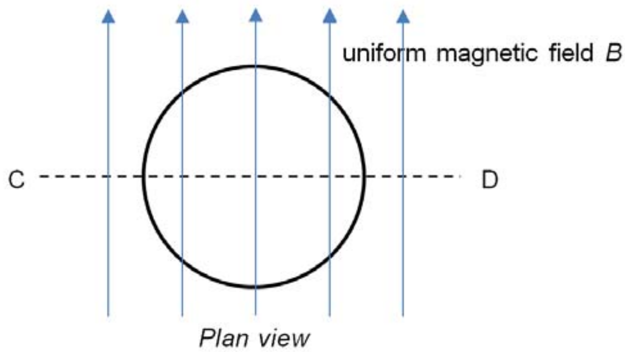


Fig. 3.1

The coil rotates about the axis CD at constant angular velocity.

(i) Using the axes in Fig. 3.2, sketch the following graphs, starting from when the coil is in the position as shown in Fig 3.1. No values need to be shown on either axes.

1. Variation of the magnetic flux linkage with time for one complete cycle. Label this graph as B. [2]

2. Variation of the induced e.m.f. with time for one complete cycle. Label this graph as E. [2]

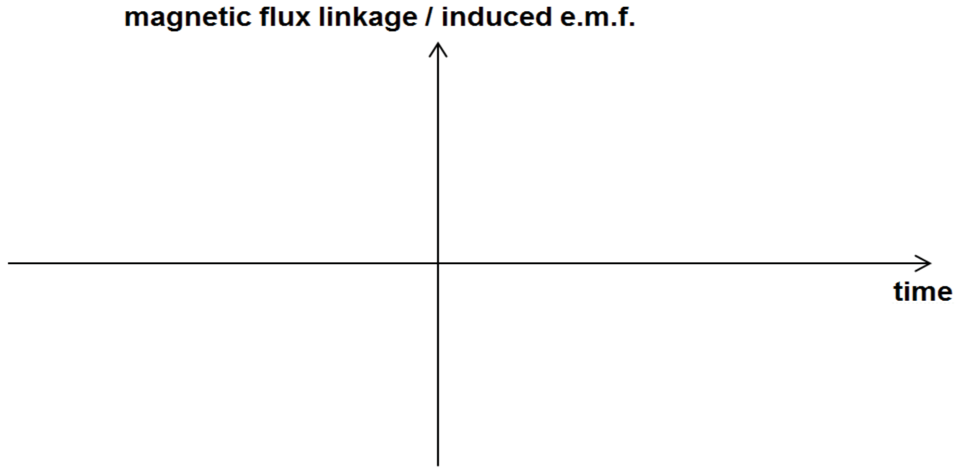


Fig. 3.2

(ii) Determine the amplitude of the induced e.m.f. when the coil is rotating at a constant angular velocity of 18.0 rad s^{-1}.

e.m.f. = ……………………….. V [2]

4 **(a)** What is meant by *mass defect* of a nucleus?

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

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

(b) The Singapore one-cent coin has a mass of 3.0 g. Assuming that it is made entirely of $^{64}_{29}\mathrm{Cu}$ atoms, calculate the energy that would be required to separate all the neutrons and protons in the coin. The following data is given:

rest mass of $^{64}_{29}\mathrm{Cu}$ nucleus = 63.92976 *u*
rest mass of neutron = 1.00867 *u*
rest mass of proton = 1.00728 *u*
You may ignore the rest mass of the electron.

energy required = ……………………….. J [5]

(c) A recent theory suggests that the proton may be unstable with a half-life of the order of 10^{34} years. After how many years would 1% of the 3 x 10^{33} protons in a swimming pool be expected to decay?

number of years = ……………………….. [3]

(d) In a particle detector, such as a cloud chamber, particles leave tracks which can be photographed. One such photograph is sketched in Fig. 4.1. The sketch shows a series of events started by the particle responsible for track A. Tracks D and E were not visible in the original photograph but have been added to the sketch. Such tracks were always straight. Other tracks are curved due to a uniform magnetic field acting at right angles to the plane of the sketch. All the tracks are in the plane of the sketch.

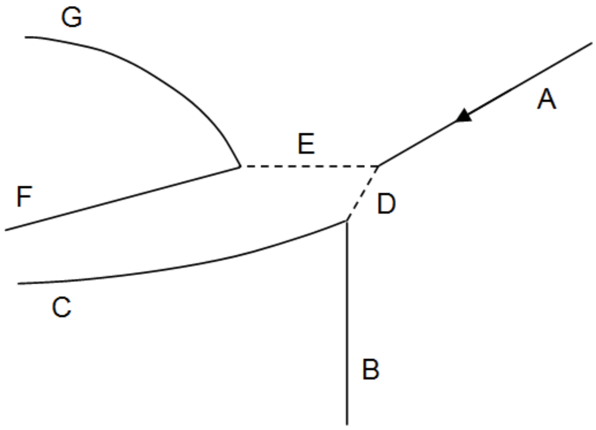


Fig. 4.1

State and explain what can be deduced from each of the following observations:

(i) Tracks D and E are straight.

……………………………………………………………………………………………

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

(i) Track C appears to be more curved than track B.

……………………………………………………………………………………………

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

(iii) Tracks B and C curve in opposite directions.

……………………………………………………………………………………………

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

Section B

Answer **two** questions in this section

5 In this question, all effects of air resistance may be neglected.
A firework of mass m is launched with an initial velocity of magnitude v at an angle of 60° to the ground, which is horizontal.

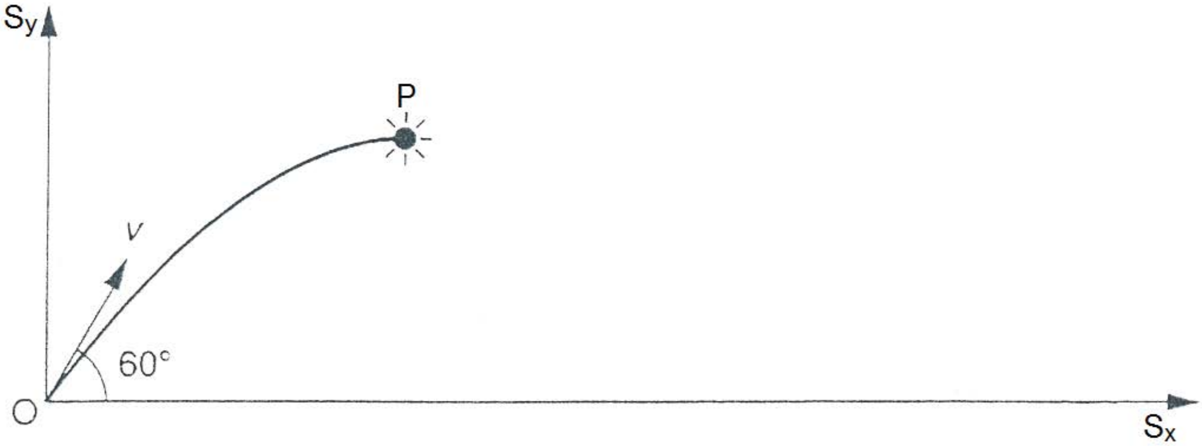


Fig. 6.1

Fig 6.1 shows the path of the firework from the point of projection O to the point of maximum height, P. At the instant when the firework is at P, it explodes and separates into two parts, A and B. The mass of A is $\frac{2}{3}m$, and the mass of B is $\frac{1}{3}m$. Immediately after the explosion, part A is momentarily at rest, and part B moves horizontally. Parts A and B then move along different paths, but strike the ground at exactly the same time.

(a) **(i)** Show that expressions for the magnitudes of the following are both $\frac{1}{2}mv$.

1. Momentum of the firework immediately *before* the explosion:

[2]

2. Momentum of part B immediately *after* the explosion:

[2]

(ii) By determining the velocity of part B immediately after the explosion, deduce an expression for the additional kinetic energy supplied to parts A and B by the explosion.

kinetic energy = ……………………….. J [4]

(b) On Fig 6.1, sketch the paths followed by parts A and B after the explosion. Label these paths clearly. [2]

(c) Explain, by showing appropriate calculations, why the two parts of the firework reach the ground at the same time.

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

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

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

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

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

…………………………………………………………………………………………………… [3]

(d) The firework moves with initial velocity v of 25.0 ms^{-1} and has mass of 0.35 kg. Determine the distance between parts A and B when they strike the ground.

distance = ……………………….. m [4]

(e) For part A, for the time starting from immediately after the explosion until it hits the ground, use the axes below, showing known values on the X-axis, sketch graphs to show

(i) how its gravitational potential energy varies with time, [2]

(ii) how its kinetic energy varies with time, [2]

6 **(a)** Two long, straight wires are held parallel to each other, as shown in Fig. 7.1, and are connected to a circuit such that they carry current of the same magnitude, flowing in the same direction.

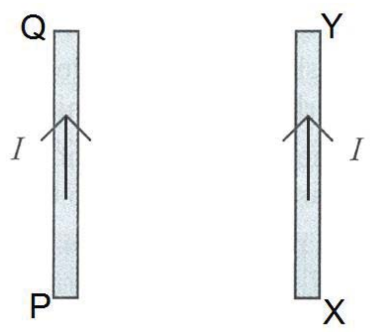


Fig. 7.1

Fig. 7.2 shows a plan view from the top end of the wires.

Fig. 7.2

(i) Draw arrows on Fig. 7.2, to show the direction of

1. the magnetic field at Q due to the current in wire XY (label as **B**), [1]

2. the force at Q as a result of the magnetic field due to the current in wire XY (label as **F**), [1]

(ii) State, by reference to an appropriate Newton's law of motion, the direction of the force on wire XY.

....

.... [2]

(b) In an experiment, a student set up a horizontal steel wire of the same kind in **(a)**, such that it is fixed at one end and kept under tension using standard mass suspended over a pulley at the other end, as shown in Fig. 7.3.

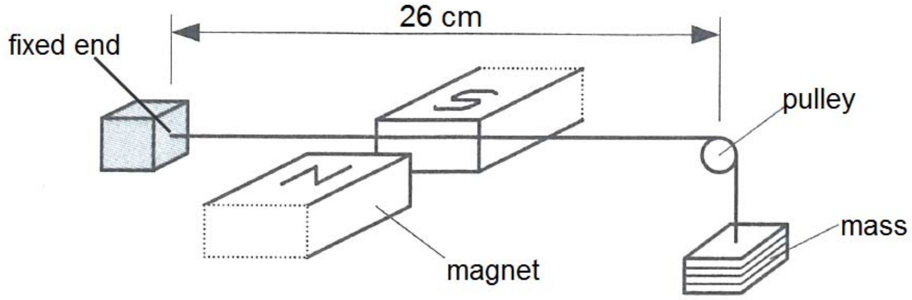


Fig. 7.3

The two ends of the wire, at the fixed point and the pulley, are connected to an low-voltage alternating supply. Poles of a magnet are placed near to the center of the horizontal section of the wire, producing a magnetic field that is at right angles to the wire.

By changing the amount of suspended mass, the tension in the wire can be varied, thereby changing the speed at which waves may travel along the wire. With the alternating supply switched on, the student noticed that when the suspended mass is increased gradually, starting from a small value, the amplitude of vibration of the wire would increase to a maximum and becomes smaller when more mass is added.

(i) Explain

1. why the wire vibrates,

....

....

....

....

....

.... [3]

2. Why, at one value of the tension, the amplitude of vibration is a maximum.

....

....

....

....

....

.... [3]

(ii) The distance between the fixed point and the pulley is 26 cm.

1. draw a sketch to illustrate the shape of the stationary wave on the wire, [1]

2. determine the wavelength of this stationary wave.

wavelength = ……………………….. m [1]

(iii) It is known that speed of propagation v of a wave on a string depends on tension T in the string and linear density μ (mass per unit length), by the equation

$$v = \sqrt{\frac{T}{\mu}} \ .$$

The wire has a mass of 12 g and total length of 1.00 m, and it first vibrates with maximum amplitude when the mass is 800 g.

Determine frequency of vibration of the wire.

frequency = ……………………….. Hz [4]

(iv) Outline briefly the use of a stroboscope as an alternative experimental method with which the frequency of vibration of the wire at this mode of vibration can be verified.

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

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

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

(c) At a distance d from a long straight wire carrying a current I, the magnetic flux density B is given by

$$B = 2.0 \times 10^{-7} \times \frac{I}{d}$$

By using the expression given above, and by making **reasonable estimates** of the magnitudes of the quantities involved, explain why any two wires carrying alternating current are not seen to vibrate under normal circumstances.

………

………

………

………

………

……… [3]

7 **(a)** Ruby is a crystal of aluminium oxide (Al_2O_3) in which some aluminium ions are replaced by chromium ions. It contains 0.05% to 0.5% of chromium and its colour is pink. It is the energy levels of chromium, which takes part in lasing action to produce the distinct red colour laser light in the ruby laser.

Fig 7.1 below shows the energy level diagram of chromium. The energy values shown are relative to the ground state, E_1, which is taken to be 0 eV.

Flashes of light (optical pumping) are used to achieve population inversion in the lasing medium. During this process, electromagnetic radiation of wavelength 550 nm is used to excite chromium atoms from E_1 to E_3.

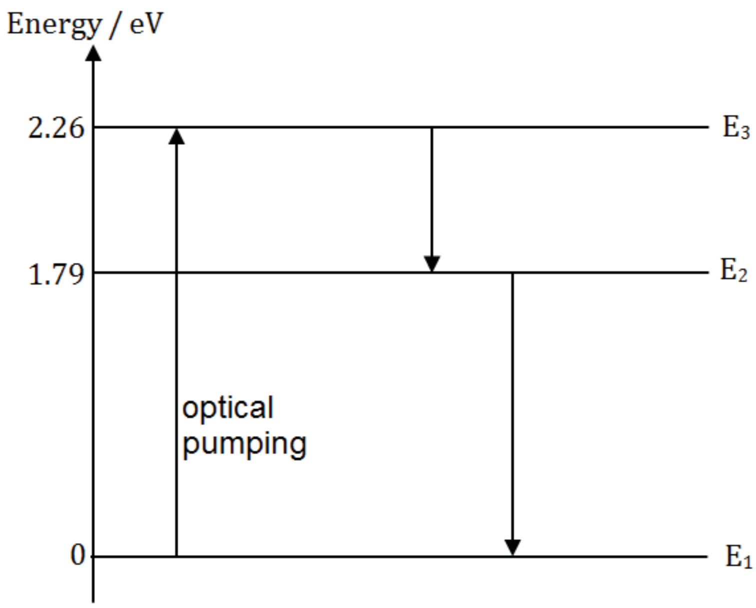


Fig. 7.1

(i) Stimulated emission and spontaneous emission are two processes in which photon emissions can take place.

Explain the main difference between how these processes **can** happen.

....

.... [1]

(ii) Explain what is meant by *population inversion* and why it is an essential condition in laser production.

....

....

....

.... [2]

[Turn over

(iii) **1.** By estimating a suitable value of wavelength for the laser and using suitable calculations, determine the lasing transition.

lasing transition: …………………………... [3]

2. Hence determine the exact wavelength of the laser.

wavelength = …………………………... m [1]

(b) A student uses the ruby laser in **(a)** in the setup shown in Fig. 7.2 below. In the setup, two metal electrodes A and B are sealed into an evacuated glass envelope and a potential difference V, measured using the voltmeter, is applied between them.

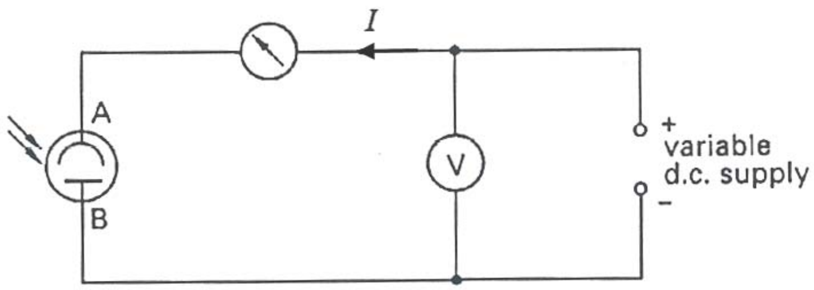


Fig 7.2

Electrode B is then illuminated with the ruby laser and I, current in the circuit, is measured for various values of V. The results are shown in Fig. 7.3.

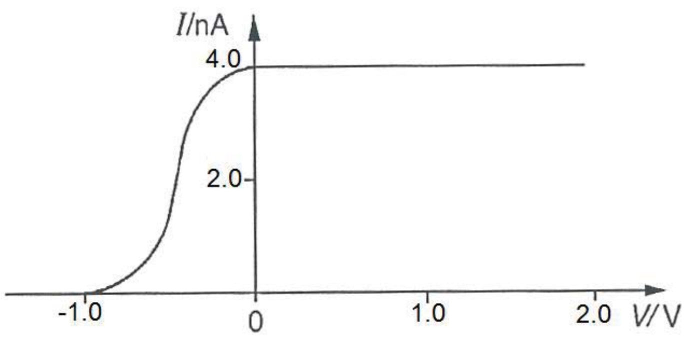


Fig 7.3

(i) **1.** Explain briefly why current I flows in the circuit when Electrode B is illuminated with the ruby laser.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

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

2. One observation made in this experiment is that below a certain frequency of irradiation, there will not be any current obtained. Explain the significance of this observation.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(ii) From **Fig 7.3**, deduce

1. the maximum kinetic energy of the photoelectrons that move from electrode B to A

maximum kinetic energy = ………………………….. J [1]

2. the work function energy for the electrode B.

work function = ………………………….. J [2]

(iii) The average intensity of the ruby laser is 10.0 x 10^3 Wm^{-2}. The area of electrode B is 3.0 cm^2.

1. Estimate the number of photons incident per second on the irradiated surface.

number of photons incident per second = ………………………….. [2]

2. The current recorded on the ammeter is 2.5 μA.

Determine the number of electrons emitted per second from surface B.

number of electrons emitted per second = ………………………….. [2]

3. Hence determine the yield ratio

$$\frac{\text{number of electrons emitted per second}}{\text{number of photons incident per second}}$$

ratio = ………………………….. [1]

4. Comment on your answer to **(iii) 3.**

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

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

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

END OF PAPER

2017 Preliminary Exam II

Pre-university 3

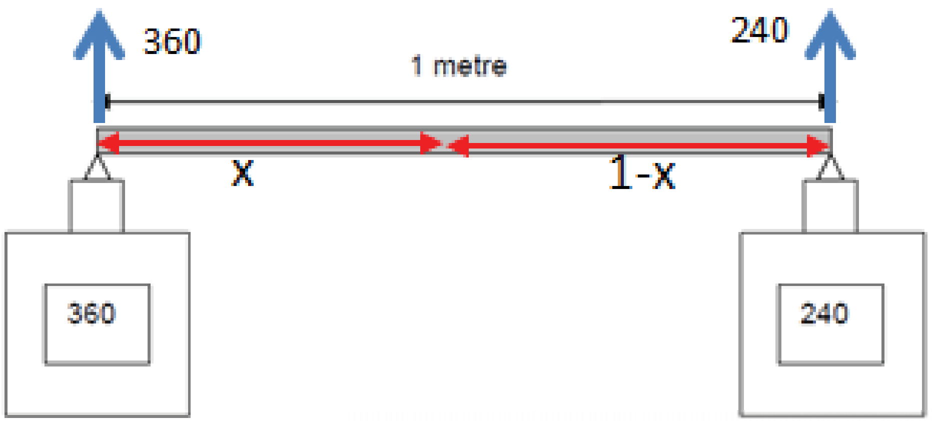
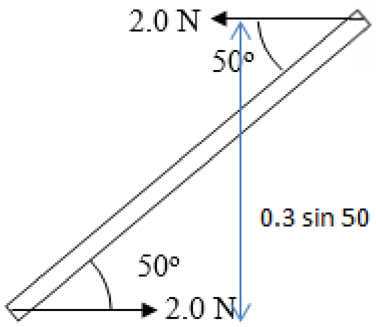
H2 Physics

9646 / 01

Mark Scheme

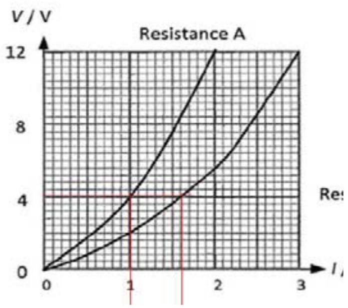
1. B	11. A	21. D	31. B
2. B	12. A	22. D	32. A
3. C	13. D	23. C	33. B
4. C	14. A	24. B	34. C
5. C	15. C	25. A	35. D
6. A	16. B	26. C	36. B
7. A	17. B	27. A	37. A
8. D	18. A	28. C	38. D
9. C	19. C	29. A	39. C
10. B	20. B	30. D	40. D

Paper 1 suggested solutions		
1.	B	General Knowledge
2.	B	Using Q = I.t Q = 12 $\frac{\Delta Q}{Q} = \frac{\Delta I}{I} + \frac{\Delta t}{t}$ $\frac{\Delta Q}{Q} = \frac{0.05}{2} + \frac{0.01}{6}$ = 0.02667 = 2.7%
3.	C	t = time taken for 1st chestnut to fall through 12 m, from rest t_1 = time taken for 1st chestnut to fall through first 2.0 m t_2 = time taken for 1st chestnut to fall through last 10.0 m = time taken for 2nd chestnut to fall through 12 m 12.0 = ½ (9.81) t^2 → t = 1.564 s 2.0 = ½ (9.81) t_1^2 → t_1 = 0.6386 s $t_2 = t - t_1$ = 0.9254 s Let u be the initial speed of 2nd chestnut. 12.0 = u (0.9254) + ½ (9.81)(0.9254)^2 → u = 8.415 m s^{-1}
4.	C	At U-turn, there should be change of sign for velocity => a straight line that cuts into opp-sign region a is gradient of v-t graph and should be same throughout. Same sign for acceleration as decelerate when v and a opp sign at first, then accelerate when v and a becomes same sign after U-turn.
5.	C	Area under F-t graph = Change in momentum Area = (6)(x/3) + ½ (4)(2/3 x) = 20 units X = 6

6.	A	From the first diagram, it can be deduced that block Z is rougher than block X. When block Z is in contact with the table surface, it requires a smaller force to keep the blocks at constant velocity compared to when block Y is in contact with the table. So, Y is rougher than Z. Hence, the order of decreasing roughness is YZX.
7.	A	 360 x X = (1-X) x 240 X = 0.4 m Hence it is 0.1 m to the left.
8.	D	

9.	**C**	Work Done = F.S cos θ = 2500 x 15 cos 30 = 32476 J = 32500 J
10.	**B**	Ep = mgh = 4.2 x 9.81 x 0.29 = 11.94 J = 12J (2 SF) Since the mass is lower than original position, the gain is Ep is negative. Hence Ep = -12 J F = kx (Using Hooke's Law) 4.2 x 9.81 = k (0.29) K = 142 Es = ½ k x^2 = ½ (142)(.29)^2 = 5.97 J = 6.0J (Positive)
11.	**A**	Direction of velocity is changing. Hence it is not the same.
12.	**A**	Tension is minimum at the top. Fnet = $m r \omega^2 = T + mg$ $T = m (r \omega^2 - g)$
13.	**D**	$F_M = \frac{GMm}{\frac{d^2}{2}} = 4\frac{GMm}{d^2}$ to Left $F_{2M} = \frac{G(2M)m}{\frac{d^2}{2}} = 8\frac{GMm}{d^2}$to right Net force is $\frac{4GMm}{d^2}$ to the right
14.	**A**	Consider potential at surfaces of the planets: $\phi_A = -\frac{GM}{r}$ $\phi_B = -\frac{G(8M)}{2r} = 4\phi_A$ Hence, potential at surface of planet A must be smaller in magnitude compared to the potential at surface of planet B (ie options A or B). The gravitational potential near each of the planets is mainly due to that planet and the graphs must be reciprocal curves. Alternatively – use Graphic Calculator to plot and compare

15.	**C**	f = n $\omega = 2\pi f = 2\pi n$ rad s^{-1}
16.	**B**	KE = ½ m $\omega^2(X_0^2 - X^2)$ = ½ x 0.15 x ω^2 x $(0.025^2 - 0.01^2)$ = 0.62 $\omega^2 = 15746$ Since $\omega = 2\pi f$ f = 19.9 Hz = 20 Hz
17.	**B**	Heat supplied = heat absorbed Pt = mc ΔT (1000)(200) = (1.5) c (357 – 300) c = 2339 = 2400 J kg^{-1} K^{-1}
18.	**A**	the term Nm/V is total mass of gas per unit volume, thus density 2.0 x 0.3 x sin 50 = 0.460 Nm
19.	**C**	$V = f\lambda$ $\omega = 2\pi f = 0.35$ f = 0.0557 λ = 0.50 / 0.0557 = 8.97 = 9.0 m (2 SF)
20.	**B**	$\Delta\phi = \frac{\Delta t}{T} \times 2\pi = \frac{1}{8} \times 2\pi = \pi/4$
21.	**D**	$finge\ sep\ x = \frac{\lambda D}{a}$ To increase x, increase wavelength.
22.	**D**	**A** is correct. **B** is correct. $n_y\lambda_y = n_v\lambda_v$ $\frac{\lambda_y}{\lambda_v} = \frac{n_v}{n_y}$ $\frac{600}{400} = \frac{n_v}{n_y} = \frac{3}{2}$

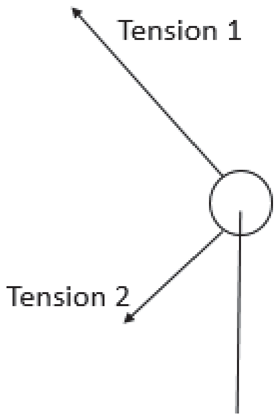
		C is correct. $n \le \frac{d}{\lambda}$ $\le \frac{1\times10^{-2}}{5000}\times\frac{1}{600\times10^{-9}}$ ≤ 3.33 **D** is incorrect Red light will diffract more than violet light because red light has longer wavelength than violet light.
23.	**C**	Field lines are further apart, hence the field strength is weaker.
24.	**B**	$qV = ½ mv^2$ $1.6 \times 10^{-19} \times (40 – 10) = ½ (9.11 \times 10^{-31}) v^2$ $v = 3.25 \times 10^6$ m s^{-1}
25.	**A**	V = WD/Q = 20/5 = 4
26.	**C**	 From graph, Current is 1.0 A and 1.6 A Totally current is 2.6 A.
27.	**A**	Using the potential Divider Method: Potential at Y = $2 \times \frac{5}{6} = 1.667$ Potential at X = $2 \times \frac{3}{6} = 1.0$ Hence potential difference = 0.667

28.	**C**	6 // 8 = 3.429 Total Resistance = 3.429 + 2 = 5.429 Current = V/R = 10 / 5.429 = 1.842 A V = I R = 1.842 x 3.429 = 6.3165 I across 6 ohm = V/R = 6.3165/6 = 1.053 = 1.1 A (2 SF)
29.	**A**	According to FLHR, the force on the positive ions is DOWNwards.
30.	**D**	Knowledge of velocity selector
31.	**B**	magnetic flux Taken to be ideal case, all of the magnetic flux would be inside the soft iron ring core. All other quantities will be different due to the different dimensions or number of turns of the two coils.
32.	**A**	When rod EF is moved to the left, by Lenz's Law (or Fleming's Right hand Rule), induced current flows anticlockwise in the closed loop EFHG. Current flows from H to G. By Fleming's Left hand Rule, rod GH will experienced a magnetic force to the left, while rod EF will experience a magnetic force to the right. Rod EF will slow down while rod GH speeds up until both rods achieve the same speed to the left. At this time, the flux through EFHG remains constant, there will no longer be induced emf or current in the closed loop, the rods will continue to move leftward at a constant speed.
33.	**B**	1. Square the graph 2. Find Total Area : 1x 10^{-6} x 10^{-6} + 4 x 10^{-6} x 2 x 10^{-6} = 9 x 10^{-12} 3. Mean: Area / Period = 9 x 10^{-12}/ 3 x 10^{-6} = 3 x 10^{-6} 4. Sq:$\sqrt{3 \times 10^{-6}}$ = 1.73 x 10^{-3} A
34.	**C**	Increasing the angular frequency increases both the angular frequency and the maximum induced emf
35.	**D**	**D**

		$E=\frac{1}{2}mv^2 \Rightarrow p=\sqrt{2mE}$ $\lambda=\frac{h}{p}=\frac{h}{\sqrt{2mE}}\propto\frac{1}{\sqrt{m}}$ **The fringe spacing Δx for double-slit experiment is proportional to λ, thus** $\Delta x \propto \frac{1}{\sqrt{m}}$ $\frac{(\Delta x)_{C60}}{(\Delta x)_n}=\sqrt{\frac{m_n}{m_{C60}}}=\frac{1}{\sqrt{720}}$
36.	**B**	Transmission coefficient is higher for electrons, hence higher chance to tunnel
37.	**A**	At very low temperature, no external energy to create electron-hole pair.
38.	**D**	electron-deficient impurity atoms IS Group III elements, introduces a donor energy level near to vb. At zero kelvin, so no energy for electrons to move to cb.
39.	**C**	Nuclide $^{156}_{64}Gd$ has 156 nucleons. total binding energy = (156)(1.3) = 202.8 pJ
40.	**D**	30 / 20 = 1.5 half-lives for X => new activity A = $(½)^{1.5}A_o$= 0.354 A_o 30 / 15 = 2 half-lives for Y => new activity A = $(½)^2 A_o$ = 0.250 A_o total activity of the mixture = 0.354A_o + 0.250 A_o = 0.60 A_o

2017 Prelim Exam II
Pre-university 3
H2 Physics
9646 / 02
Mark Scheme

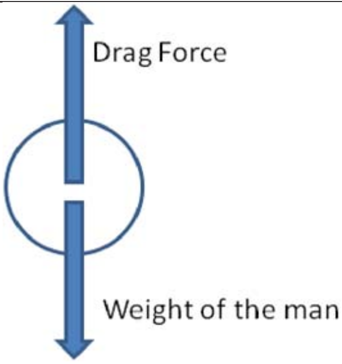
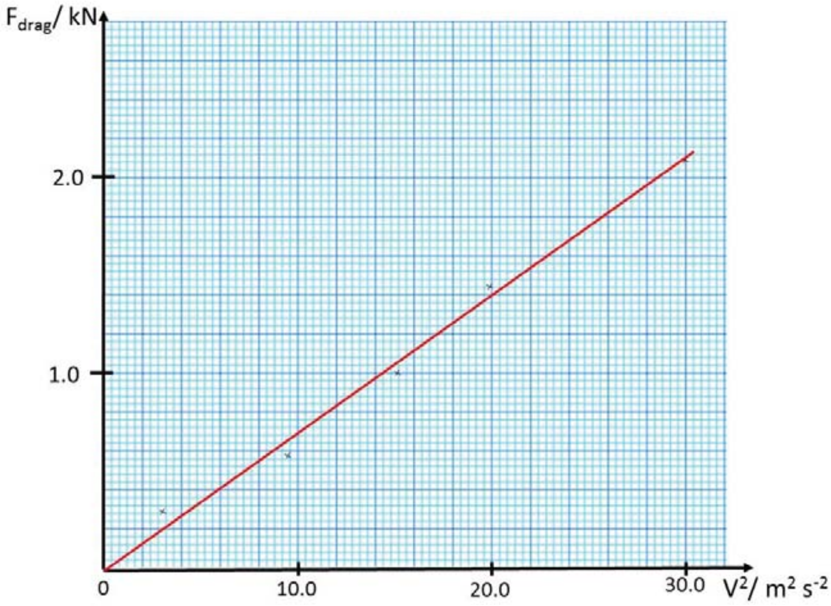
Section A

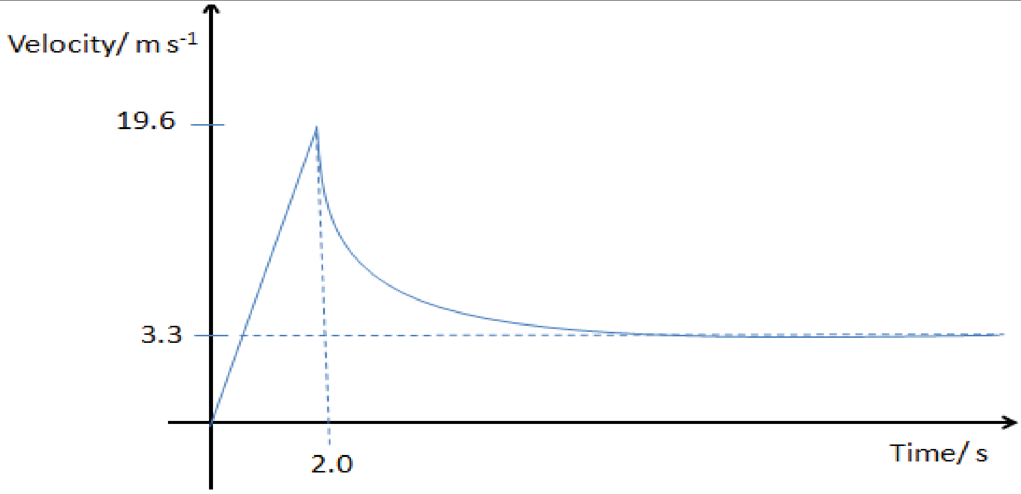
1	**(a)**		**A1**
	(b)	$\theta = \cos^{-1}(1.00 / 1.25)$ $= 36.87°$ Sum of forces along the Y Axis = 0: $T_U \cos\theta = T_L \cos\theta + mg$ (show correct substitution) $T_L = 21.0$ N (shown)	**C1** **M1** **A0**

	(c)	$F_C = mr\omega^2$ $T_U \sin\theta + T_L \sin\theta = m(1.25 \sin\theta)\omega^2$ $\omega = 4.266$ rad s^{-1} f = 40.7 rev min^{-1}	M1 M1 A1
	(d)	$T_L = 0$ $T_U = mg / \cos\theta = 49.0$ N $T_U \sin\theta = m(1.25 \sin\theta)\omega^2$ ω = 3.13 rad s^{-1} f = 29.9 rev min^{-1}	M1 M1 A1
	(e)	$T_U \sin\theta = m(1.25 \sin\theta)\omega^2$ => T_U becomes smaller $T_U \cos\theta = mg$ => $\cos\theta$ becomes bigger θ becomes smaller Alternate answer: With lower spin frequency, smaller centripetal force Fc is needed. As Fc is provided by horizontal component of Tension ($T_u \sin\theta$), which now is a smaller value required, θ becomes smaller too.	A1 A1 A1 A1
2	(a)	Coherence refers to source 1 and source2 having a **constant phase difference** between each other. This can be achieved by connecting the 2 speakers to the same source	A1 A1
	(b)	When S1 is moved, the **path difference** between S1 and S2 changes. When the path difference is a multiple of the wavelength, there is a constructive interference, this gives rise to a high intensity sound being produced. When the path difference is 0.5λ, 1.5 λ, 2.5 λ, a destructive interference is produced.	A1 A1
	(c)	Path difference = 0.5 λ to change from a max to min 0.5 λ = 0.082 m λ = 0.164 m	 A1

	(d)(i)	Path difference = 0.082 λ = 0.082 f = 4100 Hz v = f λ = 336.2	**C1** **A1**
	(d)(ii)	At the original position, it is closer to the source as the intensity of the wave decreases as it is further from the source.	**A1**
	(e)	Let I = KA^2 Hence K = $\frac{I}{A^2}$ $A_2 = \sqrt{\frac{3I}{K}} = \sqrt{3I \times \frac{A^2}{I}} = \sqrt{3}$ A Summation of A + A_2 = (1 +$\sqrt{3}$)A = 2.732A $I_{new} = K(2.732A)^2$ $= \frac{I}{A^2} \times 7.464\,A^2 = 7.46$ I	 **C1** **C1** **A1**
3	**(a)**	The electric force acting per unit positive charge.	**A1**
	(b)i	Positive to negative Evenly spaced out and symmetrical	**A1**
	(b)ii	E = V/d = 4000 / 0.05 = 80000	**A1**
	(b)iii	1.6×10^{-19} C (Knocking out 1 electron)	**A1**
	(b)iv	Since it is a "**Show**" question, student must state the law of conservation of energy: Gain in KE = Work Done by the E field $\frac{1}{2} mv^2 - 0 = q\,\Delta V$ $\frac{1}{2} mv^2 = qV$ $\frac{1}{2} mV^2 = 1.6 \times 10^{-19} \times 2000$ $V = \sqrt{\frac{2 \times 1.6 \times 10^{-19} \times 2000}{m}} = \sqrt{\frac{6.4 \times 10^{-16}}{m}}$	 **M1** **M1** (with correct substitution)
	(b)v	*Since acceleration = 0 (Outside the E Field)* *d/t = v* $\sqrt{\frac{6.4 \times 10^{-16}}{m}} = \frac{1.5}{2.3 \times 10^{-6}}$ *m = 1.50 x 10^{-27}kg*	**C1** **A1**

4	(a)	Using potential Divider formula $12 \times \frac{R}{R+1000} = 11$ 12R = 11R + 11000 R = 11000 Ohm	C1 A1
	(b)i	R = 11000 Ohm V = 3V I = V/R = 3/11000 = 2.73 x 10^{-4} ohm	A1
	(b)ii	R/1000 x 12 = 3 R = 250 ohm (1000 – 250) / 1000 = 0.75 m	A1
	(b)iii	I = V/R = 12/1000 = 0.012 A Power = I^2R = 0.012^2 x 750 = 0.108 W	C1 A1
	(c)	When the bulb is placed parallel to AB, the effective resistance decreases as resistance of the lamp is very small compared to the voltmeter's resistance. Hence there is very little PD across AB and there is insufficient PD to light up the bulb.	A1 A1
5	(a)	Input to the primary coil is connected to an alternating voltage and hence an AC current flows through the primary coil The ac sets up a **varying magnetic field in the iron core which links the primary coil with the secondary coil** This **changing magnetic flux linkage induces an alternating emf across each turn of the wire in the secondary coil.** According to **Faraday's law of Electromagnetic induction, the rate of change of magnetic flux linkage is directly proportional to the emf induced.**	A1 A1 A1
	(b)(i)	It is the steady current which would dissipate heat at the same rate in a given resistor as the AC.	A1
	b(ii)	$\frac{V_s}{V_p} = \frac{I_p}{I_p} = \frac{N_s}{N_p}$ $\frac{V_s}{240} = \frac{2.0}{I_p} = \frac{10}{500}$ $\boldsymbol{V_s = 4.8\ V}$ $\boldsymbol{I_s = 100\ A}$ Assumption: Transformer is 100% efficient	A1 A1 A1

6	a	Light weight, Water Resistant, Good Elasticity, Cheap, Durable,	A1
	b		A1 (Not looking out for magnitude)
	c	MC6 has a higher rate of descent/terminal velocity. It has a smaller effective area as compared to MC1 and hence has a smaller air resistance as compared to that arising from MC1.	A1 A1
	d	The air at sea level is denser and hence will produce a larger air resistance, leading to smaller rate of descent. The air at 9000 ft is less dense and hence produced a lower air resistance.	A1
	e (i)		**M1 Pass through origin** **A1 line of best fit**
	(ii)	Read off from graph x = 16, Y = 1.16 kN (Answer varies according to student's graph, ECF)	A1
	(iii)	$F_{drag} = ½\, \rho\, C_D\, A\, v^2$ Gradient = 1400/ 20 = 70 ½ p C_D A = gradient = 70 A = 75.88 m^2	M1 M1 A1
	(iv)	MC6 since MC6 has an area of 75.4 m^2	A1
	f	v = u + at v = 0 + (9.81)(2) = 19.62 m s^{-1}	A1

	g	 **A1** **Right Shape** **A1** **Proper annotation of important values**	
7	**Variables**	Identification of IV and DV IV = Speed of Dart v DV = Depth on target, d	**M1**
		Constant Variables Distance travelled by dart, same type of dart (Sharpness, mass), same material for absorption material	**M1**
	Diagram	Placement of photo gates and data logger Placement of pump to the blowgun to shoot the dart Placement of blowgun pointing at the target	**M1** **M1** **M1**
	Procedure	Speed of the dart measured using Photogate and datalogger Depth of penetration measured using verniar callipers (Depth measuring probe) Pump used to vary the speed of the dart	**M1** **M1** **M1**
	Analysis	Hypothesis: $d = Mv^n$ Plot a graph of lg d against lg v Gradient is n, lg M is the Y intercept	**M1** **M1**
	Safety	Stay clear of the absorption target Ensure that the blowgun is not connected to the pump	**M1**
	Accuracy	Take multiple reading of the velocity and depth and take average	**M1**

2017 Prelim Exam II

Pre-university 3

H2 Physics

9646 / 03

Mark Scheme

Section A

1	(a)(i)	Gravitational potential is the work done per unit mass by an external agent to bring a mass from infinity to that point in the field.	B1
	(ii)	Gravitational potentials have negative values as the field force is attractive by nature, and so the external agent does negative work in bringing a mass into the field.	B1
	(b)(i)	Make ref to graph in recognizing that potential (or GPE) of particle **increases** from M_1 to M_2 ; therefore by **COE**, gain GPE => Loss KE and hence KE is **lesser than initial.**	M1 A1
	(c)	Field strength is zero where potential-gradient dV/dr (= g) is zero x = 4.8 x10^9 m; (allow answers in the range of 4.5 to 5.0)	M1 A1
	(d)	field strength due to M_1 = field strength due to M_2 at 4.8 x10^9 m $\frac{GM_1}{r_1^2} = \frac{GM_2}{r_2^2}$ $\frac{M_1}{4.8^2} = \frac{M_2}{7.2^2}$ $\frac{M_1}{M_2} = 0.44$ (allow answers in range 0.36 to 0.48)	C1 A1

2 (a)(i) — **A4**

	increase in internal energy / J	heat supplied to gas / J	work done on gas /J
A to **B**	**+750**	**+750**	**0**
B to **C**	1200	0	**+1200**
C to **D**	-1350	**-1350**	**0**
D to **A**	-600	0	**-600**

Max 4 marks. Minus 1 mark for each wrong answer.

(ii)1. In each cycle, net work done on gas (by pump) = +600 J — **M1**

Min power to run pump = (600)(20) = 12 000 W — **M1, A0**

(ii)2. In each cycle, supply of heat by the pump = 1350 J (process C to D)
Rate of heat supplied by pump = (1350)(20) = 27 000 W — **A1**

(b) Using one of the processes with a known starting temp (B to C, or A to D)

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

T_B = 720 K — **C1**

$\frac{P_1}{T_1} = \frac{P_2}{T_2}$ for C to D, — **C1**

$T_B = 2T_C$

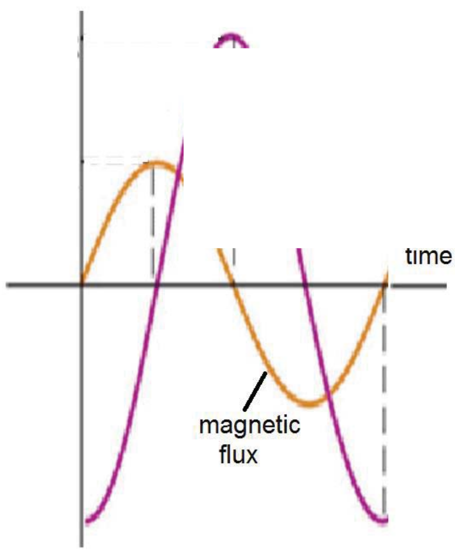
T_C = 360 K,

Thus change in temperature = 360 - 720 = - 360 K — **A1**

3 (a)(i) Faraday's Law states that the magnitude of the induced emf is **directly proportional** to the **rate of change of magnetic flux linkage.** — **B2**

Lenz's Law states that the **polarity of the induced emf** is such that it will produce a current that **creates a magnetic field so as to oppose** the change in magnetic flux linkage that is producing the induced emf. — **B2**

(b)(i) 1. and 2.



Magnetic flux linkage graph -
Sinusoidal shape = 1 mark
Sine shape (starts from 0)
= 1 mark — **B2**

Induced e.m.f -
Correct shape = 1 mark
(deduct if inaccurate or kinks)

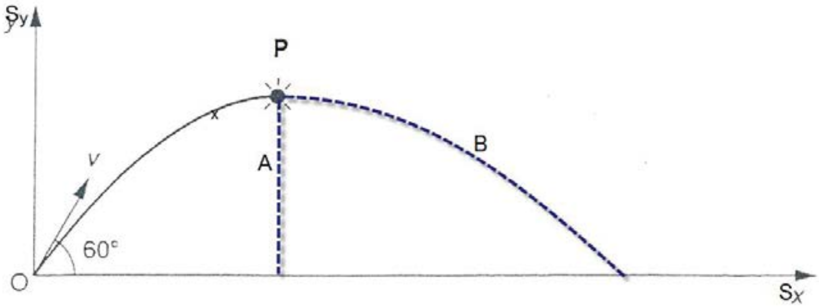
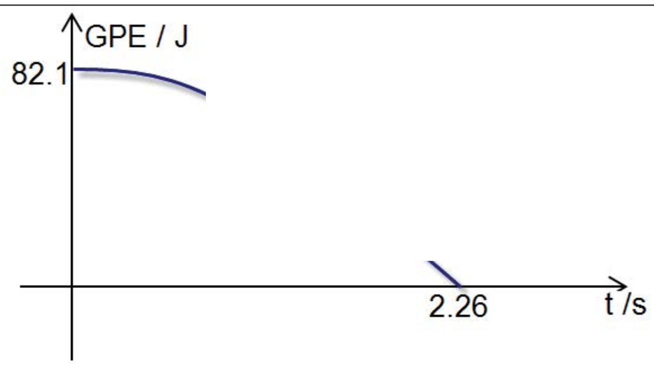
Correct phase relationship with flux linkage graph = 1 mark — **B2**

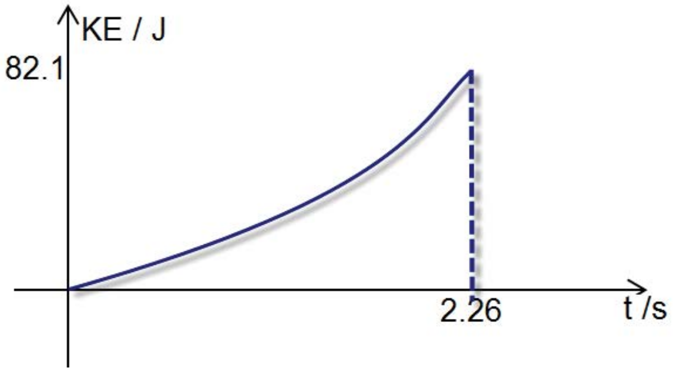
* accept also set of inverted graph

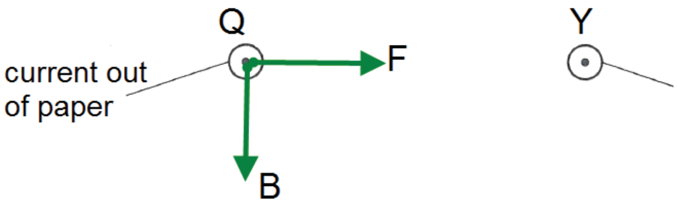
	b(ii)	$E = NBA\omega$ $E = (400)(5 \times 10^{-5})(25 \times 10^{-4})(18.0)$ $E = 9.0 \times 10^{-4}$ V	C1 A1
			10
4	(a)	Mass defect is the **loss in mass** due to the **release of energy** in **forming the nucleus** from the individual protons and neutrons.	B1
	(b)	The number of Cu atoms in the 3.0 g one-cent coin, $N = \frac{M\ coin}{Molar\ Mass} \times N_A = \frac{3}{64} \times 6.02 \times 10^{23} = 2.83 \times 10^{22}\ atoms$ **C1 for division. C1 for conversion from u to kg.** For each nucleus, the binding energy is given by, $E = \left[\left(29m_p + 35m_n\right) - m_{Cu}\right]c^2$ $E = \left[\left(29 \times 1.00728\right) + \left(35 \times 1.00867\right) - 63.92976\right] \times 1.66 \times 10^{-27} \times \left(3.00 \times 10^8\right)^2$ **C1 for** $E = 8.74 \times 10^{-11}$ J **finding number of nucleons. C1 for use of E = mc²** Total energy involved is given by, $E_{Total} = 2.83 \times 10^{22} \times 8.74 \times 10^{-11} = 2.47 \times 10^{12}$ J	C2 C2 A1

	(c)	1% decay => remaining N = 0.99 of No $0.99 = e^{-\lambda t}$ T = 1.45 x 10^{32} years **C1 for use of decay equation** **C1 for use of $\lambda = \ln 2/t_{1/2}$**	**C2** **A1**
	(d)(i)	Tracks D and E are straight, so the particles making these tracks are unaffected by the magnetic field and so must be electrically neutral.	**B1**
	(ii)	If both particles responsible for Track B and C have the same velocity, then the mass to charge ratio of particles in B is higher than the mass to charge ratio of particles in C. Or If both particles responsible for Track B and C have the same momentum, then the charge of particles in B is lower than the charge of particles in C. Or If both particles responsible for Track B and C have the same mass to charge ratio, then the velocity of particles in B is higher than the velocity of particles in C.	**B1**
	(iii)	Track B is the path of a charged particle that is opposite in sign to the particle responsible for track C.	**B1**
			12
5	**(a)(i)**	At highest point P , $V_x = v\cos 60° = ½\ v$ $V_y = 0$ So velocity at P = ½ v Momentum p = m(½ v) = ½ mv	**M1** **M1** **A0**
	(ii)	By PCOM, ½ mv = 2/3 m (0) + p_B p_B= ½ mv	**M1** **A0**
	(iii)	p_B= ½ mv => V_B = 3/2 V initial KE before explosion = ½ m $(V/2)^2$ = 1/8 mV^2 final KE after explosion = $KE_A + KE_B$ = 0 + ½ (1/3 m)$(3/2\ V)^2$ = 3/8 mV^2 Additional KE = 3/8 mV^2 - 1/8 mV^2 = ¼ mV^2	**C1** **C1** **C1** **A1**

[Turn over

	(b)	 **B1 – A is vertically drop** **B1 – B path is longer than from O to P (higher hor velocity after explosion)**	**B2**
	(c)	At P, both A and B have same vertical velocity of 0 ms^{-1}, and both experience same downwards vertical acceleration of 9.81 ms^{-2}, and both are at same vertical height above ground. Using $s = ut + ½ at^2$ in vertical dir, $h = 0 + ½ gt^2$ $t = \sqrt{\frac{2h}{g}}$ for both A and B	**M1** **M1** **A1**
	(d)	A falls directly below P. Time to fall to ground, $t = \sqrt{\frac{2h}{g}}$ for both A and B For B, $S_x = (3/2V)(t) = \frac{3}{2}v\sqrt{\frac{2h}{g}}$ … (1) Using initial projection to find h, $V^2 = u^2 + 2as$ in vert dir, $0^2 = (V\sin 60)^2 - 2gh$ $h = \frac{3v^2}{8g}$ = 23.891 m Subst h into (1), S_x = 82.762 = <u>82.8 m</u>	**C1** **C1** **C1** **A1**
	(e)i	 **B1 for correct shape** **B1 for correct values on X-axis**	**B2**

	(e)ii	 **B1 for correct shape** **B1 for correct values on x-axis**	**B2**
			20

6	**(a)(i) 1. and 2.**		**B1** **B1**
	(a)(ii)	By **Newton's 3rd Law**, direction of force on XY is **towards left.**	**B1** **B1**
	(b)(i)1.	When current flows in the wire, it **interacts with the magnetic field** of the permanent magnet, giving rise to a **magnetic force F** on the wire. Direction of F can be determined using **FLHR** to be either **upwards or downwards, depending on direction of current** in wire. As the a**.c. changes direction, force F changes direction** too and thus wire vibrates.	**M1** **M1** **A1**
	(b)(i)2.	**Tension of wire affects natural frequency f_o of vibration** of the wire. When tension is at a value such that **f_o coincides with frequency of the a.c. source,** **there is maximum energy transfer,** resonance occurs and amplitude of vibration becomes maximum.	**M1** **M1** **A1**
	(b)(ii) 1.	Sketch to show fundamental mode - One of the lines must be dotted	**A1**
	(b)(ii) 2.	Wavelength = 2 (26) = 0.52 m	**A1**
	(iii)	density μ (mass per unit length) = 0.012 kgm^{-1} T = mg = (0.8)(9.81) = 7.848 N $v = \sqrt{\frac{T}{\mu}}$ = 25.573 f = v/λ = 49.180 = <u>49.2 Hz</u>	**C1** **C1** **C1** **A1**

[Turn over

	(iv)	Set up a stroboscope with adjustable frequency of flashing of light at right angles directly in front of the vibration wire. When frequency of flashing is same as the standing wave, the latter will appear to stand still and frequency can then be read off the stroboscope's meter.	B1
	(c)	Consider wires of 1 m, and large current of 10 A (fuse typically is 13A), separated by distance of 0.10 m. By F = BIL , force of 2.0 x 10^{-6} N acts on wires Estimate weight of wires of 1m around 0.10 to 0.50 N Thus magnetic force is of 5 orders smaller than weight of wire and no vibration will occur. Award 1 mark - if no estimates made, or unreasonable in most, and only stating magnetic force is too weak, or magnetic force is too small.	Up to B2 A1
			20

7	(a)(i)	Stimulated emission is triggered by an external photon while spontaneous emission happens on its own accord.	B1
	(ii)	Population Inversion is when there is more number of excited atoms in the higher energy than there are in a lower energy state. It is essential condition for lasing as it ensures that the probability that an incident photon will stimulate emission exceeds the probability that the photon will be absorbed.	B1 B1
	(iii)1.	As the laser light is red, a suitable estimate for the wavelength of red light is 700 nm Therefore, the energy transition involved should be about $\Delta E = hc / \lambda_{red} = \frac{(6.63\times10^{-34})(3.0\times10^{8})}{(700\times10^{-9})(1.6\times10^{-19})}$ = 1.78 eV Thus likely transition is <u>E_2 to E_1</u>	C1 C1 A1
	(iii)2.	exact wavelength of the laser = 694 nm	A1
	(b)(i)1.	In photoelectric effect, atoms at the irradiated metal surface absorb photon energy and breaks free, to be ejected out. An attractive e-field between the electrodes will move these electrons across the gap and forms a current in the circuit.	B1 B1

	(b)(i)2.	By Wave model, in which energy absorption is continuous and accumulative, even with light source of low frequency, so long as sufficient time is given for energy absorption, there should be electrons ejected to form a current. The observation of presence of a threshold frequency below which no photocurrent is obtained shows up the particulate nature of light, in which energy absorption takes place in quantised manner.	B1 B1
	(ii)1.	maximum kinetic energy = eVs = 1.6×10^{-19} J	A1
	2.	work function = hf – max KE = hc/λ - max KE = 1.2643×10^{-19} J = 1.26×10^{-19} J	M1 A1
	(iii)1.	P = $(10.0 \times 10^{3})(3.0 \times 10^{-4})$ = 3.0 W Power = $\frac{N}{t}hf$ N/t of photons = 1.047×10^{19}	M1 A1
	2.	$I = \frac{Q}{t} = \frac{Ne}{t}$ N/t of electrons = 1.5625×10^{13} = 1.56×10^{13}	M1 A1
	3.	yield ratio = 1.49×10^{-6}	A1
	4.	The small yield is due to not all photons are absorbed by surface photons.	B1
			20