Physics Preliminary Examination
Higher 2

PHYSICS

Paper 1 Multiple Choice

9646/01
30 Aug 2016
1 hour 15 minutes

Additional Materials: 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 and Index number in the answer sheet provided.

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

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 Question Paper.

DATA AND FORMULAE

Data

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

Formulae

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

1 Which estimate is realistic?

A The order of magnitude of the frequency of bluetooth signal is 10^9 Hz.
B The acceleration of the Singapore MRT when moving off from a station is $10\ m\ s^{-2}$.
C The density of air at atmospheric pressure is $1.2\ g\ cm^{-3}$.
D The order of magnitude of pressure of air in a car tyre is 10^3 Pa.

2 When computing systematic and random errors, the following pairs of properties of errors in an experimental measurement may be obtained:

X_1: error can possibly be eliminated
X_2: error cannot possibly be eliminated
Y_1: error is of constant sign and magnitude
Y_2: error is of varying sign and magnitude
Z_1: error can be reduced by averaging repeated measurements
Z_2: error cannot be reduced by averaging repeated measurements

Which properties apply to the **random errors**?

A X_1, Y_1, Z_2
B X_1, Y_2, Z_2
C X_2, Y_2, Z_1
D X_2, Y_1, Z_1

3 In an experiment to determine the thickness of the glass of a boiling tube, the following readings were taken using vernier calipers.

Internal diameter, $d_1 = (2.064 \pm 0.004)$ cm
External diameter, $d_2 = (2.560 \pm 0.004)$ cm

The uncertainty in the thickness of the glass is

A ± 0.002 cm
B ± 0.004 cm
C ± 0.008 cm
D ± 0.016 cm

4 A ball is dropped from a height of 20 m and rebounds with a speed which is $\frac{3}{4}$ of the speed with which it hits the ground.

What is the time interval between the first and second bounces?
(Assume that g is $10\,m\,s^{-2}$)

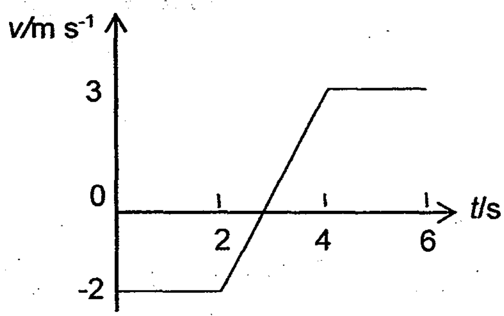
A 1.5 s B 2.5 s C 3.0 s D 4.0 s

5 Two stones, X and Y, of different mass are dropped from the top of a cliff. Stone Y is dropped a short time after stone X. Air resistance is negligible.

Whilst the stones are falling, the distance between them will

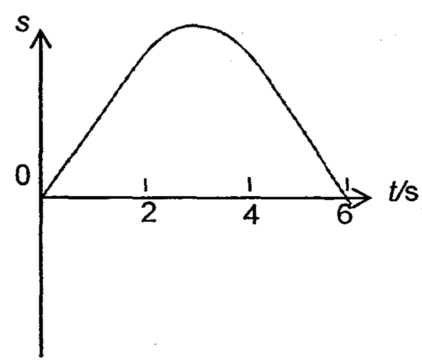
A Decrease if the mass of Y is greater than the mass of X
B Increase if the mass of X is greater than the mass of Y
C Decrease whether the mass of X is greater or less than the mass of Y
D Increase whether the mass of X is greater or less than the mass of Y

6 The figure below shows the velocity vs time (v - t) graph of an object. At time t = 0 s, the object's displacement from the origin is 0 m.

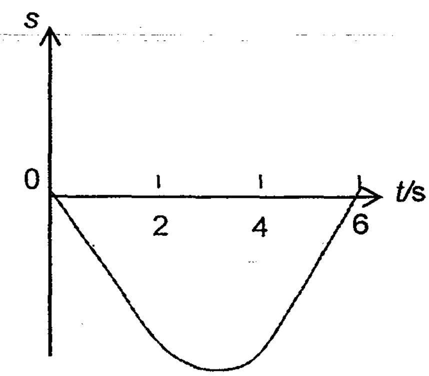


Which of the following best shows the corresponding displacement versus time (s - t) graph of the object?

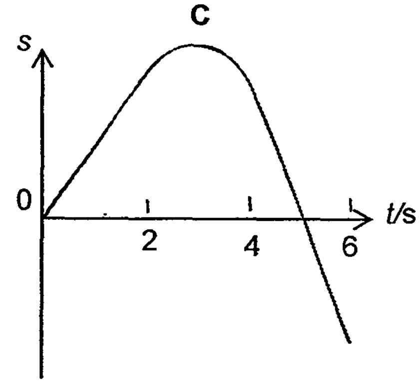
A



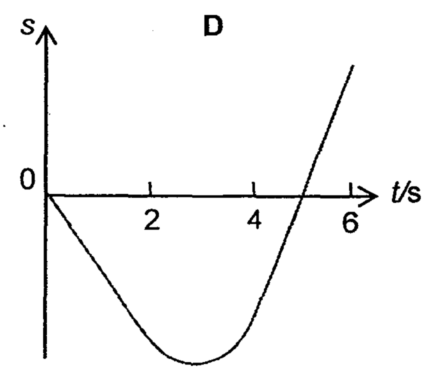
B



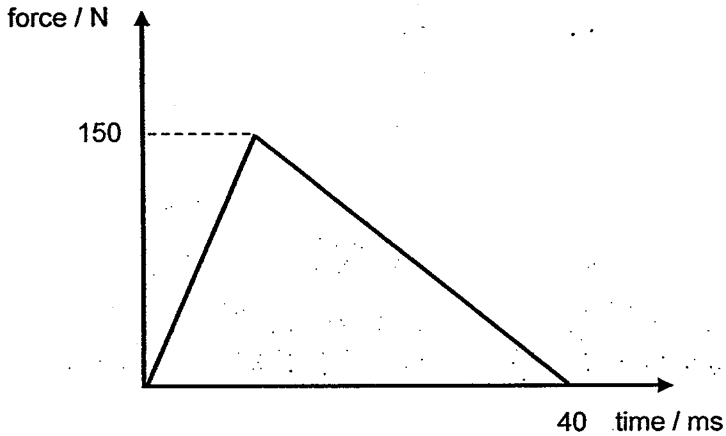
C



D



7 When a player serves a tennis ball of mass 0.060 kg, it is given an impulse of the form shown by the diagram.



Assuming the tennis ball was moving normally towards the racket at 5.0 m s^{-1} just before the racket hits it, its speed, in m s^{-1}, when it leaves the racket is

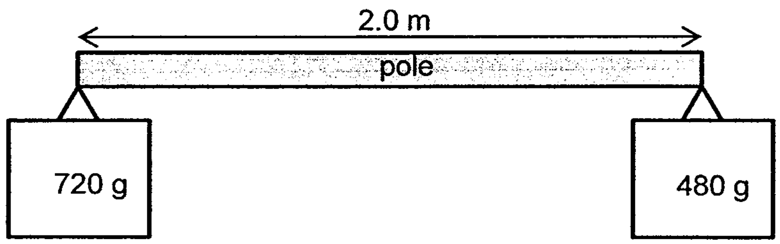
A 45 **B** 50 **C** 55 **D** 95

8 A car of mass 1000 kg moving at 5.0 m s^{-1} on an icy road collides with another car of mass 600 kg moving at 3.0 m s^{-1} in the opposite direction. After the collision, the lighter car moves off at 2.5 m s^{-1} in the initial direction of the heavier car.

What is the speed of the heavier car after the collision?

A 0.5 m s^{-1} **B** 1.7 m s^{-1} **C** 5.3 m s^{-1} **D** 8.3 m s^{-1}

9 A pole of length 2.0 m has non-uniform composition, so that the centre of gravity is not at its geometrical centre. The pole is laid on supports across two weighing balances as shown in the diagram below. The balances (previously set to zero) recorded readings of 720 g and 480 g respectively.



Where is the centre of gravity of the pole with respect to its geometrical centre?

A $\frac{1}{5}$ metre to the left

B $\frac{1}{5}$ metre to the right

C $\frac{1}{3}$ metre to the left

D $\frac{1}{3}$ metre to the right

10 A force of 1000 N is needed to lift the hook of a crane at a steady velocity. The hook is then used to lift a load of mass 1000 kg at a velocity of 0.50 m s^{-1}.

How much of the power developed, in kW, by the motor of the crane is used in lifting the load?

A 4.9 **B** 5.0 **C** 5.4 **D** 5.5

11 An object, immersed in a liquid in a tank, experiences an upthrust.

What is the physical reason for this upthrust?

A The value of the acceleration due to free fall in the liquid increases with depth
B The pressure in the liquid increases with depth
C The density of the body differs from that of the liquid
D The density of the liquid increases with depth

12 A point mass moves through a circular arc of length s and radius r in time t.

What is the angular velocity about the center of the circle?

A $\frac{s}{rt}$ **B** $\frac{r}{st}$ **C** $\frac{2\pi}{st}$ **D** $\frac{2\pi t}{r}$

13 A small spherical planet has radius R = 2000 m and has no atmosphere. The acceleration due to gravity on the surface of this planet is 2.0 m s^{-2}.

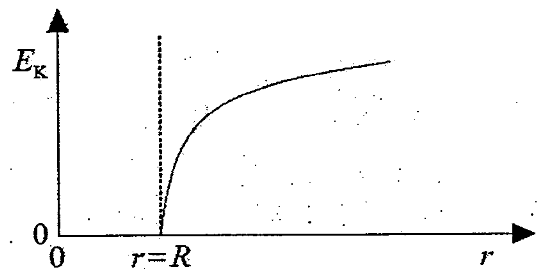
At an altitude of 3000 m above the surface of the planet the magnitude of the gravitational field strength is

A 1.3 N kg^{-1} **B** 0.89 N kg^{-1} **C** 0.80 N kg^{-1} **D** 0.32 N kg^{-1}

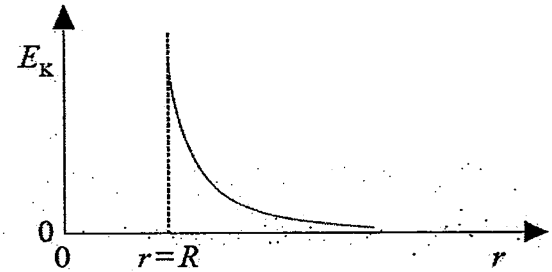
14 The kinetic energy E_K of a satellite in orbit varies with its distance r from the centre of a planet of radius R.

Which one of the following graphs best shows the variation of its E_K with r?

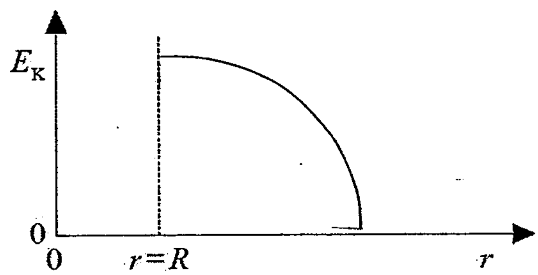
A



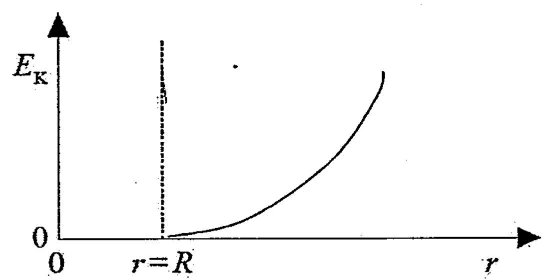
B



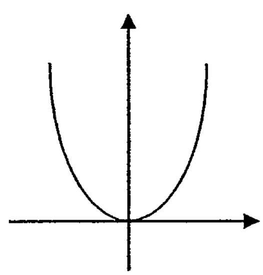
C



D



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



Which quantities have been plotted to produce this graph?

A acceleration and time

B kinetic energy and displacement

C potential energy and displacement

D kinetic energy and time

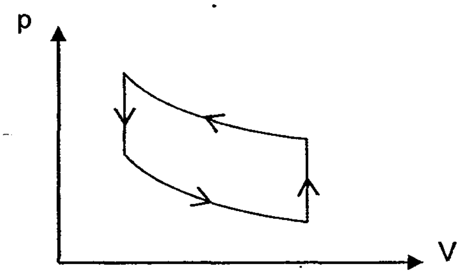
16 A mass attached to the lower end of a spring oscillates about its equilibrium position

At which points in the path of the mass do the gravitational potential energy of the mass (GPE), the elastic potential energy in the spring (EPE) and the kinetic energy of the mass (KE) have their highest values?

	GPE	EPE	KE
A	bottom	middle	top
B	bottom	top	middle
C	top	bottom	middle
D	top	bottom	top

17 An ideal gas undergoes a cycle of processes as shown in the p-V diagram.

Which statement correctly describe the situation?



A The internal energy of the gas increases over one complete cycle.

B The gas gives out more heat than it absorbs over the whole cycle.

C Over the entire cycle, the gas absorbs heat and does net work on its environment.

D The two curved portions of the graph represent adiabatic process.

18 Which statement about internal energy is correct?

A The internal energy of a system can be increased without transfer of energy by heating

B The internal energy of a system depends only on its temperature

C When the internal energy of a system is increased, its temperature always rises.

D When two systems have the same internal energy, they must be at the same temperature.

19 The first law of thermal dynamics may be expressed as shown.

$$\Delta U = q + W$$

where ΔU is the change in internal energy,
q is the heating of the system,
W is the work done on the system.

A fixed mass of ideal gas at high pressure is contained in a balloon. The balloon suddenly bursts, causing the gas to expand and cool.

In this situation, which row describes the values of ΔU, q and W ?

	ΔU	q	W
A	negative	negative	positive
B	negative	zero	negative
C	positive	zero	negative
D	positive	negative	positive

20 Which of the following about polarisation is TRUE?

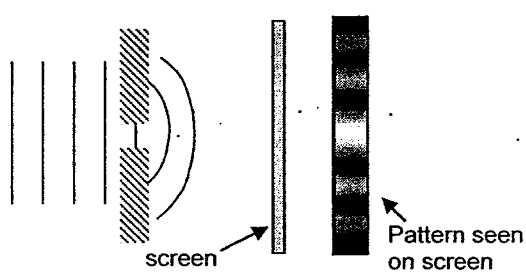
A Sound wave produced by a tuning fork can be polarised

B All electromagnetic waves can be polarised

C Polarisation restrict the vibration of a wave to the vertical direction

D When unpolarised light of intensity I_o, passes through a polariser, the intensity of the light transmitted I is given by Malus' law where $I = I_o \cos^2\theta$ and θ is the angle between the vertical and the transmission axis of the polariser.

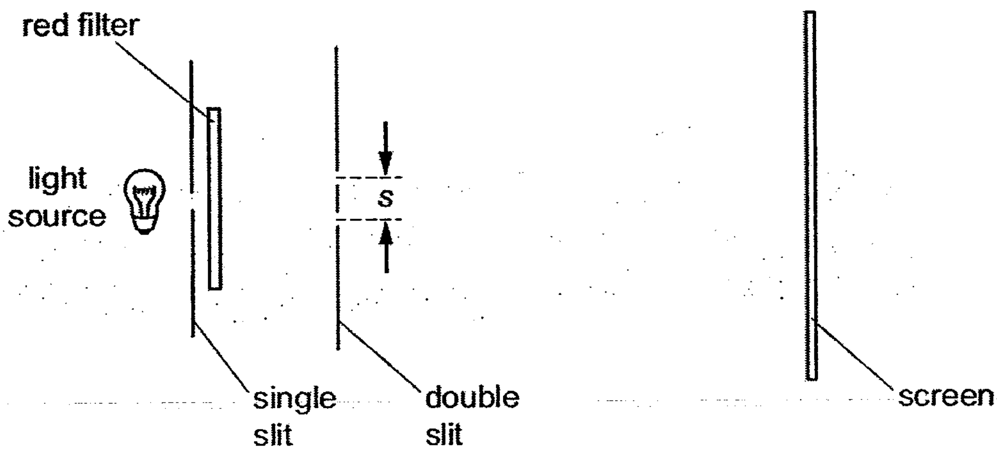
21 A student carried out an experiment on diffraction of water waves in a ripple tank. He passed plane water waves through a single slit, where the wavelength of water waves is comparable to the slit separation. He obtained the following results.



What is the best explanation for the interference pattern seen on the screen?

A The waves reflected from the surrounding walls
B The waves are not coherence
C There are secondary wavelets within the single slit
D There are secondary wavelengths within the plane wave

22 A student sets up an experiment to investigate double-slit interference of light but finds that the interference fringes observed on the screen are too close to each other to be distinguished.



Which change would help the student to distinguish the fringes?

A decrease the distance *s* between the two slits

B increase the width of each slit

C move the screen closer to the light source

D use a blue filter instead of a red filter

23 Monochromatic light of wavelength 650 nm is incident normally on a diffraction grating. The angle between the two third-order beams is 56°.

What is the spacing of the lines on the grating?

A 2.4 μm **B** 2.8 μm **C** 4.2 μm **D** 7.2 μm

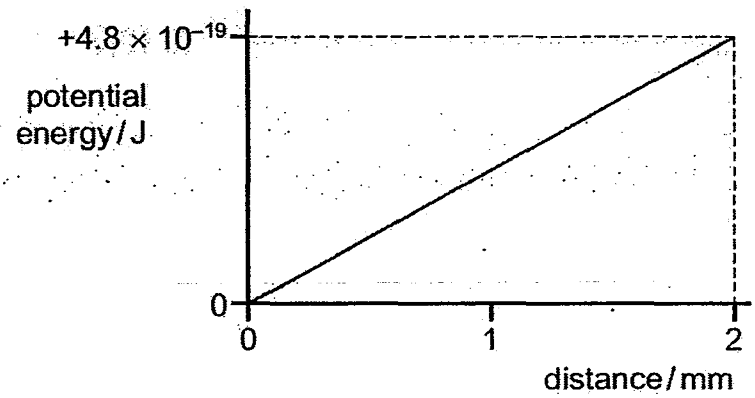
24 When two point charges, each $+Q$, are distance r apart, the force between them is F.

What is the force between point charges of $+Q$ and $+2Q$ when they are distance $\frac{r}{2}$ apart?

A F **B** $2F$ **C** $8F$ **D** $16F$

25 Two parallel plates R and S are 2.0 mm apart in a vacuum. An electron with charge -1.6×10^{-19} C moves along a straight line in the electric field between the plates.

The graph shows how the potential energy of the electron varies with its distance from plate R.



Which deduction is not correct?

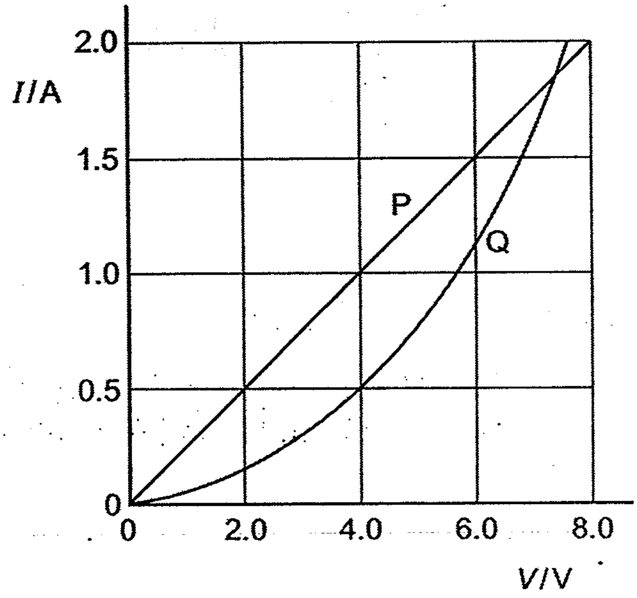
A The electric field between R and S is uniform.
B The electric field strength is 3000 $N C^{-1}$.
C The force on the electron is constant.
D The magnitude of the potential difference between R and S is 3 V.

26 The current in a component is reduced uniformly from 100 mA to 20 mA over a period of 8.0 s.

What is the charge that flows during this time?

A 160 mC **B** 320 mC **C** 480 mC **D** 640 mC

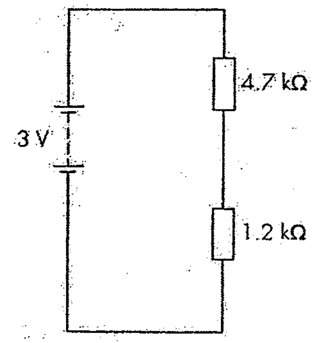
27 The I-V characteristics of two electrical components P and Q are shown below.



Which statement is correct?

A P is a resistor and Q is a filament lamp.
B The resistance of Q increases as the current in it increases
C At 1.9 A the resistance of Q is approximately half that of P.
D At 0.5 A the power dissipated in Q is double that in P.

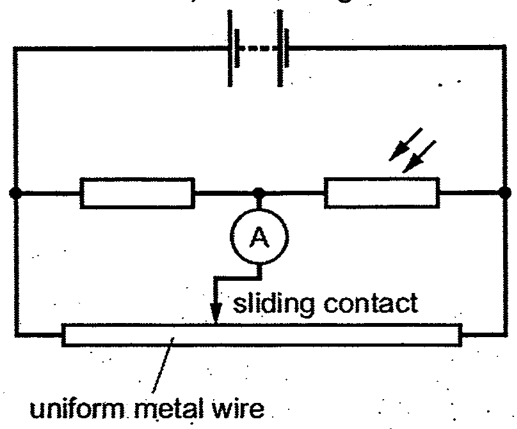
28 A student wants to use a voltmeter to measure the potential difference across the 1.2 kΩ resistor.



What is smallest resistance a voltmeter can have if it is to measure the potential difference across the 1.2 kΩ resistor without introducing a systematic error of more than 1%?

A 0.60 kΩ **B** 1.2 kΩ **C** 60 kΩ **D** 95 kΩ

29 In the potentiometer circuit shown, the reading on the ammeter is zero.



The light-dependent resistor (LDR) is then covered up and the ammeter gives a non-zero reading.

Which change could return the ammeter reading to zero?

A Decrease the supply voltage.
B Increase the supply voltage.
C Move the sliding contact to the left.
D Move the sliding contact to the right.

30 An electron is projected with velocity v into a region where there exist a uniform electric field of strength E perpendicular to a uniform magnetic field of flux density B.

If the electron velocity is to stay constant, v must be

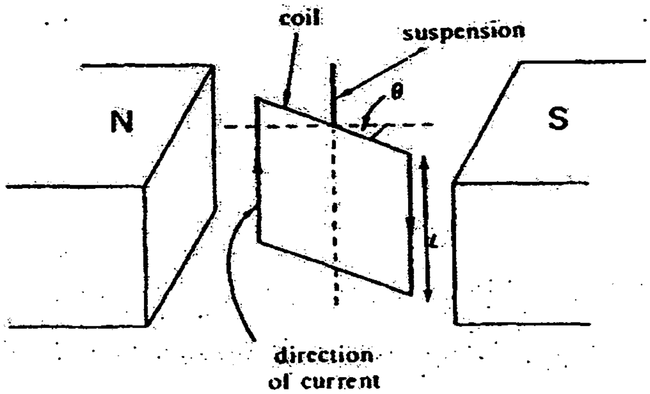
A of magnitude $\frac{B}{E}$ and parallel to B.

B of magnitude $\frac{E}{B}$ and parallel to E.

C of magnitude $\frac{B}{E}$ and perpendicular to both E and B.

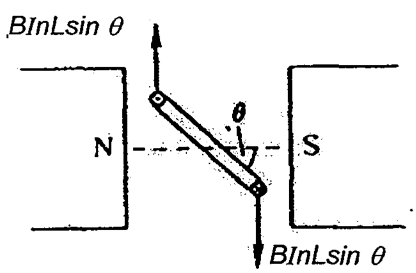
D of magnitude $\frac{E}{B}$ and perpendicular to both E and B.

31 A current I is carried by a square coil of n turns and side L suspended vertically as shown in a uniform horizontal magnetic field of flux density B.

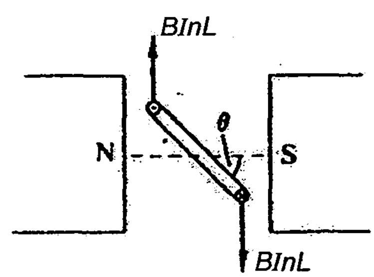


Which one of the following plan (*top-view*) diagrams correctly shows the magnitude and direction of the forces acting on the vertical sides of the coil?

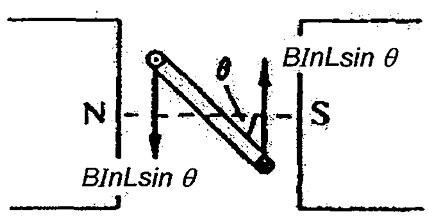
A



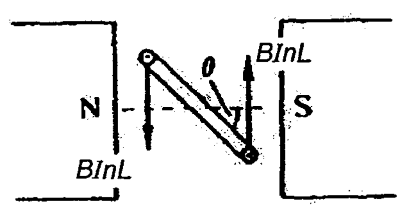
B



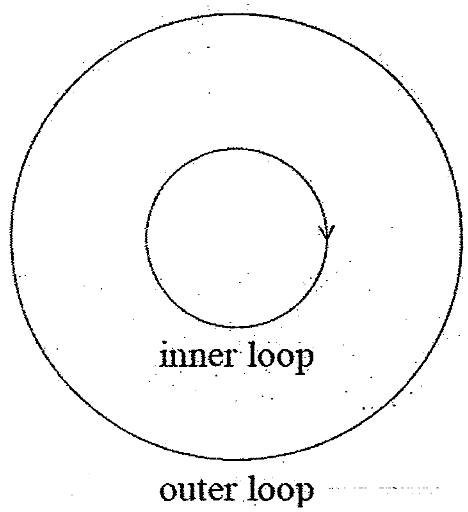
C



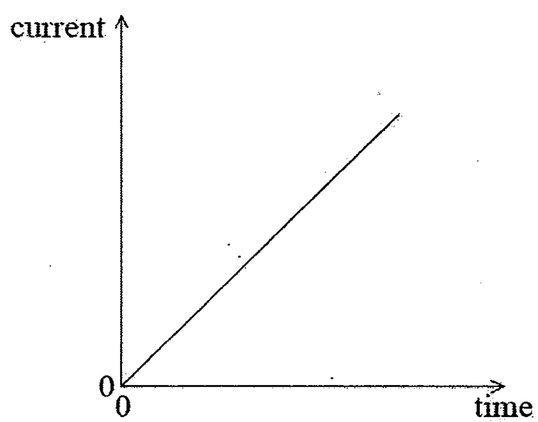
D



32 The diagram below shows two concentric loops lying in the same plane.



The current in the inner loop is clockwise and increases with time as shown in the graph below.



The induced current in the outer loop is

A constant in the clockwise direction.
B constant in the anticlockwise direction.
C variable in the clockwise direction.
D variable in the anticlockwise direction.

33 Two light bulbs are glowing at the same brightness. One is supplied with alternating current and the other with direct current. Both bulbs have a resistance of 4 Ω (assumed constant). The direct current bulb draws 3 A at 12 V.

What is the peak value of the current in the alternating current bulb?

A 1.5 A **B** 2.1 A **C** 3 A **D** 4.2 A

34 Electrons gain kinetic energy and accelerate when a potential difference is applied.

Through what potential difference (p.d.) must electrons be accelerated so they will have
(a) the same wavelength as an x-ray of wavelength 0.150 nm , and
(b) the same energy as the x-ray of 0.150 nm ?

	p.d. to accelerate electrons to have the same wavelength as an x-ray of wavelength 0.150 nm	p.d. to accelerate electrons to have the same energy as the x-ray of 0.150 nm
A	67 V	67 V
B	67 V	8300 V
C	8300 V	67 V
D	8300 V	8300 V

35 Which one of the following shows the correct sequence of events in a helium-neon laser?

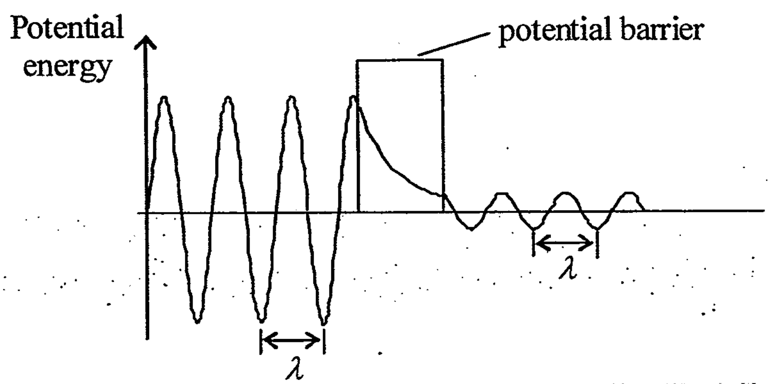
A Neon atoms excite helium atoms to a metastable state. Excited helium atoms undergo stimulated emission of red light to a lower energy state followed by spontaneous emission to ground state.

B Neon atoms excite helium atoms to a higher energy state. Excited helium atoms undergo spontaneous emission to a metastable state followed by stimulated emission of red light to ground state.

C Helium atoms excite neon atoms to a metastable state. Excited neon atoms undergo stimulated emission of red light to a lower energy state followed by spontaneous emission to ground state.

D Helium atoms excite neon atoms to a higher energy state. Excited neon atoms undergo spontaneous emission to a metastable state followed by stimulated emission of red light to ground state.

36 The diagram below shows the wave function of a particle tunnelling through a potential energy barrier from the left. It is observed that the amplitude of the wave function decreases upon passing through the barrier, but that the wavelength λ remains constant.



What deductions can be made from these two observations?

	Amplitude of the wave function decreases	**Wavelength λ remains constant**
A	Mass of the particle reduces upon passing through the barrier.	Momentum of the particle remains unchanged after passing through the barrier.
B	Intensity of the particle reduces upon passing through barrier.	Energy of the particle remains unchanged after passing through the barrier.
C	Energy of the particle reduces upon passing through the barrier.	Momentum of the particle remains unchanged after passing through the barrier.
D	Reduced probability of finding the particle after the barrier.	Energy of the particle remains unchanged after passing through the barrier.

37 An electron is incident on a rectangular potential barrier with a kinetic energy of 2.0 eV. The barrier height is 6.0 eV and its width is $d = 1.0 \times 10^{-10}$ m.

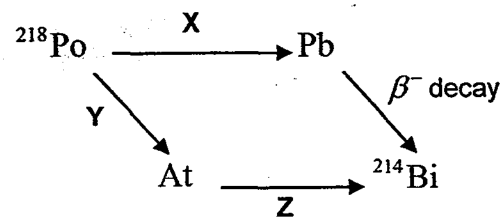
If the width of the barrier is increased to d' and the transmission coefficient is halved, the ratio $\frac{d'}{d}$ is

A 0.50 **B** 0.76 **C** 1.3 **D** 2.0

38 Rutherford's alpha-particle scattering experiment established that

A most of the mass of the atom is concentrated at the nucleus.
B the nucleus is made up of protons and neutrons.
C electrons have a negative charge.
D electrons revolve around the nucleus.

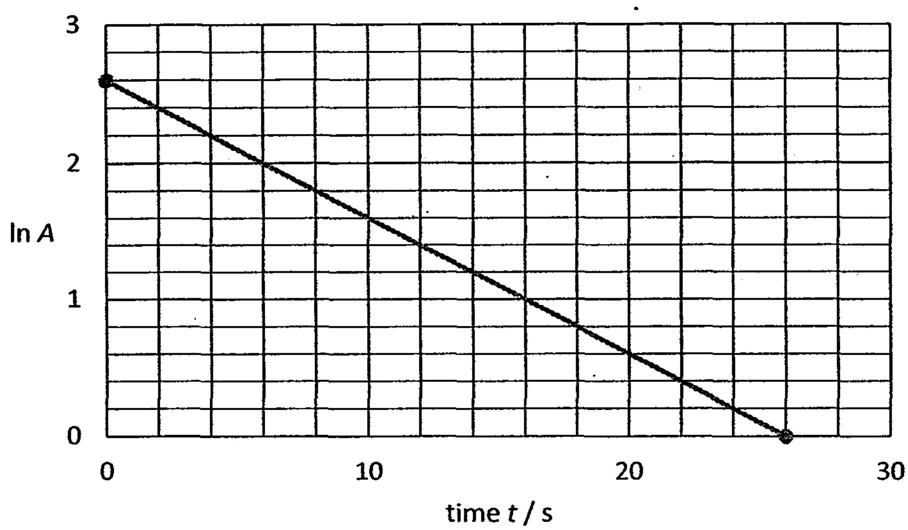
39 ^{218}Po decays to ^{214}Bi via two pathways as shown in the figure below:



What are the possible radioactive decay modes **X**, **Y** and **Z**?

	X	Y	Z
A	α decay	α decay	β^- decay
B	α decay	β^- decay	α decay
C	α decay	β^- decay	γ decay
D	γ decay	α decay	β^- decay

40 The graph below shows how the count-rate A of a radioactive source as measured by a Geiger counter varies with time t.



The relationship between A and t is

A $A = 2.6\, e^{-0.1\, t}$
B $A = 2.6\, e^{-10\, t}$
C $A = 13\, e^{-0.1\, t}$
D $A = 13\, e^{-10\, t}$

H2 Physics P1

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

Physics Preliminary Examination
Higher 2

CANDIDATE NAME		CLASS	
CENTRE NUMBER	S 3 0 0 4	INDEX NUMBER	

PHYSICS **9646/02**

Paper 2 Structured Questions

24 August 2016

1 hour 45 minutes

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

READ THESE INSTRUCTIONS FIRST

Write your Name and Index number in the spaces 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.
It is recommended that you spend about 1 hour 15 minutes on this 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 Examiners' use only	
1	/ 8
2	/ 7
3	/ 8
4	/ 7
5	/ 7
6	/ 7
7	/ 16
8	/ 12
Total	/ 72

For Examiner's Use

DATA AND FORMULAE

Data

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

Formulae

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

1 Fig. 1.1 shows an aeroplane flying horizontally at a steady speed of 67 m s^{-1}. A parachutist falls from the aeroplane freely for 80 m before the parachute opens.

Assume that the air resistance is negligible.

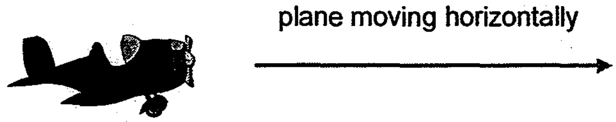


Fig. 1.1

(a) Show that the vertical component of the velocity is approximately 40 m s^{-1} when the parachutist has fallen 80 m.

[2]

(b) Determine the magnitude and direction of the resultant velocity of the parachutist at this point.

Magnitude = ... m s^{-1}

Direction = ... [3]

For Examiner's Use

(c) Sketch two labelled paths, P and Q, of the parachutist during the free fall, assuming that for path P, air resistance is negligible and for path Q, air resistance cannot be neglected.

Explain for any differences between the two paths P and Q.

[3]

For Examiner's Use

2 (a) State the **main** distinction between a systematic error and a random error in the measurements of a physical quantity.

____

____

____ [2]

(b) In a simple pendulum experiment to determine g the acceleration due to gravity, the following equation is used,

$$T = 2\pi\sqrt{\frac{l}{g}}$$

The following measurements were obtained with the help of a meter rule and stopwatch respectively.

The length of the pendulum: $l = 98.0 \pm 0.1$ cm
Average time of 10 oscillations: $t = 19.8 \pm 0.2$ s

(i) Determine the value of g with its associated uncertainty.

g = (________ ± ________) $m\ s^{-2}$ [4]

(ii) Using a different set of apparatus, another student obtained g to be 11.15 ± 0.02 m s^{-2}.

Comment on the accuracy and precision of the two set of readings.

____

____

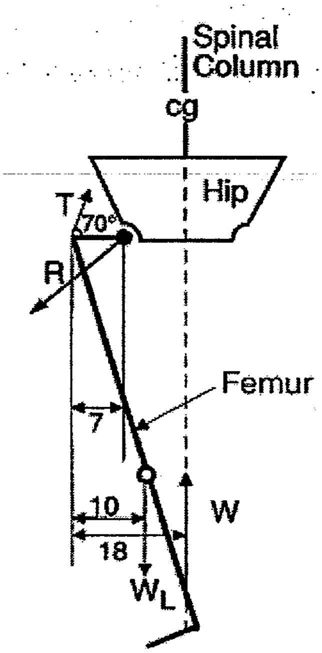
____ [1]

For Examiner's Use

3 (a) State the two conditions required for a body to be in equilibrium.

[2]

(b) When you are walking, there is an instant when only one foot is on the ground and the centre of gravity of your body is directly over that foot. Fig. 3.1 shows the forces acting on that leg.



Source:
https://medicalphysics.org/documents/WebPOTB.pdf

Fig. 3.1

The forces are the upward force on the foot equal to the weight of the body W; the weight of the leg W_L (which is approximately equal to $W / 7$); the reaction force by the hip on the femur R and the tension in the muscle group between the hip and the greater trochanter on the femur T.

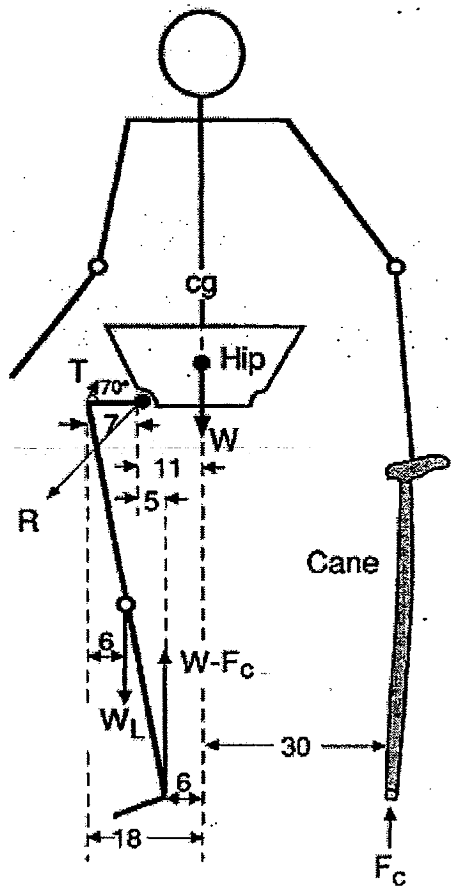
The dimensions provided are in cm.

(i) Show that $T = 1.6\,W$ and $R = 2.4\,W$.

[4]

For Examiner's Use

(ii) The use of crutches or a cane can reduce the force on the hip joint. Fig. 3.2 shows the effect of the use of a cane on the body.



Source: https://medicalphysics.org/documents/WebPOTB.pdf

Fig. 3.2

Note that the cane is in the hand opposite to the injured hip and the force pushing upward on the cane F_C reduces the upward force on the foot.

Explain qualitatively how the cane can reduce the force on the hip joint.

....

....

....

....

....

.... [2]

For Examiner's Use

4 A 3.00 g copper coin at 25.0 °C drops 50.0 m to the ground.

(a) The copper is said to possess internal energy.

Explain what is meant by the internal energy of the copper coin.

[2]

(b) Assuming that 60.0 % of the change in potential energy of the coin-Earth system goes to increasing the internal energy of the coin.

Determine the coin final temperature given that the specific heat capacity of copper is 385 J kg^{-1} K^{-1}.

Final temperature = ... °C [4]

(c) State and explain if your result in (b) depends on the mass of the coin.

[1]

For Examiner's Use

5 In x-ray production, electrons are accelerated through a high voltage and then decelerated by striking a target. A continuous x-ray spectrum can then be detected.

(a) Explain how x-ray photons can be produced by the above process.

[2]

(b) A cutoff wavelength λ_{min} is one of the features that exist in the continuous x-ray spectrum.

Show that the relationship between λ_{min} and V where V is the accelerating potential in the X-ray tube *is given by*

$$\lambda_{\min} = \frac{hc}{eV}$$

where h and c are the Planck's constant and speed of light in vacuum respectively.

Explain your working clearly.

[2]

(c) **(i)** In a particular x-ray tube, the accelerating potential difference is 50 kV and the cutoff wavelength is at 2.50×10^{-11} m.

Determine a value for the Planck constant.

Planck constant = ... J s [1]

(ii) Suggest a suitable experiment using cutoff wavelength limit of the continuous x-ray spectrum to determine a better estimate of the value of the Planck constant.

....

....

.... [2]

6 (a) By reference to the photoelectric effect, state what is meant by the threshold frequency.

....

.... [1]

(b) Electrons are emitted from a metal surface when light of a particular wavelength is incident on the surface.

Explain why the emitted electrons have a range of values of kinetic energy below a maximum value.

....

.... [2]

(c) The wavelength of the incident radiation is λ in a Photoelectric Effect experiment.

The variation with $1/\lambda$ of the maximum kinetic energy E_{MAX} of electrons emitted from a metal surface is shown in Fig. 6.1.

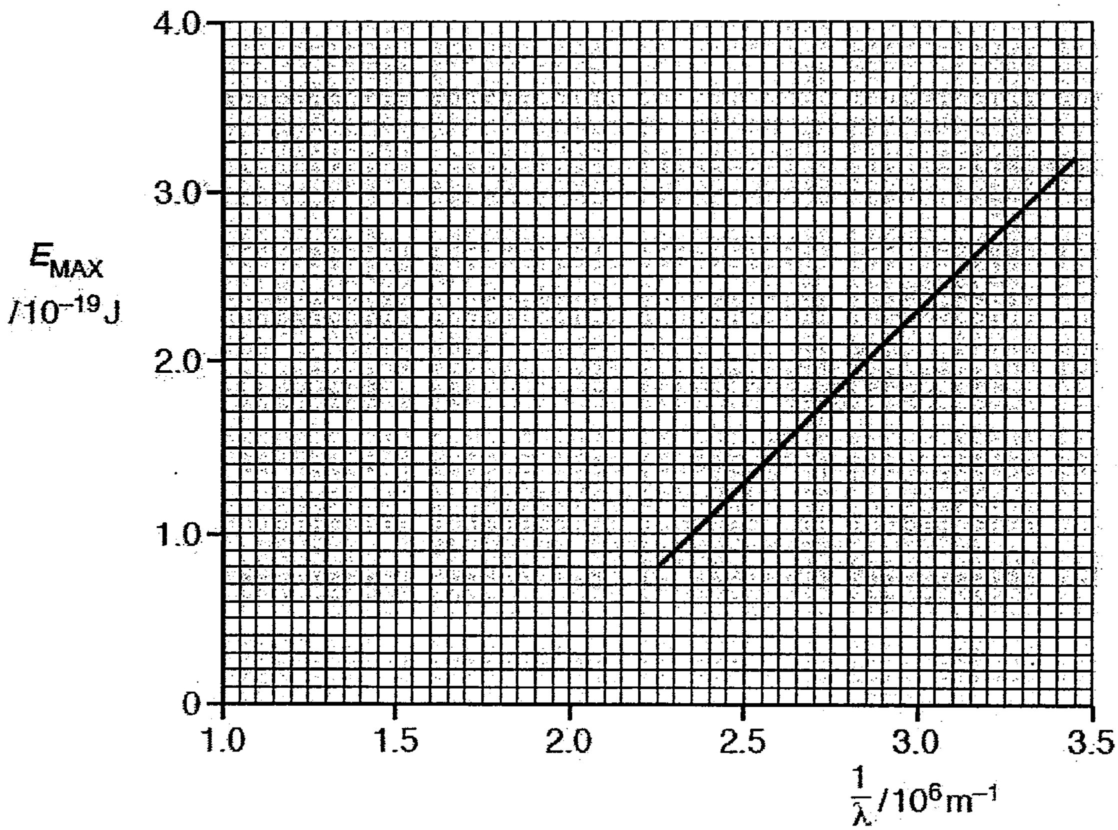


Fig. 6.1

Using the data from Fig. 6.1, determine

(i) the work function energy Φ.

$\Phi =$ ______________ J [1]

(ii) the associated *de Broglie's wavelength* of the electron that was emitted with the maximum kinetic energy when a frequency of 7.5×10^{14} Hz falls on the metal.

de Broglie's wavelength = ______________ m [3]

7 An **earthquake** is the perceptible shaking of the surface of the Earth, resulting from the sudden release of energy in the Earth's crust. This sudden motion causes shock waves (seismic waves) to radiate from their point of origin called the focus and travel through the earth. It is these seismic waves that can produce ground motion which people call an earthquake.

Vibrations from an earthquake are categorised as P, S or L seismic waves. They travel through the Earth in different ways and at different speeds. They can be detected and analysed.

P-waves (P stands for **primary**) arrive at the detector first. They are *longitudinal waves.* These waves can travel through any type of material, including fluids, and can travel at nearly twice the speed of S waves.

S-waves (S stands for **secondary**) arrive at the detector of a seismometer seconds later. They are *transverse waves.* S-waves can travel only through solids.

L-waves (L stands for **long**) are the slowest, travel over the surface and causes the most damage.

The speed of an earthquake wave is not constant but varies with many factors. Speed changes mostly with depth and rock type. P waves travel between 6.0 and 13 km s^{-1} and S waves are slower and travel between 3.5 and 7.5 km s^{-1}.

In earthquake seismology, the time interval between the first arrivals of transverse (S) and longitudinal (P) waves, is proportional to the distance from the earthquake source.

In order to locate the epicenter of an earthquake you will need to examine its seismograms as recorded by at least three different seismic stations. On each of these seismograms you will have to measure the S - P time interval (in seconds). The S - P time interval will then be used to determine the distance the waves have traveled from the epicenter to that station.

(a) Distinguish between longitudinal and transverse waves.

____

____

____

____

____ [2]

(b) **Fig. 7.1** shows a structure of the Earth's interior and regions where P or S-waves may not be detected.

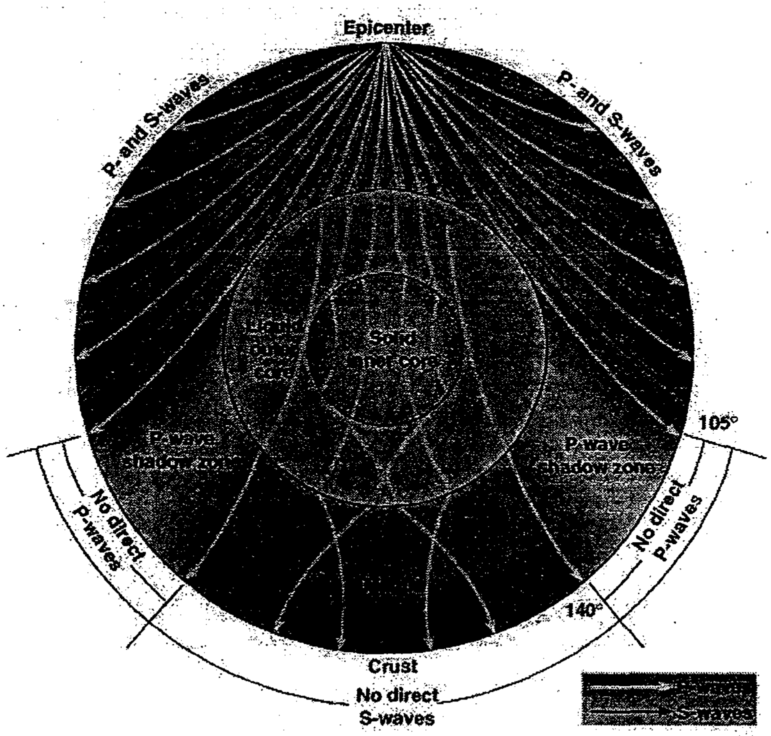


Fig. 7.1

Explain why no S-waves are detected directly opposite the epicenter.

____

____ [1]

(c) Fig. 7.2 shows the variation with distance (in kilometers) from the epicenter of the time (in seconds) taken for the S and P waves to reach the seismic station from the epicenter.

Fig 7.3 shows three seismographs from **Akita, Pusan and Tokyo Seismic Stations** of the earthquake that occurred in 1995, in the Kansai area of Japan near Kobe, called the Kobe earthquake. This earthquake took place near major population centers and caused significant loss of life and property damage.

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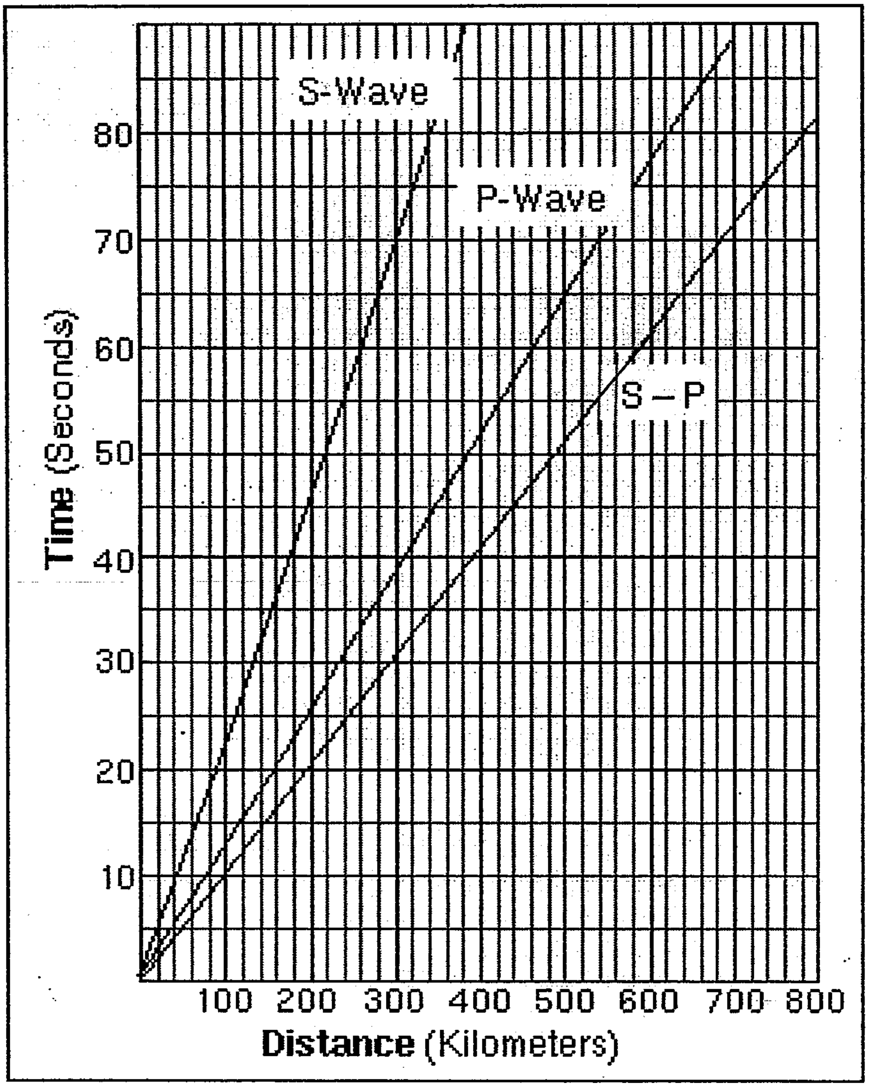

Fig. 7.2

(Source: http://engineeringseismologywithmearul.blogspot.sg/)

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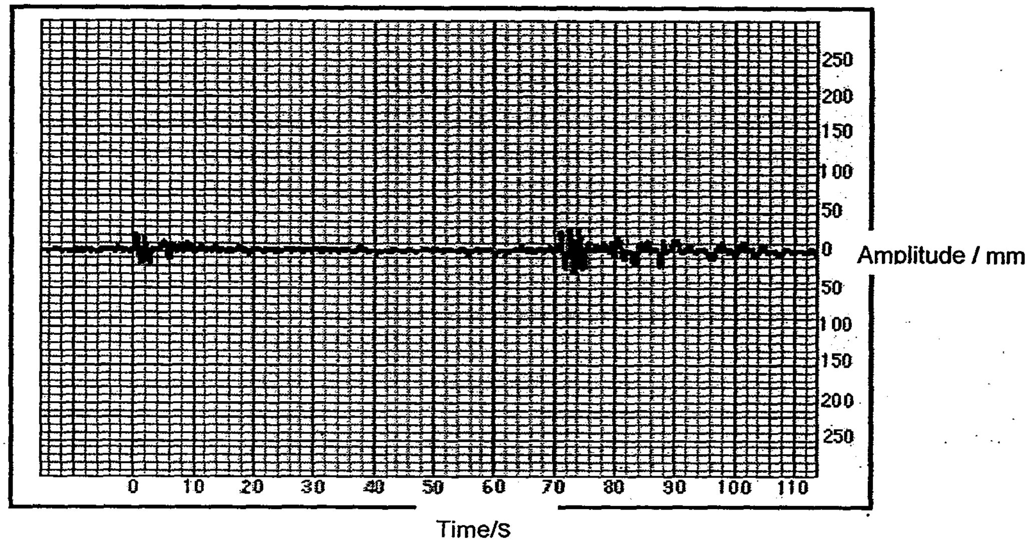
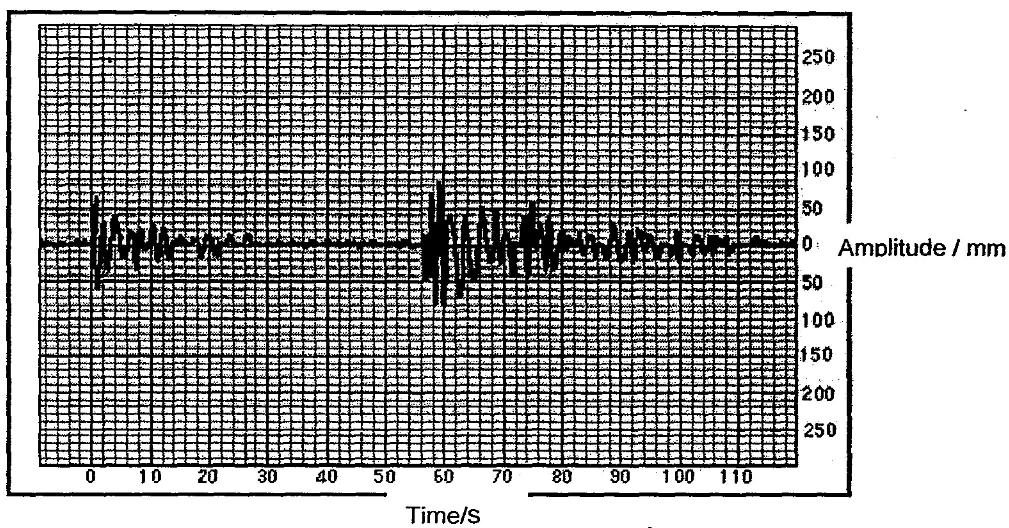
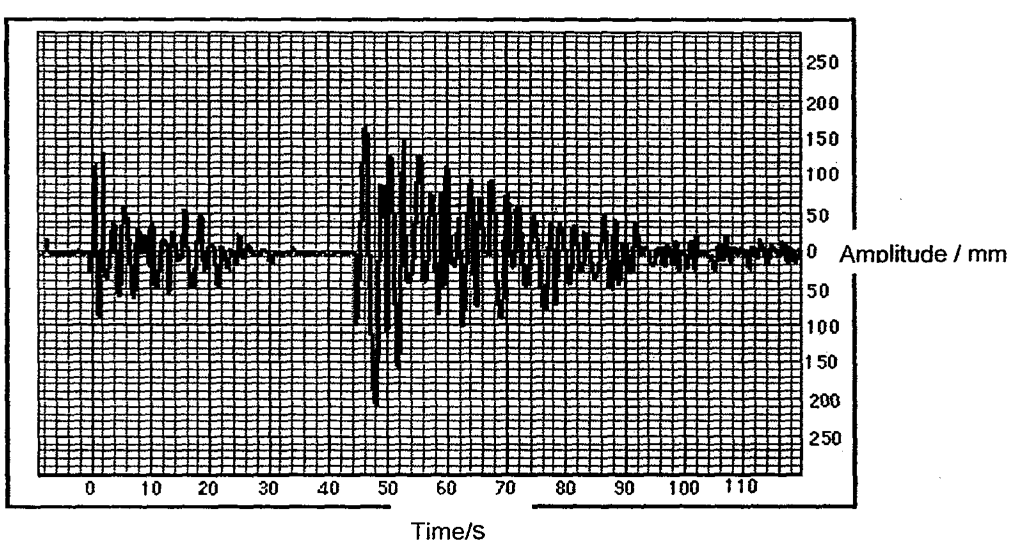


Akita Seismic Station



Pusan Seismic Station



Tokyo Seismic Station

Fig 7.3 Seismograms from Akita, Pusan and Tokyo Stations
(Source: http://www.geo.umass.edu)

For Examiner's Use

(i) Using the data given in Fig. 7.2 and Fig. 7.3, complete Fig. 7.4

SEISMOGRAPH STATION	Difference in Arrival Time between P and S waves / s	Distance to Epicenter / km	Amplitude of the S wave /mm
AKITA	71	695	
PUSAN			90
TOKYO	44		

Fig. 7.4

[3]

(ii) Hence determine the approximate location of the epicenter of the earthquake on the location map in Fig. 7.5. Label your location "X"

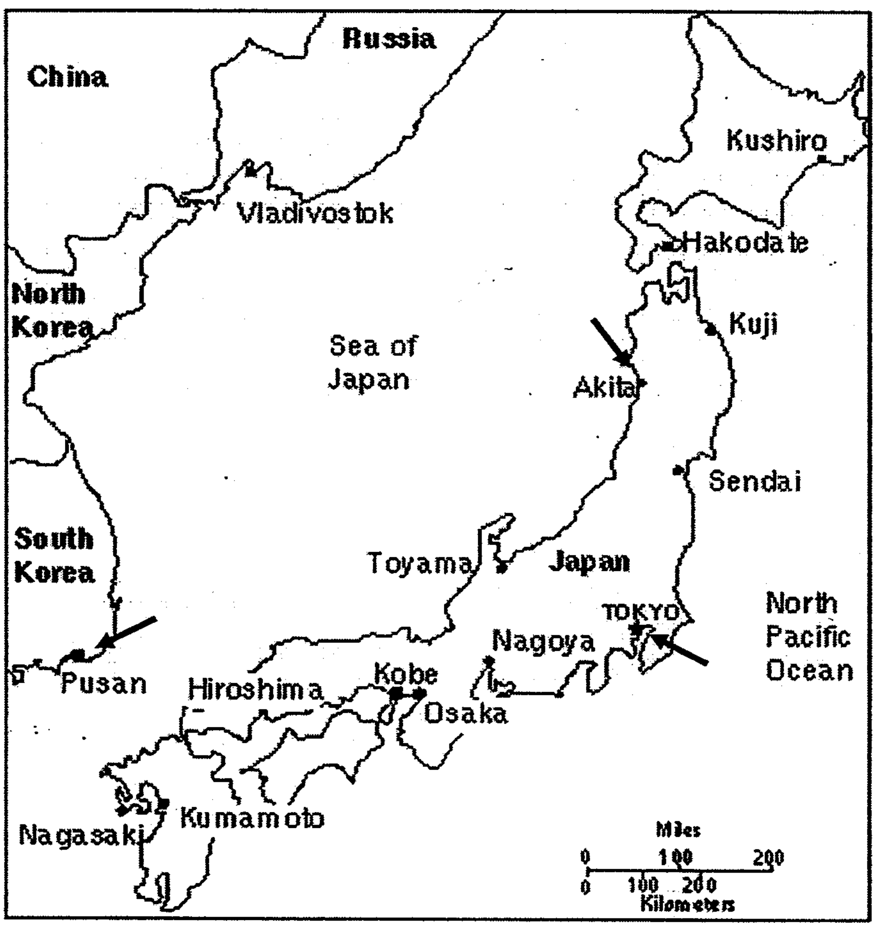


Fig. 7.5

[3]

For Examiner's Use

(iii) The intensity of an earthquake on the Richter scale can be easily determined using a nomogram as shown in Fig. 7.6

For each station, connecting the distance on the Distance scale and the amplitude on the Amplitude scale with a straight line, the intersection on the Magnitude scale is the Richter scale reading for the earthquake.

If distance of the station from the earthquake's epicenter is 100 km and amplitude of the earthquake recorded at the station is 1 mm, the magnitude of the earthquake is 3.0 on the Richter scale, as shown in the sample line drawn in Fig. 7.6.

1. State one other factor that may affect the amplitude of the S-wave recorded besides the intensity of the Earthquake.

.... [1]

2. Using your answers from Fig. 7.4 and the nomogram in Fig 7.6, construct and determine the magnitude of the earthquake on the Richter scale.

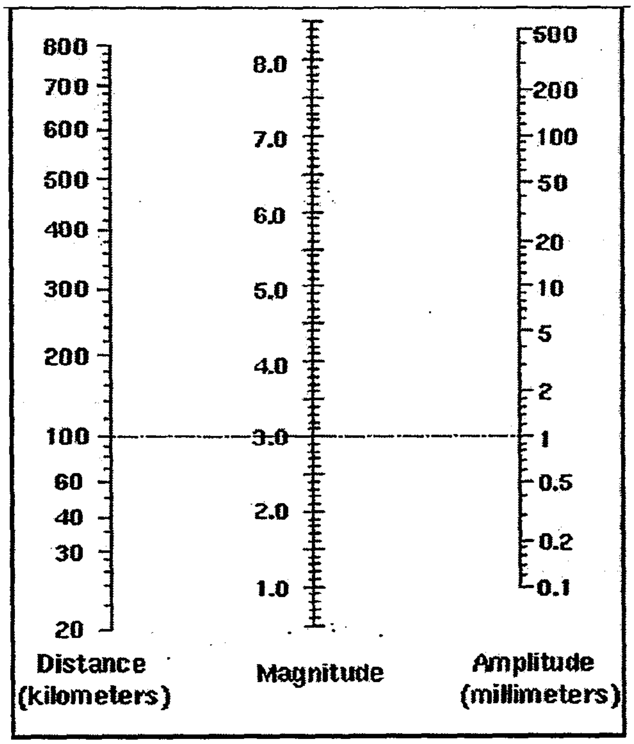


Fig 7.6

Magnitude = ... [2]

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(d) The Richter magnitude scale used in (c) was developed in 1935 by Charles F. Richter of the California Institute of Technology as a mathematical device to compare the size of earthquakes. The magnitude of an earthquake is determined from the logarithm of the amplitude of waves recorded by seismographs. The magnitude of an earthquake on a Richter Scale M is related to the intensity (I) of the S-wave according to the equation

$$M = \log\left(\frac{I}{I_o}\right)$$

where I_0 is a reference intensity.

The amount of energy radiated by an earthquake is a measure of the potential for damage to man-made structures. The Richter magnitude M, is related to the energy released E in ergs (1 erg = 10^{-7} J) through the equation

$$\log E = 1.5\,M + 4.8$$

(i) On 26 Dec 2004, an underwater 9.0-magnitude earthquake off the coast of Aceh, Indonesia, sent giant tidal waves into coastal areas in Indonesia, Thailand, Malaysia, Sri Lanka, Bangladesh, India, Myanmar, the Maldives and Somalia, resulting in at least 159 000 people dead. This is known as the great Sumatra Earthquake

1. Determine the ratio of the intensity of the Sumatra Earthquake to the Kobe Earthquake

Ratio = ... [1]

2. Hence explain why we use the Richter scale, which is a logarithmic scale, instead of just a normal scale based on the intensity I.

____

____

____ [1]

(ii) Determine the ratio of the energy released from the Sumatra Earthquake to the Kobe Earthquake.

Ratio = ... [1]

(e) The death toll in the 2015 Chile Illapel Earthquake with magnitude 8.3 was 14 whereas that from the 2015 Nepal Earthquake with magnitude 7.8 was almost 9000.

Suggest a possible reason why higher magnitude earthquakes may not always lead to higher death tolls.

____

____ [1]

8 A student is investigating the flow of water through a horizontal tube.

The rate Q (volume per unit time) at which water flows through a tube depends on the pressure difference per unit length across the tube.

The student has the use of a metal can with two holes. A narrow horizontal tube goes through the hole in the side of the can. The can is continuously supplied with water from a tap. The level of water in the can is kept constant by the position of a wide vertical tube which passes through the hole in the bottom of the can as shown in Fig. 8.1. Both tubes may be moved along the holes.

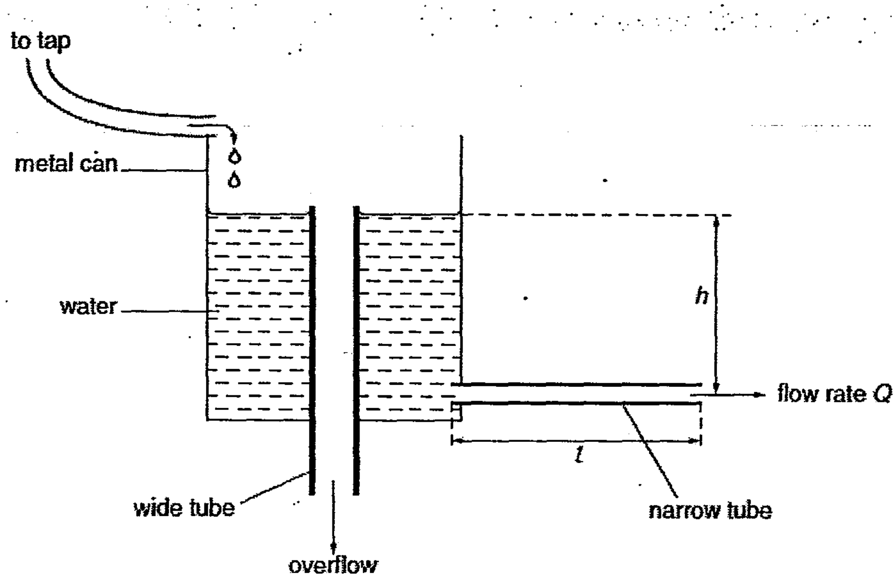


Fig. 8.1

It is suggested that the relationship between the flow rate Q of water through the narrow horizontal tube and the vertical height *h* is

$$Q = \frac{2\pi\rho g h d^4}{l\eta}$$

where ρ is the density of water, g is the acceleration of free fall, d is the internal diameter of the tube, l is the length of the tube and η is a constant.

Design a laboratory experiment to test the relationship between Q and *h* and determine a value for η.

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

(a) the identification and control of variables,
(b) the equipment you would use,
(c) the procedure to be followed,
(d) how the relationship between Q and *h* is determined and η is obtained,
(e) any precautions that would be taken to improve the accuracy and safety of the experiment..

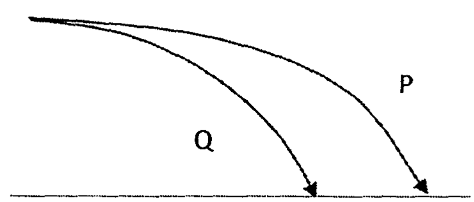
For Examiner's Use

Diagram

For Examiner's Use

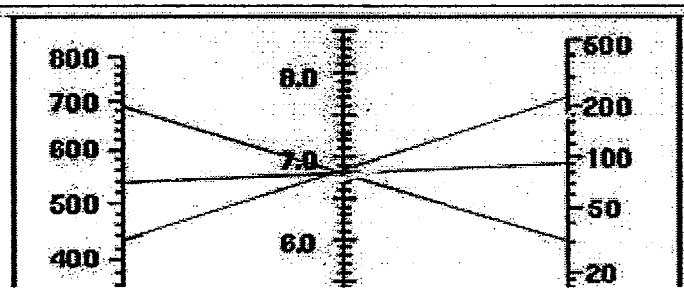
For Examiner's Use

[12]

Qn	
1	
(a)	Applying $v^2 = u^2 + 2as$ in the vertical direction $v^2 = 0 + 2 \times 9.81 \times 80$
	$v = 39.6(1818)$ $= 40\ \text{m s}^{-1}$ (shown)
(b)	$v_y = 39.61818\ \text{m s}^{-1}$
	$v_x = 67\ \text{m s}^{-1}$
	$v = \sqrt{(39.61818^2 + 67^2)}$ $= 77.83701\ \text{m s}^{-1}$ $= 77.8\ \text{m s}^{-1}$
	$\tan\theta = v_y / v_x$ $= 39.61818 / 67$ $\theta = 30.6°$ $= 31°$ below horizontal
(c)	 Horizontal velocity will no longer be constant and decrease with time. Vertical velocity will increase at a slower rate as net acceleration downwards is decreased.
2(a)	Systematic errors are errors that results in the measurements deviating from the true value by a fixed magnitude and direction/ of the same sign and magnitude / with the same magnitude on same side of the true value / having a fixed pattern Random errors are errors that results in the measurements deviating from the of value with no fixed magnitude and direction / of different sign and magnitude on either side of the true value with no fixed magnitude / no fixed pattern.
b(i)	$g = 4\pi^2 \frac{l}{T^2} = 9.869\ \text{m s}^{-2}$
	$\pm\frac{\Delta g}{g} = \pm\left(\frac{\Delta l}{l} + \frac{2\Delta t}{t}\right)$ (or $\left(\frac{\Delta l}{l} + \frac{2\Delta T}{T}\right)$)
	$= \pm\frac{0.1}{98.0} + \frac{2(0.2)}{19.8}$ (or $\frac{0.1}{98.0} + \frac{2(0.02)}{1.98}$) $= \pm 0.021(2)$
	$\pm\Delta g = \pm 0.0212 \times 9.869$ $= \pm 0.21\ m\,s^{-2}$
	Hence $g = (9.9 \pm 0.2)\ m\,s^{-2}$

(ii)	$g = (9.9 \pm 0.2)ms^{-2}$ More accurate, less precise $g = (11.15 \pm 0.02)ms^{-2}$ Less accurate, more precise
3	
(a)	Resultant forces zero in all directions Resultant torque / moments zero about any axes / point
b)(i)	Mention the point where moments was taken,
	Clockwise *M* = Anti-clockwise *M* $T\sin70° (0.07) + W/7 (0.03) = W(0.11)$ $T = 1.60(713)\ W$
	Resolving forces in the x-direction, $R_X = 1.60713\ W\cos70°$ $= 0.54967\ W$ *or* Resolving forces in the y-direction, $R_Y = W + 1.60713\ W\sin70° - W/7$ $= 2.36735\ W$
	$R = \sqrt{(0.54967\ W)^2 + (2.36735\ W)^2}$ $= 2.43(033)\ W$
(b)(ii)	When taking moments about the pivot to determine *T*, the moment due to the upward force on the foot is greatly reduced as both the upward force on the foot (due to the cane) and perpendicular distance from the foot to *R* is reduced, leading to a smaller *T* and hence horizontal component of *R*. The reduced upper force on the foot (due to the cane) and smaller *T* also reduced the vertical component of *R*. Therefore *R* is reduced.
4(a)	Sum of the Random vibrational kinetic energy of atoms and Random potential energy between atoms of the iron.
(b)	$W_{on} = 0$, or $\Delta U = mc\Delta\theta$ Decrease in GPE → increase in internal energy $0.6mg\Delta h = mc\Delta\theta$ $\theta_f = \frac{0.6g\Delta h}{c} + 25 = 25.8\ °C$
(c)	From (b) Change in temp. is independent of mass or Mass cancels away on both sides of equation
5(a)	When the electrons decelerate, it loses energy, the lost in energy is the energy of the X-ray photons.
	As there is a range of decelerations/energy lost, there is a range of energy of the X-ray photons.
(b)	Energy gain by electron due to accelerating potential = eV
	Electron loses all this energy in the single collision to produce the x-ray photon $eV = hc/\lambda_{min}$.

(c)(i)	$h = \dfrac{1.6 \times 10^{-19} \times 50000 \times 2.50 \times 10^{-11}}{3 \times 10^{8}}$ $=6.7 \times 10^{-34}$ J s
(ii)	Suggested Improvement. Vary accelerating potential and observe cutoff wavelength from continuous spectrum.
	Plot λ_{min} vs 1/V Determine *h* from (e/c) gradient
6	
(a)	Minimum freq of em radiation/photon for release of electrons from surface of metal
(b)	E_{MAX} corresponds to electron emitted from surface
	electron (below surface) requires energy to bring it to surface, so less than E_{MAX}
(c)(i)	$\Phi = hc/\lambda_o$
	$= 6.63 \times 10^{-34} \times 3.00 \times 10^{8} \times 1.85 \times 10^{6}$
	$= 3.68 \times 10^{-19}$ J
(ii)	$1/\lambda = 2.5 \times 10^{6}$, $E_{max} = 1.3 \times 10^{-19}$ J
	$\lambda = h/p$
	$= \dfrac{h}{\sqrt{2mE}}$
	$= 1.36 \times 10^{-9}$ m
7	
(a)	LW – oscillations of particles parallel to direction of transfer of energy of wave
	TW – oscillation of particles perpendicular to direction of transfer of energy of waves
(b)	S-waves cannot pass through the liquid outer core as it is a transverse wave and hence cannot cause compression of liquid and hence cannot travel through liquid.
(c)(i)	Akita – 30 mm Pusan – 56 s, 540-550 km, Tokyo – 425-435 km, 210 mm All amplitudes correct Time interval for Pusan correct Distance for Pusan (allow ecf) and Tokyo read correctly
(ii)	Understand must draw 3 circles center at stations All circles drawn with compass and correct scale Epicentre at KOBE
(iii)1.	-Distance from epicenter -Scattering at boundary of different materials, cracks etc. -Absorption due to rocks in Earth Any other suitable answers

	 Magnitude = 6.8
(d)(i) 1.	Ratio = $10^9/10^{6.8}$ = 158
2.	The above shows that a change in magnitude of 2.2 correspond to a change in intensity of about 160 times. Hence using a log scale allows us to compress the scale to more manageable numbers
(ii)	Ratio = $10^{(1.5)(2.2)}$ = 1995 (2000)
(e)	- Population of area - Stricter Building codes – earthquake proof buildings - time information needed to reach residents

8			
	Basic Procedure (2 marks)		
	Vary *h* and determine Q or IV – h; DV - Q	**P1**	
	Explained how *h* is varied by changing position of vertical/larger tube by moving it up or down vertically.	**P2**	**[Max 2]**
	Diagram (1 mark)		
	Labelled diagram of apparatus which includes labelled measuring cylinder/calibrated beaker to receive water or beaker on balance if finding mass	**D1**	**[Max 1]**
	Methods of data collection (2 marks)		
	Explained how Q is determined correctly. Example: *Measuring volume collected from beaker over a given time t with the help of a stopwatch*	**M1**	
	Measure *h* and *l* with a rule/caliper and *d* with a travelling microscope	**M2**	**[Max 2]**
	Analysis (1 marks)		
	Plot a graph of Q against h or lg Q against lg h or any other suitable graph and explained how η is determined.	**A1**	**[Max 1]**
	Example: $$\eta = \frac{2\pi\rho g d^4}{l \times gradient}$$		
	Safety (1 mark)		**Any 1**
	Reason method to prevent spills, e.g. use tray/sink/cloth on floor.	**S1**	
	Reasoned method to prevent injury when adjusting metal/glass tubes by wearing protective gloves.	**S2**	
	No electrical devices present as water is involved in the experiment	**S3**	**[Max 1]**
	Further detail (3 marks)		**Any 3**
	Repeat experiment for same *h* and average	**F1**	
	Details on measuring *h* to the centre of the horizontal tube e.g. add radius of tube	**F2**	
	Method to measure mass and V and and hence density	**F3**	
	Fill beaker nearly full to reduce %tage uncertainty in measuring of Q	**F4**	
	Determine average *d* or *l* from at least 3 readings from difference position of tube.	**F5**	
	Method to check that tube is horizontal	**F6**	
	Start timing and record V only when water starts flowing out of the narrow tube	**F7**	
	Place Container below wide tube to collect overflow water	**F8**	
	Relationship is valid if straight line passing through origin. (if lg-lg graph, gradient = 1)	**F9**	
	Tap turned on at correct volume to ensure that water overflow to maintained constant *h* when taking readings.	**F10**	**[Max 3]**
	Control (2 marks)		
	stated *l* and *d* are CV by using the same narrow tube.	**C1**	
	Explain how *l* is kept constant "Explain how narrow tube is ensured to be horizontal throughout" Note: If slanted, *l* horizontally will change	**C2**	

	Explain how ρ is kept constant "Check that temperature of liquid is kept constant for ρ to be constant."	C3	[Max 2]

Physics Preliminary Examination
Higher 2

CANDIDATE NAME		CLASS	
CENTRE NUMBER	S 3 0 0 4	INDEX NUMBER	

PHYSICS **9646/03**

Paper 3 Longer Structured Questions

25 Aug 2016

2 hours

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

READ THESE INSTRUCTIONS FIRST

Write your Name and Index number in the spaces 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 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 Examiners' use only	
Section A	
1	/ 10
2	/ 10
3	/ 10
4	/ 10
Section B	
5	/ 20
6	/ 20
7	/ 20
Total	/ 80

For Examiner's Use

DATA AND FORMULAE

Data

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

Formulae

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

For Examiner's Use

Section A

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

1 **(a)** Define the *radian*.

....

.... [1]

(b) A small particle of mass m is pulled to the top of a frictionless half-cylinder of radius R by a cord that passes over the top of the cylinder. The force exerted by the cord is F. Mass m is moving at constant speed of 2.0 m s^{-1}.

The mass m is 100 g.
Radius R is 2.0 m.

The side-view is shown in Fig. 1.1

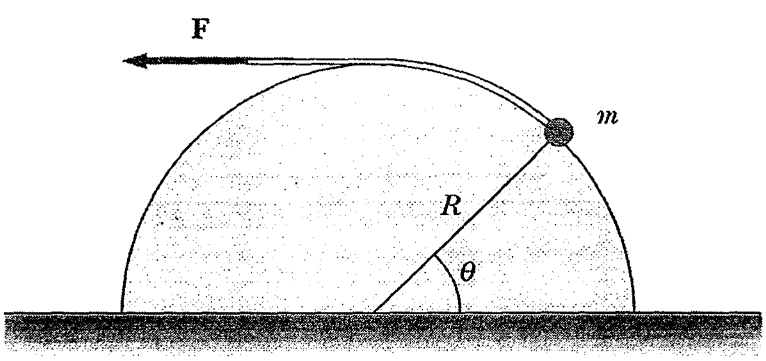


Fig. 1.1

(i) On Fig. 1.1 draw the free-body diagram for the forces acting on m. [2]

(ii) Hence show, with appropriate explanation, $F = mg \cos \theta$.

[1]

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(iii) The graph of how F varies with θ is given in Fig. 1.2.

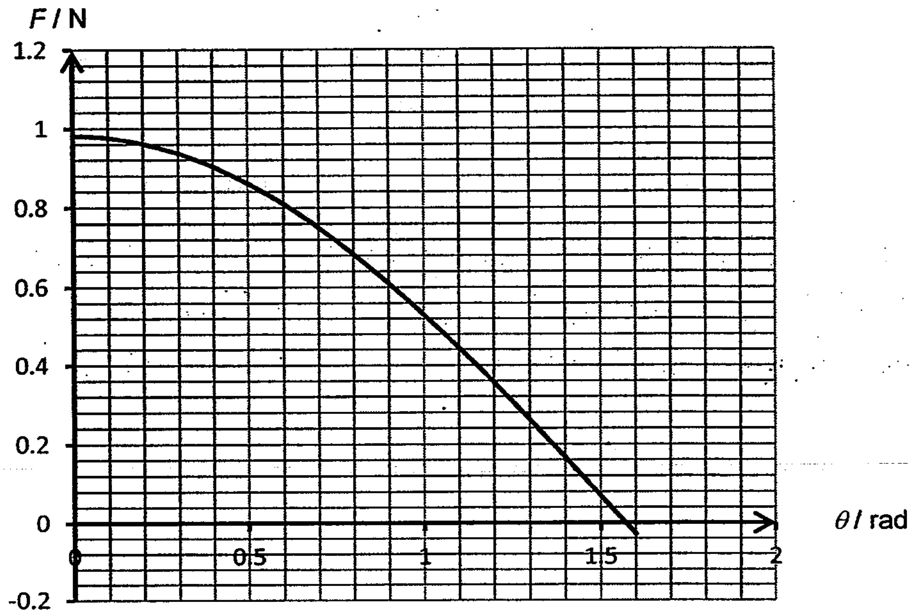

Fig 1.2

State the relationship between the work done by force F and area under the $F - \theta$ graph.

.... [1]

(iv) Hence or otherwise, determine the work done by the variable force F in moving the particle at constant speed from the bottom to the top of the half cylinder.

Work done = ... J [2]

For Examiner's Use

(v) On Fig 1.3. Sketch the variation with θ,

1. the gravitational potential energy of the mass m, (label it G) and
2. the kinetic energy of mass m (label it K).

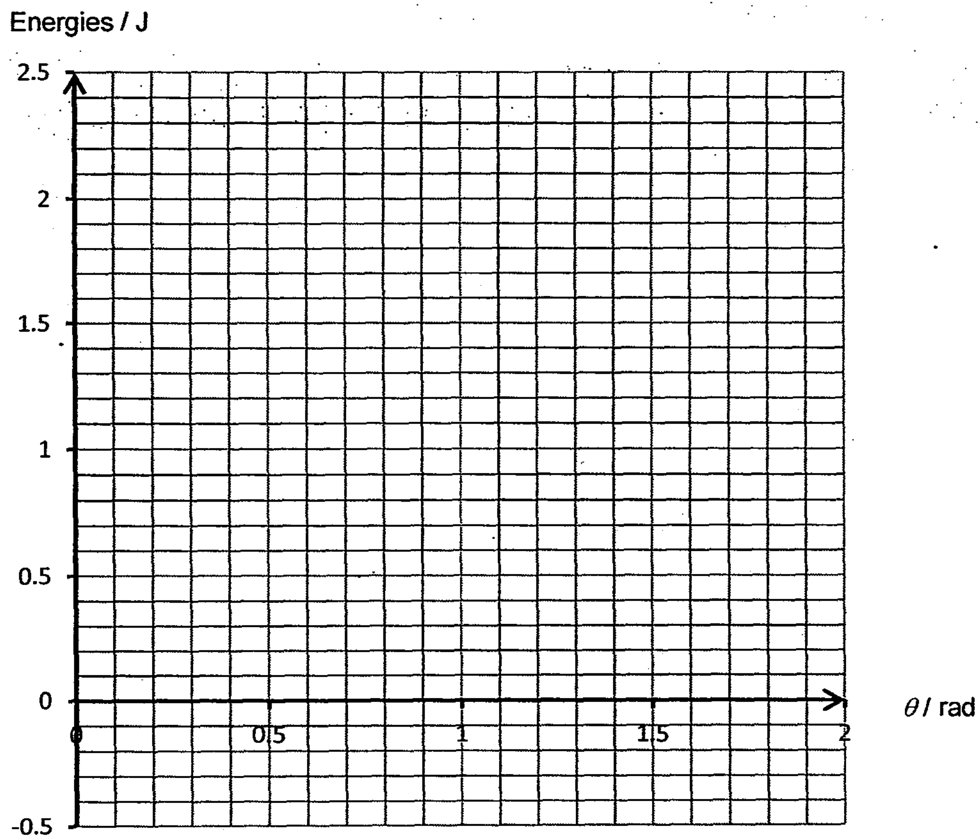

Fig. 1.3

[3]

2 A microwave oven, shown in Fig 2.1 consists of a reflective casing on the opposite wall of the microwave source and a turntable at the bottom that rotates. It produces microwave of frequency 2.45 GHz within the oven.

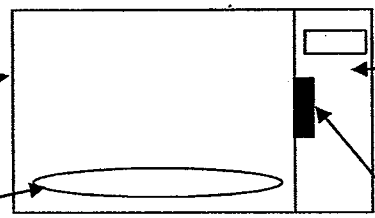

Fig 2.1

Water molecules are electric dipoles (that is, they have one positive end and one negative end). In the oscillating field of the microwave oven, the water molecules in trying to align with the changing field, oscillate rapidly. Thus the water molecules in the food get heated up and hence the food gets heated up.

(a) Explain how standing waves are formed inside the microwave oven.

____

____

____

____

____

____ [3]

(b) **<u>The turntable of the oven is removed from the oven</u>** so that oven's content will not rotate during heating. A wet piece of cardboard is placed flat in a microwave oven. The cardboard is then micro-waved for a short while. Stripes of dry regions regularly spaced apart are seen on the cardboard.

(i) Explain the formation of these dry stripes and hence deduce their distances apart.

____

____

____

____

____

____ [3]

(ii) The interior of the microwave oven is 30.5 cm wide.

In the space below, **draw the amplitude-position graph** of the standing wave pattern in the oven. Mark the positions on the graph with "D" that would produce dry patches on the wet cardboard as mentioned.

[2]

For Examiner's Use

(c) <u>**The turntable of the oven is now placed back in the oven**</u>. After five minutes of cooking a dish (with live ants in it) in a microwave wave, and upon removing it, it is noticed that several ants are inside the oven apparently unharmed by the intense microwave radiation.

Explain why some of the ants survived.

____

____

____

____ [1]

(d) Explain the purpose of the turntable of the microwave oven.

____

____

____

____ [1]

3 Fig. 3 shows two circuit which could be used to act as a dimmer switch for a lamp.

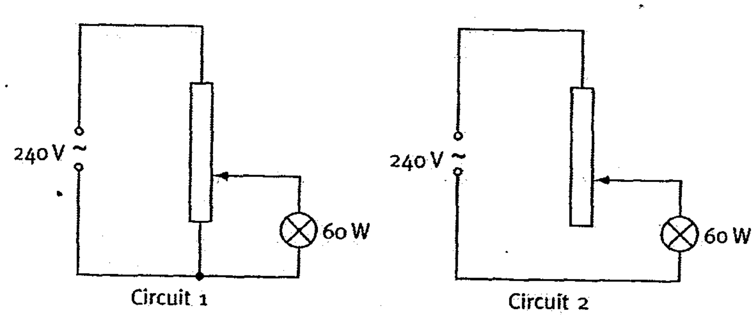

Fig. 3

(a) With reference to energy conversion in the bulbs, explain what do you understand by potential difference across the bulbs

____

____

____ [2]

(b) Explain **one** advantage circuit 1 has over circuit 2.

____

____

____

____ [2]

For Examiner's Use

(c) One problem with circuit 1 is that there is always a current in the resistor.

With an aid of a diagram, explain how this problem could be rectified.

[2]

(d) **(i)** The lamp is rated at 60 W at 240 V.

Calculate the resistance of the lamp filament at its normal operating temperature.

resistance = ______ Ω [2]

(ii) State and explain how the resistance of the filament at room temperature would compare with the value calculated in (d)(i).

[2]

4 (a) (i) Describe how the emission line spectra can be explained using the idea of discrete electron energy levels in isolated atoms.

[2]

(ii) State the conditions and state of the atoms such that they are sufficiently isolated so that line spectra can be observed.

[2]

(b) Fig. 4 illustrates some of the electron energy levels in an isolated atom of an alkaline metal for the outer (valence) electron. Four possible electron transitions are shown.

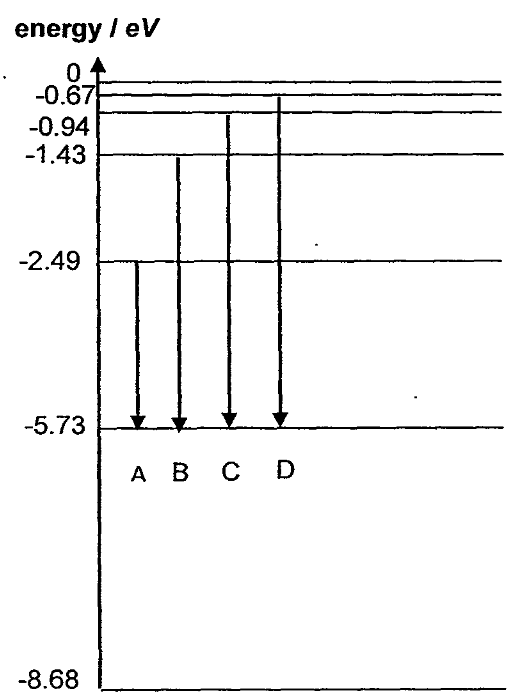

Fig. 4

For Examiner's Use

(i) Determine the energy required to remove the outer electron at the lowest energy level shown in Fig. 4 from the atom.

Energy = ... J [1]

(ii) State which of the transitions A, B, C or D in Fig 4 would lead to the emission of radiation of the shortest wavelength.

Ans ____________ [1]

(iii) Calculate the wavelength of this radiation.

wavelength = ... nm [1]

(iv) State the region of the electromagnetic spectrum in which this radiation lies.

Region is ____________ [1]

(c) Sketch the appearance of the spectrum in order of increasing wavelength which these four transitions produce. Label the transitions responsible for each line.

[1]

(d) The work function energy of lithium differs from the energy required to remove the outer electron from an isolated lithium atom.

Suggest why this is so.
(Hint: Work function is the minimum energy needed to remove a delocalized electron from the solid metal surface)

____

____

____ [1]

For Examiner's Use

Section B

Answer **two** questions for this section.

5 Fig. 5.1 below shows the decay series of Uranium-238. Uranium undergoes a series of alpha and beta decays to become a stable isotope of Lead-206 after a long period of time.

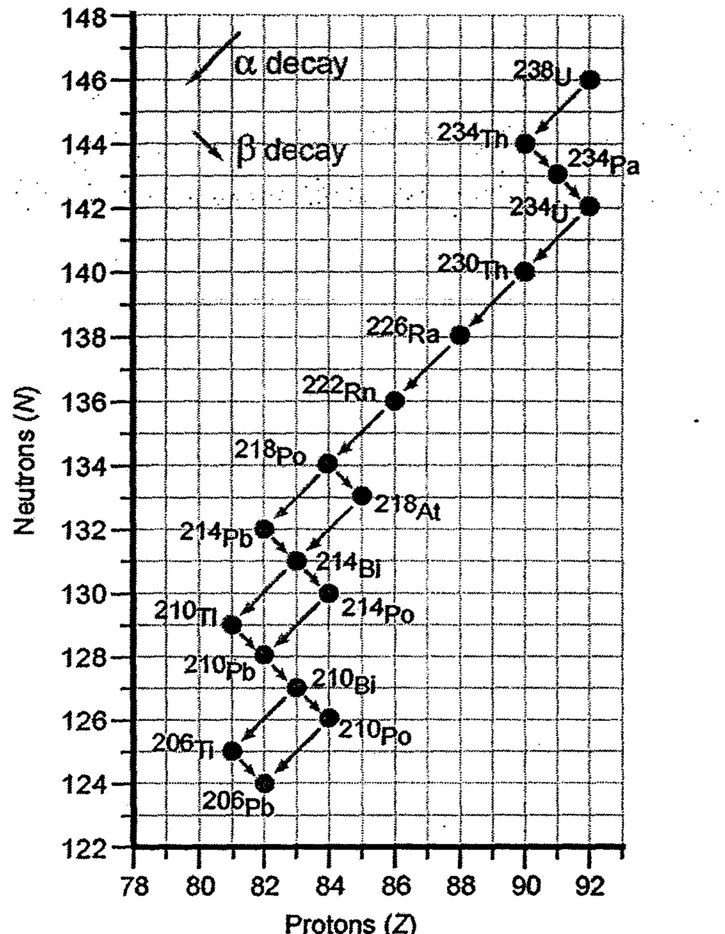

Fig. 5.1

(a) Suggest why stable nuclei tend to have a greater proportion of neutrons to protons in their nucleus.

____

____ [1]

(b) It can be seen that all the daughter nuclei that result from the decay of Uranium – 238 have a multiple four nucleons lesser than that of Uranium.

Explain why this is so.

____

____

____ [1]

For Examiner's Use

(c) State the Principle of Conservation of Linear Momentum.

[2]

(d) A stationary Radon (^{222}Rn) nucleus decays spontaneously into a Polonium (^{218}Po) nucleus via an α decay. It may be assumed that no γ - ray is emitted during this decay.

The rest masses of the nuclei involved are given as shown:

Rn: 222.0176 *u*,
Po: 218.0090 *u*,
α: 4.0026 *u*,
where *u* is the unified atomic mass constant.

(i) Write down the nuclear equation which describes this decay.

[2]

(ii) Show that the net energy released during this reaction is about 8.96×10^{-13} J

[2]

(iii) Using **(c)**, show that $\dfrac{\text{Kinetic energy of } \alpha \text{ particle}}{\text{Kinetic energy of Po nucleus}} = \dfrac{218}{4}$

[5]

(iv) Hence, calculate the speed of the α particle.

Speed = ____________________ m s^{-1} [3]

(e) The Polonium (Po) nucleus subsequently decays spontaneously into an Astatine (At) nucleus via a β decay. It may be assumed that no γ- ray is emitted during this decay.

Fig. 5.2 shows the variation with kinetic energy of β particles produced during the decay of the number of β particles emitted.

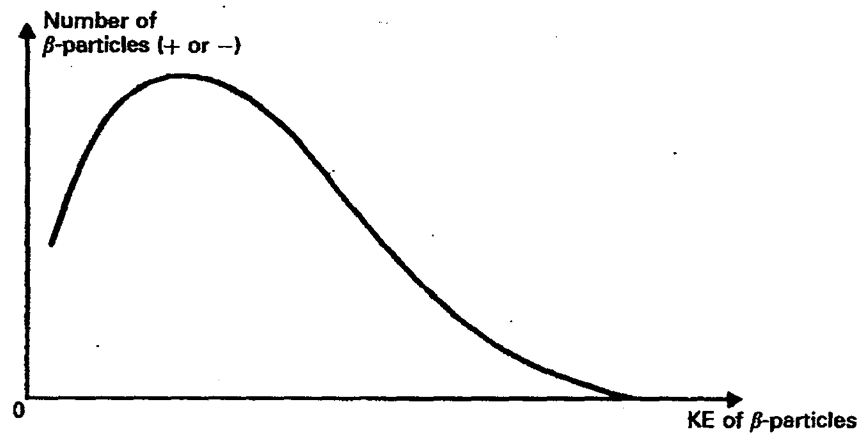

Fig. 5.2

(i) Explain how Fig 5.2 provided evidence for the discovery of the neutrino, which was emitted during a β decay.

____

____

____ [2]

(ii) A student suggests that the Astatine nucleus and β particle would be moving in opposite directions after the decay.

Comment on the validity of this statement.

____

____

____

____ [2]

6 (a) State the type of field, or fields, that may cause a force to be exerted on a particle that is

(i) uncharged and moving,

______________________________ [1]

(ii) charged and stationary,

______________________________ [1]

(iii) charged and moving at right-angles to the field.

______________________________ [2]

(b) (i) Explain what is meant by a magnetic field.

____

____

____

______________________________ [2]

(ii) Conventionally, arrows on field lines define the direction of a force acting on an object.

State the property of the object that experiences a force **in a direction opposite** to the direction of a magnetic field.

______________________________ [1]

(iii) **Fig. 6.1** shows the cross-section of two long vertical wires perpendicular to the page. The electric current in the left hand wire is downwards into the page whereas the current in the right hand wire is outwards from the page. The current in the left hand wire is greater than the current in the right hand wire.

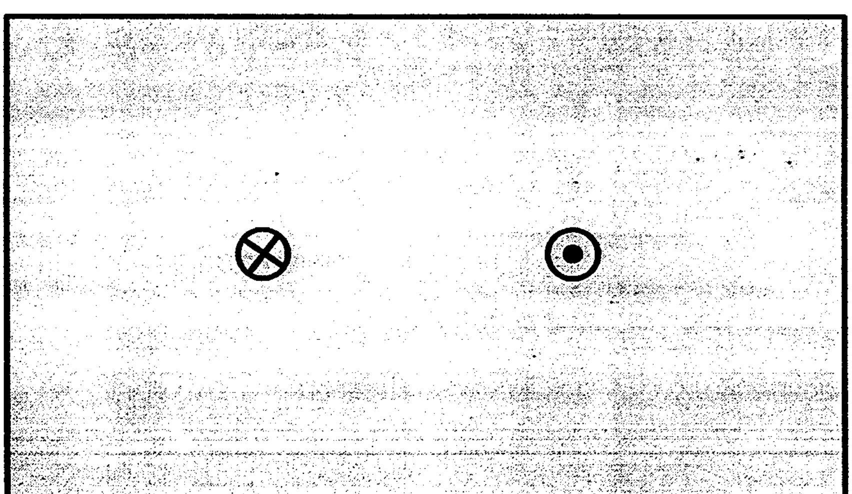

Fig. 6.1

Sketch the resultant magnetic field pattern around the wires within the shaded area. Indicate direction arrows on the field lines. [3]

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(c) The path of the negatively-charged particle travelling at constant speed before it enters a uniform magnetic field is shown in Fig. 6.2.

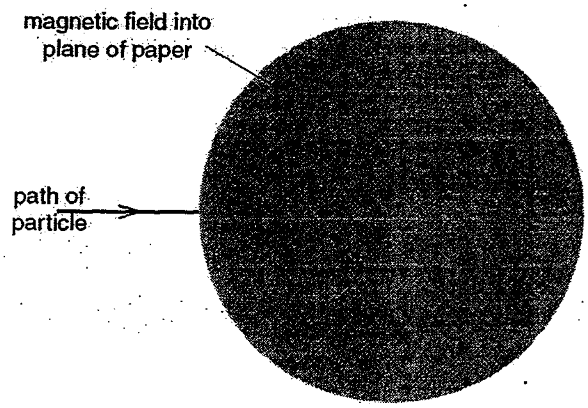


Fig. 6.2

(i) Explain why the path of the particle in the magnetic field is the arc of a circle.

....

....

....

....

.... [2]

(ii) On Fig. 6.2, sketch the path of the particle in the magnetic field and as it emerges from the field. [2]

(d) **(i)** Define *electric potential* at a point.

....

....

.... [2]

(ii) Two isolated point charges A and B are separated by a distance of 30.0 cm, as shown in Fig. 6.3.

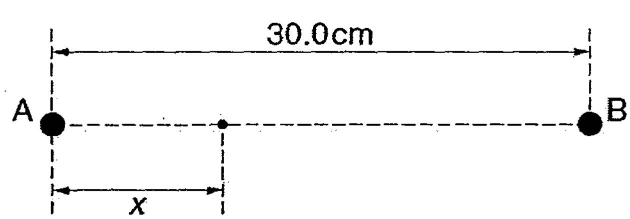


Fig. 6.3

The charge at A is + 3.6 × 10^{-9} C.
The variation with distance x from A along AB of the resultant electric

For Examiner's Use

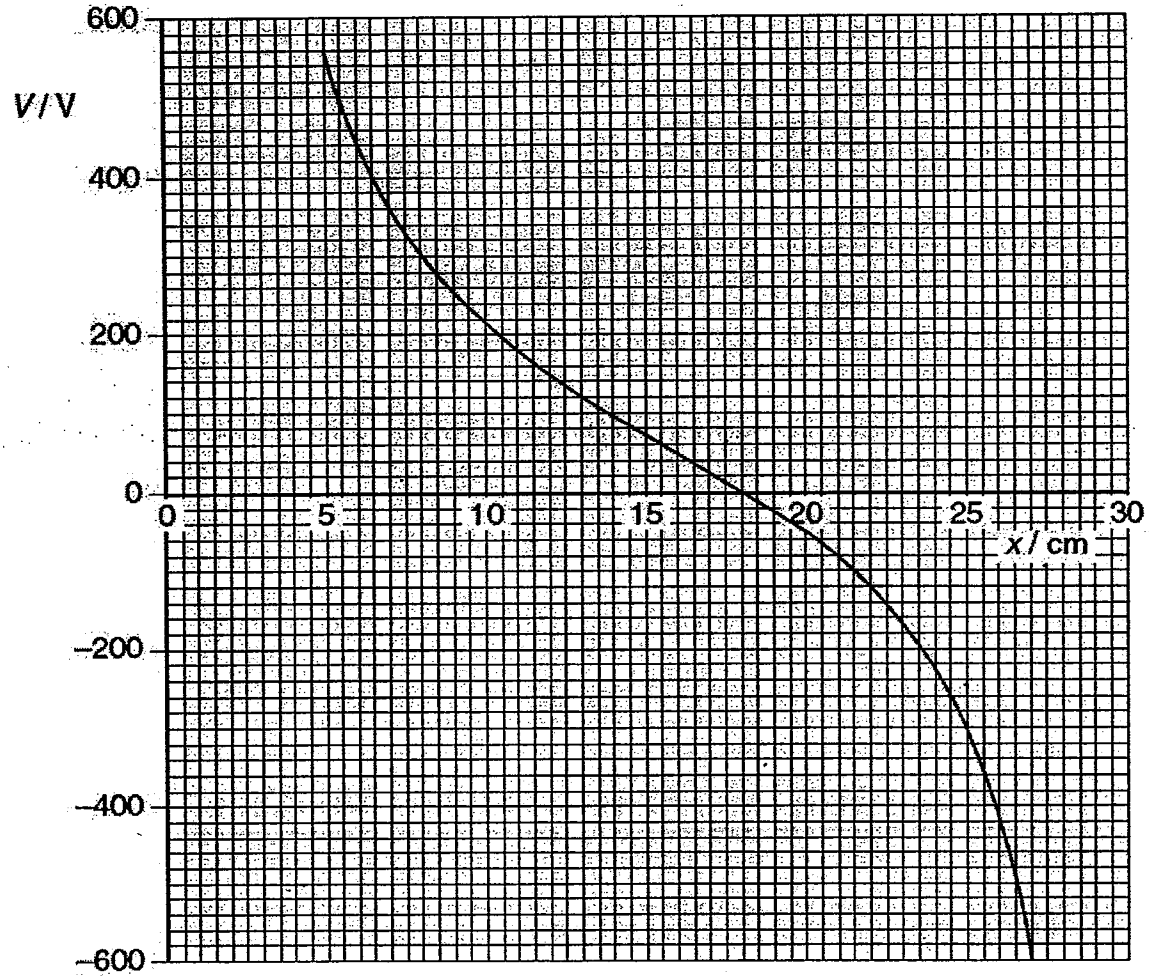
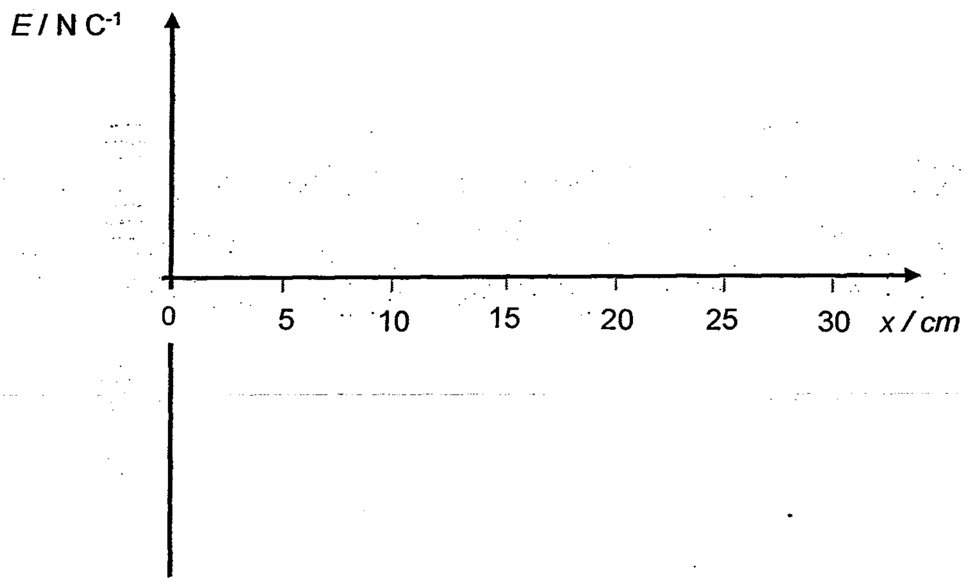


Fig. 6.4.

1. Determine the charge at B.

Charge = ... C [2]

2. Sketch on Fig 6.5 the variation with distance *x* from A along AB of the resultant electric field strength *E* for x = 5.0 cm to 27.0 cm.
(*Calculation of actual value of E is not required.*)



[2]

Fig. 6.5

For Examiner's Use

7 (a) A conducting rectangular loop of mass M, resistance R and dimensions w by l falls from rest into a magnetic field B as shown in Fig. 7.1.

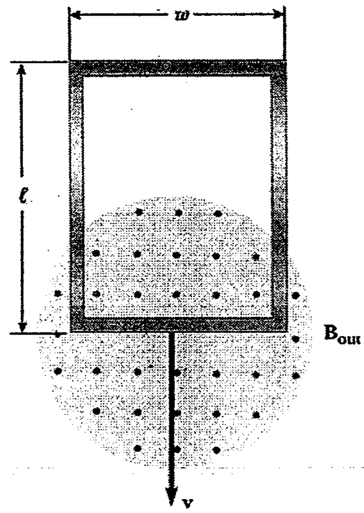


Fig 7.1

(i) **1.** During the time interval before the top edge of the loop reaches the field, the loop approaches a terminal speed v_t.

Explain why there is an electromagnetic force acting on the bottom edge of the loop but not on the top edge of the loop.

____

____

____ [2]

2. By considering the forces acting on the loop, or otherwise, show that $v_t = \frac{MgR}{B^2w^2}$

[3]

3. Briefly explain why v_t is dependent on R.

____

____

____ [2]

For Examiner's Use

(ii) The top of the rectangular loop is now attached with a spring of spring constant k = 12.5 N kg^{-1}, and the loop is set to oscillate. The mass M of the loop = 500 g.

Graph A in Fig 7.2 shows the variation with time, the displacement of the loop when the magnetic field is switched off.

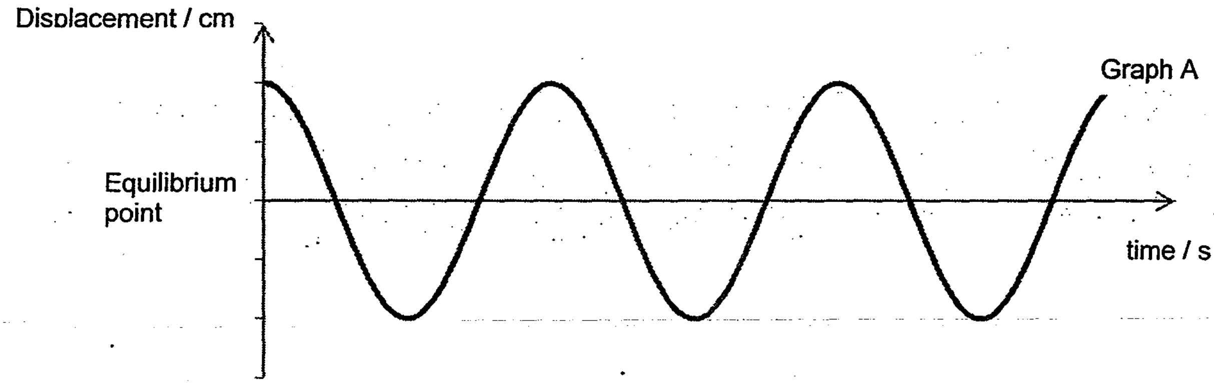


Fig. 7.2

1. When the magnetic field is switched off, the loop oscillates in a simple harmonic motion described by the equation:

$$a = -\frac{k}{M}x$$

where x is the displacement of loop from equilibrium and a is the acceleration of loop

Determine the period, T, of the oscillation.

T = ... s [3]

2. The magnetic field is switched on again.

Sketch in Fig. 7.2, the variation with time of the displacement of the loop. Label the graph B.

[2]

For Examiner's Use

3. The loop is damaged and does not form a closed conducting loop. With the magnetic field still turned on, state and explain the changes, if any, to graph A in Fig 7.2

[2]

(b) This part of the question is on transformer.

In the ideal transformer shown in Fig 7.3, the turn ratio $N : N_2$ is 5 : 2, and the source root-mean-square (r.m.s.) voltage, V_s is 80.0 V.

The source resistance, *Rs*, has yet to be determined.

The load resister R_L is 50.0 Ω. A CRO measures the potential difference across the load to be V_{RMS} = 25.0 V

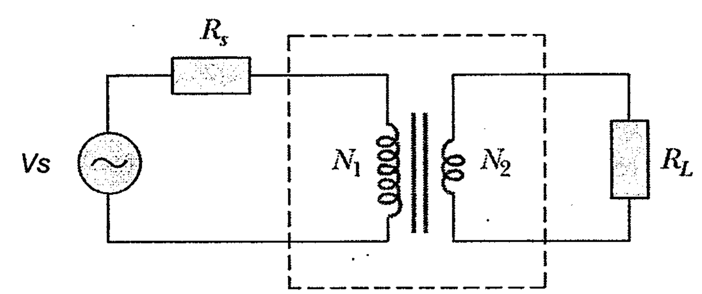


Fig 7.3

(i) Explain why transformers do not work when a steady direct current is used.

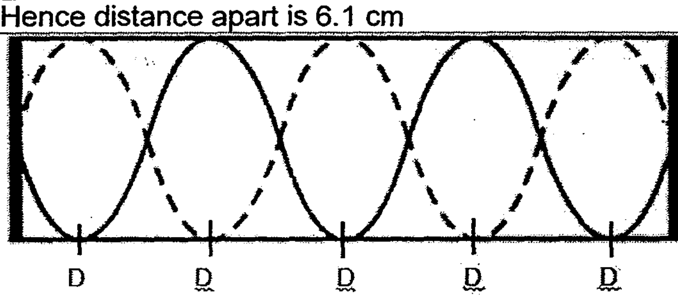
[2]

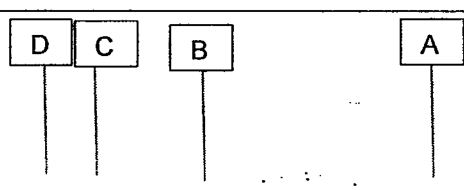
(ii) The potential difference across the primary coil of the transformer is *Vp* . The current through the primary coil is *Ip*.

Write an equation relating *Vsource*, *Vp*, *Ip* and *Rs*. [1]

(iii) Hence or otherwise, determine the source resistance, *Rs*.

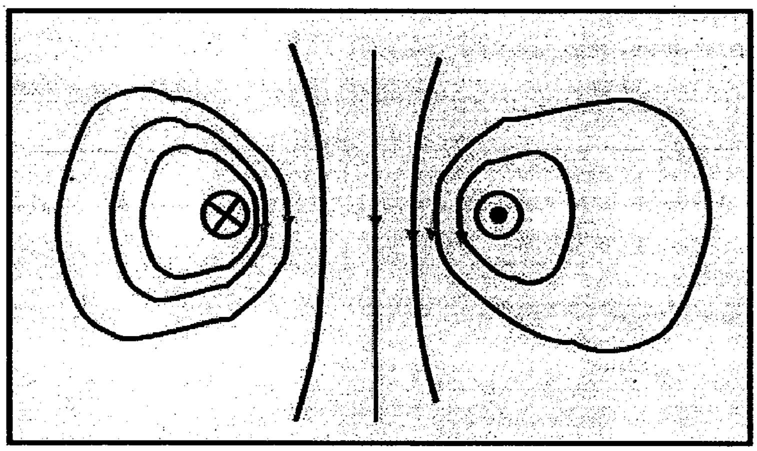
source resistance, *Rs* = ... Ω [3]

Qn	Suggested MS
1(a)	The radian is defined as the angle subtended at the centre of a circle by an arc length equal in length to the radius of the circle. .
1(b)(i)	Weight downwards Normal contact force radially drawn *F* tangential to curvature upwards
(ii)	At constant speed, sum of tangential forces = 0 (Resolve forces tangentially)
(iii)	WD = R x area under *F*-θ graph
(iv)	Determine area under graph correctly (Range 0.9 – 1.1) Or WD by F = gain in GPE = 1.96 J
	WD by F = area x 2 Or since gain in KE = 0
(v)	G = mgR sinθ G starts of 0 and around 2 J at $\pi/2$ (1.57)
	K is constant at 0.20 J
2	
(a)	There are standing waves produced in the microwave oven during the cooking process because incident wave from the left gets reflected by the reflective wall on the right and they superimpose /overlap /interfere
	The conditions must be right such that the distance between the source and wall must be integral multiples of half the wavelength of the microwave.to form standing wave (*with nodes at the ends.*)
	as they have the same speed, frequency and (*almost*) the same amplitude (follows any of the M1 mark)
(b)(i)	Intensity of the microwave is strongest (largest amplitudes) at the antinodes, hence the dry regions are the regions of antinodes
	Wavelength = $3.0 \times 10^8 / 2.45 \times 10^9$
	= 0.1224 m = 12.2 cm
	Hence distance apart is 6.1 cm
(ii)	
(c)	*So there are regions in the oven where the microwave has high amplitude (antinodes) and there are region where the microwave has no displacement (node). Thus ants can stay away from the regions of high amplitude which has high heat and thus stay alive.*
	Understand that the ants will stay away from the position of antinodes / continuously move to positions of nodes to stay alive.

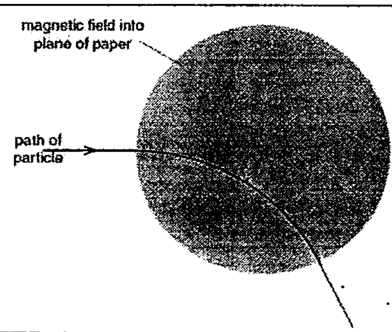
(d)	The turntable enables different parts of the food to move to the antinodes of the standing wave and get heated up. Thus it helps heat up the food more uniformly.
3(a)	Amount of electrical energy converted to heat and light
	per unit charge / when unit charge flow across the bulb
(b)	Bulb in 1 can be fully switched off.
	In 2, there is always pd across bulb/ there is always current through bulb (or equivalent)
(c)	Diagram with a switch in the appropriate location of the circuit.
	switch
(d)(i)	$R = \frac{V^2}{P} = \frac{240^2}{60}$ $= 960\,\Omega$
(ii)	Resistance lower since Room temperature lower than working temperature
	Rate of lattice vibration lower
4 (ai)	
	Energy levels occupied by Electrons in the atom are discrete. When electrons transit from a higher energy level to a lower energy level, it emit photons of energy that corresponds to energy difference between the 2 discrete energy levels.
	Thus only particular frequencies are emitted/observed since E = hf
(aii)	Atoms (*or electrons*) are in high energy states so either gas at a high temperature or high voltage applied across it.
	Gaseous state to be sufficiently far apart.
(b)(i)	$8.68 \times 1.60 \times 10^{-19} = 1.39 \times 10^{-18} J$. This is ionization energy.
(ii)	D, since it has the largest energy
(iii)	$\lambda = \frac{hc}{(-0.67 - (5.73))(1.60 \times 10^{-19})} = 245\,nm$
(iv)	UV
(d)	
	Order of lines correct (at least A or D labelled and Spacing roughly as shown
(f)	In a metal, the electrons are delocalized compared to the electrons in an isolated atom that are attracted to the nucleus. Hence ionization energy which is the energy need to remove the electron from the atom is different from Work function energy
5	
(a)	A high ratio of protons to neutrons would make the nucleus unstable due to the repulsive nature of the electrostatic force between protons.
(b)	Alpha decay causes a loss of 4 nucleons while beta decay has no effect on the number of nucleons

(c)	Total initial momentum = total final momentum of a system provided there is no net external force acting on the system.
(d) (i)	${}^{222}_{86}Rn \rightarrow {}^{218}_{84}Po + {}^{4}_{2}He + energy$
(d)(ii)	Energy released = $(m_{Rn} - (m_{Po} + m_{He}))c^2$
	= (222.1706 – (218.0090 + 4.0026)) x 1.66 x 10^{-27} x (3.00 x $10^8)^2$
	= 8.964 x 10^{-13} J
(d)(iii)	By COM, total p initial = total p final $m_{Rn}(0) = m_{Po} v_{Po} + m_{He} v_{He}$
	$m_{Po} v_{Po} = -m_{He} v_{He}$
	$KE = ½ m v^2 = p^2 / 2m$
	$\frac{\text{KE of } \alpha \text{ particle}}{\text{KE of Po nucleus}} = \frac{\frac{p_\alpha^2}{2m_\alpha}}{\frac{p_{Po}^2}{2m_{Po}}}$
	$= \frac{m_{po}}{m_\alpha}$
	$= \frac{218}{4}$
(d)(iv)	KE of α particle = (218 / (218 + 4)) x 8.964 x 10^{-13} ½ (4 x 1.66 x 10^{-27}) v^2 = (218 / 222) x 8.964 x 10^{-13} v = 1.63 (1.62830) x 10^7 m s^{-1}
(e)(i)	Range of KE of β particles produced For energy to be conserved, there must be another particle / wave (neutrino) that accounts for the remaining energy produced
(e)(ii)	Student is correct if anti-neutrino is emitted along the same axis as the *At* nucleus and β particle so that linear momentum can be conserved in all directions. OR Student is wrong as there should be an angle between the paths of the *At* nucleus and β particle because the anti-neutrino is also emitted so that linear momentum can be conserved in all directions.
6(a)	
(i)	Gravitational
(ii)	Gravitational and Electric Field
(iii)	Magnetic

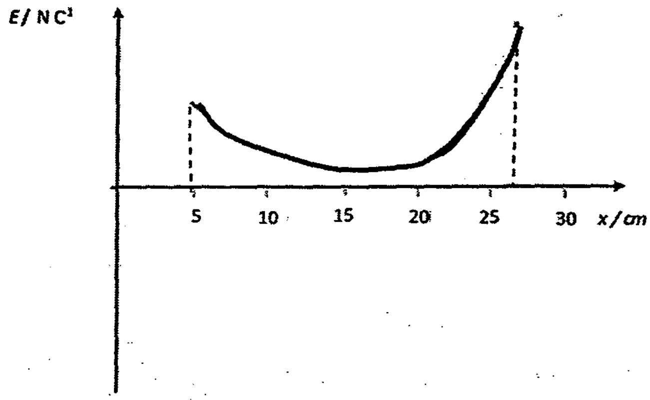
	Gravitational and Electric
(b)(i)	B-field is a region of space where a charge moving not parallel to the field or conductor carrying a current not placed parallel to the field or a magnetic object experience a magnetic force.
	Region of space with one correct example stated
	With at least a correct 2nd example
(ii)	S-pole of a magnet
(iii)	



(c)	
(i)	Force is always constant
	and always normal to motion of charged particle
	Hence provides the centripetal force
(ii)	



(d)	
(i)	WD by an external agent on a small positive point test charge per unit charge
	To bring the charge from infinity to the point.
(ii)1.	$V_A + V_B = 0$ at x = 18 cm.
	$(3.6 \times 10^{-9}) / (4\pi\varepsilon_o \times 18 \times 10^{-2})$ $+ q / (4\pi\varepsilon_o \times 12 \times 10^{-2}) = 0$
	$q = -2.4 \times 10^{-9}$ C
(ii)2	

	
7(a)(i) 1	Explained why induced current present
	Explained why magnetic force on bottom edge and not on top edge
(i)(2)	1. constant speed, forces on loop $BIw = mg$, 2. By definition $I = \frac{\epsilon}{R}$, 3. By Faraday's Law $\epsilon = Bwv_t$ 1,2,3 gives $v_t = \frac{MgR}{B^2w^2}$
(i)(3)	When R increases, induced current drops Induced/resistive force drops Higher v_t
(ii)1	$\omega^2 = \frac{k}{m}$ $T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{0.5}{12.5}}$ T=1.26 s
(ii)2	Light damping/moderate dampling: Amplitude decreases gradually; T ~ unchanged / increases
(ii)3	No induced current No damping / resistive force /no loss of energy
(b)(i)	When steady dc used, the magnetic field from primary remains a constant, hence no change in flux linkage (*experienced in the core.*) Hence no induced emf experienced by secondary coil
(ii)	$V_s = I_p R_s + V_p$
(iii)	Turn ratio: $\frac{N_p}{N_s} = \frac{V_p}{V_{sec}} = \frac{5}{2}$, $V_p = \frac{5}{2} \times 25\ V = 62.5\ V$ Energy transferred via transformer: $62.5 \times I_p = 25 \times \frac{1}{2}, I_p = 0.20$ Hence $80 = 0.20R_s + 62.5$