Candidate Name: ______________________________

Class	Adm No

H

millennia institute

2018 Preliminary Exams

Pre-University 3

H2 PHYSICS **9749/01**

Paper 1 Multiple Choice **19 September 2018**

Additional Materials: OMR Answer Sheet **1 hour**

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 **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.

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

Formulae

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

1 Which of the following pair of physical quantities includes a scalar quantity and a vector quantity?

A work, magnetic flux density

B voltage, frequency

C resistance, charge

D tension, electric field

2 The acceleration of free fall g was determined during an experiment by a student. The table below shows the recorded measurements.

Readings / m s^{-2}				
9.25	9.23	9.25	9.24	9.23

Which of the following gives a suitable description of the readings?

A The readings were accurate with large systematic error.

B The readings were accurate with large random error.

C The readings were precise with large systematic error.

D The readings were precise with large random error.

3 An e-scooter travels at a uniform velocity of 15 ms^{-1} along a level road and passes a motorised bicycle which is initially at rest at t = 0 s. The motorised bicycle immediately accelerates uniformly along the same direction to catch up with the e-scooter. At t = 6 s, both the e-scooter and the motorised bicycle are 54 m apart.

What additional time will it take for the motorised bicycle to catch up with the e-scooter?

A 4.6 s **B** 9.0 s **C** 10.0 s **D** 15.0 s

4 A squash ball approaches a squash player who gives it a hard hit with a swing of her racket. The ball then returns directly to her opponent.

Which of the following is true about the squash ball and the racket during the time of contact?

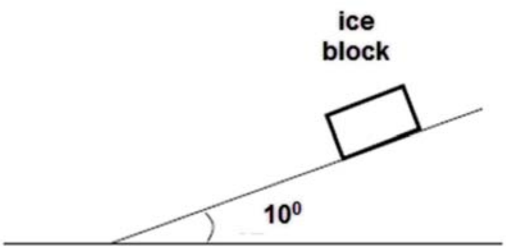
A The force on the racket due to the ball is smaller than the force on the ball due to the racket because the ball is much smaller and lighter than the racket.

B The force on the racket due to the ball is smaller than the force on the ball due to the racket because the ball moves off with high speed after the contact whereas the racket does not.

C The force on the racket due to the ball is larger than the force on the ball due to the racket because smaller mass means smaller force.

D The force on the racket due to the ball is equal to the force on the ball due to the racket.

5 A block of ice of mass 1.8 kg slides down a smooth slope from rest.



What is the momentum of the ice block after 3.0 s?

A 9.2 kg m s^{-1} **B** 18.4 kg m s^{-1} **C** 27.2 kg m s^{-1} **D** 53.0 kg m s^{-1}

6 A missile of mass 3M was projected with a velocity of 50.0 m s^{-1} at an angle of 80° above the horizontal. At the highest point, it explodes into three equal fragments X, Y and Z. Fragment X moves vertically upwards with velocity of 25.0 m s^{-1}. Fragment Y moves vertically downwards with velocity of 25.0 m s^{-1}.

What is the velocity of fragment Z?

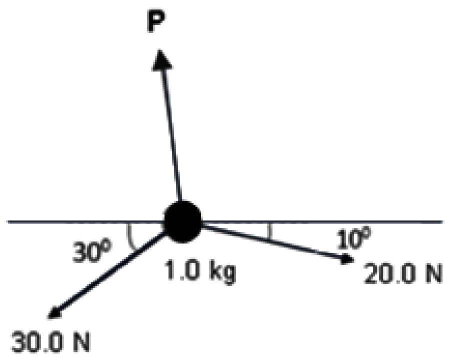
A 8.6 m s^{-1} horizontally.

B 26.0 m s^{-1} horizontally.

C 8.6 m s^{-1} at an angle of 80° above the horizontal.

D 26.0 m s^{-1} at an angle of 80° above the horizontal.

7 A 1.0 kg mass is at rest on a smooth horizontal surface. Three forces keep the 1.0 kg mass in equilibrium.



What is the magnitude of force **P**?

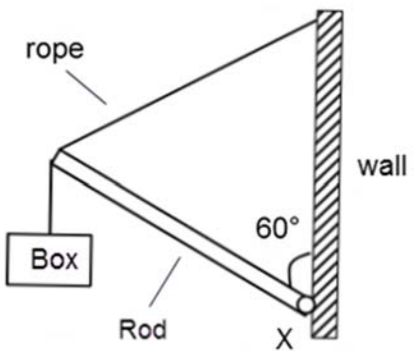
A 6.3 N **B** 12.2 N **C** 18.5 N **D** 19.5 N

8 A 0.15 kg plastic cube of volume 1.0×10^{-3} m^3 is held at rest at the bottom of a tank of liquid of density 3000 kg m^{-3}. The cube is then released and rises up until it reaches a constant speed.

What is the upthrust on the plastic cube?

A 0.0 N **B** 1.5 N **C** 28.0 N **D** 29.4 N

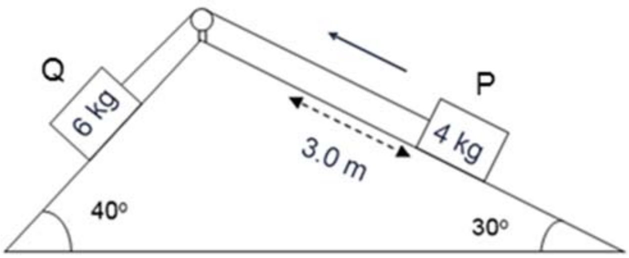
9 A uniform rod of weight 50 N and length L is hinged at X to a wall as shown. A rope of length L supports the rod and is also attached to the wall. A box of weight 24 N is suspended at the other end of the rod.



What is the tension in the rope?

A 28 N **B** 49 N **C** 74 N **D** 85 N

10 Two masses P and Q are connected by a light inextensible string which passes over a frictionless pulley. P and Q are initially at rest and their masses are 4.0 kg and 6.0 kg respectively. When Q is released, P moves up the plane inclined at 30^0 to the horizontal as shown.



What will be the speed of Q after P has moved 3.0 m up the plane?

A 2.3 m s^{-1} **B** 3.3 m s^{-1} **C** 4.3 m s^{-1} **D** 5.3 m s^{-1}

11 A motorised boat moving at constant speed S through still water experiences total drag X.

What is the power of the motorised boat?

A X^2 S **B** ½ XS^2 **C** XS **D** ½ XS

12 A ball is inside a pail that is moving in a vertical circle of radius 70.0 cm. The ball will just remain in contact with the pail at the top of the circular path if the pail is rotating with a minimum speed V.

What is the minimum speed V of the pail?

A 2.6 m s^{-1} **B** 3.7 m s^{-1} **C** 26.0 m s^{-1} **D** 37.0 m s^{-1}

13 A planet X has half the mass of the Earth and half its radius. The accelecration due to gravity on the Earth's surface is g.

What is the acceleration due to gravity on the surface of planet X?

A ¼ g **B** ½ g **C** g **D** 2 g

14 The mean kinetic energy of the gas molecules of an ideal gas at 573 K is 1.6×10^{-23} J.

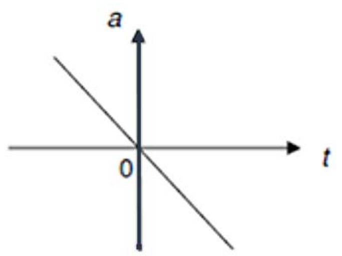
Which of the following correctly shows the values of temperature and mean kinetic energy of the gas molecules when the gas molecules are travelling twice as fast?

	temperature / K	kinetic energy / J
A	873	3.2×10^{-23}
B	1370	3.2×10^{-23}
C	2292	6.4×10^{-23}
D	2573	6.4×10^{-23}

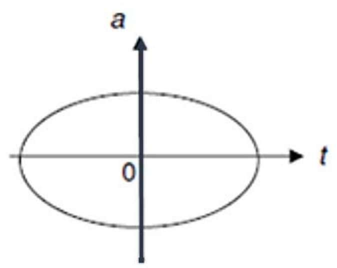
15 The bob of a pendulum is moving in simple harmonic motion. The bob has maximum potential energy at time t = 0 s.

Which of the following graphs best describes the variation of the acceleration *a* of the bob with time *t*?

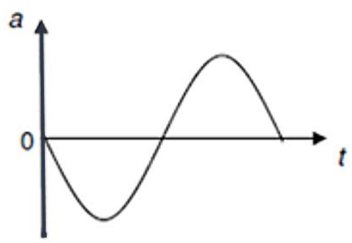
A



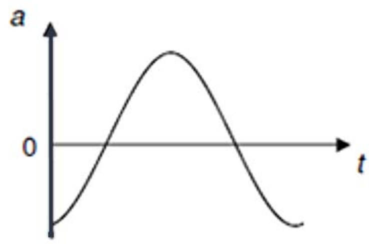
B



C



D



16 A mass of 20 g is oscillating vertically in simple harmonic motion. The displacement of the mass is given by the equation

$$x = 6.0 \times 10^{-3} \sin(3\pi t)$$

where x is in metres and t in seconds.

What is the magnitude of the maximum force acting on the mass?

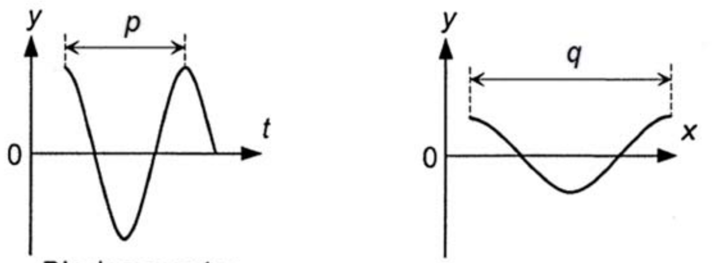
A 0.01 N **B** 0.50 N **C** 1.80 N **D** 10.7 N

17 A longitudinal wave of frequency 100 Hz is traveling in a gas at a speed of 200 m s^{-1}. The phase difference between 2 points P and Q along the path of the wave is $5\pi/4$ radian.

What is the distance between points P and Q?

A 0.525 m **B** 1.05 m **C** 1.15 m **D** 1.25 m

18 The same progressive wave is represented by the following graphs.



Displacement *y* against time *t* for constant position

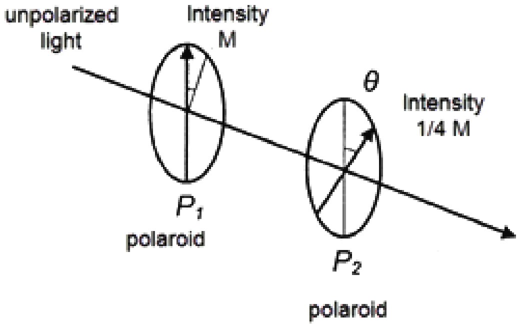
Displacement *y* against position *x* for constant time

Which of the following gives the speed of propagation of the progressive wave?

A pq **B** $\frac{p}{q}$ **C** $\frac{q}{p}$ **D** $\frac{1}{q}$

[Turn over

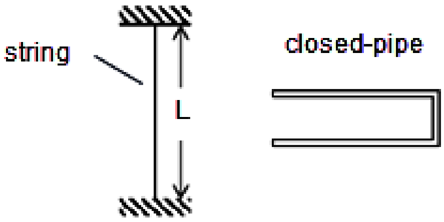
19 A beam of plane-polarised light of intensity *M* after passing through polaroid P_1 falls normally on to a thin sheet of Polaroid P_2 as shown below. When polaroid P_2 is rotated through an angle θ, the transmitted beam through polaroid P_2 has an intensity of ¼ *M*.



What is the angle θ between the plane of incident polarisation and the polarising direction of the polaroid P_2?

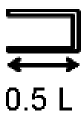
A 60^0 **B** 45^0 **C** 30^0 **D** 22.5^0

20 The figure shows a stretched string of length L placed near a closed-pipe. The fundamental mode of oscillation in the string occurs when the speed of waves in the string equals the speed of soundwaves in the air.

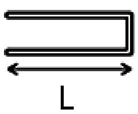


In which closed-pipe below will the sound produced by the string cause resonance in the pipe?

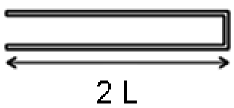
A



B



C



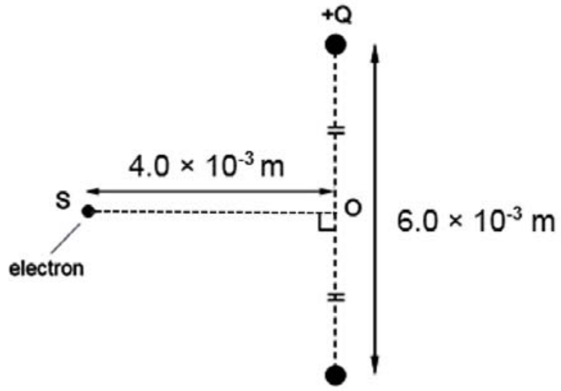
D

21 Red light of wavelength 700 nm passes through a Young's double-slit arrangement. Fringes of separation Z are observed in a plane 1.20 m away from the slits. The light source is then replaced with blue light of wavelength 420 nm.

At what distance from the slits would fringes of the same separation Z be observed?

A 0.60 m **B** 0.72 m **C** 1.67 m **D** 2.00 m

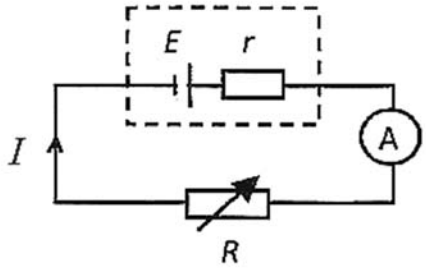
22 Two identical point charges +*Q* of $+1.45 \times 10^{-15}$ C each are fixed 6.0×10^{-3} m apart as shown below. An electron is then projected with a speed V into the plane of the paper at point S which is 4.0×10^{-3} m away from the perpendicular bisector between the two charges.



Which of the following gives the magnitude of net force on the electron and the speed V with which the electron must be projected into the plane of the paper at S to just perform circular motion with its centre at point O.

	net force / N	speed V / m s^{-1}
A	8.34×10^{-20}	1.2×10^{4}
B	1.33×10^{-19}	2.4×10^{4}
C	8.34×10^{-20}	2.4×10^{4}
D	1.33×10^{-19}	1.2×10^{4}

23 A battery of e.m.f. E and internal resistance r delivers a current I through a variable resistor R as shown below.



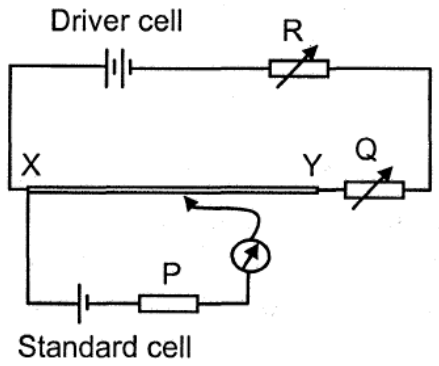
The table below shows two different values of R and corresponding currents I measured using an ammeter of negligible resistance.

R / Ω	I / A
1.0	3.0
2.0	2.0

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

A 3.0 V **B** 3.5 V **C** 4.0 V **D** 6.0 V

24 The potentiometer is to be calibrated with a standard cell using the circuit shown. XY is a 1.000 m along uniform wire.



The balance point is found to be nearer X. The accuracy of the balance length can be improved by having the balance point nearer to Y.

What should be varied to ensure the balance point is near Y?

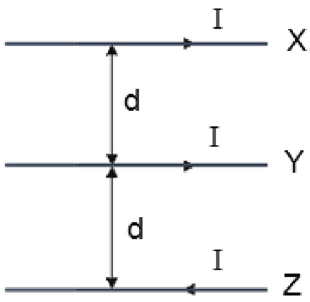
A increasing P

B increasing R

C replacing the wire with one of higher resistance per unit length

D reducing Q

25 The three parallel wires X, Y and Z carry currents of equal magnitude I in the direction shown.



Which one of the following gives the direction of the resultant force experienced by Y due to the currents in X and Z?

A along Y

B towards Z.

C towards X.

D Along Z

26 An e.m.f is induced in a coil of wire that is rotating inside a magnetic field.

Which one of the following does not affect the magnitude of e.m.f induced in the coil?

A the angular velocity of the coil

B the resistance of the coil

C the number of turns of the coil

D the magnetic flux density

27 When a sinusoidal e.m.f of peak value V is connected across a resistor R, a current of peak value I flows through it.

What is the mean power dissipated in the resistor?

A I^2R **B** $\frac{IV}{\sqrt{2}}$ **C** $\frac{IR^2}{\sqrt{2}}$ **D** $\frac{V^2}{2R}$

28 When electrons are accelerated and then stopped suddenly by a metal, X-rays are produced. The accelerating voltage across an X-ray tube is doubled.

Which of the following is true when the accelerating voltage across the X-ray tube is doubled?

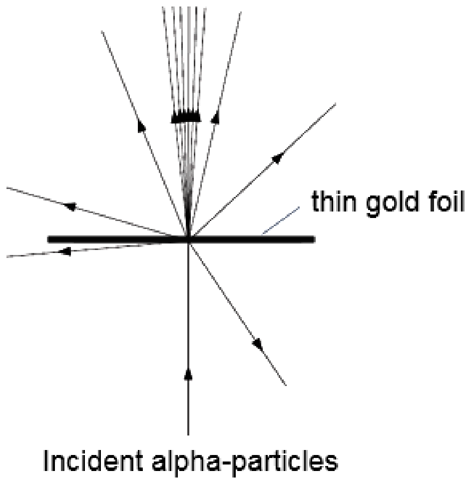
A The intensity of the X-ray beam is doubled.

B The wavelengths of the characteristics lines are halved.

C The minimum wavelength of the X-rays is halved.

D The X-rays are most probably less penetrating.

29 The diagram shows a thin gold foil bombarded with alpha-particles.



What does the results of this experiment provide?

A wave properties of a gold atom

B size of a gold nucleus

C mass number of a gold atom

D binding energy of a gold nucleus

30 A radioactive sample of half-life of 10 minutes is placed 40.0 cm away from a radioactivity detector. The detector gives an average count-rate of 39.0 s^{-1}. In the absence of the radioactive sample, the detector records an average count-rate of 5.0 s^{-1}.

After 20 minutes, the detector, which is still facing the radioactive sample, is moved 20.0 cm nearer the radioactive sample. The sample can be regarded as a point source of radiation.

What is the average count rate on the detector?

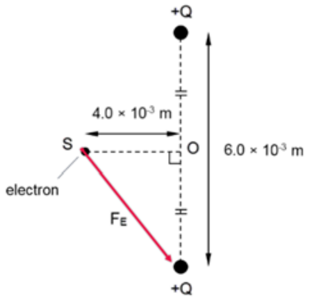
A 8.5 s^{-1} **B** 13.5 s^{-1} **C** 34.0 s^{-1} **D** 39.0 s^{-1}

2018 PU3 H2 PHY PE2
MARK SCHEME

Paper 1 (30 Marks)

1.	A	Work, magnetic flux density
2.	C	True g = 9.81 mean <g>=9.242 – large systematic error - not accurate Δg = (9.25-9.23)/2=0.02 – small random error – precise
3.	B	At t=6 s, $S_A - S_B = 54$ $\rightarrow$ (15 x 6) – (½ x a_B x 6^2) = 54 $\rightarrow$ a_B = 2.0 m s^{-2} Let the time for B to catch up with A be T. $S_A = S_B$ 15 x T= ½ x 2 xT^2 $\rightarrow$ T= 15.0 s Hence additional time =15 – 6 = 9 s.
4.	D	The force on the racket must be equal and opposite to the force on the ball based on Newton's 3rd Law.
5.	A	Acceleration along slope: a = g sin 10^0 = 1.7 velocity of block after 3.0 s: v=u +at = 0 + 1.7(3) = 5.1 momentum p=mv = 1.8 x 5.1 = 9.18 kg m s^{-1}
6.	B	At maximum height, initial horizontal velocity = 50 cos 80^0 = 8.62 m s^{-1} At this instance when the missile explodes. Total vertical momentum is zero By conservation of momentum, total initial momentum (hor) = total final momentum of fragment Z (hor) 3M (8.62) = Mv (of fragment z) v = 25.9 m s^{-1}
7.	D	Resolving forces vertically 30 sin 30^0 + 20 Sin 10^0 = P_y P_y = 18.5 N Resolving forces horizontally -30 cos 30^0 + 20 cos 10^0 = P_x P_x = -6.28 N P= $(18.5^2 + 6.28^2)^{1/2}$ = 19.5 N
8.	D	Upthrust U= weight of fluid displaced U= (3000)(9.81)(1 x10^{-3}) = 29.4 N
9.	B	Principle of moments about X T sin60° x L = 50 x ½ L sin60° + 24 x L sin60^0 T = 25 + 24 = 49 N
10.	B	COE: gain in GPE by P + gain in KE by P and Q = Loss of GPE by Q 4 x 9.81 x 3sin30^0 + ½ (6+4) v^2 = 6 x 9.81 x 3sin40^0 v^2 = 10.9 v =3.31 m s^{-1}
11.	C	At constant speed, Driving force on boat = Total frictional drag X *P* = F v = XS
12.	A	At the top: net force = centripetal force $\frac{mv^2}{r} = mg + N$ Normal force N > 0 for ball to remain inside pail.

		$\frac{mv^2}{r} > mg$ $v > \sqrt{rg} = \sqrt{0.7 \times 9.81} = 2.6 \text{ m s}^{-1}$
13.	D	Earth's surface $g=GM/R^2$ Planet X surface $g_x = G(0.5M) / (0.5R)^2 = 2\ GM/R^2 = 2g$
14.	C	K.E. of a molecule = ½ m v_{rms}^2 KE = 3/2 kT T (in K) and KE are proportional to v_{rms}^2 When v increases to 2v New KE= ½ m $(2v)^2$ = ½ m v^2 x 4 = 1.6 x 10^{-23} x 4 =6.4 x 10^{-23} J New T= 573 x4 = 2292 K
15.	D	Bob has maximum PE at t = 0 means that object starts at either extreme positions at t = 0. Since acceleration is proportional to displacement, the acceleration should be either a positive maximum or negative maximum at t = 0.
16.	A	Max force = m a_{max} = m $\omega^2 x_0$ = 20 x 10^{-3} $(3\pi)^2$ (6 x 10^{-3}) = 1.07 x 10^{-2} ≈ 0.01 N
17.	D	Wavelength of wave λ =v/f =200 / 100 = 2.0 m Phase difference $\frac{x}{\lambda} = \frac{\phi}{2\pi}$ x= $\frac{\phi}{2\pi}\lambda = \frac{\frac{5\pi}{4}}{2\pi}$ x 2 = $\frac{5}{4} = 1.25m$
18.	C	Period T = *p* , frequency f=1/T=1/*p* , wavelength λ = *q* Wave speed v = fλ = *q/p*
19.	A	Malus law $I = I_0 \cos^2\theta$ ¼ M = M $\cos^2\theta$ cosθ =0.5 θ = 60^0
20.	A	String: Fundamental wavelength L=λ/2 Fundamental freq= v /λ =v/2L (v=fλ) Closed pipe: Fundamental wavelength L' =λ/4 Fundamental frequency= v /4L' Resonance: Driving frequency of string = fundamental freq of pipe v/2L = v /4L' L' = ½ L
21.	D	Fringe separation: $x = \frac{\lambda D}{a}$ Red light: $Z = \frac{(700 \times 10^{-9})(1.2)}{a}$ Blue light: $Z = \frac{(420 \times 10^{-9})(D)}{a}$ (same separation) D= (700/420) (1.2)= 2.00 m

22.	B	 $\theta = \tan^{-1}\left(\frac{4}{3}\right) = 53.13°$ $F_E = \frac{Qe}{4\pi\varepsilon_0 x^2} = \frac{(1.45\times10^{-15})(1.6\times10^{-19})}{4\pi\varepsilon_0 (5.0\times10^{-3})^2} = 8.3444\times10^{-20}$ N $F_{net} = 2\times F_E \sin\theta = 1.3351\times10^{-19}$ N For circular motion, $F_{net} = ma_c$ $1.3351\times10^{-19} = \frac{(9.11\times10^{-31})v^2}{4.0\times10^{-3}}$ $v = 2.4\times10^4$ m s^{-1}
23	A	COE: E = IR + Ir E = (3.0)(1.0) + (3.0)r …………(1) E = (2.0)(2.0) + (2.0)r …………(2) Solving simultaneous equations: E = 6.0 V
24	B	To shift the balance point to near Y, only increasing the resistance of the variable resistor R will reduce the pd across wire XY (potential divider) Reducing Q will shift the point to near X. Varying P has no effect as current flow is zero at balance. Likewise, replacing the wire with one of higher resistance per unit length will shift the balance point towards X.
25	C	Currents in X and Y are in the same direction. X and Y will experience attractive force towards each other (i.e. force on Y is towards X). Currents in Y and Z are in opposite directions. Y and Z will experience repulsive force away from each other (i.e. force on Y is away from Z towards X). Resultant force is towards X.
26	B	Faraday's Law, the e.m.f. induced in the coil of wire rotating in a magnetic field is proportional to the rate of change of flux in the coil. $E = -\frac{d\phi}{dt} = -\frac{d(NBA)}{dt}$ Hence emf does not depend on resistance of coil.
27.	D	Given: peak voltage V and peak current across a resistor R Mean power of a sinusoidal cycle <p> = ½ peak power <p> = ½ x (V_{peak}^2 /R)
28.	C	Work done of electrons = energy of x-ray photons emitted (For max photon energy) eV = hf = hc/λ λ inversely proportional to potential difference When V is doubled, λ is halved.
30.	D	Background = 5 s^{-1} ; Actual Count rate C = 39 – 5 = 34 s^{-1} 20 minutes later (2 half-lives) Actual C=34 $(0.5)^2$ = 8.5 s^{-1} $C \propto 1/r^2$ $\frac{C_2}{C_1} = \frac{r_1^2}{r_2^2} = \left(\frac{40}{20}\right)^2 = 4$ Reading on detector C_2= 4 x 8.5 + **5** =39.0 s^{-1}

	Class	Adm No
Candidate Name: ______________________		

H

millennia institute

2018 Preliminary Exams
Pre-University 3

H2 PHYSICS **9749/02**

Paper 2 Structured Questions **14 September 2018**

Candidates answer on the Question Paper. **2 hours**

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Do not turn over this page until you are told to do so.

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

The use of an approved scientific calculator is expected, where appropriate.
Answer **all** questions.

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

For Examiner's Use		
1		/10
2		/9
3		/11
4		/12
5		/8
6		/10
7		/20
Presentation		
Total		/80

Data

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

Formulae

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

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

1 **(a)** A speed boat has an initial velocity of 12 m s^{-1} south. The speed boat then changes its course to a final velocity of 16 m s^{-1} east. Determine the magnitude of the change in velocity, Δv, of the speed boat, and the angle between vector Δv and the north direction.

magnitude of Δv = ………………… m s^{-1} [1]

angle between Δv and north = ……………………….° [1]

(b) A student uses a pair of vernier caliper to take several measurements of the diameter of a rubber ball. He applies different pressures when closing the gap of the vernier caliper. State and explain whether this introduces a systematic error or random error into the readings.

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

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

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

(c) The energy per unit time, P radiated by an object with a surface area A at thermodynamic temperature T is given by

$$P = e\sigma AT^4$$

where e is the emissivity of the surface and σ is the Stefan-Boltzmann constant.

(i) Given that the SI unit for σ is W m^{-2} K^{-4}, determine the base units of emissivity, e.

base units of e = …………………. [2]

(ii) In an experiment to determine emissivity e of a circular surface area of diameter d of an object, the following measurements are taken:

P = (3.0 $\pm$ 0.2) W
d = (5.0 $\pm$ 0.1) cm
T = (500 $\pm$ 1) K
σ = 5.67 X 10^{-8} W m^{-2} K^{-4}

Determine the value of emissivity, e of the surface and express it with its associated uncertainty.

e = …………………. $\pm$ …………………. ………….. [4]

2 (a) Derive, from the equations for uniformly accelerated motion in a straight line, the equation

$$E_k = \frac{1}{2}mv^2.$$

[3]

(b) A 2.0 kg box on a frictionless incline of angle 40° is connected by a cord that runs over a massless and frictionless pulley to a light spring of spring constant k = 120 N m^{-1}, as shown in Fig. 2.1. The box is released from rest along the inclined plane when the spring is unstretched.

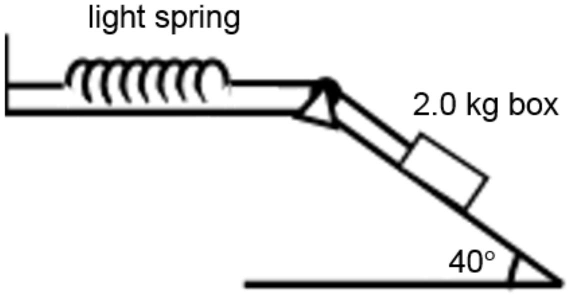


Fig 2.1

(i) Calculate the energy stored in the spring when the box reaches 10 cm down along the incline.

energy = …………………. J [1]

(ii) Determine, *D*, the distance along the incline moved through by the box before it comes to a stop.

D = …………………. m [2]

(iii) State what will happen to the answer calculated in **(b)(ii)** if the inclined angle is increased.

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

(iv) The frictionless incline is now replaced by a rough incline. Assuming the friction between the rough incline and the box is 5.0 N, determine *D'*, the new distance moved through by the box before it comes to a stop.

D' = …………………. m [2]

3 **(a)** State what is meant by *simple harmonic motion*.

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

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

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

(b) A smooth ball of mass m is held between two fixed points A and B by two similar springs, each of spring constant k, as shown in Fig. 3.1.

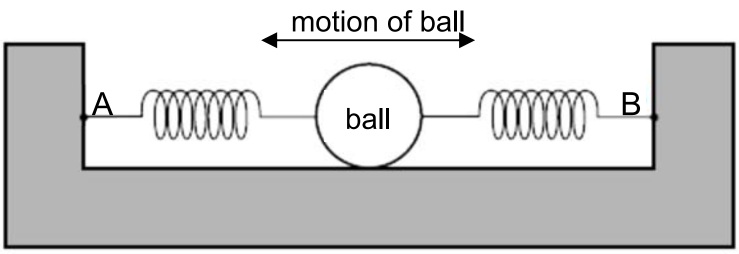


Fig. 3.1

When the ball is in equilibrium, the extension of each spring is e. The ball is then displaced a small distance x to the right along the axis of the springs. The ball is then released and oscillates on the smooth surface along the straight line joining points A and B.

(i) Show that the acceleration a of the ball is given by the equation

$$a = -\frac{2kx}{m}$$

[3]

(ii) The mass m of the ball is 900 g and the spring constant k is 120 N m^{-1}. The maximum acceleration of the ball is 5.2 m s^{-2}.

1. Determine the frequency of oscillation of the ball.

frequency = …………………. Hz [2]

2. Determine the amplitude of the oscillation.

amplitude = …………………. m [2]

3. Determine the maximum kinetic energy of the ball.

maximum kinetic energy = …………………. J [2]

4 **(a)** A contractor tries to measure the depth of a new well shaft to build a ladder to reach the bottom of the shaft. He uses an audio oscillator with adjustable frequency and applies it across the top of the well. Two successive resonances are heard at 70.6 Hz and 90.8 Hz. The speed of sound is 343 ms^{-1}. Determine the depth of the well.

depth of well = …………………. m [3]

(b) An engineering student designed an Automated Guided Vehicle (AGV) using interference of radio waves from two coherent emitters 2.0 m apart emitting radio waves of frequency *f* that are in phase as shown in Fig. 4.1. The computer on the AGV detects and searches for lines of constructive interference and adjusts the AGV so that it is always aligned along the centre-line, in the middle of the emitters.

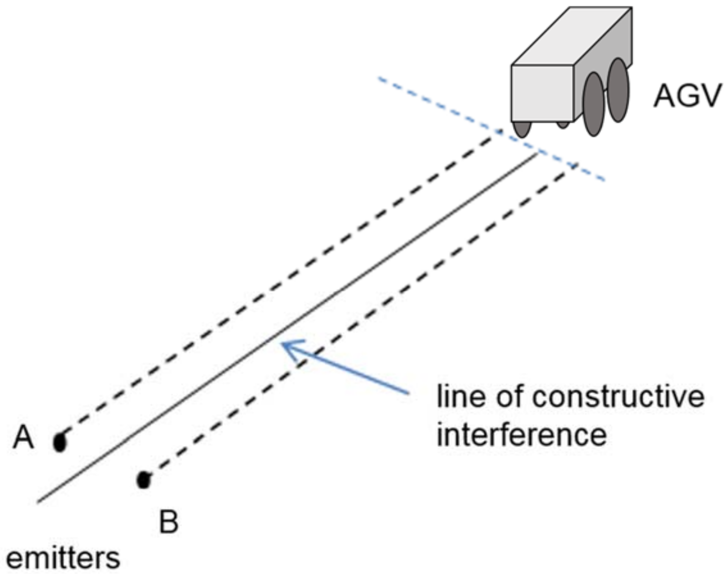


Fig 4.1

(i) State and explain one disadvantage in using this method for the AVG to align itself along the centre-line.

....

....

.... [2]

(ii) During one such operation, the AGV strays off the centre-line as shown in Fig. 4.2.

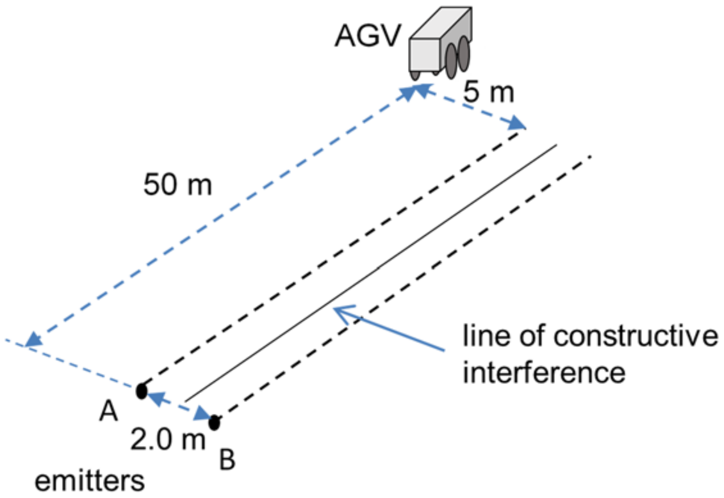


Fig 4.2

Fig. 4.3 shows the radio signals X and Y detected by the receiver on the AGV.

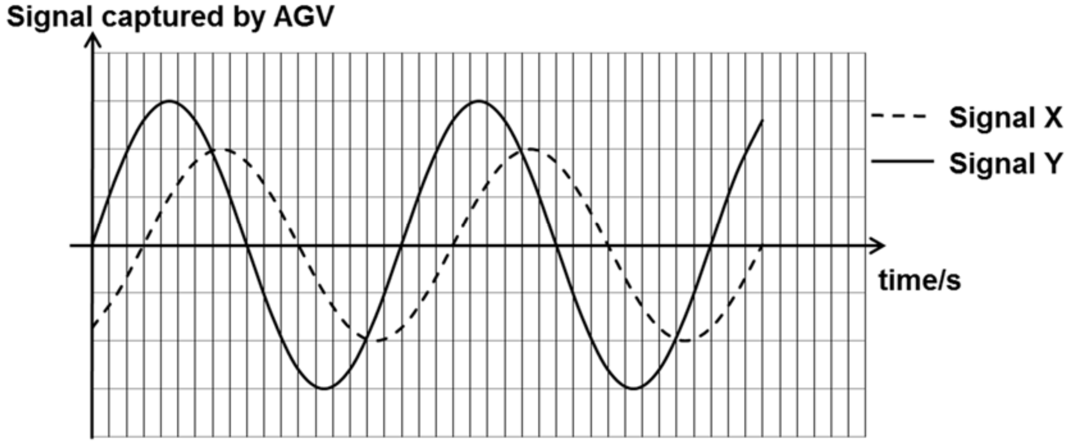


Fig 4.3

1. State and explain whether the source of signal X is from emitter A or B.

....

....

....

.... [2]

[Turn over

2. State the phase difference between signals X and Y.

phase difference = …………………. rad [1]

3. Assuming the path difference is less than one wavelength, determine frequency *f* of the radio wave used.

frequency *f* = …………………. Hz [4]

5 **(a)** Define *electric potential* in an electric field.

....

.... [1]

(b) Two spherical charges P and Q, each of mass m = 0.20 g are separated by a horizontal distance of 30 mm as shown in Fig. 5.1. P has a charge of +20 μC and Q has a charge of –40 μC.

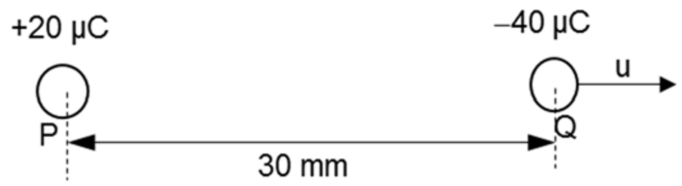


Fig 5.1

(i) In Fig 5.2, r represents the distance from centre of P towards centre of Q. On the axis provided, sketch the variation of the resultant electric potential V between boundaries A and B.

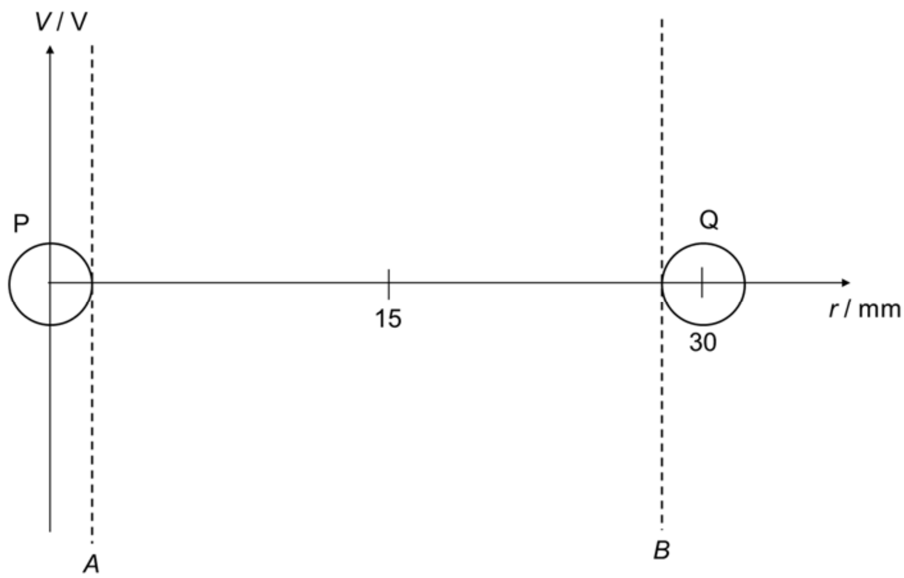


Fig 5.2

[3]

(ii) Q is then projected away from P with an initial speed *u* such that it reaches a position far enough beyond the influence of charge P.

1. Determine the electric potential energy of Q at its initial position.

electric potential energy = …………………. J [2]

2. Determine the minimum initial speed *u* required.

minimum speed *u* = …………………. m s^{-1} [2]

6 **(a)** 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]

(b) An evacuated tube contains two parallel metal electrodes, one of which is an emitter of electrons and the other a collector. The emitter has a work function energy of 2.0 eV and is illuminated with electromagnetic radiation of wavelength 410 nm. The area illuminated on the emitter is 24 mm^2. The potential difference *V* between the collector and the emitter is adjusted, and the photocurrent *I* is measured. Fig. 6.1 shows the variation of *I* with *V*.

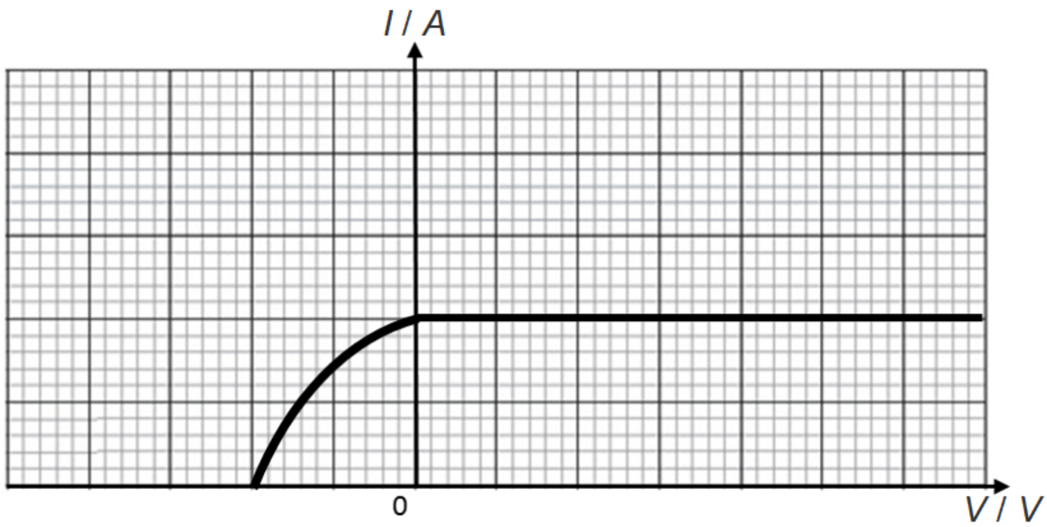


Fig 6.1

On Fig 6.1, sketch graphs to show the variation of *I* with *V* when the following changes are made to the original setup.

(i) The wavelength of the electromagnetic radiation is kept constant but its intensity is reduced by half. Label the graph **(i)**. [2]

(ii) The wavelength of the electromagnetic radiation is decreased but its intensity is kept constant. Label the graph **(ii)**. [2]

(iii) At a particular setting, a photocurrent of 4.8×10^{-10} A was observed.

1. Determine the rate of emission of photoelectrons.

rate of emission = …………………. s^{-1} [1]

2. Hence, determine the intensity of the light source, assuming that 1 in 2500 photons succeeds in ejecting an electron from the surface.

intensity = …………………. W m^{-2} [3]

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7 A German astronomer, Johannes Kepler, deduced that for a planet in a circular orbit around the Sun, its period of rotation T and the radius of its orbit r, is related by

$$T^2 \propto r^3 .$$

(a) Using Newton's law of gravitation and considering the mass of Saturn to be M, show that, for a circular orbit of a moon around Saturn,

$$T^2 = \frac{4\pi^2}{GM} r^3 .$$

[3]

(b) Table 7.1 contains some of the data for the major moons of Saturn.

Table 7.1

moon	period T / 10^6 s	mean distance from centre of Saturn r / 10^9 m	lg (T / s)	lg (r / m)
Enceladus	0.121	0.238	5.08	8.38
Tethys	0.164	0.295	5.21	8.47
Rhea	0.380	0.501		
Titan	1.38	1.26		
Lapetus	6.83	3.56	6.83	9.55

Complete Table 7.1 for the moons Rhea and Titan. [2]

(c) Fig. 7.1 shows a graph representing the variation of lg (T / s) with lg (r / m) for the moons of Saturn, with some of the data from Table 7.1 plotted.

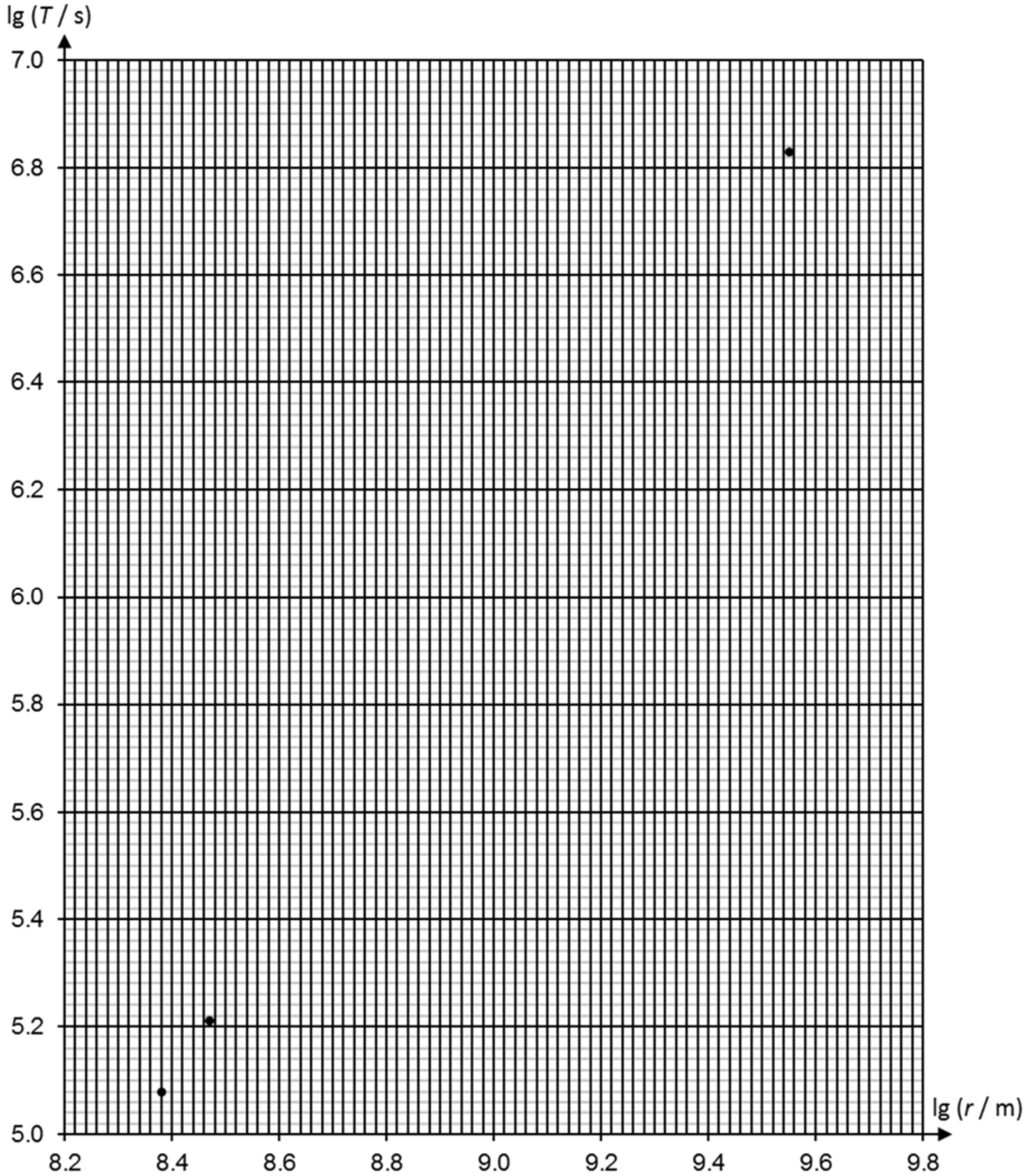

Fig 7.1

On Fig 7.1,

(i) plot the points corresponding to the moons Rhea and Titan. [1]

(ii) draw the line of best fit for all the data points. [1]

(d) **(i)** Determine the gradient of the graph in Fig 7.1.

gradient = …………………. [2]

(ii) Hence, discuss whether the data in Fig 7.1 supports the relation given in **(a)**.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

(e) Dione, which is another moon of Saturn, has an orbital radius of 3.78×10^5 km.

Using the graph in Fig. 7.1, determine the period of Dione's orbit around Saturn.

period = …………………. s [2]

(f) Scientist were able to determine the mass of planets in the Solar System through studying the orbits of their moons.

(i) Using Fig 7.1, determine the mass of Saturn.

mass = …………………. kg [2]

(ii) A student studying the orbits of the moons of Saturn decides to determine the mass of Saturn with the orbital radius and period of Titan only.

Discuss one disadvantage of using this method as compared to **(f)(i)**.

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

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

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

(iii) It was reported that another moon of Saturn, Mimas, has a period of rotation 7.78×10^4 s and orbits at a height of 1.79×10^5 km above Saturn's surface. Comment on the accuracy of this report.

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

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

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

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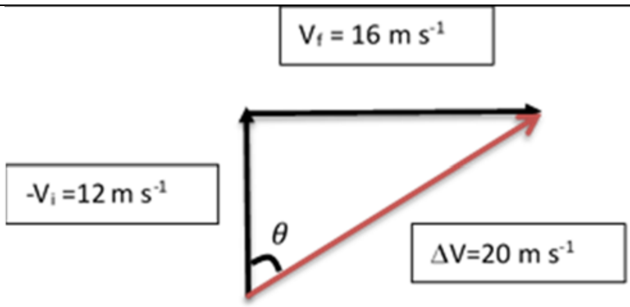
2018 Preliminary Exams

Pre-university 3 Paper 2

H2 Physics

9749

Mark Scheme

	Mark Scheme	
1 (a)		C0
	Change in Velocity = Final V – Initial V Magnitude = $\sqrt{(16^2 + 12^2)} = 20$	A1
	Direction, θ = tan^{-1} (16/12) = 53.13˚ = 53.1°	A1
(b)	This is because as different pressures are applied in closing the gap of the vernier calipers, the readings will be **inconsistent and fluctuate around the average reading.**	M1
	Random error.	A1
	OR	
	This is because the pressure applied can be consistently more than what is necessary hence resulting in a reading **consistently less than the actual reading.**	M1
	Systematic error.	A1
(c)(i)	Units of e = $\dfrac{units\ of\ P}{units\ of\ (\sigma A T^4)}$ = $\dfrac{W}{(Wm^{-2}K^{-4})(m^2)(K^4)}$	C1
	= 1 (OR No units)	A1
(ii)	e = $\dfrac{P}{\sigma A T^4}$ = $\dfrac{P}{\sigma(\pi \frac{d^2}{4})T^4}$	C1
	= $\dfrac{3}{(5.67x10^{-8})(\pi \frac{0.05^2}{4})500^4}$ = 0.4312 $\dfrac{\Delta e}{e} = \dfrac{\Delta P}{P} + 2\dfrac{\Delta d}{d} + 4\dfrac{\Delta T}{T} = \dfrac{0.2}{3} + 2(\dfrac{0.1}{5}) + \dfrac{4}{500}$	M1
	Δe = (0.115)(0.431) = 0.05 e ± Δe = (0.4312 ± 0.05) (mark is for calculating e and Δe correctly)	C1
	Therefore, e ± Δe = (0.43 ± 0.05) (Mark for correct decimal places)	A1

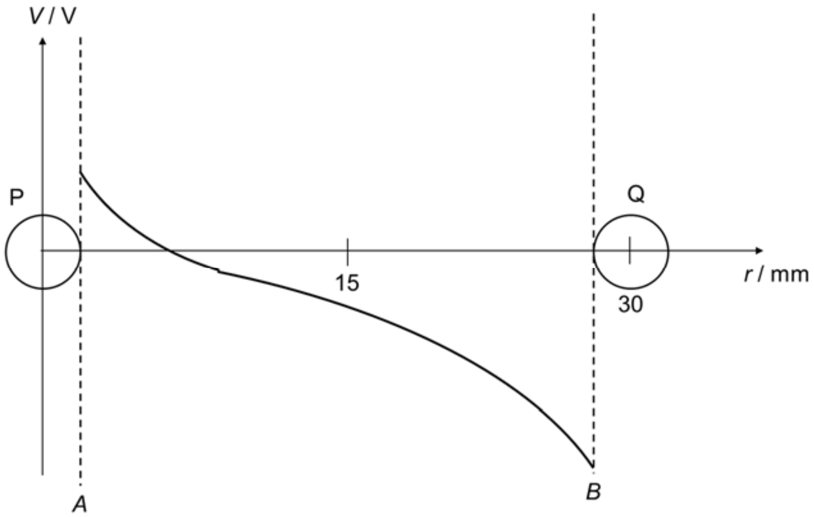
2	**Concepts tested:** Work, Energy, Power	
(a)	For an object mass *m*, moved by a force *F*, undergoing acceleration *a* through a displacement *s*, with initial velocity *u* and final velocity *v*. F = ma Work done = Fs = mas	M1
	$v^2 = u^2 + 2as$	M1
	$Work\ done = mas = \frac{1}{2}mv^2 - \frac{1}{2}mu^2 = Gain\ in\ kinetic\ energy$ $if\ u = 0, \quad work\ done = kinetic\ energy$	M1
	$E_k = \frac{1}{2}mv^2$	A0
(b)(i)	EPE = ½ k s^2 = ½ (120)(10 × 10^{-2})^2 = 0.60 J	A1
(b)(ii)	Using COE: $KE_i + GPE_i + EPE_i = KE_f + GPE_f + EPE_f$ 0 + (2.0)(9.81)(Dsin40) + 0 = 0 + 0 + ½ (120)D^2	C1
	D = 0.210 m	A1
(b)(iii)	D will increase.	B1
(b)(iv)	Using COE: KE + GPE + EPE = KE + GPE + EPE + $W_{by\ box}$ 0 + (2.0)(9.81)(D'sin40) + 0 = 0 + 0 + ½ (120)D'^2 + (5.0)D'	C1
	D' = 0.127 m	A1

3 (a)	Simple harmonic motion is defined as the motion of an object whose acceleration *a* is **proportional** to its displacement *x* from a fixed point (equilibrium position)	B1
	and is always **directed towards** that fixed point.	B1
(b)(i)	forces in springs are $k(e + x)$ and $k(e - x)$ resultant = $k(e + x) - k(e - x)$ = $2kx$	C1
	By Newton's Second Law, F_{net} = ma	M1
	negative sign explained as the acceleration is always oppositely directed to the displacement. $a = -\frac{2kx}{m}$	M1 A0
(b)(ii)1	$\omega^2 = \frac{2k}{m}$ $(2\pi f)^2 = \frac{2 \cdot (120)}{0.900}$	

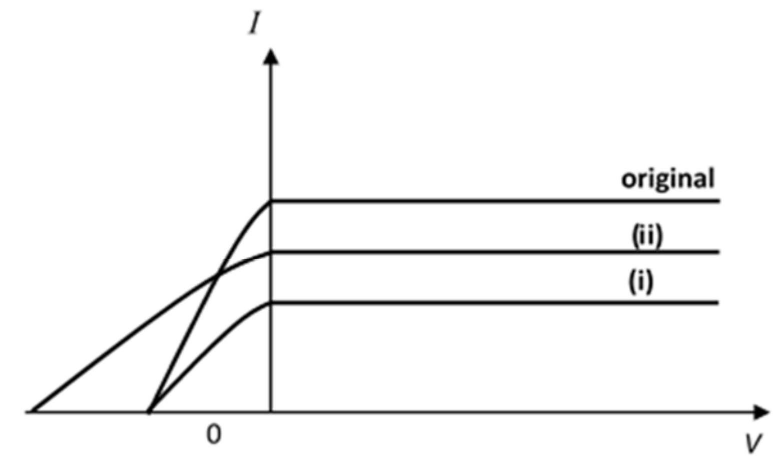
		C1
	f = 2.60 Hz	A1
(b)(ii)2	$a_0 = \omega^2 x_0 = 5.2$ $x_0 = \dfrac{5.2}{\left(\dfrac{2\cdot(120)}{0.900}\right)}$	C1
	$= 1.95 \times 10^{-2}$ m or 1.95 cm	A1
(b)(ii)3	Max kinetic energy = $\frac{1}{2}m(\omega x_0)^2$ $= \frac{1}{2}(0.900)\left(\frac{2\cdot(120)}{0.900}\right)(0.0195)^2$	M1
	= 0.0456 J	A1

4 (a)	Show understanding of how the stationary of one open and one close if formed via 2 diagrams	C1
	$\lambda_1\left(\frac{n}{2}+\frac{1}{4}\right) = D$ $\lambda_2\left(\frac{n+1}{2}+\frac{1}{4}\right) = D$ $\frac{343}{70.6}\left(\frac{n}{2}+\frac{1}{4}\right) = \frac{343}{90.8}\left(\frac{n}{2}+\frac{3}{4}\right)$ $n = 3$	M1
	$D = 8.50\ m$	A1
(b)(i)	There are multiple lines of constructive interference apart from the middle line between the emitters.	M1
	The AGV might align itself to these other lines of constructive interference instead.	A1
(b)(ii)1	The intensity of signal is lower as the signal travels further spreads over a larger surface area as it is further from the AGV,	M1
	The signal is from Emitter B.	A1
(b)(ii)2	$\frac{\pi}{3}$ rad or 1.05 rad	B1
(b)(ii)3	Dist. from A to AGV = $\sqrt{7^2+50^2}$ = 50.488 m Dist. from B to AGV = $\sqrt{5^2+50^2}$ = 50.249m	C1
	$\frac{\Delta x}{\lambda} = \frac{\Delta\phi}{2\pi} = \frac{\pi}{3(2\pi)}$ $\Delta x = \frac{\lambda}{6}$ Path Difference = $\frac{\lambda}{6}$ = 50.488 – 50.249 = 0.238m	

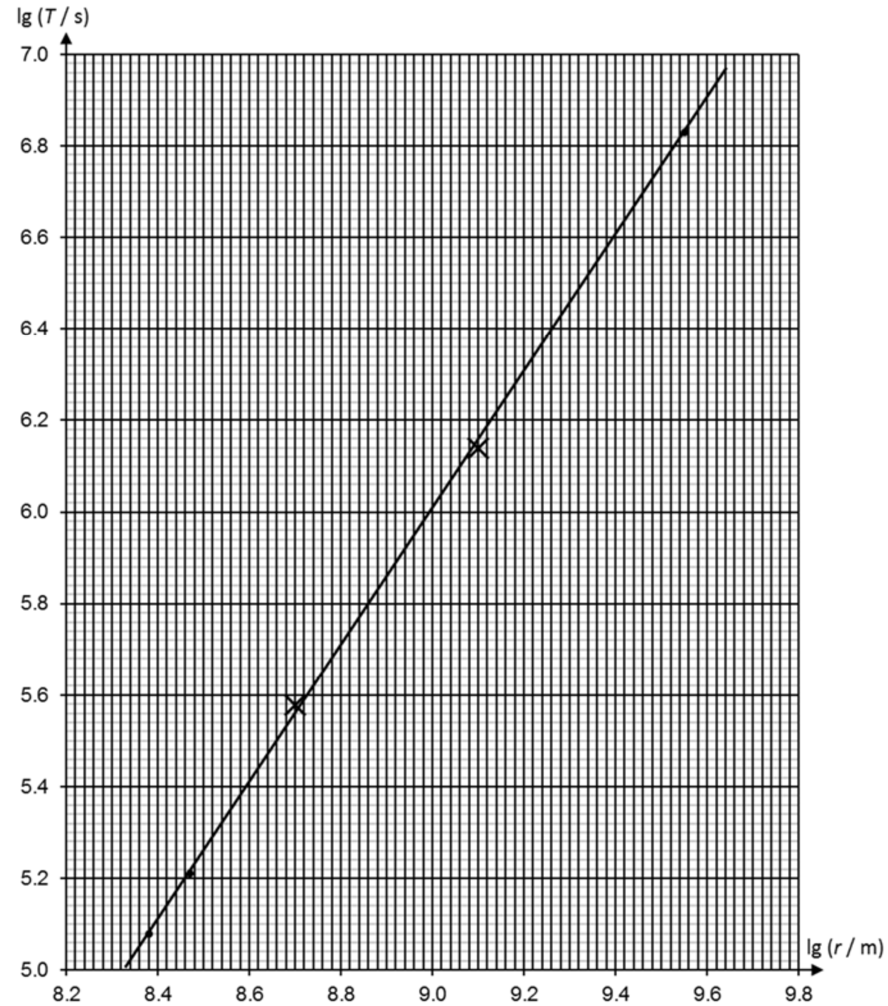
	λ = 1.429 m	C1
	$f = \dfrac{3 \times 10^8}{1.429}$	C1
	= 2.10 x 10^8 Hz (2 to 3 sf)	A1

5 (a)	Electric potential at a point is the **work done per unit positive charge to bring a small charge from infinity to that point**	B1
(b)(i)	 **[B1] shape: non-zero gradient** **[B1] r axis intercept nearer to P** **[B1] magnitude of V at B > magnitude of V at A**	
(b)(ii)1	Electric potential energy = $\dfrac{Q_P Q_Q}{4\pi\varepsilon_o r}$ $(9 \times 10^9)\dfrac{(+20 \times 10^{-6})(-40 \times 10^{-6})}{0.030}$	C1
	= – 240 J	A1
(b)(ii)2	By conservation of energy, $KE_i + EPE_i = KE_f + EPE_f$ $\frac{1}{2}(0.20 \times 10^{-3})u^2$ + (-240) = 0	C1
	u = 1550 m s^{-1}	A1

6 (a)	Max KE possessed by electron emitted from surface layer	B1
	Electrons below the surface loses energy along the way as they move towards surface, so less KE than KE_{max}	B1

(b)(i)	 ½ intensity ➔ current is reduced by half	B1
	same stopping potential	B1
(b)(ii)	wavelength is decreased but intensity is constant ➔ number of photons is reduced so current decreases. Can decrease below (i) current.	B1
	but higher stopping potential	B1
(b)(iii)1	$n = \frac{I}{e} = \frac{4.8\times10^{-10}}{1.6\times10^{-19}}$ = **3.0×10^9 s^{-1}**	A1
(b)(iii)2	The intensity, i $i = N(\frac{hc}{\lambda})(\frac{1}{A})$ where N = number of photons incident per second = 2500n	C1
	$i = \frac{Nhc}{A\lambda} = \frac{2500(3.0\times10^{9})(6.63\times10^{-34})(3.0\times10^{8})}{(24\times10^{-6})(410\times10^{-9})}$	C1
	= 0.152 W m^{-2}	A1

7 (a)	Let the mass of the satellite be *m*. According to Newton's Law of Gravitation, $F_G = \frac{GMm}{r^2}$ Centripetal force $F_c = mr\omega^2$	M1
	When the satellite orbits around the planet in a circular orbit, the gravitational force acting on the satellite by the planet **provides** the centripetal force for the orbit. $F_C = F_G$ $mr\omega^2 = \frac{GMm}{r^2}$	M1
	$mr(\frac{2\pi}{T})^2 = \frac{GMm}{r^2}$ $T^2 = \frac{4\pi^2}{GM}r^3$	M1 A0

(b)	Rhea: $\lg T = \lg(0.380 \times 10^6) = 5.58$ $\lg r = \lg(0.501 \times 10^9) = 8.70$	B1
	Titan: $\lg T = \lg(1.38 \times 10^6) = 6.14$ $\lg r = \lg(1.26 \times 10^9) = 9.10$	B1
(c)(i)	 correct plots	B1
(c)(ii)	Best fit line	B1
(d)(i)	Gradient $= \dfrac{6.60 - 5.11}{9.40 - 8.40}$	M1
	= 1.49 (within 1.47 – 1.53)	A1

(d)(ii)	The moons of Saturn which orbit in circular paths must obey $T^2 = \frac{4\pi^2}{GM}r^3$. Linearising this equation will lead to the equation $\lg T = \frac{1}{2}\lg\frac{4\pi^2}{GM} + \frac{3}{2}\lg r$.	M1
	On a graph showing the variation of $\lg T$ with $\lg r$, this equation is represented by a straight line with a **gradient of 1.5**. Since the gradient of the graph in Fig 7.2 is 1.49, the data supports he relationship in **(a)**.	A1
(e)	$\lg(3.78 \times 10^8) = 8.58$ From the graph, the corresponding value for $\lg T$ is 5.38.	C1
	Hence, $T = 10^{5.38} = 2.40 \times 10^5$ s	A1
(f)(i)	$$\lg T = \frac{1}{2}\lg\frac{4\pi^2}{GM} + (1.49)\lg r$$ Substituting (9.40, 6.60) $$6.60 = \frac{1}{2}\lg\frac{4\pi^2}{(6.67 \times 10^{-11})M} + (1.49)(9.40)$$	M1
	$M = 3.84 \times 10^{26}$ kg	A1
(f)(ii)	Multiple sets of readings were used in calculating the mass in **(f)(i)**, as compared to only one set used in the student's calculation. Using multiple sets of readings help to **reduce the random error** through the use of a best fit line.	B1
	This means that the student's calculation will be less accurate than the values calculated in **(f)(i)**.	B1
(f)(iii)	Using $T = 7.78 \times 10^4$ s, $$\lg(7.78 \times 10^4) = \frac{1}{2}\lg\frac{4\pi^2}{(6.67 \times 10^{-11})(3.84 \times 10^{26})} + 1.49\lg r$$ r = 1.79 $\times 10^5$ km	M1
	r is the orbital radius, which is the distance from the centre of Saturn to the centre of the Moon Mimas, not from the surface of Saturn.	M1
	Thus the report is inaccurate.	A1

	Class	Adm No
Candidate Name: ______________________		

H

millennia institute

2018 Preliminary Exams
Pre-University 3

H2 PHYSICS **9749/03**

Paper 3 Long Structured Questions **17 September 2018**

Candidates answer on the Question Paper. **2 hours**

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Do not turn over this page until you are told to do so.

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

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

Section A
Answer all questions.

Section B
Answer **one** question only.

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

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

For Examiner's Use		
Sect A		
1		**/10**
2		**/12**
3		**/13**
4		**/7**
5		**/7**
6		**/11**
Sect B		
7		**/20**
8		**/20**
Presentation		
Total		**/80**

Data

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

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

[Turn over

Section A

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

1 **(a)** Fig. 1.1 shows the variation of force F with the extension x of a spring.

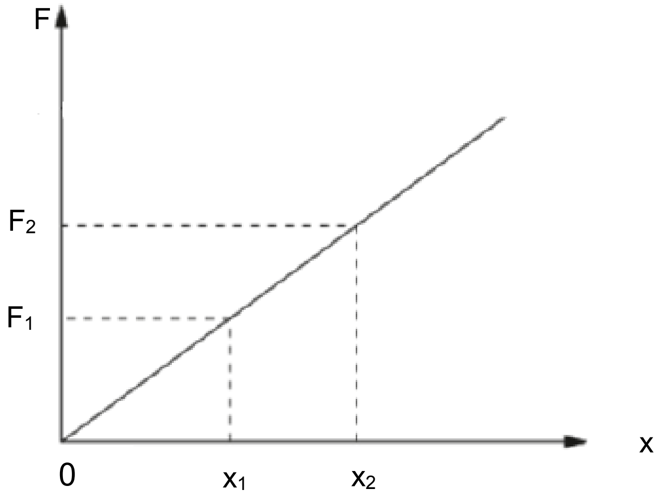


Fig. 1.1

The extension of the spring is increased from x_1 to x_2.
Show that the work done W in extending the spring is given by

$$W = \frac{1}{2} k \left(x_2^2 - x_1^2\right)$$

where k is the spring constant.

[2]

(b) Fig. 1.2 shows a signboard suspended by two elastic springs.

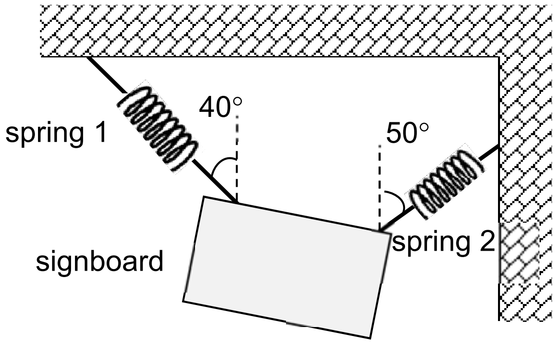


Fig. 1.2

(i) State the conditions for equilibrium.

……………………………………………………………………………………………

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

(ii) On Fig. 1.2, draw and label clearly the forces acting on the signboard. Mark the centre of gravity of the signboard with a dot and label the point as G. [2]

(iii) Given that the tension in spring 1 is 300 N and the tension in spring 2 is 252 N, determine the weight of the signboard.

weight = ………………….. N [2]

(iv) The signboard is pulled vertically downwards with a force of 20 N so that the springs are stretched to a new position. Determine the acceleration of the signboard immediately after it is released.

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

2 **(a)** Fig. 2.1 shows the variation of the gravitational potential ϕ with distance r along a line joining the centres of the moon and the Earth.

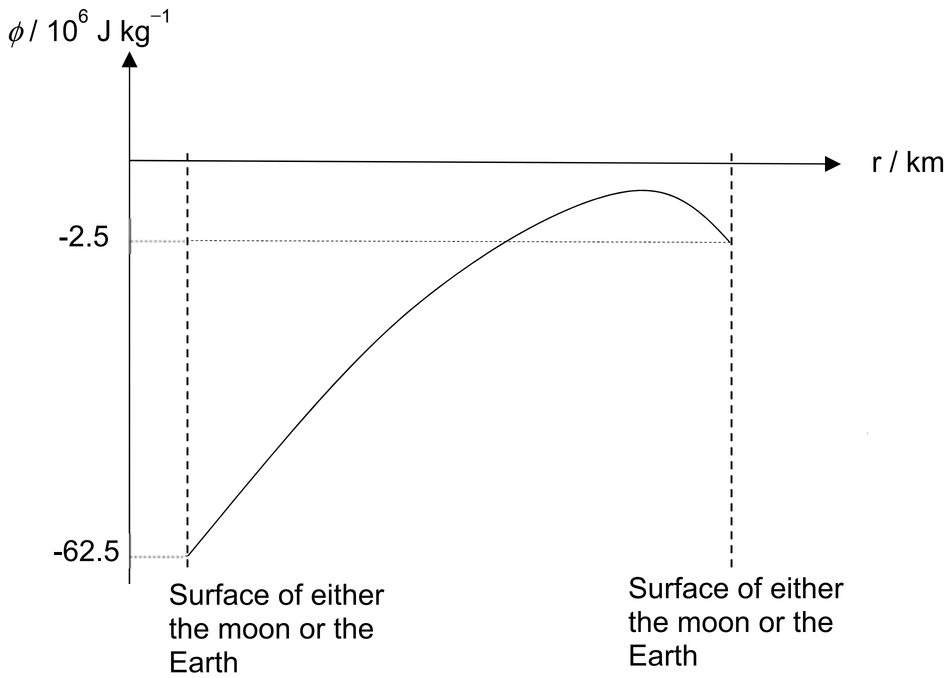


Fig. 2.1

(i) Explain whether r is measured from the moon or the Earth.

....

.... [1]

(ii) A 1500 kg meteorite needs a minimum energy of 2.25×10^9 J to reach the neutral point as it travels from the moon to the Earth.

1. Explain what is meant by *the neutral point between the moon and the Earth*.

....

.... [1]

2. Determine the gravitational potential at the neutral point.

gravitational potential = ………………. J kg^{-1} [2]

3. Determine the speed at which the meteorite would hit the Earth. You may neglect atmospheric resistance.

speed = ………………… m s^{-1} [2]

(b) The mass of the Earth is 5.98 x 10^{24} kg and the moon takes 27.4 days to orbit the Earth.

(i) Show that the distance between the centre of the Earth and the moon is about 384 000 km. [2]

(ii) Hence, determine the linear speed of the moon.

linear speed = ……………………. m s^{-1} [2]

(c) An astronaut in a spacecraft orbits around the Earth in a circular path. The astronaut appears to float inside the spacecraft. Students A and B provide some explanations about this observation of weightlessness.

1. Student A claims that the astronaut floats because he has no weight.
2. Student B claims that the astronaut floats because both the astronaut and the spacecraft have the same centripetal force.

Comment on the validity of each of these explanations.

1. ....

....

2. ....

.... [2]

3 **(a)** **(i)** One of the assumptions of the kinetic theory of gases is that the motion of gas molecules is random. Therefore explain why the average momentum of the gas molecules in a container is zero.

[2]

(ii) According to the kinetic theory of gases, explain how a gas exerts a pressure on the walls of a container.

[3]

(b) A student designed an air-filled “load-lifting” system where the air could be uniformly heated by suitably located electrical heaters in the enclosure of the system. All sides of the enclosure have good thermal insulation and the top surface is movable vertically.

The volume of air inside the enclosure at tempature of 300 K and pressure of 101.0 kPa is 2.000 m^3.

When a load of mass 500 kg is placed on the top of the movable surface of the system, an average depression of 5.0 cm of the top surface is observed and the volume of air in the enclosure is reduced to 1.947 m^3.

(i) State the first law of thermodynamics.

[2]

[Turn over

(ii) The air may be considered as an ideal gas. Determine

1. the change in internal energy of the air in the system after the load is placed on top of the movable surface.

change in internal energy = ……………………. J [3]

2. the new pressure of air in the system.

new pressure = ………………….. kPa [3]

Question 4 begins on next page

4 Fig. 4.1 shows how the resistance of a light-dependent resistor (LDR) varies with the intensity of the light incident on it.

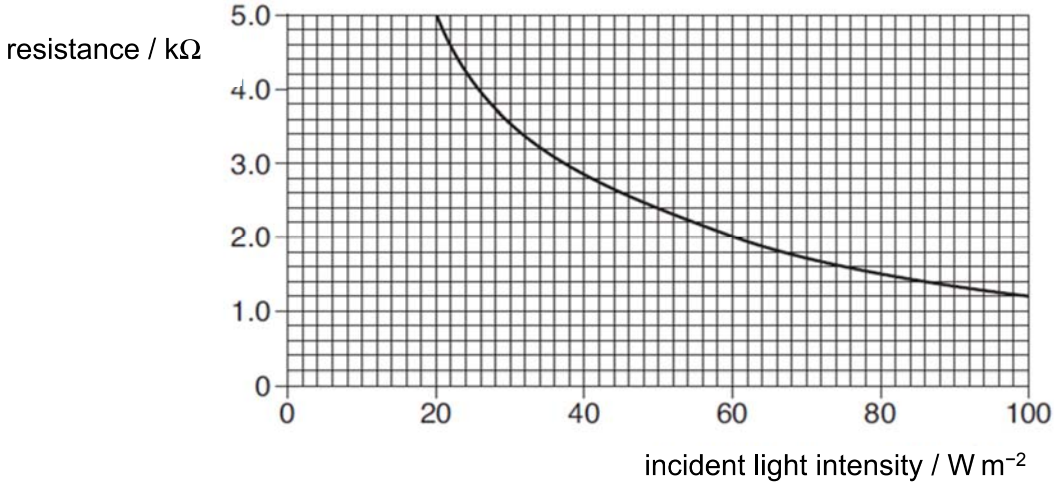


Fig. 4.1

Fig. 4.2 shows a light-sensing potential divider circuit used in a lamp where the potential difference across the LDR can be used to control the brightness of the lamp in a room.

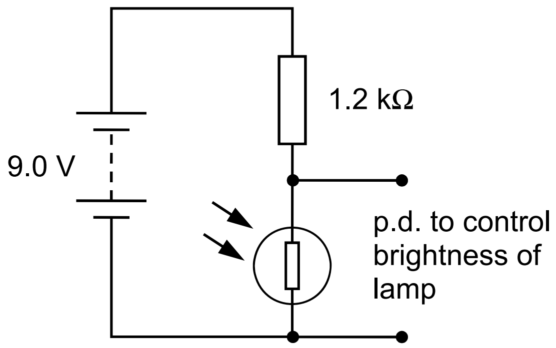


Fig. 4.2

The battery has an e.m.f. of 9.0 V and negligible internal resistance. A fixed resistor of 1.2 kΩ and the LDR is connected in series with the battery. When the room is in a low-light condition, the potential difference across the LDR reaches 7.0 V.

(a) State and explain *quantitatively*, if the resistance of the LDR is inversely proportional to the intensity of the light incident on it.

....

....

.... [1]

(b) Calculate the resistance R of the LDR.

R = ………………….. kΩ [3]

(c) Use Fig. 4.1 to determine the intensity of light incident on the LDR.

light intensity = ... $W\,m^{-2}$ [1]

(d) Fig. 4.3 shows a close-up of the LDR device used in the circuit in Fig. 4.2. The LDR consists of a uniform strip of semiconductor whose resistance is dependent on the intensity of the light incident on it. The cross-sectional area of the strip is $0.50\ mm^2$.

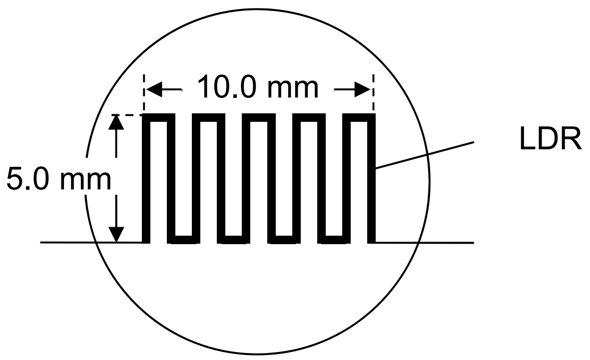


Fig. 4.3

Use your answer in **(b)** to estimate the resistivity of the LDR.

resistivity = ... Ω m [2]

5 **(a)** **(i)** Fig. 5.1 shows the cross section of a wire XY which carrying a constant current flowing out of the plane of the paper at right angles. Sketch the magnetic flux pattern due to the current. [2]

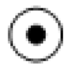


Fig. 5.1

(ii) The current-carrying wire XY in **(a)(i)** is placed in the region between the poles of a strong magnet. Sketch in Fig. 5.2 the resultant magnetic flux pattern in the region between the poles of a magnet. [2]

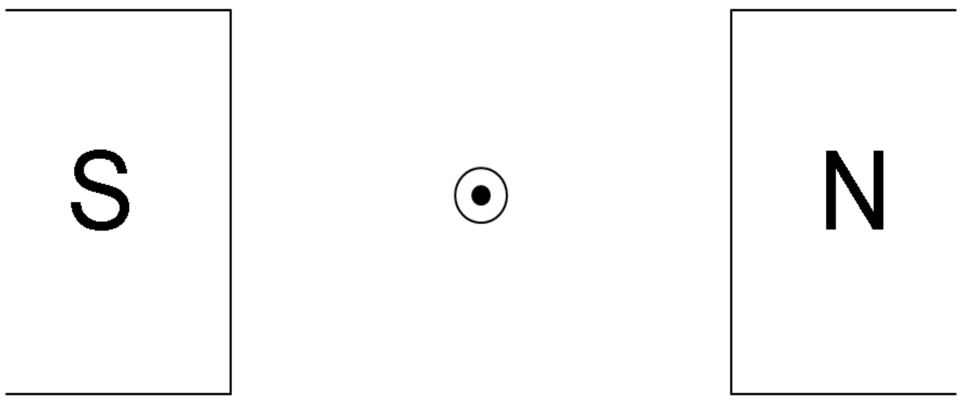


Fig. 5.2

(b) The setup in **(a)** is now placed on a top-pan balance as shown in Fig. 5.3 and Fig. 5.2 shows the front view. Outside the region between the poles of the strong magnet, the flux density can be considered as zero. When there is no current passing through XY, the top-pan balance is tared.

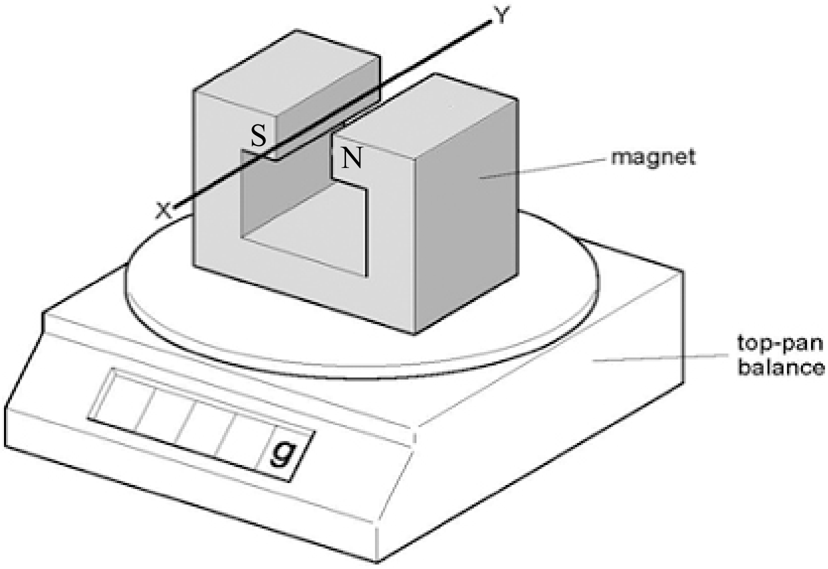


Fig. 5.3

A direct current is now passed through the wire in the direction from Y to X.

State and explain the observation in the reading on the top-pan balance.

……

……

……

……

…… [3]

6 The radioactive isotope plutonium-238 ($^{238}_{94}Pu$) has a half-life of 86 years and decays by emitting an alpha particle with little or no gamma emission. The daughter nucleus is an isotope of uranium (U).

The mass of $^{238}_{94}Pu$ is 238.0496 u and the mass of an α-particle is 4.0026 u.

(a) Write down an equation representing the decay, indicating clearly the atomic number and mass number of each nucleus.

.... [1]

(b) The total kinetic energy of the products is 5.649 MeV.

(i) Calculate the mass of the uranium nucleus formed in the reaction, giving your answer in terms of atomic mass units to 4 decimal places.

mass of uranium nucleus = ... u [3]

(ii) By using the principle of conservation of momentum, show that the ratio of the kinetic energy of the alpha particle to that of the uranium nucleus is 58.5. [3]

(iii) Hence, calculate the kinetic energy of the alpha particle.

kinetic energy = ……………………… MeV [2]

(c) Satellites can be powered by the energy produced by the decay of plutonium. Plutonium is not placed in its pure form in the satellites, but installed as bricks of plutonium dioxide, PuO_2. PuO_2 is a ceramic and when it is shattered, it breaks into large pieces rather than smaller and more dangerous dust.

(i) Explain why there is no difference in the probability of decay of plutonium whether it exists as pure plutonium or in the form of PuO_2.

………………………………………………………………………………………………

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

(ii) Suggest a reason why large pieces of PuO_2 pose less of a health risk than plutonium dust, which can be inhaled into the body.

………………………………………………………………………………………………

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

Section B

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

7 **(a)** A ball of mass 320 g is projected at an angle by a ball launcher. Air resistance is not negligible. The ball is launched from a height of 0.50 m above the level ground.

The variation with time t of the vertical velocity component v_y of the ball is shown in Fig. 7.1.

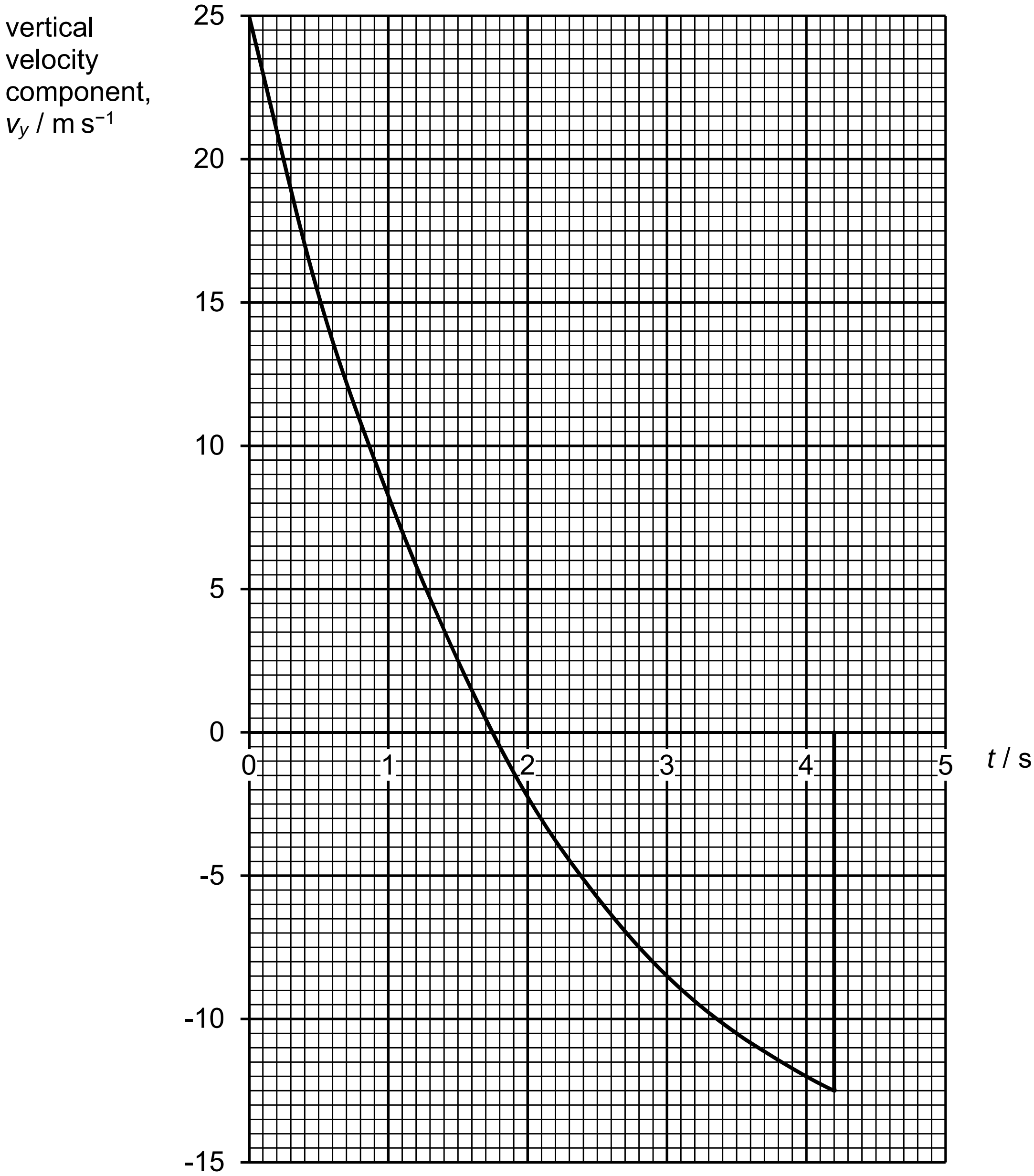


Fig. 7.1

(i) Estimate the vertical height from level ground reached by the ball at t = 1.0 s.

height = ……………………………… m [2]

(ii) Estimate the vertical component of the air resistance that is acting on the ball at t = 1.0 s.

air resistance = ……………………………….N [3]

(iii) In the case that air resistance is negligible, the ball has a horizontal velocity component of 12.0 m s^{-1}.

1. On Fig. 7.1, sketch a graph to show the variation with time *t* of the velocity vertical component of the ball. Label this line Z. [2]

2. Hence, determine the resultant velocity of the ball at t = 1.0 s.

velocity = ……………….. m s^{-1} [2]

(b) Another 2 balls, X and Y are travelling towards each other along a horizontal frictionless surface.

(i) Show how the principle of conservation of linear momentum can be derived using Newton's Laws.

....

....

....

....

....

....

.... [3]

(ii) **1.** The two balls collided and rebounded in opposite directions. Table 7.1 shows data for X and Y during the collision.

Table 7.1

ball	**mass / g**	**velocity just before collision / m s^{-1}**	**velocity just after collision / m s^{-1}**
X	50	+4.5	-1.8
Y	M	-2.8	+1.4

The positive direction is horizontal and to the right.

Use your answer in **(b)(i)** to determine the mass of Y.

mass of Y = ... kg [3]

2. State and explain quantitatively whether the collision is elastic.

....

.... [2]

(iii) The variation of the force that X exerts on Y with time is shown in Fig. 7.2.

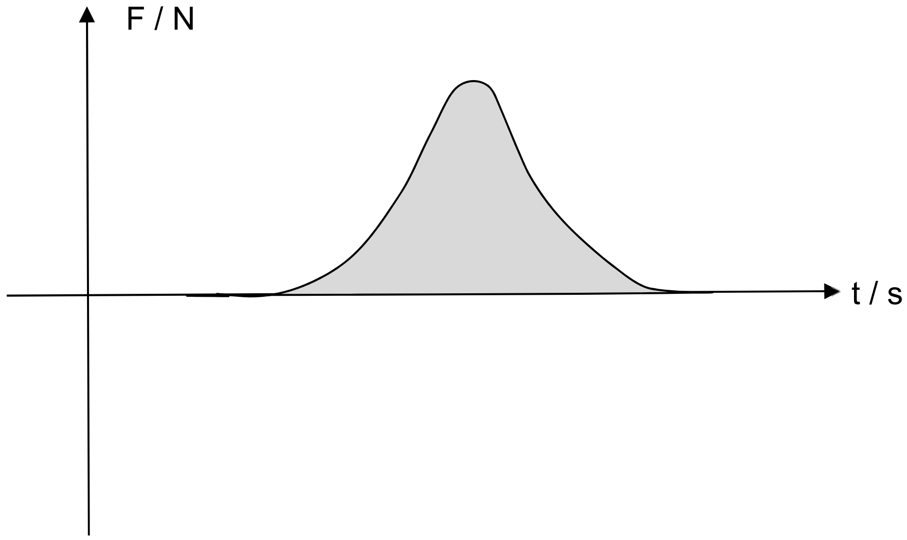


Fig. 7.2

1. Sketch a graph on Fig. 7.2 to show the variation of the force that Y exerts on X with time. Explain your answer.

....

.... [2]

2. Explain what the shaded area in Fig. 7.2 represents.

....

.... [1]

8 Fig. 8.1 shows a rectangular coil. The coil has 25 turns with dimensions of 15.0 cm by 6.0 cm.

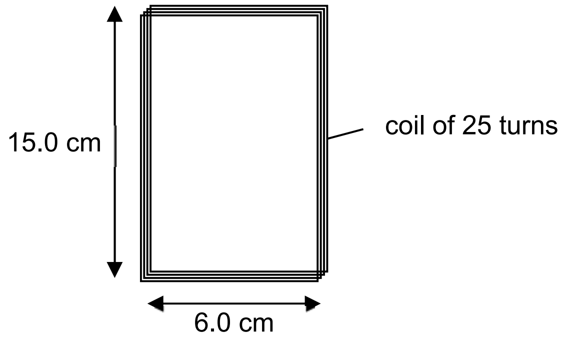


Fig. 8.1

(a) **(i)** Define magnetic flux.

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

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

(ii) A uniform magnetic field of flux density 25 mT is at right angles to the plane of the coil initially.

Calculate the magnetic flux through the coil at this instance.

magnetic flux =……………......Wb [1]

(b) **(i)** Fig. 8.2 shows the sinusoidal variation with time *t* of the magnetic flux density *B* that is passing through the rectangular coil in Fig. 8.1.

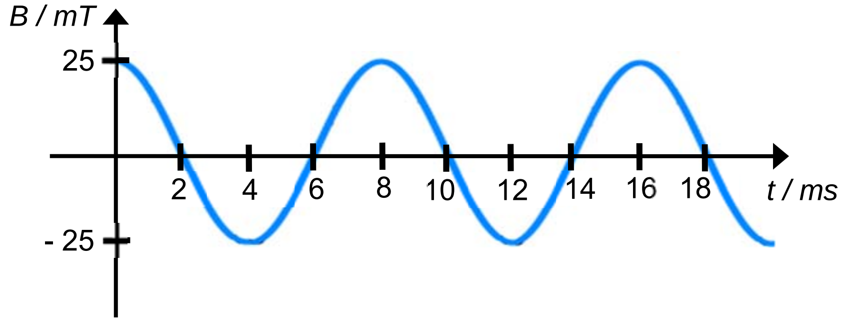


Fig. 8.2

Using Faraday's Law, explain why the variation in magnetic flux density passing through the coil as shown in Fig. 8.2 leads to a generation of sinusoidal alternating e.m.f.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

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

(ii) Show that the equation for the induced e.m.f. of the coil is

$$E = NAB_o \frac{2\pi}{T} \sin\left(\frac{2\pi}{T} t\right)$$

where *N* is the number of turns in the coil, *A* is the area of coil, B_0 is the maximum magnetic flux density and *T* is the period of the change in magnetic flux density.

[2]

(iii) Hence, determine the maximum magnitude of the induced e.m.f. of the coil.

maximum e.m.f. = ………………. V [2]

(iv) On Fig. 8.3, sketch a graph to show the variation with time of the e.m.f. induced in the coil from 0 ms to 16 ms. [2]

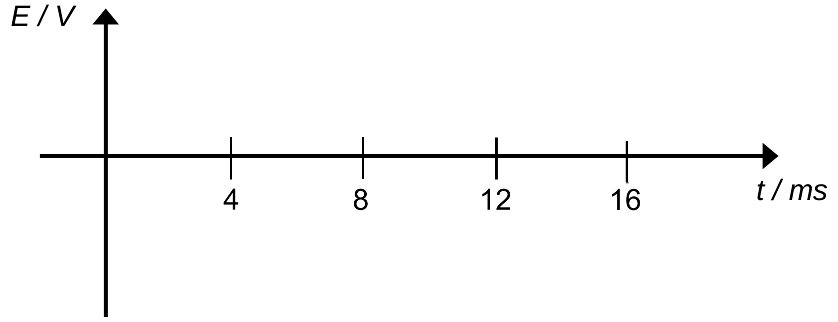


Fig. 8.3

(c) **(i)** The AC generated by the rectangular coil passes through a transformer. The primary coil of the ideal transformer has 15 turns.

Assuming that the transformer is ideal, calculate the number of turns in the secondary coil if the value of root-mean-square potential difference of the output at the secondary coil is 240 V.

number of turns =…………….…..... [3]

(ii) A non-ideal transformer has an input e.m.f. of 12 V while the secondary coil draws a current of 0.25 A with a potential difference of 240 V.

If the efficiency of the transformer is 81 %, determine the current in the primary coil.

current =…………….…..... A [2]

(d) In many distribution systems for electrical energy, the power is transmitted using alternating current at high voltages.

Suggest and explain an advantage, one in each case, for the use of

(i) alternating voltages,

....

....

.... [2]

(ii) high voltages.

....

....

.... [2]

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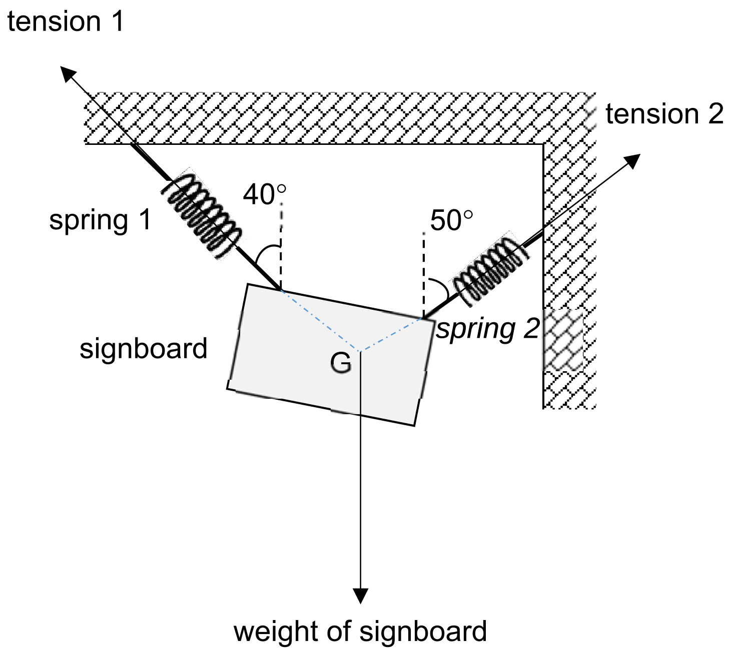
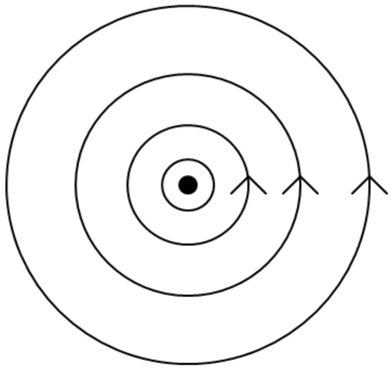
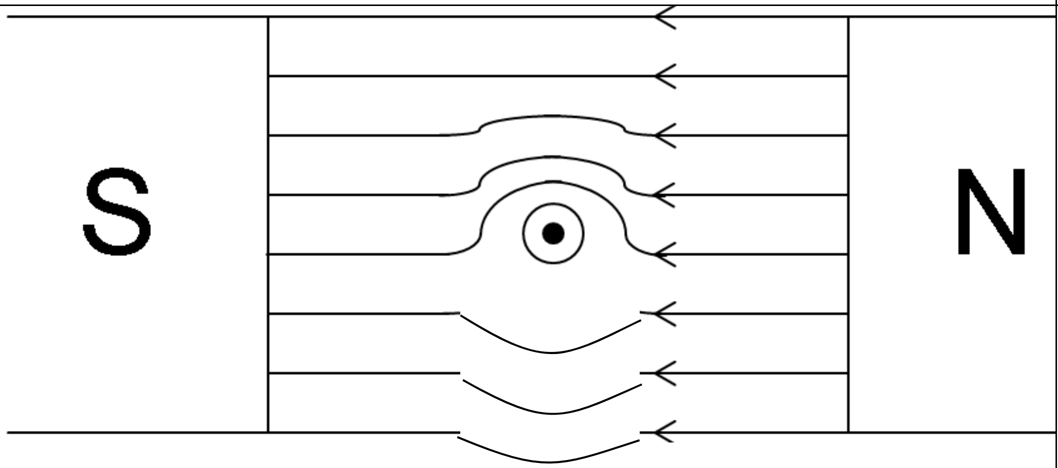
Suggested Answers for PU3 PRELIM Paper 3

1	**(a)**		Work done is the area under the graph of F-x graph, Area of trapezium = ½ $(F_1 + F_2)(x_2 - x_1)$ = ½ $(kx_1 + kx_2)(x_2 - x_1)$, = ½ $k(x_2^2 - x_1^2)$	M1 M1 A0
	(b)	**(i)**	There is <u>zero net force</u> acting on the signboard. There is <u>zero net torque about any axis</u> acting on the signboard.	B1 B1
		(ii)	 3 forces clearly labelled G is at the intersection of lines of action of *tension 1*, *tension 2* and *weight*	 B1 B1
		(iii)	Weight = $T_1 \cos 40° + T_2 \cos 50°$ = 300 cos 40° + 252 cos 50° = 391.8 = 390 N	C1 A1
		(iv)	Net force acting on the board immediately after released = 20 N Initial net acceleration = F/m = 20/(391.8/9.81) = 0.501 ≈ 0.50 m s^{-2} [allow ecf from (aiii)]	 C1 A1

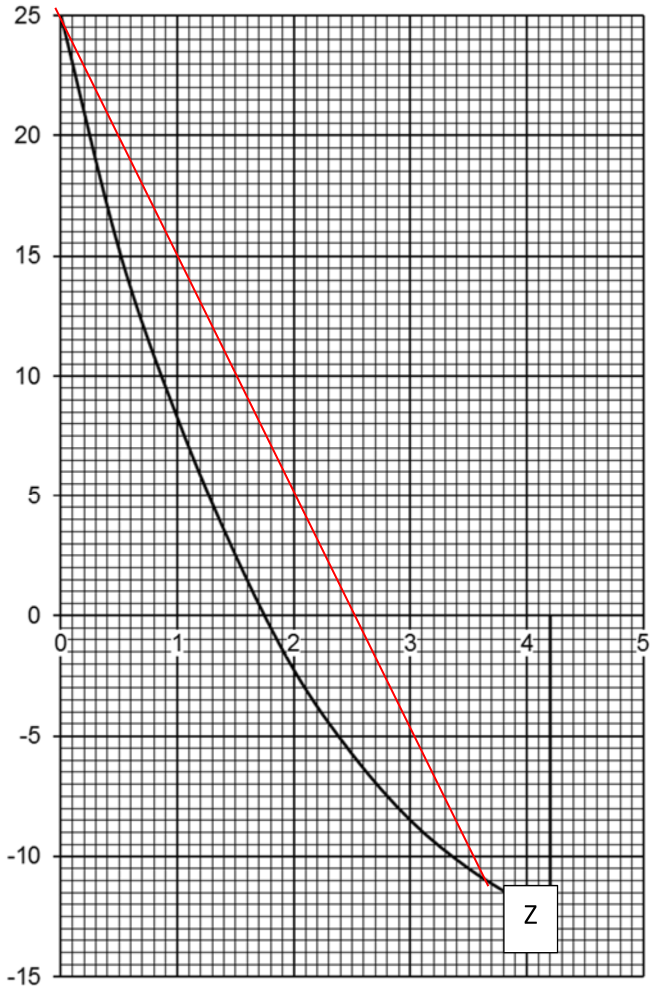
2	**(a)**	**(i)**		As r approaches zero, the potential drops lower. This corresponds to the potential near the larger mass. Therefore, r is measured from the Earth.	B1
		(ii)	**1**	It is the point where the gravitational field strength due to Earth is **equal and opposite** to the gravitational field strength due to the Moon or net gravitation field strength is zero	B1
			2	2.25×10^9 J = m x $\Delta \phi_{\text{moon – max}}$ = 1500 x $\Delta \phi_{\text{moon – max}}$ $\Delta \phi_{\text{moon – max}} = 1.5 \times 10^6$ J kg^{-1} $\phi_{max} - \phi_{moon} = \phi_{max} - (-2.5 \times 10^6) = 1.5 \times 10^6$ $\phi_{max} = -1.0 \times 10^6$ J kg^{-1} Allow ecf from (a)(i)	C1 A1
			3	$\frac{1}{2} m v^2 = m \times \Delta \phi_{\text{earth – max}}$ $\frac{1}{2} v^2 = \Delta \phi_{\text{earth – max}} = 61.5 \times 10^6$ v = 11 100 m s^{-1}	C1 A1
	(b)	**(i)**		Gravitational force provides the centripetal force. $$\frac{GMm}{r^2} = mr(\frac{2\pi}{T})^2$$ $$\frac{6.67 \times 10^{-11}\,(5.98 \times 10^{24})m}{r^2} = mr(\frac{2\pi}{27.4 \times 24 \times 3600})^2$$ r = 384 000 km	M1 M1 A0
		(ii)		Linear speed = r ω $= 3.84 \times 10^8 \times \left(\frac{2\pi}{27.4 \times 24 \times 3600}\right)$ = 1020 m s^{-1}	C1 A1
	(c)	1.		Student A’s explanation is not valid because both the astronaut and spacecraft will always have weight due to the force of gravity while they are orbiting around the Earth, even if it is small.	B1
		2.		Student B’s claim is not correct. The centripetal force is the resultant force which is the force of gravity in this case. <u>Both have different masses hence their centripetal force is different</u>.	B1

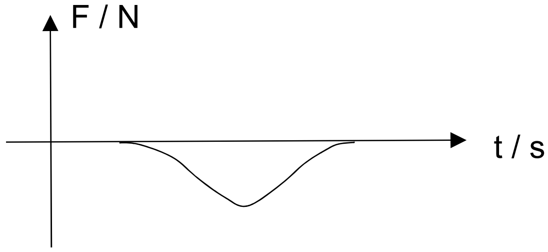
3	**(a)(i)**	Random motion of a large number of molecules in random velocity means no preferred direction of movement or the molecules move in different/all directions with a root-mean-square speed. Momentum is a **vector** given by the product of mass and velocity. Since the velocities cancel/ or idea of speed in opposite directions, the average velocity is zero and hence the average momentum of the gas molecules of same mass in a container is zero.		**M1** **A1**
	(a)(ii)	When the gas molecules hit the wall of the container, they rebound off the wall with the same speed and experiences **a rate of momentum change** normal to the wall**, implying there is force acting on the molecule by the wall.** Other molecules also have a momentum change normal to the wall when they strike and rebound. By **Newton's third law**, the molecules exert an equal and opposite force on the walls. Since there are a large number of molecules, the number of collisions at any instant in time is very large and practically constant, resulting in a constant gas pressure. The pressure on the walls of the container is the **average force per unit area exerted by the molecules on the walls of the container**.		**B1** **B1** **B1**
	(b)(i)	<u>Increase in internal energy of a system</u> is the <u>sum</u> of the <u>work done on the system</u> and <u>heat supplied to the system</u>.		**B1** **B1**
	(b)(ii)	**1.**	Top surface moves down due to load acting a force on it, hence WD by load **on air** = mgx = 500 x 9.81 x 0.050 = 245 J Since system is well insulated, $Q_{to\ air}$ = 0 Using the first law of thermodynamics, Increase in U = $Q_{to\ air} + W_{on\ air}$ = 0 + 245 J = 245 J	 **C1** **C1** **A1**
		2.	Using the equation of state for an ideal gas, $p_1V_1 = nRT_1$ ----- (1) $p_0V_0 = nRT_0$ ----- (2) (1) – (2): $p_1V_1 - p_0V_0 = nRT_1 - nRT_0 = nR\,(T_1 - T_0)$ Given that $U = \frac{3}{2}nRT,\ \ p_1V_1 - p_0V_0 = \frac{2}{3}\Delta U$ $p_1(1.947) - (101 \times 10^3)(2.000) = \frac{2}{3}(245)$ p_1 = 103.8 kPa = 104 kPa	 **C1** **C1** **A1**

4	**(a)**	$(5)(20) \neq (100)(1.2)$ R IS not inversely proportional to light intensity. Accept % difference, with justification	**M1** **A0**
	(b)	When the potential difference across the LDR is 7.0 V, **potential difference across the 1.2 kΩ resistor = 2.0 V** Using $V = IR$ $2.0 = (1.2 \times 10^3)\ I$ $I = 1.67 \times 10^{-3}$ A $R = \frac{V}{I} = \frac{7.0}{1.67 \times 10^{-3}}$ = 4200 Ω or 4.2 kΩ Alternatively, use potential divider method to determine R.	**C1** **C1** **A1**
	(c)	From **Fig. 4.1**, light intensity = 24 W m^{-2}	**A1**
	(d)	Length of strip, $\lambda = (10 \times 5.0 \times 10^{-3}) + (10.0 \times 10^{-3}) = 0.060\text{m}$ Using $R = \frac{\rho \lambda}{A}$, $\rho = \frac{RA}{l} = \frac{4200 \times 5.0 \times 10^{-7}}{0.060} = 3.5 \times 10^{-2}\ \Omega\,\text{m}$	**C1** **A1**

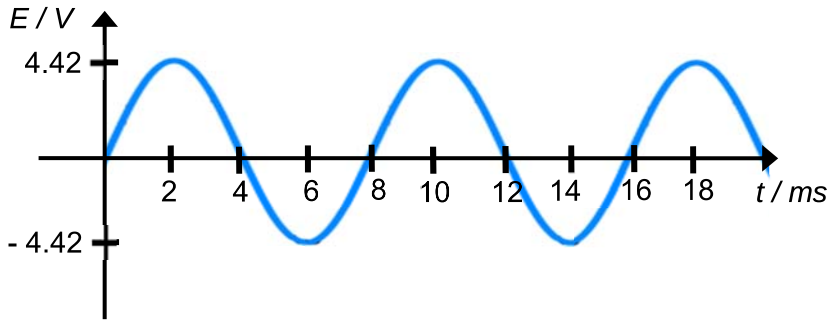
5	**(a)(i)**	 Direction At least 3 concentric circles with increasing spacing	 **B1** **B1**
	(ii)	 uniform field near magnet poles stronger field on top, weaker field below	 **B1** **B1**
	(b)	By Fleming's left hand rule, there is a downward force on wire by magnet. By Newton's third law, there is an upward force on magnet by wire. Since there is a upward force on magnet due to wire carrying current, there will be a decreased in balance reading.	**B1** **B1** **B1**

6	**(a)**	${}^{234}_{94}Pu \rightarrow {}^{234}_{92}U + {}^{4}_{2}He$	A1
	(b)(i)	Applying conservation of mass-energy, $(m_{Pu} - m_U - m_\alpha)\ c^2$ = energy released = E_k of the products $(238.0496 - m_U - 4.0026) \times (1.66 \times 10^{-27})\ c^2 = 5.649\times10^6 \times (1.60\times10^{-19})$ m_U = 234.0410 u (4 dp)	 C1 C1 A1
	(b)(ii)	By the principle of conservation of momentum $m_{Pu}v_{Pu} = m_u v_u + m_\alpha(-v_\alpha)$ $0 = m_U v_U - m_\alpha v_\alpha$ $\frac{v_\alpha}{v_U} = \frac{m_U}{m_\alpha}$ Ratio of E_k = $\frac{E_{K,\alpha}}{E_{K,U}} = \frac{\frac{1}{2}m_\alpha v_\alpha^2}{\frac{1}{2}m_U v_U^2}$ $= \frac{m_\alpha}{m_U}(\frac{m_U}{m_\alpha})^2$ $= \frac{m_U}{m_\alpha}$ $= \frac{234.0410}{4.0026}$ = 58.5	 M1 M1 A1 A0
	(b)(iii)	$E_{K,U} + E_{K,\alpha}$ = 5.649 MeV $\frac{1}{58.5} E_{K,\alpha} + E_{K,\alpha}$ = 5.649 MeV $E_{K,\alpha}$ = 5.55 MeV	 C1 A1
	(c)(i)	Radioactivity is a spontaneous process that is <u>not affected by any physical condition or the chemical combination</u> in which the nucleus exists. Hence, the properties of the nucleus remain unchanged no matter what chemical compound it is found in.	B1
	(c)(ii)	Alpha particles are readily absorbed by a sheet of paper and cannot penetrate the outer, protective layers of skin. Hence, plutonium is not a hazard as long as it remains outside the skin. When the dust is inhaled into the lungs, the emitted alpha particles deliver all their energy to sensitive internal tissues and may cause damage.	 B1

7	(a)	(i)	vertical height from ball launcher = (1x8) + ½ (0.8)(25-8) + 18 (0.1 x 0.5) = 15.7 m Veritical height from the level ground = 15.7 + 0.5 = 16.2 m	M1 A1
		(ii)	Acceleration at t = 1.0 s = gradient at t = 1.0s = -12.1 m s^{-2} Using F2L, mg + Fair = ma Fair = ma – mg = 0.320 (12.1 – 9.81) = 0.733 N	M1 M1 A1
		(iii) 1.	 Gradient = 9.8 m s^{-2} Negative gradient	A1 A1
		2.	At t = 1.0 s, vertical velocity = 15.25 m s^{-1} since horiztonal velocity = 12.0 m s^{-1}	M1

			Resultant velocity = $\sqrt{15.25^2 + 12^2}$ = 19.4 m s^{-1}		A1
	(b)	**(i)**	Consider a collision that occurs when X collides with Y in a straight line. By **Newton's second law** the change in momentum for X, $\Delta p_x = F_{YX}*\Delta t$, where F_{YX} is the force Y exerts on X and Δt is the duration the force is exerted while the change in momentum for Y, $\Delta p_Y = F_{XY}*\Delta t$, where F_{XY} is the force X exerts on Y. By **Newton's third law**, $F_{YX} = - F_{XY}$ since they are an action-reaction pair. Hence, $\Delta p_X = - \Delta p_B$. This implies $p_{XF} – p_{XI} = - (p_{YF} – p_{YI})$, where p_{XF} is the final momentum of X, p_{XI} is the initial momentum of X, p_{YF} is the final momentum of Y and p_{YI} is the initial momentum of Y. Rearranging, $p_{XI} + p_{YI} = p_{XF} + p_{YF}$. This implies the **total initial momentum is the same as the total final momentum if no external force acts on this system**.		B1 B1 B1
		(ii)	**1.**	$m_xu_x + m_yu_y = m_xv_x + m_yv_y$ $50(4.5) + m_y(-2.8) = 50(-1.8) + m_y(1.4)$ $m_y(1.4+2.8) = 50(4.5+1.8)$ m_y = 75 g = 0.075 kg	M1 C1 A1
			2.	total initial kinetic energy/KE not equal to the total final kinetic energy/KE or relative speed of approach is not equal to relative speed of separation, showing calculation – e.g. relative speed of approach = 4.5 – (-2.8) = 7.3 while relative speed of separation = 1.4 – (-1.8) = 3.2 so not elastic or is inelastic	M1 A1
		(iii)	**1.**	 According to Newton's 3rd Law, the forces exerted on the bodies by each other are equal in magnitude and act in opposite directions.	B1 B1
			2.	Change in momentum of Y or impulse on Y	A1

8	(a)	(i)	The **product** of the **magnetic flux density** **normal** to the surface and the **area of the surface**.	B1
		(ii)	$\phi = BA = 0.025 \times 0.150 \times 0.060$ $\phi = 2.25 \times 10^{-4}$ Wb (also accept -2.25×10^{-4})	A1
	(b)	(i)	As the sinusoidal magnetic flux density passing through the coil is changing, the **magnetic flux linkage** through the coil is **changing periodically**. **By Faraday's law**, an **e.m.f. is induced** or generated in the coil. At times, the magnetic flux density is increasing while at other times it is decreasing. The **polarity of the induced e.m.f. would be different** when **magnetic flux density increases** as **compared** to the polarity of the e.m.f. as **magnetic flux density decreases**, thus generating an alternating current.	B1 B1 B1
		(ii)	From Fig. 8.2, the magnetic flux density is given by, $B = B_0 \cos\left(\frac{2\pi}{T}t\right)$ By Faraday's law and Lenz' Law, the e.m.f. is given by $E = -\frac{d\Phi}{dt}$, where $\mathbf{\Phi}$ is the magnetic flux linkage. $E = -\frac{dNBA}{dt}$ $E = -NA\frac{dB}{dt} = -NA\frac{d}{dt}B_0 \cos\left(\frac{2\pi}{T}t\right)$ Therefore, $E = NAB_0 \frac{2\pi}{T} \sin\left(\frac{2\pi}{T}t\right)$	M1 M1 A0
		(iii)	$E = NAB_0 \frac{2\pi}{T} \sin\left(\frac{2\pi}{T}t\right)$ Since the maximum magnitude of induced e.m.f. is when $\sin\left(\frac{2\pi}{T}t\right) = 1$, $E_{max} = NAB_0 \frac{2\pi}{T} = 25 \times 0.150 \times 0.060 \times 0.025 \times \frac{2\pi}{0.008}$ $= 4.42$ V	C1 A1

		(iii)	 sine function max E and period	A1 A1
	(c)	(i)	Root-mean-square voltage of input, $$V_{rms} = \frac{V_0}{\sqrt{2}}$$ $$V_{rms} = \frac{4.42}{\sqrt{2}} = V_P$$ $$\frac{N_S}{N_P} = \frac{V_S}{V_P}$$ No. of turns in sec coil, $$N_S = \frac{V_S}{V_P} N_P = \frac{240}{\frac{4.42}{\sqrt{2}}} \times 15 = \frac{240\sqrt{2}}{4.42} \times 15$$ $$N_S = 1150$$	C1 M1 A1
		(ii)	For efficiency, $\frac{\text{Power output}}{\text{Power input}} \times 100\%$ $= \frac{\text{Power in secondary coil}}{\text{Power in primary coil}} \times 100\%$ $= \frac{0.25 \times 240}{12I} \times 100\% = 81\%$ Therefore, $I = 6.17$A	C1 A1
	(d)	(i)	can change (output) voltage efficiently or to suit different consumers/appliances by using transformers	B1 B1
		(ii)	for same power, current is smaller	B1

			less heating in cables/wires or thinner cables possible or less voltage loss in cables	**B1**