JURONG JUNIOR COLLEGE
JC2 Preliminary Examination 2018

CANDIDATE NAME			
CLASS		INDEX NUMBER	

PHYSICS **9749/1**

Higher 2

Multiple Choice **14 September 2018**

1 hour

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

Write your **name** and **class** in the spaces provided at the top of this page.

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, class and index number on the Answer Sheet in the spaces provided.

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

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.

(This question paper consists of 17 printed pages)

Data

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

Formulae

uniformly accelerated motion,	s	$= ut + \frac{1}{2}at^2, \quad v^2 = u^2 + 2as$
work done on/by a gas,	W	$= p\,\Delta V$
hydrostatic pressure,	p	$= \rho g h$
gravitational potential,	ϕ	$= -\dfrac{Gm}{r}$
temperature,	T/K	$= T/°C + 273.15$
pressure of an ideal gas,	p	$= \dfrac{1}{3}\dfrac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule,	E	$= \frac{3}{2}kT$
displacement of particle in s.h.m.,	x	$= x_o \sin \omega t$
velocity of particle in s.h.m.,	v	$= v_o \cos \omega t$
	v	$= \pm\,\omega\sqrt{(x_o^2 - x^2)}$
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	$= \dfrac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage,	x	$= x_o \sin \omega t$
magnetic flux density due to a long straight wire	B	$= \dfrac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	$= \dfrac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid	B	$= \mu_o n I$
radioactive decay	x	$= x_o \exp(-\lambda t)$
decay constant	λ	$= \dfrac{\ln 2}{t_{1/2}}$

1 The speedometer in a car consists of a pointer which rotates. The pointer is situated several millimetres from a calibrated scale.

What could cause a random error in the driver's reading of the car's speed?

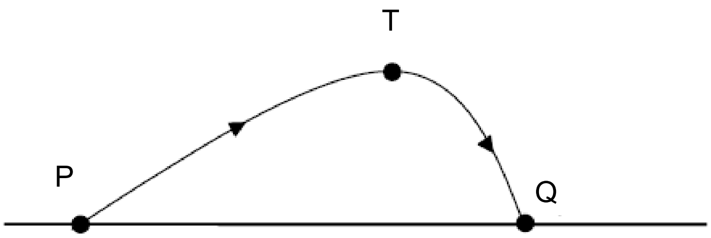
A The car's speed is affected by the wind direction.

B The speedometer does not read zero when the car is at rest.

C The speedometer reads 5% higher than the car's actual speed.

D The driver's eye is not always in the same position in relation to the pointer.

2 In the presence of air resistance, a stone is thrown from P and follows a path in which the highest point reached is T as shown in the diagram below.



Given that the drag force acting on the stone is directly proportional to the magnitude of its instantaneous velocity, the vertical component of the acceleration of the stone is

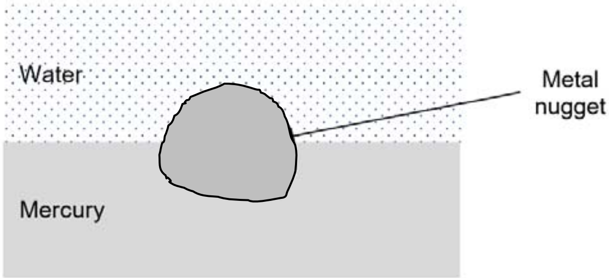
A highest at point P.

B highest at point T.

C highest at point Q.

D constant through the travelled path.

3 A metal nugget floats in between some water and mercury. The densities of the metal nugget, mercury and water are 7900 kg m^{-3}, 13600 kg m^{-3} and 1000 kg m^{-3} respectively.



What is the ratio of the volume of the nugget submerged in water to that in mercury?

A 0.541

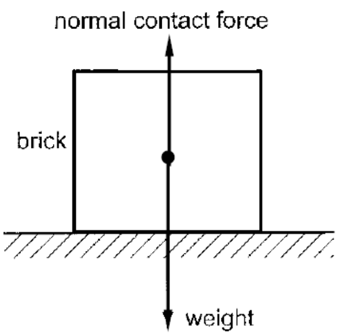
B 0.826

C 0.924

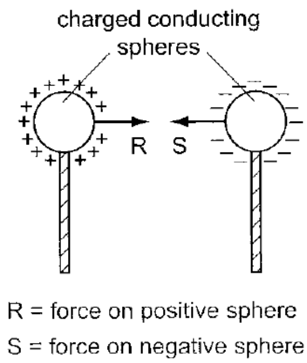
D 1.21

4 Which diagram shows a pair of forces that are **not** related to one another by Newton's third law?

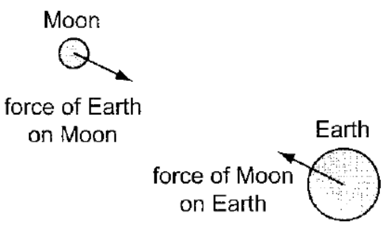
A



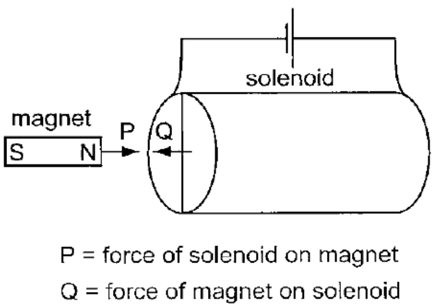
B



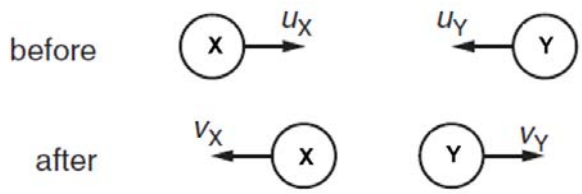
C



D



5 Two balls **X** and **Y** approach each other along the same straight line and collide elastically. Their speeds are u_X and u_Y respectively. After the collision they move apart with speeds v_X and v_Y respectively. Their directions are shown below.



Which of the following equations is correct?

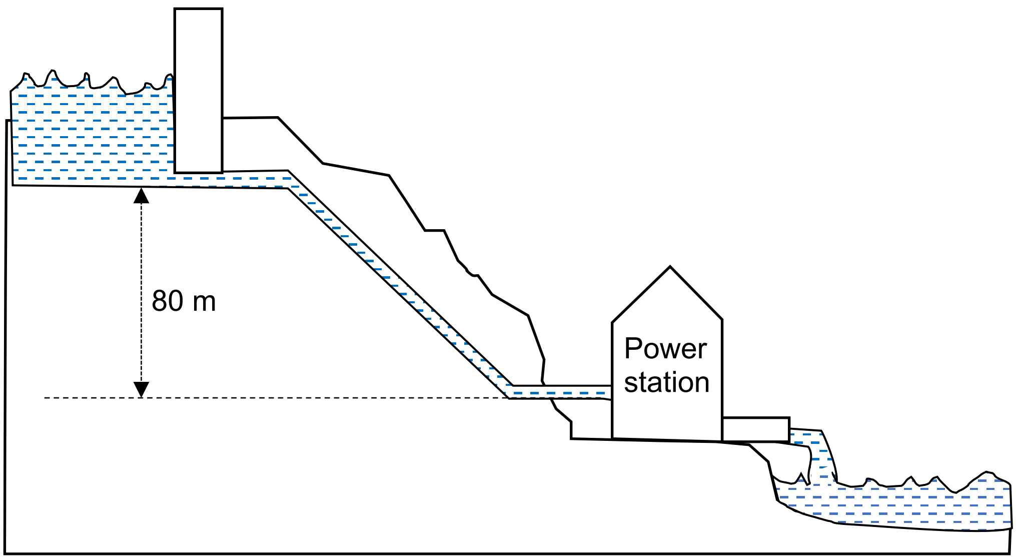
A $u_X - u_Y = v_Y - v_X$

B $u_X + u_Y = v_X - v_Y$

C $u_X + u_Y = v_X + v_Y$

D $u_X - u_Y = v_X - v_Y$

6 A hydroelectric power station is shown.



Water is supplied from a reservoir which is 80 m above the power station. The water passes through its turbines at a rate of 6.0 $m^3 s^{-1}$.

Assume that the density of water is 1000 kg m^{-3}. If the efficiency of the power station is 60%, what is the electrical power output?

A 0.29 MW

B 1.9 MW

C 2.8 MW

D 4.7 MW

7 A particle travels at a constant speed around a circle of radius r with centripetal acceleration a. What is the time taken for ten complete revolutions?

A $\frac{\pi}{5}\sqrt{\frac{a}{r}}$

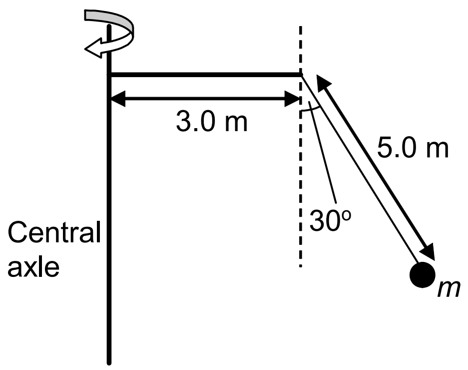
B $\frac{\pi}{5}\sqrt{\frac{r}{a}}$

C $20\pi\sqrt{\frac{a}{r}}$

D $20\pi\sqrt{\frac{r}{a}}$

8 A mass m, attached to one end of an inextensible string of length 5.0 m, is made to move in a horizontal circle as the vertical central axle is rotated. In a particular circular motion, the string makes an angle of 30° with the vertical as shown below.

Calculate the period of the mass about the central axle.



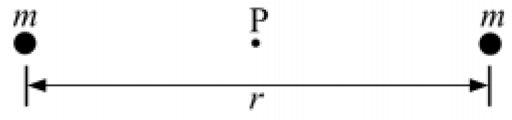
A 1.0 s

B 3.5 s

C 4.8 s

D 6.2 s

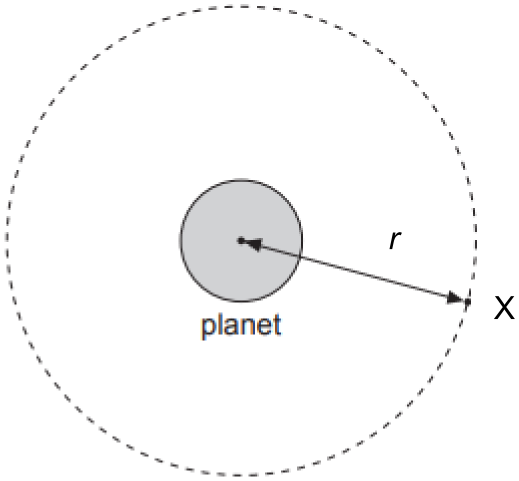
9 The figure below shows two objects of equal mass m separated by a distance r.



Which of the following gives the correct values of the gravitational field strength and gravitational potential at the mid-point P between the two objects?

	gravitational field strength	**gravitational potential**
A	$-\dfrac{8Gm}{r^2}$	$-\dfrac{4Gm}{r}$
B	$-\dfrac{8Gm}{r^2}$	0
C	0	$-\dfrac{4Gm}{r}$
D	0	0

10 A satellite X is in a circular orbit of radius r about the centre of a spherical planet of mass M.



Which of the following gives the correct expressions for the centripetal acceleration a and the speed v of the satellite?

	centripetal acceleration *a*	**speed *v***
A	$\frac{GM}{2r}$	$\sqrt{\frac{GM}{2r}}$
B	$\frac{GM}{2r}$	$\sqrt{\frac{GM}{r}}$
C	$\frac{GM}{r^2}$	$\sqrt{\frac{GM}{2r}}$
D	$\frac{GM}{r^2}$	$\sqrt{\frac{GM}{r}}$

11 The r.m.s. speed of the molecules of a gas at 295 K is decreased by 20 %.

What is the new temperature of the gas?

A – 84.4 ˚C

B – 37.2 ˚C

C 189 ˚C

D 236 ˚C

12 A piston is pushed into a cylinder containing an ideal gas such that the pressure of the gas increases to 1.5 times its initial value while the volume decreases to half its original value.

Which one of the following statements is correct?

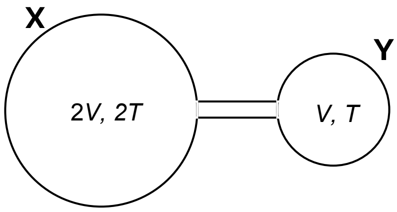
A The average random kinetic energy of the gas molecules increases.

B Work is done by the gas on its surroundings.

C Heat is extracted from the gas.

D There is no change in the internal energy of the gas.

13 An ideal gas is contained in two spherical containers X and Y of volume 2V and V respectively, connected by a hollow tube of negligible volume. The containers X and Y are maintained at temperatures 2T and T respectively. The setup is shown in the figure below.



Determine the ratio $\dfrac{\text{number of moles of gas in container X}}{\text{number of moles of gas in container Y}}$.

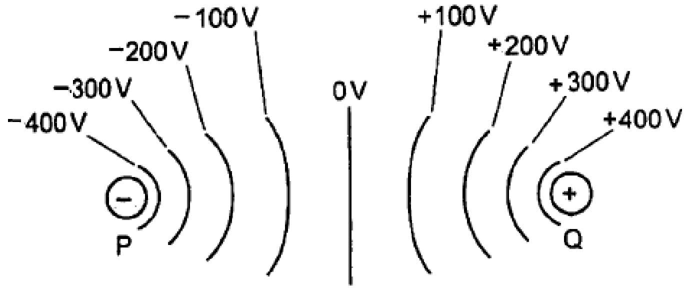
A 0.25

B 1.00

C 2.00

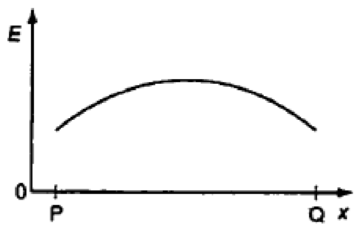
D 4.00

14 An object with a negative charge is placed at P and a similar object with a positive charge is placed at Q. The diagram shows the equipotential lines between these two objects.



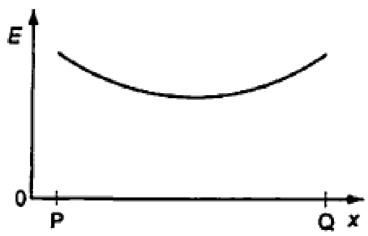
Which graph shows the variation with distance *x* along line PQ of the electric field strength *E*?

A



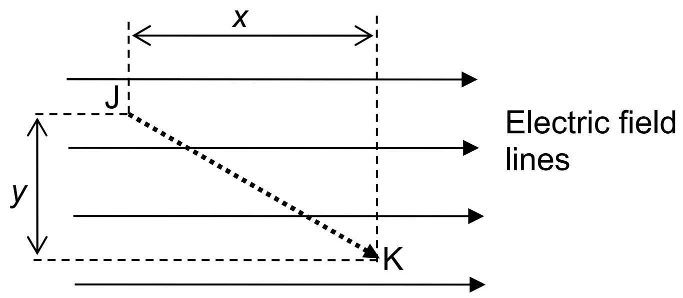
B

C



D

15 A small negative charge (- q) is placed at point J inside a uniform electric field of field strength E. It is then moved from point J to point K.



What is the change in electric potential energy of the charge?

A gain of qEx

B loss of qEx

C gain of $qE\sqrt{x^2 + y^2}$

D loss of $\dfrac{q}{4\pi\varepsilon_o\sqrt{x^2 + y^2}}$

16 A p-n junction diode has the forward current-p.d. characteristic as shown in Fig 16.1. It is connected in series with a variable, low voltage d.c. power supply, a meter of negligible internal resistance and a 50 Ω resistor as shown in Fig 16.2.

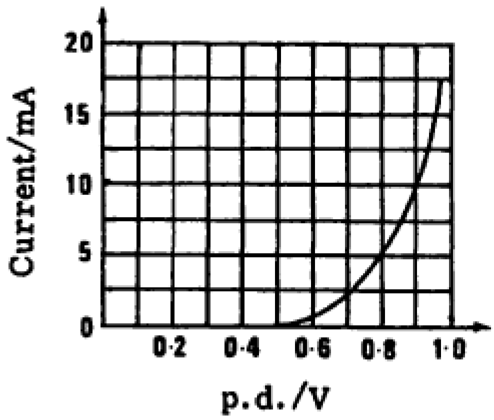


Fig 16.1

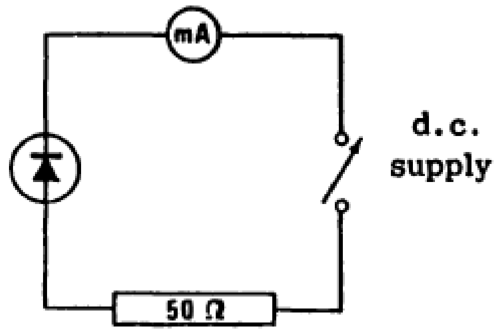


Fig 16.2

When the meter reads 5 mA, the potential difference across the supply is about

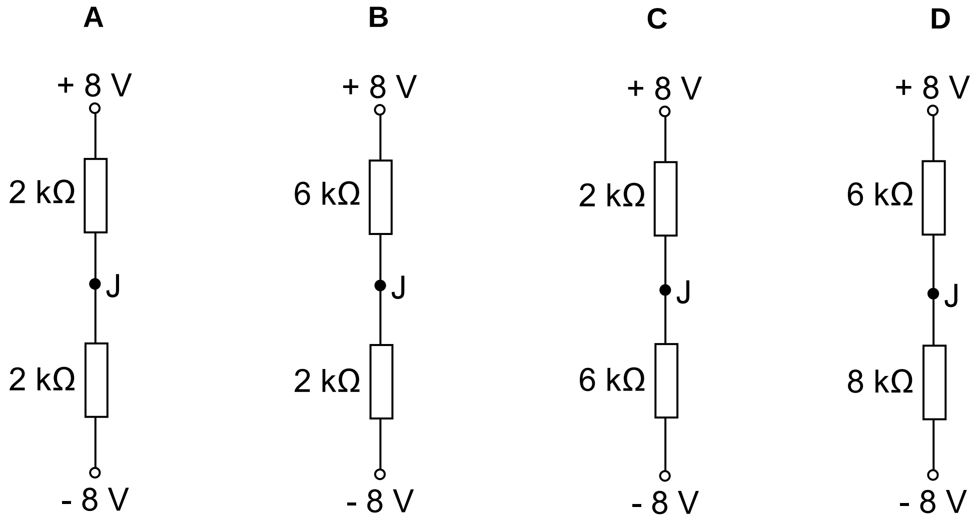
A 0.25 V

B 0.80 V

C 1.05 V

D 1.25 V

17 In which of the circuits below is the potential at J equal to - 4 V?



18 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

19 Fig. 19.1 shows the variation with displacement *x* of the velocity *v* of a simple harmonic oscillator. Fig. 19.2 shows the variation with *t* of the net force *F* acting on the oscillator.

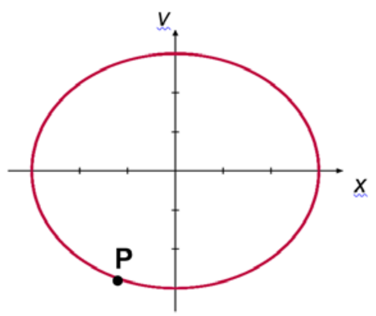


Fig. 19.1

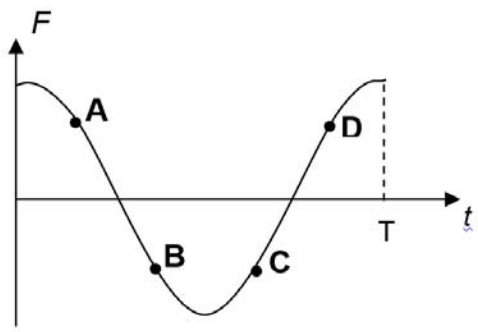
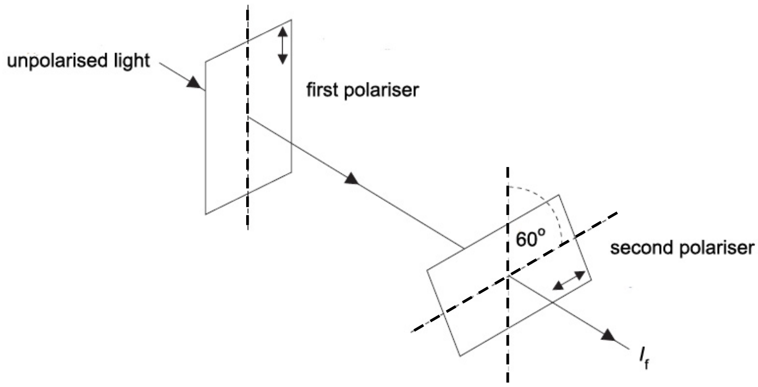


Fig. 19.2

Which of the points in Fig. 19.2 corresponds to the state of motion represented by point P in Fig. 19.1?

20 Unpolarised light is incident on a polariser. The light transmitted by the first polariser is then incident on a second polariser. The polarising axis of the second polariser is at 60° to that of the first polariser.



The intensity emerging from the second polariser is I_f .
Which of the following correctly gives the intensity incident on the first polariser?

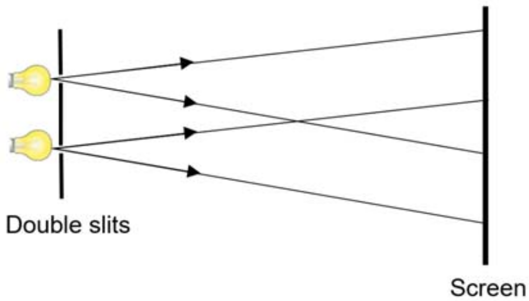
A $\frac{I_f}{8}$

B $\frac{I_f}{4}$

C $4I_f$

D $8I_f$

21 A student set up an interference effect experiment using two lamps emitting white light and a pair of slits as shown in the diagram below. However, no interference pattern was observed on a screen placed a distance away from the pair of slits.



Which of the following is the reason for the observation?

A The lamps are not point sources.

B The lamps emit light of different amplitudes.

C The light from the lamps is not coherent.

D The light from the lamps is white.

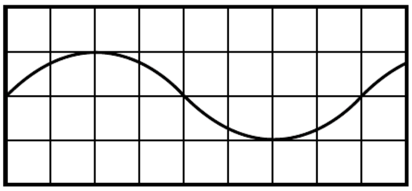
22 A stationary sound wave is set up between a loudspeaker and a wall.

A microphone is connected to a cathode-ray oscilloscope (c.r.o.) and is moved along a line directly between the loudspeaker and the wall. The amplitude of the trace on the c.r.o. rises to a maximum at a position X, falls to a minimum and then rises once again to a maximum at a position Y.

The distance between X and Y is 33 cm. The speed of sound in air is 330 m s^{-1}.

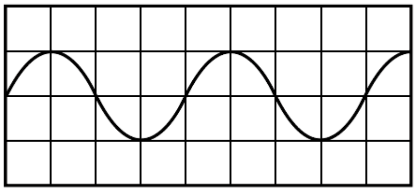
Which diagram represents the c.r.o. trace of the sound received at X?

A



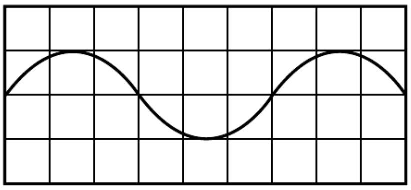
time base 0.50 ms / cm   1 cm

B



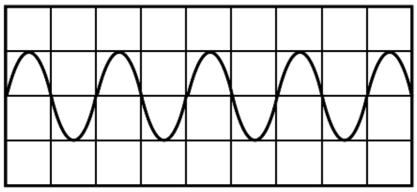
time base 0.50 ms / cm   1 cm

C



time base 0.50 ms / cm   1 cm

D



time base 0.50 ms / cm   1 cm

23 An electron moves in a circular orbit in a uniform magnetic field.

Which of the following statements is correct?

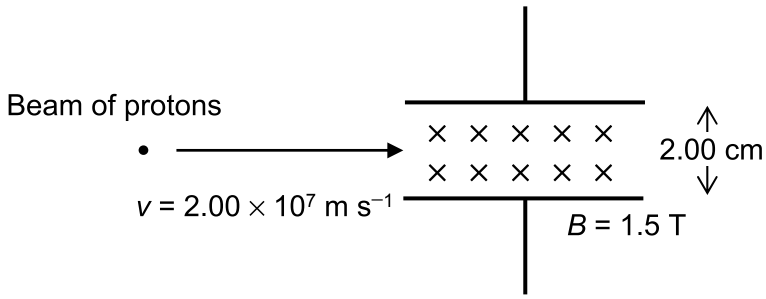
A The period of the orbit is independent of the speed of the electron.

B The momentum of the electron is dependent on its charge.

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

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

24 A beam of protons passes through a velocity selector with a plate separation of 2.00 cm as shown in the diagram below. The magnetic flux density, B is 1.5 T and directed into the plane of the paper.



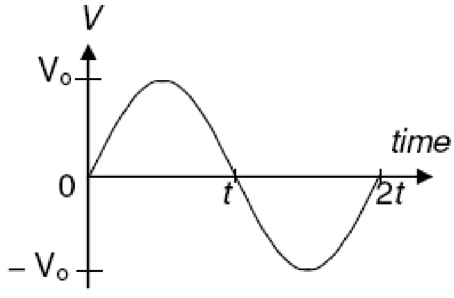
If protons travelling at 2.00×10^7 m s^{-1} pass through undeflected, what would be the direction and magnitude of the electric field?

	Direction	Magnitude
A	Downwards	6.00×10^5 N C^{-1}
B	Upwards	6.00×10^5 N C^{-1}
C	Downwards	3.00×10^7 N C^{-1}
D	Upwards	3.00×10^7 N C^{-1}

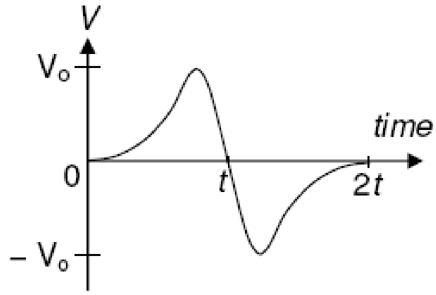
25 A bar magnet is dropped from rest vertically into a solenoid connected to a sensitive voltage sensor. The entire body of the magnet spent a time of 2*t* inside the solenoid.

Which of the following graphs best represents the time variation of the voltage, *V* recorded by the sensor?

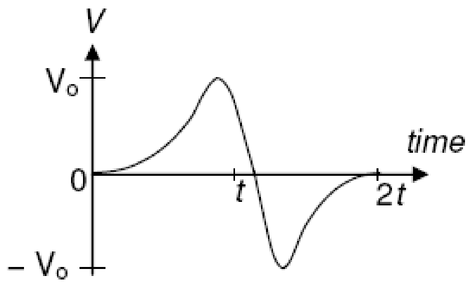
A



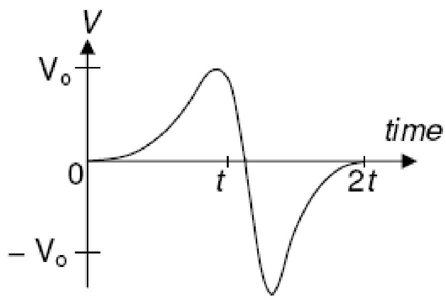
B



C



D



26 A direct current I passing a resistor produces a certain heating effect. If an alternating current is used, the resistance has to be reduced to one quarter of its value to obtain the same heating effect.

What is the peak value of the alternating current?

A I

B $\sqrt{2}\,I$

C $2\,I$

D $2\sqrt{2}\,I$

27 Which type of electromagnetic radiation is emitted when an electron in an atom makes a transition from an energy level at –1.5 eV to an energy level at –3.5 eV?

A Microwaves

B Infra-red

C Visible light

D Ultra violet

28 Which of the following is NOT a characteristic of the X-ray spectrum produced when electrons are accelerated and incident onto a target material?

A The range of wavelengths is continuous.

B The minimum wavelength is dependent on the target metal

C The minimum wavelength is dependent on the accelerating potential

D The intensity is dependent on the number of electrons incident on the target metal per unit time.

29 The activity of a sample of carbon taken from an archaeological specimen was 190 counts per minute. The activity of an equal mass of carbon taken from a living plant was 360 counts per minute. The background count was 20 counts per minute.

Taking the half-life of carbon-14 to be 5700 years, what was the approximate age of the archaeological specimen?

A 2850 year

B 5700 years

C 10800 years

D 11400 years

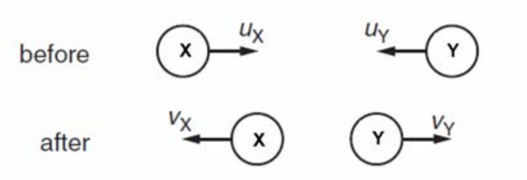
30 Radon ${}^{222}_{86}\text{Rn}$ decays by α– and β–emission to bismuth ${}^{214}_{83}\text{Bi}$.

For the decay of each nucleus of radon, how many α– and β–particles are emitted?

	α– particles	β–particles
A	1	1
B	2	1
C	1	2
D	2	2

End of Paper

JURONG JUNIOR COLLEGE
PHYSICS DEPARTMENT
JC2 Preliminary Exam 2018
9749 H2 Physics Paper 1 solutions

Qn	Ans	Suggested solution
1	**D**	Option A does not affect the driver's reading of the car's speed. Option B causes a systematic error. Option C causes a systematic error. Option D causes a parallax error, which is a random error.
2	**A**	Vertical acceleration is directly proportional to vertical resultant force. Considering only vertical direction, At P, it experiences weight and drag force in the same direction. At T, it experiences only weight and no drag force because vertical velocity is zero. At Q, it experiences weight and drag force but in opposite direction.
3	**B**	$U_w + U_m = W$ $\rho_w V_w g + \rho_m V_m g = \rho_n V_n g = \rho_n (V_w + V_m) g$ $1000 V_w + 13600 V_m = 7900 (V_w + V_m)$ $5700 V_m = 6900 Vw$ $V_w / V_m = 57/69 =$ **0.826**
4	**A**	The pair of action and reaction forces (Newton's third law) must act on ***separate*** bodies.
5	**C**	 For elastic collision, relative speed of approach = relative speed of separation $v_2 - v_1 = u_1 - u_2$ (where the sign conventions of u_1, u_2, v_1, v_2 are to the right) Hence $u_X - (-u_Y) = v_Y - (-v_X)$ → $u_X + u_Y = v_X + v_Y$
6	**C**	Raw Power input = Rate of GPE converted to Electrical Energy $= \frac{mgh}{t} = \frac{\rho Vgh}{t}$ $= \frac{1000(6.0)(9.81)(80)}{1}$ $= 4.78088$ MW Since Efficiency $= \frac{P_{out}}{P_{in}} = 0.60$ Then $P_{out} = 0.60(4.7088) =$ **2.8 MW**

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Qn	Ans	Suggested solution
7	D	$a = r\omega^2 = r\left(\frac{2\pi}{T}\right)^2 = \frac{4\pi^2 r}{T^2}$ $T = 2\pi\sqrt{\frac{r}{a}}$ $10T = 20\pi\sqrt{\frac{r}{a}}$
8	D	$F \sin 30° = m\,(3 + 5 \sin 30°)\,\omega^2$ - - - (1) $F \cos 30° = mg$ - - - (2) $\frac{(1)}{(2)}$: $\tan 30° = \frac{(3+5\sin 30°)4\pi^2}{(9.81)T^2}$ → $T =$ **6.2 s**
9	C	The gravitational field strength at P due to both masses are equal and in opposite directions → resultant field strength = 0 $\phi = \phi_m + \phi_m = -\frac{Gm}{r/2} - \left(-\frac{Gm}{r/2}\right) = -\frac{4Gm}{r}$
10	D	Gravitational force provides the centripetal force for the satellite to orbit the Earth → $\frac{GMm}{r^2} = ma$ → $a = \frac{GM}{r^2}$ $\frac{GMm}{r^2} = ma = \frac{mv^2}{r}$ $v = \sqrt{\frac{GM}{r}}$
11	A	$\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$ → $c_{rms} = \sqrt{\frac{3kT}{m}}$ $\frac{c'_{rms}}{c_{rms}} = \sqrt{\frac{T'}{T}}$ → $\frac{0.8c_{rms}}{c_{rms}} = \sqrt{\frac{T'}{295}}$ T' = 188.8 K = **–84.4 °C**
12	C	pV → $(1.5p)(0.5V) = 0.75pV$ The temperature of the gas decreases → average KE of the molecules decreases → internal energy decreases. Work is done on the gas since the volume decreases.
13	B	$n_Y = \frac{pV}{RT}$, $n_X = \frac{p(2V)}{R(2T)}$ → $\frac{n_X}{n_Y} =$ **1.00**
14	C	Direction of *E* doesn't change, only magnitude changes. *E* is greatest close to the charge and minimum at midpoint.

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<table>
<tr><th>Qn</th><th>Ans</th><th>Suggested solution</th></tr>
<tr><td>15</td><td>A</td><td>Force on electron, $F = qE$ (to the left)

Work done by electric force on electron = $-Fx$

When the electron moves to the right, it gains EPE. The amount of EPE gained is equal to the work done by the electric force (Fx), where x is the distance moved in the direction of the field lines.</td></tr>
<tr><td>16</td><td>C</td><td>From Fig. 16.1,

when current = 5 mA, p.d. = 0.8 V (across diode)

p.d. across 50 Ω resistor = (5 mA)(50 Ω) = 0.25 V

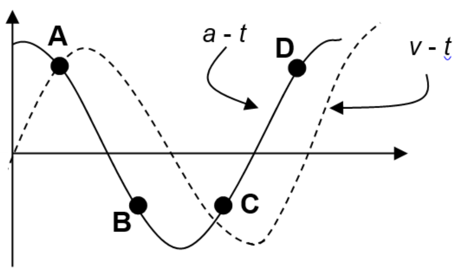
Total p.d. across supply = 0.8 + 0.25 = 1.05 V</td></tr>
<tr><td>17</td><td>B</td><td>Consider circuit B:
By potential divider,
p.d across 6 kΩ is $\frac{6}{6+2}[8-(-8)] = 12$ V

Potential at J = 8 – 12 = –4 V</td></tr>
<tr><td>18</td><td>C</td><td>Charge flows = area under the graph

= ½ (100 mA + 20 mA) (8) = 480 mC</td></tr>
<tr><td>19</td><td>D</td><td>At point P, the displacement, x is negative and velocity, v is negative.

Since $a = -\omega^2 x \Rightarrow F = ma = -m\omega^2 x$, x negative will mean F is positive (B and C no longer plausible).

Since a-t graph is a cosine graph, v-t graph will be a sine graph and hence A is not possible since its velocity is positive.


</td></tr>
<tr><td>20</td><td>D</td><td><table><tr><th></th><th>Unpolarised light</th><th>After 1st polariser</th><th>After 2nd polariser</th></tr><tr><td>Amplitude</td><td></td><td>A</td><td>$A \cos 60 = 0.5\,A$</td></tr><tr><td>Intensity</td><td></td><td>A^2</td><td>$0.25\,A^2$</td></tr><tr><td></td><td>$8I_f$</td><td>$4I_f$</td><td>I_f</td></tr></table></td></tr>
<tr><td>21</td><td>C</td><td>To be able to observe interference fringes, the waves that superpose must be coherent i.e. have a constant phase difference.</td></tr>
</table>

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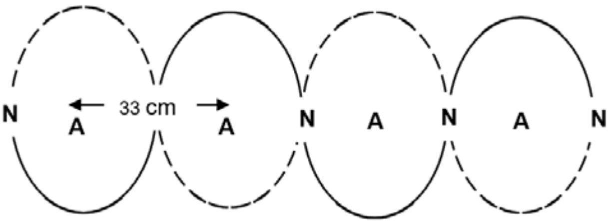
Qn	Ans	Suggested solution
22	B	 $\lambda = 2 \times 0.33 = 0.66$ m $f = v/\lambda = 330 / 0.66 = 500$ Hz $T = 1/f = 1/500 = 0.002$ s = 2 ms Period of waveform in option B = 4 cm $\times$ 0.5 ms cm^{-1} = 2 ms
23	A	Magnetic force provides centripetal force $\rightarrow Bqv = \frac{mv^2}{r} \rightarrow Bq = \frac{mv}{r} \rightarrow r = \frac{mv}{Bq}$ $Bq = \frac{mv}{r} = m\omega = \frac{2\pi m}{T} \rightarrow T = \frac{2\pi m}{Bq}$
24	C	The magnetic force acting on the proton is **upwards**. To balance this force, so that the proton would pass undeflected, the electric force on the proton acts downwards, so the electric field is directed downwards. $v = \frac{E}{B} \rightarrow E = Bv = (1.5)(2.00 \times 10^7) = \mathbf{3.00 \times 10^7\ N\ C^{-1}}$
25	D	When the bar magnet begin to fall through the solenoid, the flux linkage through the solenoid increases, inducing an e.m.f. in it. When the bar magnet falls out of the solenoid, the flux linkage through the solenoid decreases, inducing an e.m.f. in the opposite direction. As the magnet accelerates under gravity, the rate of change increases. Hence the magnitude of the induced e.m.f. is larger when the magnet falls out of the solenoid.
26	D	Same heating effect implies same power dissipated in the resistor, i.e. $P = I^2R$ For the new resistance $R_1 = R/4$, the new r.m.s. current I_1 is given by $P = I_1^2 R_1 = I_1^2 R/4 = I^2R \rightarrow I_1^2 = 4I^2 \rightarrow I_1 = 2I$ The peak current $I_o = \sqrt{2}\, I_1 = \sqrt{2}\,(2I)$
27	C	$E = [-1.5 - (-3.5)] \times 1.6 \times 10^{-19} = 3.2 \times 10^{-19}$ $E = hf = hc/\lambda \rightarrow \lambda = hc/E = 6.63 \times 10^{-34} \times 3 \times 10^8 / 3.2 \times 10^{-19}$ $= 6 \times 10^{-7}$ m $\rightarrow$ visible light
28	B	The two peaks are the ones that are dependent. The wavelengths depend on the energy of the electron and how much energy it loses in each interaction with an atom.
29	B	$A_o = 360 - 20 = 340$ min^{-1} $A = 190 - 20 = 170$ min^{-1} t = 1 half life = **5700 years**
30	B	$^{222}_{86}\text{Rn} \rightarrow {}^{214}_{83}\text{Bi} + 2\,{}^{4}_{2}\text{He} + {}^{0}_{-1}\text{e}$

JURONG JUNIOR COLLEGE
JC2 Preliminary Examination 2018

CANDIDATE NAME			
CLASS		INDEX NUMBER	

PHYSICS 9749/02
Higher 2

Structured Questions

23 August 2018

2 hours

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

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

Write your **name** and **class** in the spaces provided at the top of this page.

Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use highlighters, glue or correction fluid.

Answer **all** questions.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	
2	
3	
4	
5	
6	
7	
8	
Total	

Data

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

Formulae

uniformly accelerated motion	s	$= ut + \frac{1}{2}at^2$
	v^2	$= u^2 + 2as$
work done on/by a gas	W	$= p\,\Delta V$
hydrostatic pressure	p	$= \rho g h$
gravitational potential	ϕ	$= -\dfrac{Gm}{r}$
temperature	T/K	$= T/^{o}\text{C} + 273.15$
pressure of an ideal gas	p	$= \dfrac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
mean kinetic energy of a molecule of an ideal gas	E	$= \frac{3}{2}kT$
displacement of particle in s.h.m.	x	$= x_o \sin \omega t$
velocity of particle in s.h.m.	v	$= v_o \cos \omega t = \pm\, \omega\sqrt{(x_o^2 - x^2)}$
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	$= \dfrac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage,	x	$= x_o \sin \omega t$
magnetic flux density due to a long straight wire	B	$= \dfrac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	$= \dfrac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid	B	$= \mu_o n I$
radioactive decay	x	$= x_o \exp(-\lambda t)$
decay constant	λ	$= \dfrac{\ln 2}{t_{1/2}}$

1. A tennis ball is thrown vertically downwards from a height of 0.65 m above the ground. It leaves the hand with an initial speed of 1.5 m s^{-1}. The ball rebounds and is caught when it is travelling upwards with a speed of 1.0 m s^{-1}.

Assume that air resistance is negligible.

(a) Calculate the speed of the ball just before it strikes the ground.

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

(b) The tennis ball is thrown downwards at t = 0. It hits the ground at time t_1 and is caught at time t_2.

On Fig. 1, sketch the velocity-time graph for the motion of the ball from the time it leaves the hand to when it returns.

Assume that the contact time between the ball and the ground is negligible. The initial velocity **X** and final velocity **Y** are marked on Fig. 1.

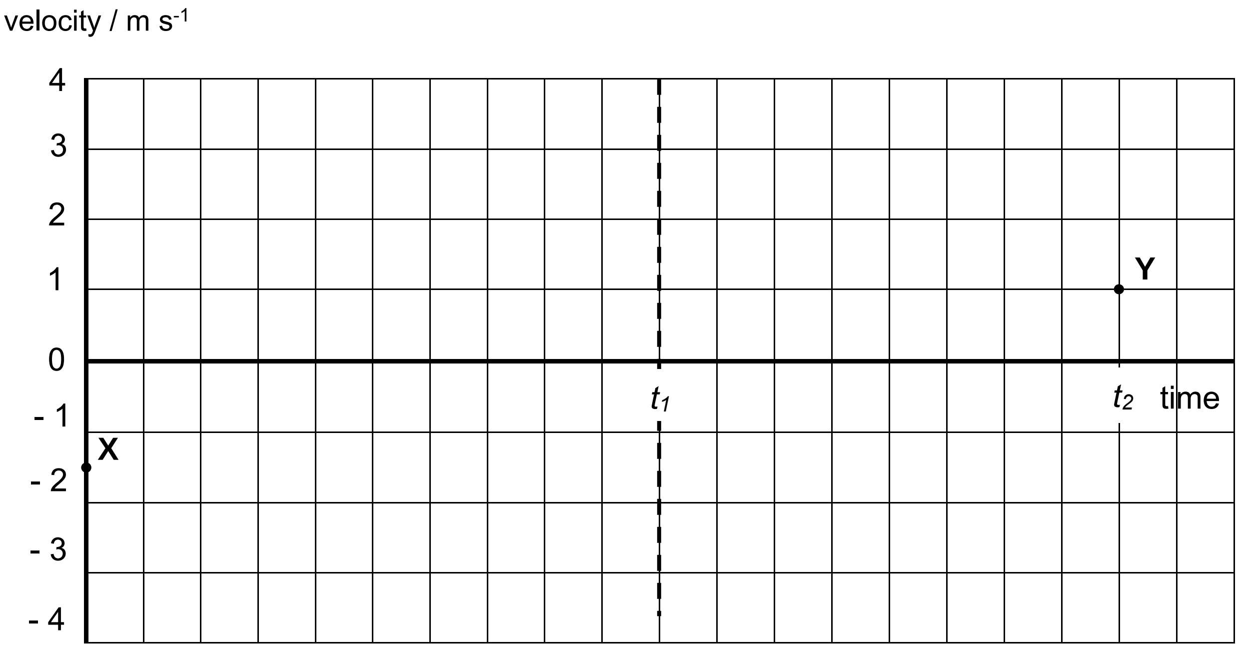


Fig. 1

[2]

(c) State and explain whether the bounce is elastic.

[2]

(d) On Fig. 1, sketch the velocity-time graph of the tennis ball if air resistance is not negligible. Label this graph **P**. [2]

2. **(a)** State the conditions for a body to be in equilibirum.

1. ______________________________

____

2. ______________________________

______________________________ [2]

(b) Fig. 2.1 shows a 70 kg climber hanging by only the crimp hold of one hand on the edge of a shallow horizontal ledge in a rock wall. The fingers are pressed down.

Her feet touch the rough rock wall at distance H = 2.0 m directly below her crimped fingers. The frictional force between her feet and the wall is 32 N. Her centre of mass is at distance a = 0.20 m from the wall.

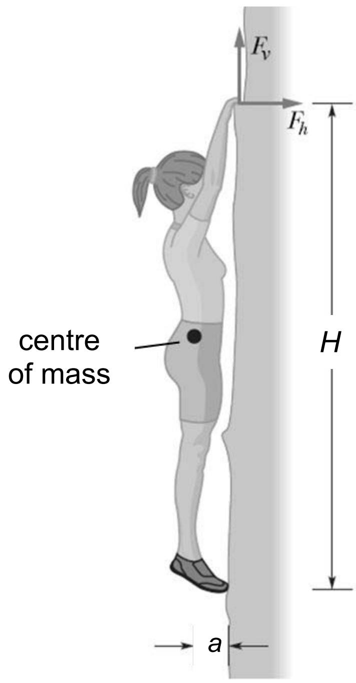


Fig. 2.1

(i) Determine the horizontal frictional force F_h acting on the fingers.

F_h = ______________ N [2]

(ii) Determine the vertical force F_v acting on the fingers.

F_v = ____________ N [2]

(iii) The weight W of the climber and the resultant force F exerted by the ledge on her fingers are indicated in Fig. 2.2. Draw and label the force S exerted by the rock wall on her feet.

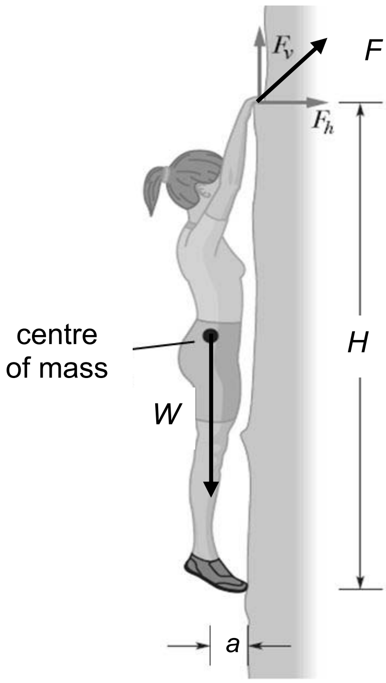


Fig. 2.2

[2]

3. A 900 kg car A travelling at 50 m s^{-1} collides inelastically with a 1500 kg car B travelling at 20 m s^{-1} in the same direction as shown in Fig. 3.1. Immediately after the collision, the velocity of car A is 25 m s^{-1} and the velocity of car B is v_B as shown in Fig. 3.2.

The collision begins at time t. During the collision, both cars are in contact for 120 ms.

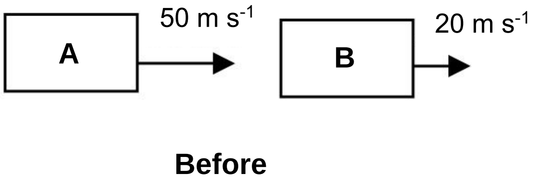


Fig. 3.1

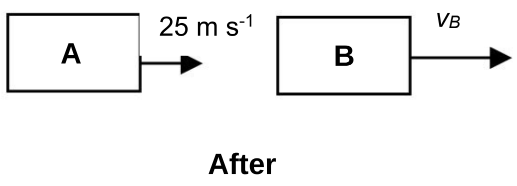


Fig. 3.2

(a) **(i)** Determine the magnitude of the velocity v_B.

magnitude of velocity v_B = ... m s^{-1} [1]

(ii) On Fig. 3.3, sketch and label the momentum-time graphs for car A and car B, before, during and after the collision. Include numerical values.

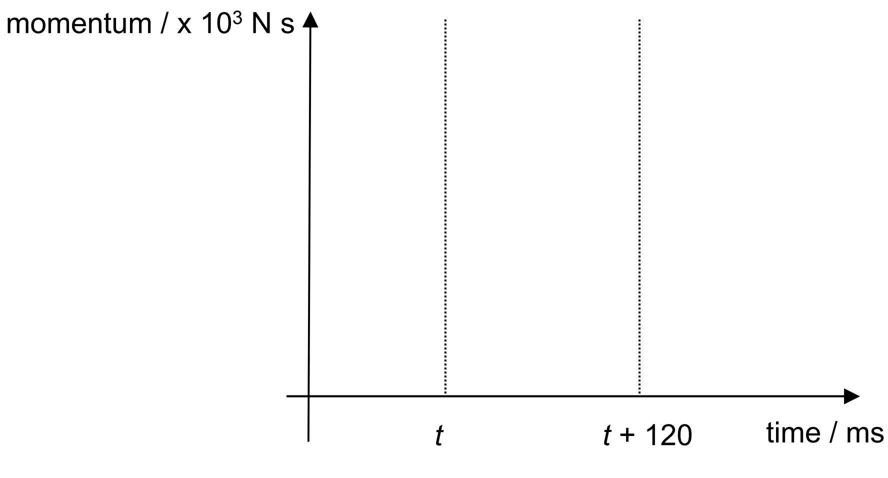


Fig. 3.3

[4]

(b) Determine the average force that car B exerts on car A during the collision.

average force = ______________ N [1]

(c) State and explain one design or feature of the car that reduces the force experienced by the driver.

....

....

....

.... [2]

4. The needle of a sewing machine is made to oscillate vertically through a total distance of 22 mm, as shown in Fig. 4.

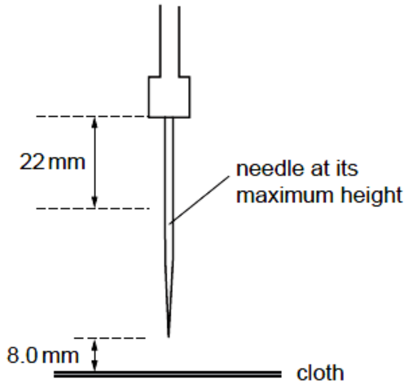


Fig. 4

The oscillations of the needle are simple harmonic with a frequency of 4.5 Hz. The cloth that is being sewn is positioned 8.0 mm below the point of the needle when the needle is at its maximum height.

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

....

....

.... [2]

(b) Determine the values of the

(i) amplitude of oscillation,

amplitude = ... mm [1]

(ii) angular frequency,

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

(iii) maximum acceleration,

acceleration = ______________ m s^{-2} [1]

(iv) displacement of the needle from its equilibrium position as it just passes downwards through the cloth (taking upward direction as positive),

displacement = ______________ mm [1]

(v) speed of the needle as it just passes downwards through the cloth.

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

5. **(a)** Fig. 5.1 shows the variation of the height of a water wave against its horizontal distance at 12 noon.

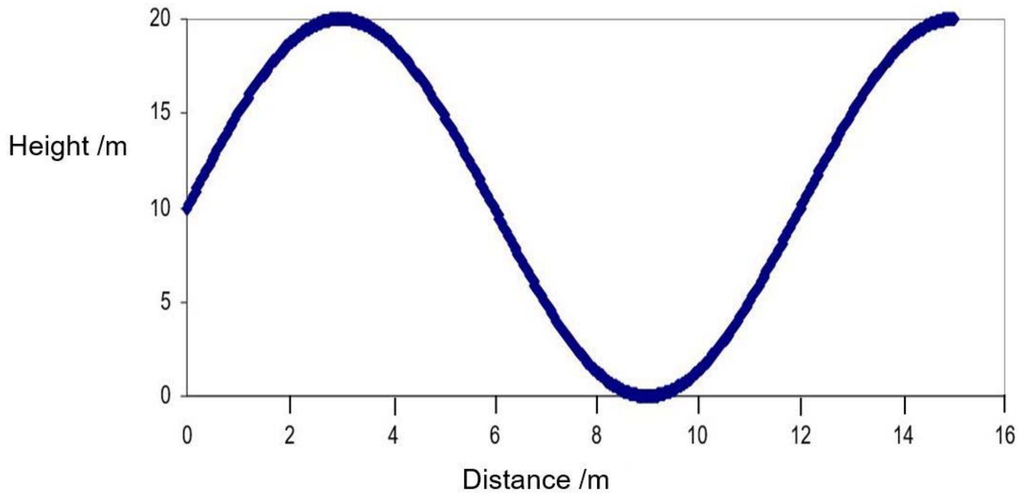


Fig. 5.1

(i) The waves are traveling at the speed of 1.25 m s^{-1}. Show that the frequency of the waves is 0.104 Hz.

[1]

(ii) Two buoys, fixed in position, are floating on the open sea.

The waves take 2.00 minutes to travel directly from one buoy to the other buoy. Determine the phase difference of the two buoys.

phase difference = ... rad [2]

(b) In Fig. 5.2, a narrow beam of monochromatic light of wavelength 590 nm passes through two different diffraction gratings A and B positioned perpendicular to each other. Assume that the distance between the two gratings is negligible.

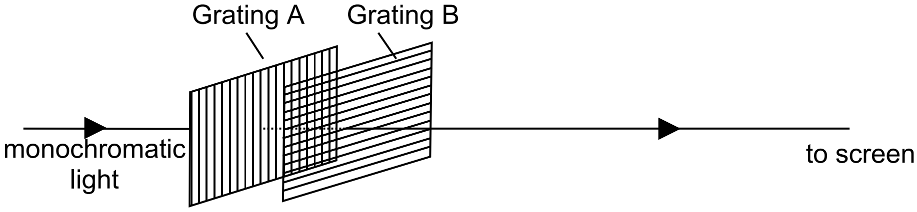


Fig. 5.2

As a result of this arrangement, a diffraction pattern is formed on a screen placed 2.5 m away from the gratings. The pattern is shown in Fig. 5.3.

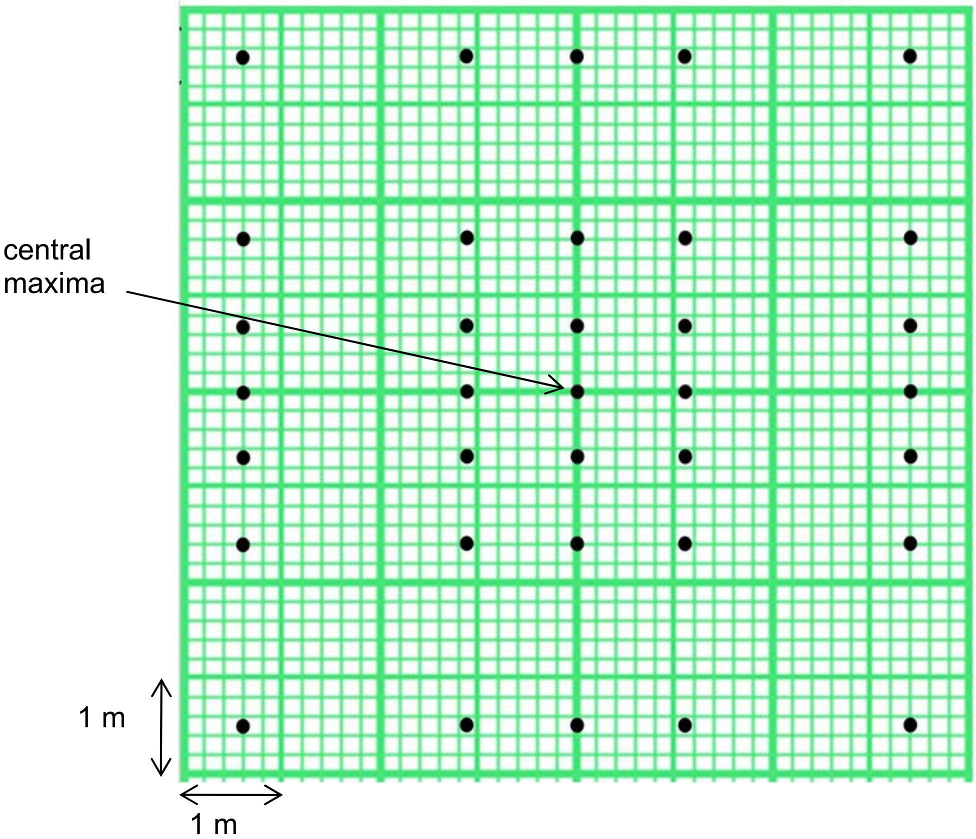


Fig. 5.3

(i) Explain the meaning of the term *diffraction*.

....

.... [1]

(ii) By taking appropriate measurements from Fig. 5.3, determine the number of lines per unit length on diffraction grating B.

number = ... lines m^{-1} [3]

(iii) Based on the diffraction pattern shown in Fig. 5.3, explain qualitatively what can be deduced about the slit separation of both diffraction gratings.

....

....

.... [2]

(iv) The two diffraction gratings are now replaced with a fine nylon mesh with 24000 nylon threads per metre of the mesh. Suggest one way in which the diffraction pattern observed would be different.

....

.... [1]

6. **(a)** Explain what is meant by photoelectric effect.

....

....

.... [1]

(b) In a photoelectric experiment, a parallel beam of monochromatic radiation is incident normally upon a metal surface of area 1.0×10^{-4} m^2 in a vacuum tube. The metal has a work function of 2.06 eV. The photocurrent I against p.d. V graph is shown in Fig. 6.1 below.

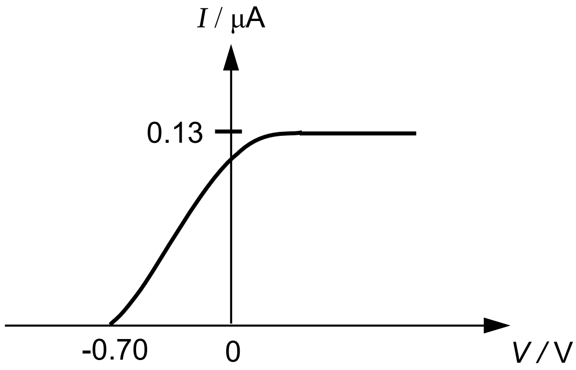


Fig. 6.1

(i) Calculate the maximum kinetic energy of the photoelectrons emitted.

maximum kinetic energy = ... J [1]

(ii) Hence, determine the frequency of radiation incident on the metal surface.

frequency = ... Hz [2]

(iii) If one photoelectron is emitted for every 8000 photons incident on the metal, calculate the intensity of the radiation incident on the metal surface.

intensity = ______________ W m^{-2} [3]

(iv) Sketch on Fig. 6.1 the graph you expect to obtain if the intensity of the radiation is halved. [1]

(v) Suggest a reason for the part of the graph in Fig. 6.1 for negative values of *V*.

____

____

____ [2]

7. **(a)** In a nuclear reaction, a uranium-235 $\left({}^{235}_{92}\text{U}\right)$ nuclide is transformed into an unstable uranium-236 nuclide $\left({}^{236}_{92}\text{U}\right)$ through bombardment by a slow-moving neutron. The unstable uranium-236 nuclide undergoes nuclear fission to form stable products of a lathium-139 nuclide $\left({}^{139}_{57}\text{La}\right)$ and a nuclide of bromine $\left({}^{A}_{Z}\text{Br}\right)$.

$${}^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \rightarrow {}^{236}_{92}\text{U} \rightarrow {}^{139}_{57}\text{La} + {}^{A}_{Z}\text{Br} + 3{}^{1}_{0}\text{n} + \gamma$$

Use the following masses in answering this question:

rest mass of ${}^{235}_{92}\text{U}$ nuclide	= 235.044u
rest mass of ${}^{139}_{57}\text{La}$ nuclide	= 138.906u
rest mass of proton	= 1.00728u
rest mass of neutron	= 1.00866u

(i) Determine the nucleon number A and proton number Z of the bromine nuclide.

A = ...

Z = ... [1]

(ii) Calculate the binding energy of the uranium-235 nuclide to 4 significant figures.

binding energy = ... MeV [3]

(iii) State the feature of this equation that indicates that a chain reaction may be possible.

....

.... [1]

(b) In a laboratory source of strontium-90, the number of atoms present in the year 2013 was 2.36×10^{13}. Strontium-90 decays by emission of a β-particle and this nuclide has a half-life of 28 years.

(i) State what is a β-particle.

....

.... [1]

(ii) Calculate the activity of the source in the year 2113.

activity = ... Bq [2]

8. Hywind, the world's first floating wind turbine that combines technologies from both the wind farming industry and the oil and gas sectors was recently commissioned off the coast of Norway in 2009. The Hywind are towed out to the open sea of density 1025 kg m^{-3} and is anchored to the seabed by three long cables as shown in Fig. 8.1. The high-speed wind turbine is used to generate electricity of output frequency of 50 Hz. One of the reasons for operating the Hywind offshore is the continuous presence of high speed wind from 8.0 m s^{-1} to 30 m s^{-1}.

Fig. 8.2 shows the different parts inside the generator housing.

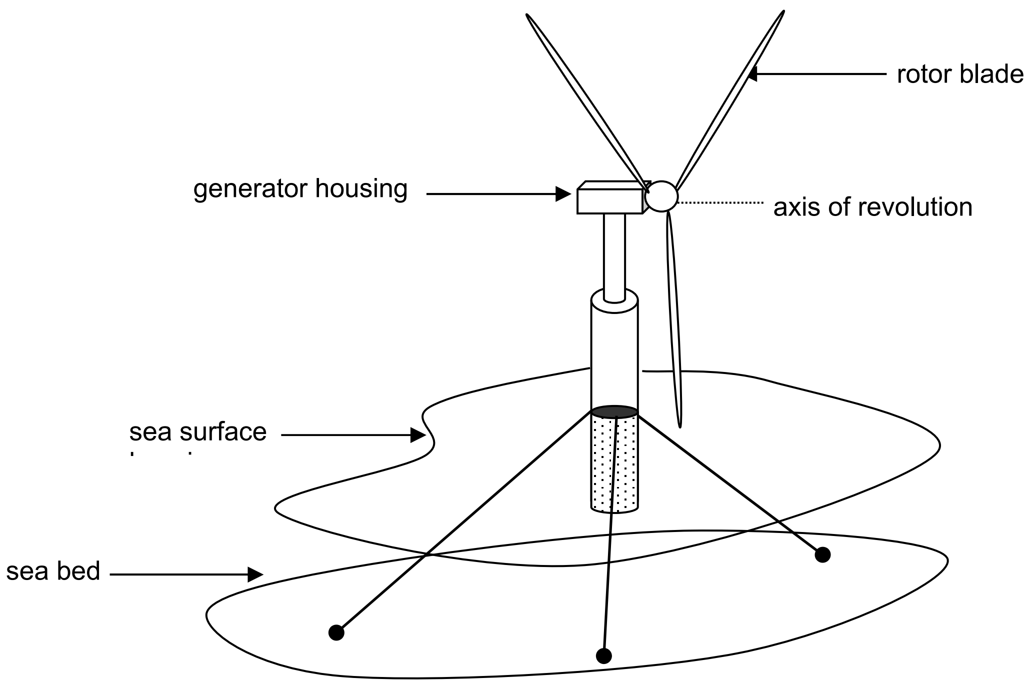


Fig. 8.1

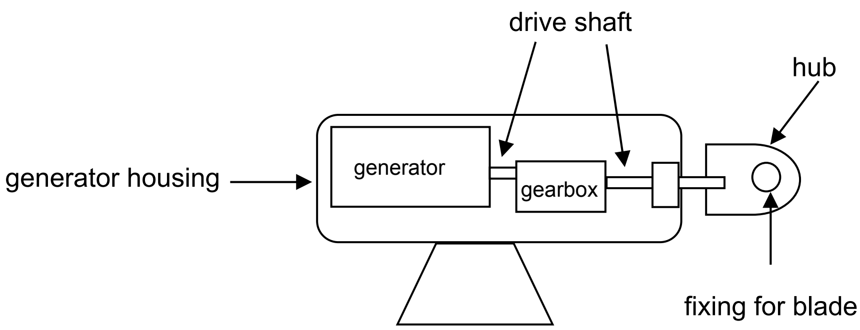


Fig. 8.2

Some information provided by the manufacturer of Hywind is given in Fig. 8.3.

Turbine mass	138 000 kg
Turbine height above the sea surface	65.0 m
Rotor blade diameter	82.4 m
Displacement of water by Hywind	5300 m^3
Diameter of submerged body	8.3 m
Range of water depth	120 - 700 m
Frequency	50 Hz

Fig. 8.3

(a) State and explain whether the generator produces direct current or alternating current.

[1]

(b) Determine the upthrust on the Hywind structure.

upthrust = ... N [1]

(c) **(i)** The turbine is located so that it faces the wind. The rotor blades are set at an angle to the plane in which they revolve so that the wind is deflected.

Explain why the rotor blades are able to revolve about the axis when subjected to the wind.

[3]

(ii) Describe briefly how electrical energy is generated using the energy from the wind.

....

....

....

.... [2]

Question 8 continues on next page

(d) Fig. 8.4 shows how the output power, P, from a wind turbine varies with the speed, v, of the wind.

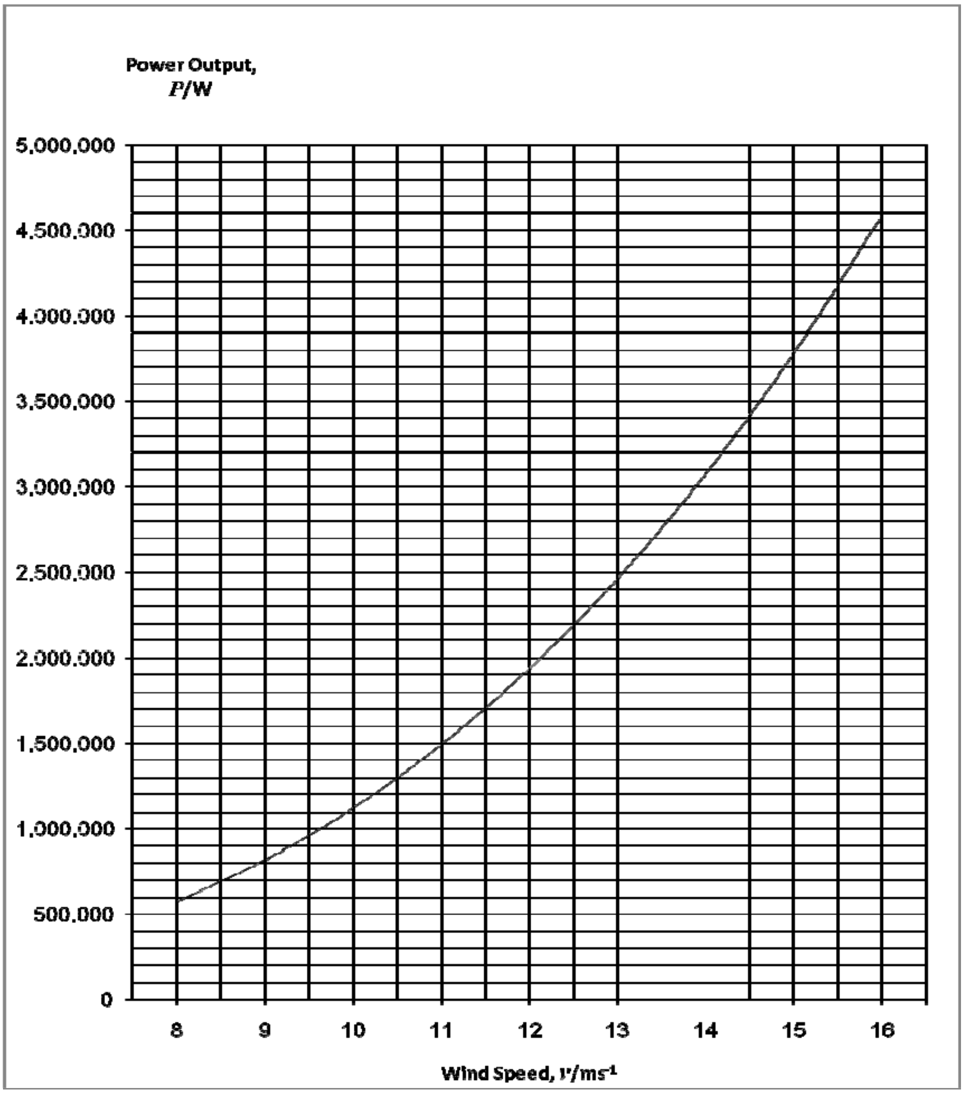


Fig. 8.4

It is thought that, for a given fixed size of the rotor blade, the electrical power output, P, varies with the wind speed v according to the expression

$$P = kv^3$$

Using the graph of Fig. 8.4, show that k is a constant.

[2]

(e) Some corresponding values of lg P and lg v for the data in Fig. 8.4 are plotted on the graph of Fig. 8.5.

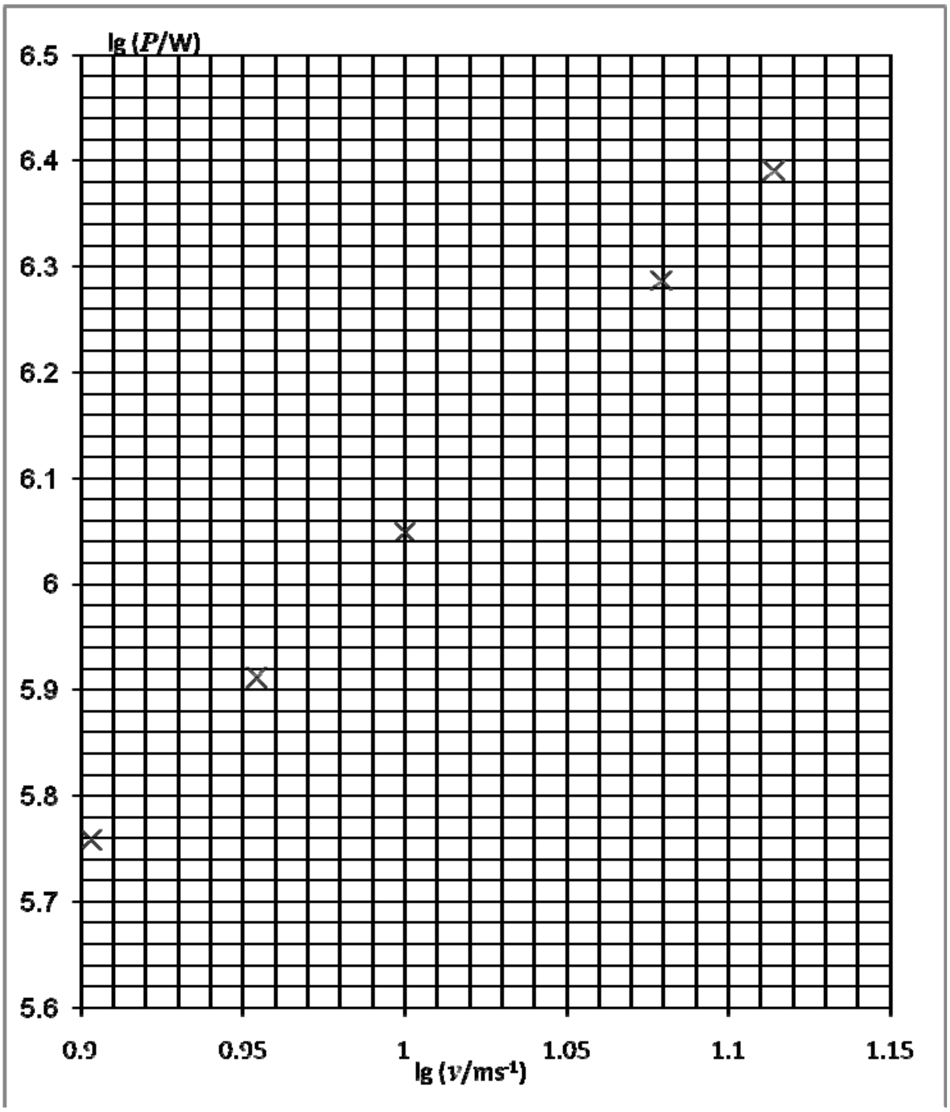


Fig. 8.5

(i) On Fig. 8.5,

1. plot the point corresponding to v = 11.0 m s^{-1}, [1]

2. draw the best fit line for all the plotted points. [1]

(ii) Determine the gradient of the line drawn in **(i) part 2**.

gradient = ______________ [2]

(iii) Hence comment on the validity of the relation given in **part (d)**.

Explain your answer.

....

....

....

.... [2]

(f) The initial kinetic energy per second of the air that passes through the wind turbine is given by ½ $\rho A v^3$, where ρ is the density of air and A is the area swept out by the rotor blades in each rotation.

Given: density of air = 1.2 kg m^{-3}

Calculate, for the wind turbine operating at wind speed of 11.0 m s^{-1},

(i) kinetic energy of air incident per second on the rotor blades,

incident wind power = ______________ MW [2]

(ii) the overall efficiency of generation of electric power.

efficiency = ______________ [1]

(g) Suggest two possible problems encountered when operating the Hywind in the open sea.

1. ....

....

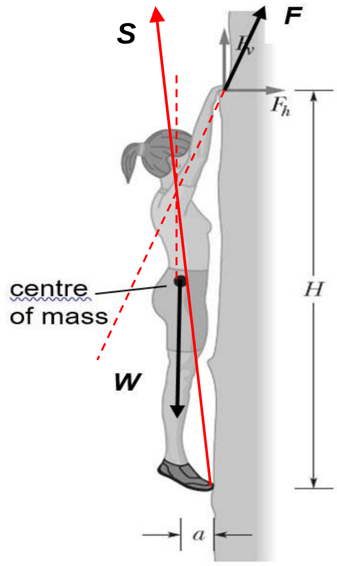
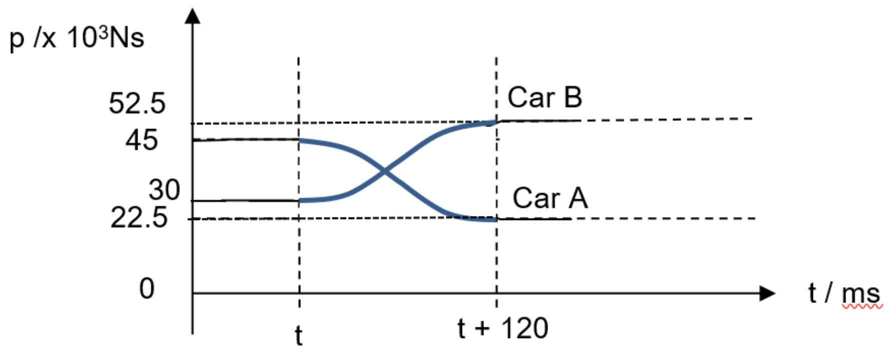
2. ....

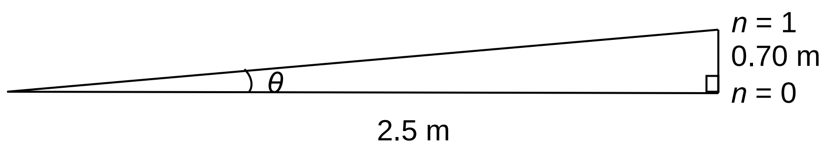
.... [2]

End of Paper

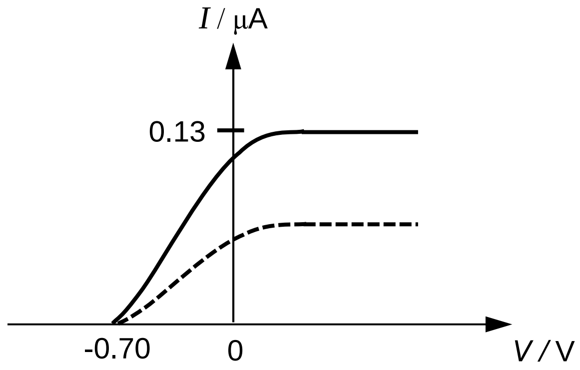
JURONG JUNIOR COLLEGE
PHYSICS DEPARTMENT
2018 JC2 Preliminary Examination
9749 H2 Physics Paper 2 Suggested Solutions

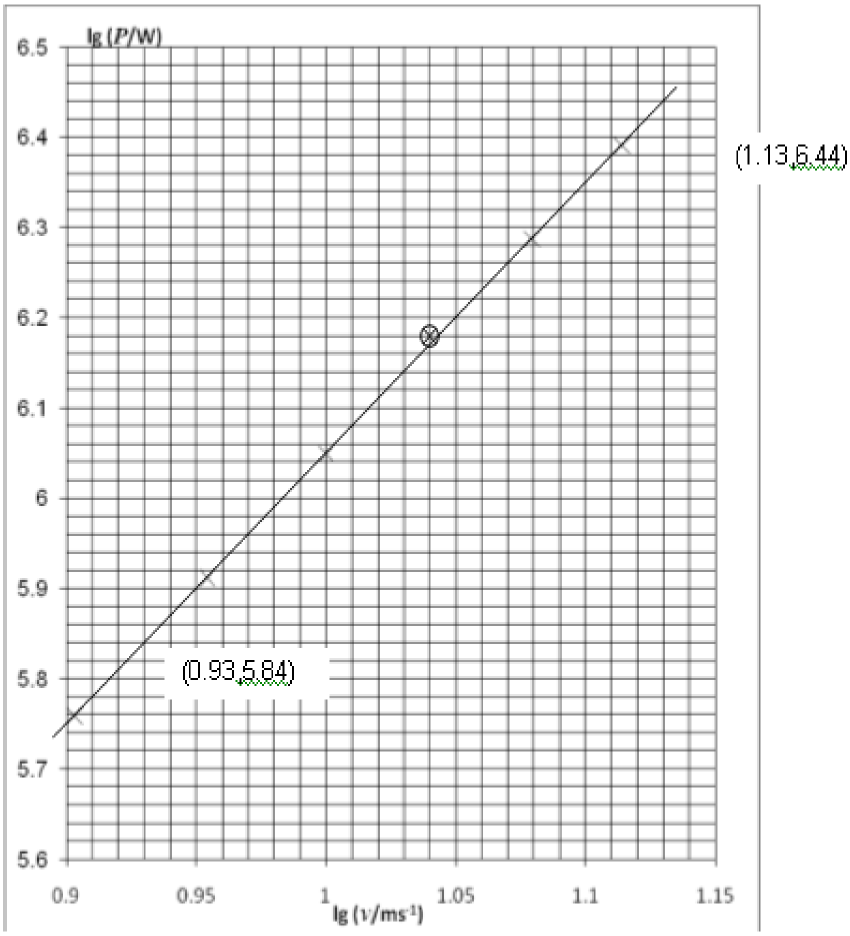
Qn	Suggested solution	Remarks
1(a)	Method 1: Using equations of motion Taking downwards to be positive: $v^2 = u^2 + 2as = 1.5^2 + 2(9.81)(0.65)$ $v = \pm 3.9 \text{ m s}^{-1}$ Final speed = **3.9 m s^{-1}** OR Method 2: Using conservation of energy Loss in GPE = Gain in KE $mgh = \frac{1}{2}m(v^2 - u^2)$ $v^2 = 2gh + u^2$ $v = 3.9 \text{ m s}^{-1}$ Final speed = 3.9 m s^{-1}	**[1] sub** **[1] ans**
MC		
(b)	 • **[1] Straight lines** from X to t_1 and t_1 to Y; and both with **negative gradients**. • **[1]** The two straight lines must be **parallel** and with **correct values (ecf)**.	
(c)	The **speed of the ball just after rebound is less than the speed just before impact**. Hence there is a loss/change in the kinetic energy of the system during the bounce. The bounce is **inelastic**.	**[1]** **[1]**
MC	State without reason, **[0]**. State with loss/change in kinetic energy **[1]**.	
(d)	Graph for downward motion - smaller gradient and duration is longer than t_1 Graph for upward motion - larger gradient and duration is shorter than $(t_2 - t_1)$	**[1]** **[1]**
2(a)	1. The **vector sum of** all external **forces** acting on a body must be **zero**. 2. The **vector sum of** all external **torques** acting on a body must be **zero**.	**[1]** **[1]**

2(b)(i)	Taking moments about contact point between feet and wall, Weight × a = F_h × H (70)(9.81)(0.20) = F_h(2.0) F_h = 68.67 N = **69 N**	**[1] sub** **[1] ans**
(ii)	Consider the vertical forces, Weight = F_v + 32 (70)(9.81) – 32 = F_v F_v = 654.7 N = **650 N**	**[1] sub** **[1] ans**
(iii)		**[1] correct general direction of *S*** **[1] passing through the point of inter-section between lines of action of *F* and *W***
3(a)(i)	Using Principle of Consevation of Linear Momentum 900 × 50 + 1500 × 20 = 900 × 25 + 1500 × v_B v_B = **35 m s^{-1}**	**[1] ans**
(ii)	 **[1]** Position and values of intial (A&B) and final (A only) momentum shown correctly. **[1]** Change of momentum takes place over same time interval. **[1]** Final momentum of B deduced correctly. (credit given if ans is given in (a)(ii))	**[1] correct shape i.e. graphs between *t* and (*t*+120) are curved correctly**
(b)	Apply $F = \dfrac{\Delta p}{\Delta t} = \dfrac{(22.5-45)\times10^3}{120\times10^{-3}}$ = **–1.9 × 10^5 N**	**[1] ans**
(c)	By undergoing deformation, **seat belts / air bags / crumple zones increase the time** for the body to be **brought to rest / change momentum**. According to Newton's second law of motion, as **change of momentum is the same**, increase in time will reduce the resultant force acting on the body.	**[2]**
MC	accept: same impulse, some energy converted to elastic PE of seat belt. Feature + longer time **[1]**; feature + same change in momentum **[1]**	

4(a)	**Simple harmonic motion** is defined as a periodic motion of a particle whose **acceleration is directly proportional to its displacement from the equilibrium position** and **this acceleration is always directed towards that position**.	**[1]** **[1]**
(b)(i)	$x_o = 22/2 =$ **11 mm**	**[1]-ans**
(ii)	$\omega = 2\pi f = 2\pi(4.5) =$ **28.3 rad s^{-1}**	**[1]-ans**
(iii)	$a = \omega^2 x_o = (28.32)^2\ (0.011) =$ **8.8 m s^{-2}**	**[1]-ans**
(iv)	$x = 11.0 - 8.0 =$ **3.0 mm**	**[1]-ans**
MC	accept no d.p., not accept 2.d.p.	
(v)	$v = \omega\sqrt{(x_o{}^2 - x^2)} = 28.3\sqrt{0.011^2 - 0.0030^2}$ = **0.30 m s^{-1}**	**[1]-sub** **[1]-ans**
5(a)(i)	Wavelength = 12 m $f = \dfrac{v}{\lambda} = \dfrac{1.25}{12}$ = 0.104 Hz	**[1] sub**
(ii)	Distance between the two buoys = (1.25)(2 × 60) = 150 m Phase difference = (150 / 12) × 2π = 25π rad which is equivalent to **π rad** OR Path difference = (1.25)(2 × 60) = 150 m = 12.5 λ Phase difference = π rad	**[1] distance** **[1] ans**
(b)(i)	Diffraction is the **spreading of waves through an aperture** or **around an obstacle.**	**[1]**
(ii)	From Fig. 5.3, separation of first order from central maximum for grating B = 0.70 m  $\tan\theta = \dfrac{0.70}{2.5} \Rightarrow \theta = 15.64°$ Using $\sin\theta = n\lambda p$ $\sin 15.64° = (1)(590 \times 10^{-9})p$ $\therefore$ $p =$ **4.57 x 10^5 m^{-1}** Note: can also use the 2nd and 3rd order separations: separation of 2nd order from central maximum = 1.6 m separation of 3rd order from central maximum = 3.5 m	**[1] working to find θ** **[1] sub** **[1] ans**
MC	Ecf within part	

5(b)(iii)	The **separation of the orders is observed to be smaller in the vertical spread**. This shows that the **angle of diffraction due to grating B is smaller**. Since $d \propto \dfrac{1}{\sin\theta}$ (from $d \sin\theta = n\lambda$), **slit spacing for diffraction grating B is larger** than that of diffraction grating A. OR The highest order that can be observed for any diffraction grating depends on the relationship $n \le \dfrac{d}{\lambda}$. Since there are **more orders observed in the vertical spread**, this implies that diffraction **grating B has a larger slit separation** than diffraction grating A,	**[1] reason** **[1] deductn**
(iv)	Any one of the following: - Approximately equal spacing of the diffraction fringes (or Equal spacing of fringes in the horizontal spread and the vertical spread) - More number of spots seen on the screen. (or Spacing between fringes decreases) - The intensity of higher order (2nd or 3rd order) fringes of the nylon mesh is approximately the same as that of the 1st order. - It would not be a sharp and distinct fringe pattern as the nylon does not have a sharp edge as that of a diffraction grating.	**[1]**
6(a)	It is the phenomenon whereby **electrons from a metal are emitted** when **electromagnetic radiation of sufficiently high frequency** is incident on the metal.	**[1]**
(b)(i)	From the graph, stopping potential is 0.70 V (not –0.70V). Hence, maximum kinetic energy of the photoelectrons = eV_s = $\mathbf{1.12 \times 10^{-19}}$ **J**	**[1]**
(ii)	$hf = \Phi + E_{k\,max} \rightarrow f = \dfrac{(2.06)(1.60\times10^{-19})+1.12\times10^{-19}}{6.63\times10^{-34}}$ $= \mathbf{6.66 \times 10^{14}}$ **Hz**	**[1] Sub** **[1] ans**
(iii)	For the photoelectrons, the saturated current $I = \dfrac{Q}{t} = \dfrac{Ne}{t}$ → No. of electrons emitted per second: $\dfrac{N}{t} = \dfrac{I}{e} = \dfrac{0.13\times10^{-6}}{1.60\times10^{-19}} = 8.13 \times 10^{11}\ s^{-1}$ Number of photons incident per second: $\dfrac{N_{photon}}{t} = (8.13 \times 10^{11})(8000) = 6.50 \times 10^{15}\ s^{-1}$ Intensity $= \dfrac{E}{tA} = \dfrac{N_{photon}(hf)}{tA} = \left(\dfrac{N_{photon}}{t}\right)\left(\dfrac{hf}{A}\right)$ $= (6.50 \times 10^{15})\dfrac{(6.63\times10^{-34})(6.66\times10^{14})}{1.0\times10^{-4}} = \mathbf{28.7\ W\ m^{-2}}$	**[1] No of electrons s^{-1}** **[1] No of photons s^{-1}** **[1] ans**
MC	Ecf within part	

6(b)(iv)	 **Fig. 1.1**	**[1]**
(v)	The negative p.d. creates a repulsion to the emitted photoelectrons causing less electrons to reach the collector. (effect) It denotes the fact that the electrons are emitted with a range of KE. (cause)	**[1]** **[1]**
7(a)(i)	A = 94, Z = 35	**[1]**
(ii)	Mass defect of U-235, m = (143)(1.00866) + (92)(1.00728) – (235.044) = 1.864 u Binding energy of U-235 = mc^2 = $(1.864)(1.66 \times 10^{-27})(3.00 \times 10^{8})^2$ = 2.785×10^{-10} J = **1741 MeV** OR 1.864 (934) = 1741 MeV	**[1] sub for *m*** **[1] working** **[1] ans**
MC	Ecf within part	
(iii)	**Neutron(s) is/are produced**	**[1]**
(b)(i)	High energy **electron**	**[1]**
(ii)	$\lambda = \dfrac{\ln 2}{28(365)(24)(3600)} = 7.85 \times 10^{-10}\ \text{s}^{-1}$ $A = \lambda N = \lambda N_o\, e^{-\lambda t} = (7.85 \times 10^{-10})(2.36 \times 10^{13})\ e^{-\frac{\ln 2}{28}(100)}$ = $\mathbf{1.56 \times 10^{3}\ s^{-1}}$	**[1] sub for λ in s^{-1}** **[1] ans**
8(a)	The generator produces **alternating current**. The information provided in Fig. 8.3 indicates **frequency** of 50 Hz which is irrelevant for direct current.	**[1]**
(b)	Upthrust on Hywind structure, W = weight of the sea water displaced = 1025 × 5300 × 9.81 = $\mathbf{5.33 \times 10^{7}}$ **N**	**[1] ans**
(c)(i)	The rotor blades exert a force on the wind to **change its momentum.** By Newton's 3rd law, there is an **equal and opposite force acting on the rotor blades.** The force on each blade causes a **moment** which results in a revolution of the rotor blade about the axis. OR There is force on blades by wind. The angled blades cause/provide a component of force in plane of rotation. The force on each blade causes a **moment** about the axis.	**[1]** **[1] N3L** **[1]**

8(c)(ii)	The **kinetic energy** of the **wind** is used to **do work in turning the coil** in the generator. The gear box coupled to the generator cause the coils in the generator to rotate and cut the magnetic flux inside the generator. The **cutting of the magnetic flux by the rotating coil** in the generator **produces electrical energy** through the effect of electromagnetic induction.	**[1]** **[1]**
(d)	Using points: (10.5, 1300000): $k = \dfrac{1300000}{10.5^3} = 1123 = 1120$ (11.5, 1700000): $k = \dfrac{1700000}{11.5^3} = 1118 = 1120$ (14.5, 3400000): $k = \dfrac{3400000}{14.5^3} = 1115 = 1120$ ***k* is approximately 1120 for all the 2 points tested.** Hence we can conclude that *k* is a constant.	**[1] working** **Any 2** **[1] reason**
(e)(i)1.	When v = 11 m s^{-1}, P = 1500000 W lg (11/m s^{-1}) = **1.04** , lg (1500000/W) = = **6.18**	**[1] correct plot**
2.		**[1] best fit line drawn**
(ii)	Using points from the graph: (0.93,5.84), (1.13,6.44) Gradient = $\dfrac{6.44 - 5.84}{1.13 - 0.93}$ = **3.0**	**[1] sub** **[1] ans**

8(e)(iii)	Given $P = kv^3$ **lg P = 3 lg v + lg k** where gradient of the line is 3. Since the experiment data shows a **straight line graph with gradient equals 3.0**, the relationship $P = kv^3$ is **valid.**	**[1] exp** **[1] comment with reason**
MC	ecf for comment	
(f)(i)	Kinetic energy of air incident per second, $P = \frac{1}{2}\rho A v^3$ $= \frac{1}{2}(1.2)\pi\left(\frac{82.4}{2}\right)^2(11.0)^3$ $= 4.26 \times 10^6$ W = **4.26 MW**	**[1] sub** **[1] ans**
(ii)	Overall efficiency $= \frac{\text{Power output}}{\text{Power input}} = \frac{1500000}{4.26 \times 10^6}$ = **0.352**	**[1] ans**
(g)	Wind speed which is excessively high leading to over current produced which will damage the generator. Rotor blades struck by lightning since they are the tallest point of the wind turbine and they have relatively pointed ends. Corrosion of the structure due to the salty environment. Power loss due to long distance transmission. Difficulty in maintenance as it is out in the open sea.	**[2] any 2**

JURONG JUNIOR COLLEGE
JC2 Preliminary Examination 2018

CANDIDATE NAME			
CLASS		INDEX NUMBER	

PHYSICS **9749/03**

Higher 2

Longer Structured Questions

10 September 2018

2 hours

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

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

Write your **name** and **class** in the spaces provided at the top of this page.

Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use paper clips, highlighters, glue or correction fluid.

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

Section A
Answer **all** questions.

Section B
Answer any **one** question.

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

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

For Examiner's Use	
1	
2	
3	
4	
5	
6	
7	
8	
9	
Total	

(This question paper consists of 26 printed pages)

Data

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

Formulae

uniformly accelerated motion	s	$= ut + \frac{1}{2}at^2$
	v^2	$= u^2 + 2as$
work done on/by a gas	W	$= p\,\Delta V$
hydrostatic pressure	p	$= \rho g h$
gravitational potential	ϕ	$= -\dfrac{Gm}{r}$
temperature	T/K	$= T/^{o}C + 273.15$
pressure of an ideal gas	p	$= \dfrac{1}{3}\dfrac{Nm}{V}\langle c^2 \rangle$
mean kinetic energy of a molecule of an ideal gas	E	$= \frac{3}{2}kT$
displacement of particle in s.h.m.	x	$= x_o \sin \omega t$
velocity of particle in s.h.m.	v	$= v_o \cos \omega t = \pm\, \omega\sqrt{(x_o^2 - x^2)}$
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	$= \dfrac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage,	x	$= x_o \sin \omega t$
magnetic flux density due to a long straight wire	B	$= \dfrac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	$= \dfrac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid	B	$= \mu_o n I$
radioactive decay	x	$= x_o \exp(-\lambda t)$
decay constant	λ	$= \dfrac{\ln 2}{t_{1/2}}$

Section A

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

1. In a simple pendulum experiment to determine the acceleration of free fall g, the following equation is used

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

The following measurements were obtained using a metre rule and stopwatch respectively.

Length of the pendulum: $l =$ (98.0 ± 0.1) cm

Average time of 10 oscillations: $t =$ (19.8 ± 0.2) s

(a) **(i)** The calculated acceleration of free fall g is 9.869 m s^{-2}.

Determine the acceleration of free fall with its associated uncertainty.

acceleration of free fall g = ... ± .... m s^{-2} [3]

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

Compare the accuracy and precision of the two sets of readings.

....

....

.... [1]

(b) Tempered glass screen protector is made of many atoms.

Estimate the number of atoms in a 0.5 mm thickness tempered glass screen protector for a mobile phone. Show your working and reasoning clearly.

number of atoms = ... [4]

2. In a bungee jump, a light elastic rope is used to attach a man to a bridge. The man has a mass of 80.0 kg while the rope has a natural length of 25.0 m and an elastic constant of 120 N m^{-1}. The man steps off the bridge and falls vertically downwards from rest. Assume that air resistance acting on the man is negligible.

(a) **(i)** Show that the extension of the rope is 6.54 m when the man is falling at maximum speed.

[1]

(ii) Determine the maximum speed of the man after he steps off the bridge.

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

(iii) Calculate the maximum kinetic energy of the man.

maximum kinetic energy = ... J [1]

(b) **(i)** Calculate the maximum extension of the elastic rope when the man is at the lowest point of his motion.

maximum extension = ... m [2]

(ii) Hence, or otherwise, determine the gravitational potential energy of the man on the bridge. Assume that gravitational potential energy of the man is zero at the lowest point of the man's motion.

gravitational potential energy = ... J [1]

(c) On Fig. 2, sketch three clearly-labelled graphs for the variation with downward displacement s of

(i) the gravitational potential energy of the man, (Label as **G**)

(ii) the elastic potential energy stored in the rope, and (Label as **E**)

(iii) the kinetic energy of the man. (Label as **K**)

Assume that gravitational potential energy of the man is zero at the lowest point of the man's motion. Take s = 0 m as the start point of motion.

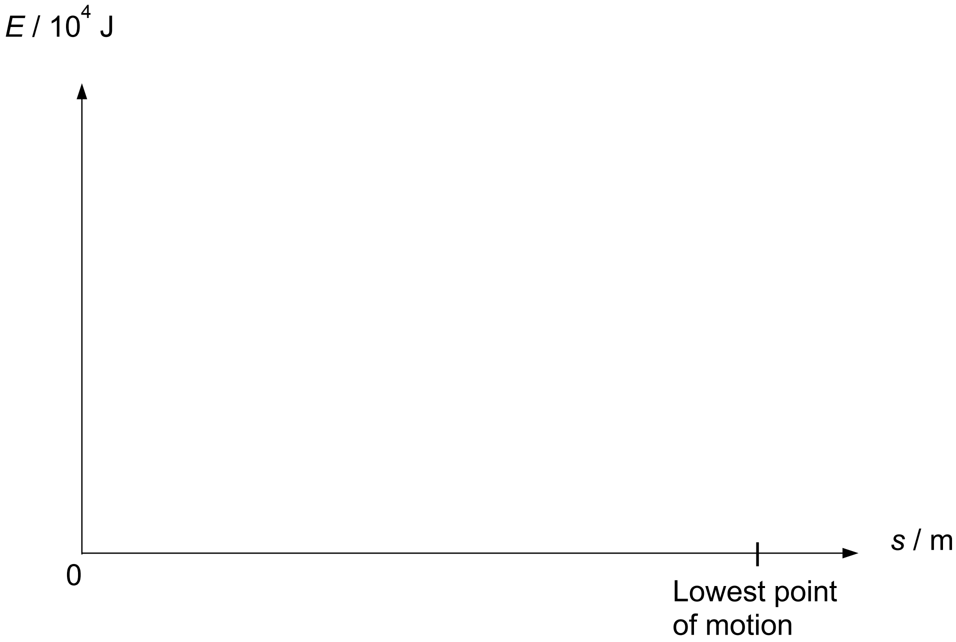


Fig. 2

[3]

3. **(a)** An elastic light cord has an unextended length of 13.0 cm. One end of the cord is attached to a fixed point C. A small mass of 0.50 kg is hung from the free end of the cord. The cord extends to a length of 14.8 cm as shown in Fig. 3.1.

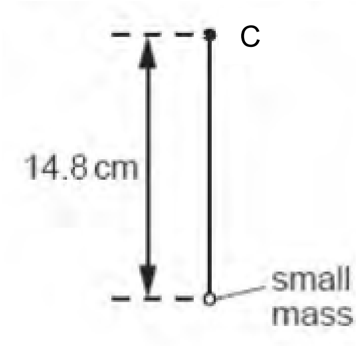


Fig. 3.1

(i) Determine the force constant k of the light cord.

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

(ii) The mass is now made to move at constant angular speed ω in a vertical plane about point C. When the cord is vertical and above C, its length is the unextended length of 13.0 cm, as shown in Fig. 3.2.

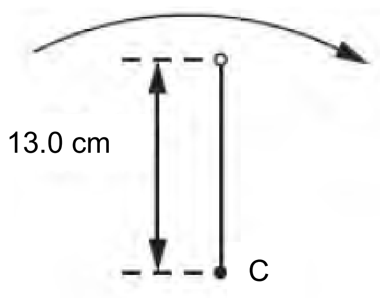


Fig. 3.2

Show that the angular speed ω of the mass is 8.7 rad s^{-1}.

[2]

(iii) The mass moves so that the cord is vertically below C, as shown in Fig. 3.3.

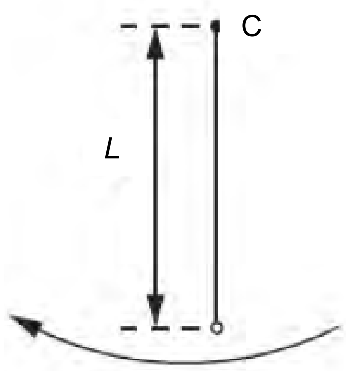


Fig. 3.3

Calculate the length *L* of the cord, assuming it obeys Hooke's law.

L = ______________ m [2]

(b) A mass m of 5.00 kg rests on the equator of the Earth as shown in Fig. 3.4. The Earth, assumed to be a perfect sphere, rotates about its axis with a period of 1.00 day. The surface of the Earth exerts a normal contact force N on the mass. The radius R of the Earth is 6.40 x 10^3 km.

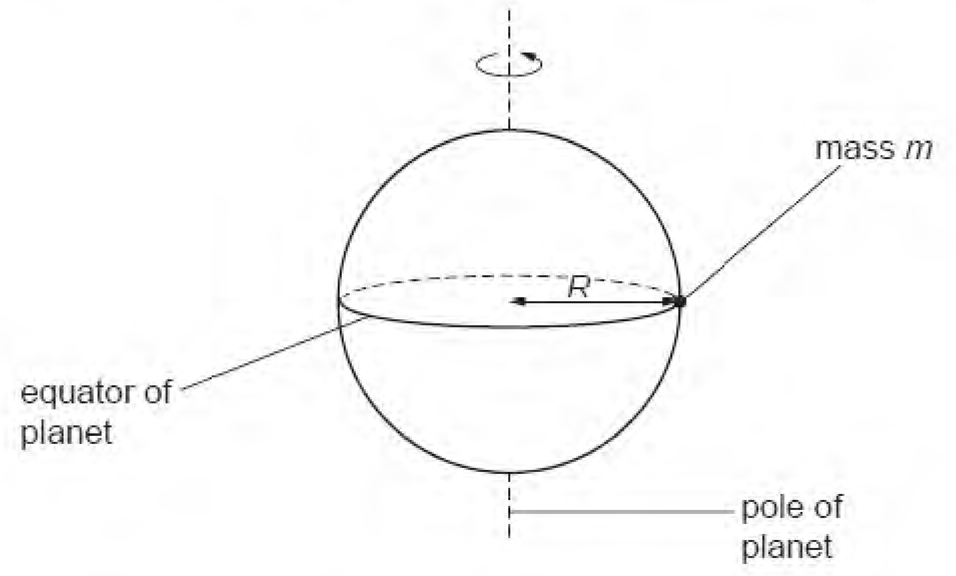


Fig. 3.4

(i) Calculate, for mass m,

1. the centripetal force F_C,

F_C = ... N [2]

2. the normal contact force N.

N = ... N [2]

(ii) Explain why the normal contact force N acting on the mass at the poles is different from the answer in **(b)(i)2.**

[2]

4. The variation of the gravitational potential ϕ with distance x from the centre of the Earth is shown in Fig. 4.1. The radius R of the Earth is 6.40×10^3 km.

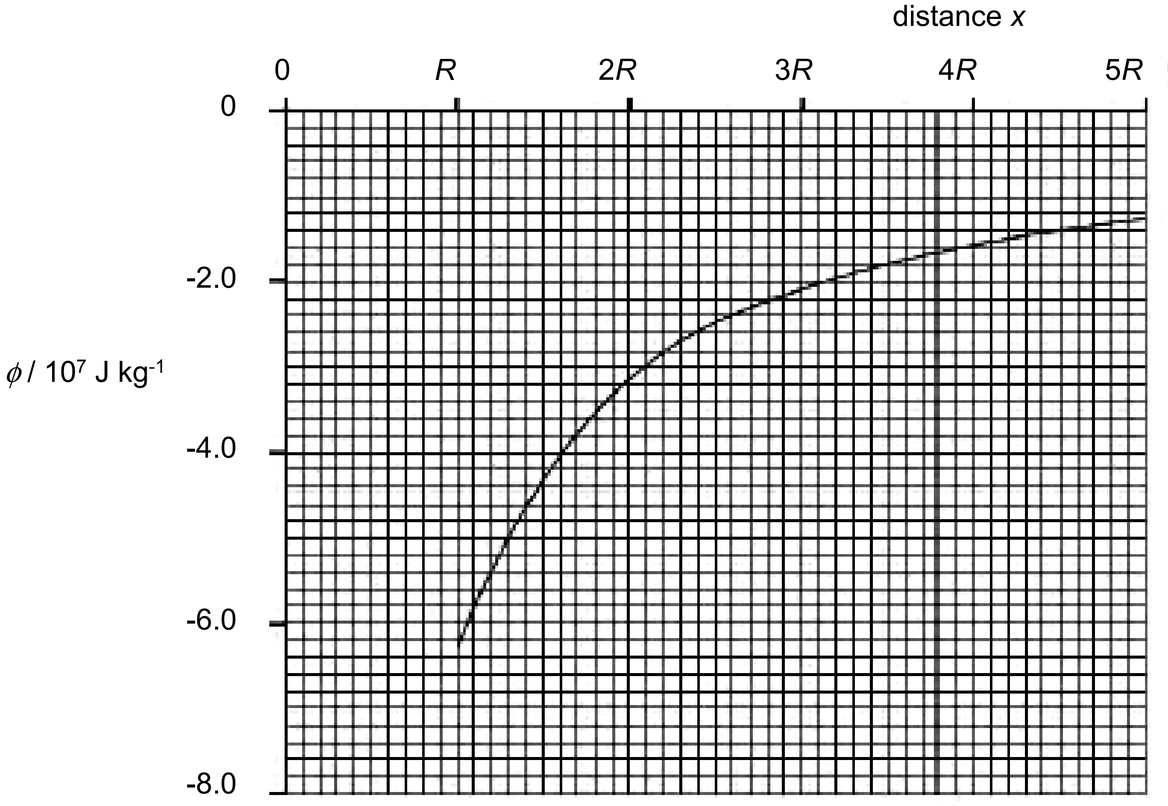


Fig. 4.1

(a) By considering the gravitational potential at the Earth's surface, determine a value for the mass of the Earth.

mass = ... kg [2]

(b) A meteorite is at rest at infinity. It travels from infinity towards the Earth.

(i) Calculate the speed of the meteorite when it is at a distance of R above the Earth's surface.

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

(ii) In practice, the Earth is not an isolated sphere because it is orbited by the Moon, as illustrated in Fig. 4.2.

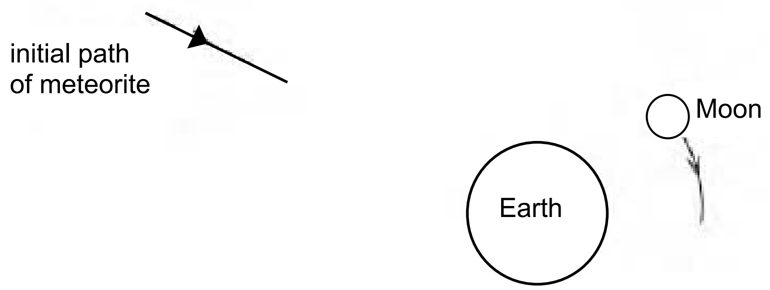


Fig. 4.2

The initial path of the meteorite is also shown.

Suggest two changes to the motion of the meteorite caused by the Moon.

....

....

....

.... [2]

5. **(a)** Define *electric field strength*.

[1]

(b) Electrons from a filament source enter a region between the parallel plates after being accelerated by an electric field. Fig. 5 below shows the electrons travelling horizontally at a speed of 2.50×10^7 m s^{-1} entering the pair of parallel plates.

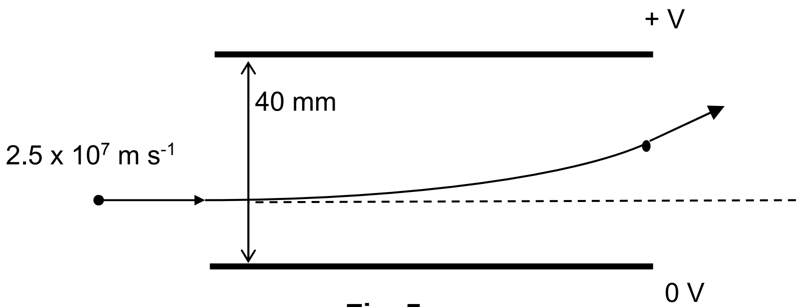


Fig. 5

(i) The electrons deviate by 30° on leaving the parallel plate of 80.0 mm long. The separation between the plates is 40.0 mm.

Calculate the time taken for the electrons to travel through the plates.

time = ... s [1]

(ii) Calculate the vertical component of the velocity when the electrons exit the parallel plates.

vertical component of velocity = ... $m\ s^{-1}$ [2]

(iii) Hence calculate the acceleration of the electrons.

acceleration = ... $m\ s^{-2}$ [1]

(iv) Calculate the potential difference *V* between the two plates.

V = ... V [2]

(v) If the plate separation is reduced, suggest how the answer to **(b)(ii)** is affected.

....

....

.... [1]

6. A small electric torch is powered by a single cell which supplies 1.6 J of energy per coulomb of charge passing through the cell. When the torch is switched on, the cell supplies a constant current of 0.50 A to bulb X. The potential difference across the bulb is 1.2 V.

(a) Show that the internal resistance, *r*, of the cell is 0.80 Ω.

[2]

(b) The bulb X is replaced by another bulb Y, which draws a current of 0.30 A. Calculate the potential difference across bulb Y.

potential difference = ... V [2]

(c) Calculate the power lost in the cell when connected to bulb Y.

power lost = ... W [2]

(d) When bulb Y is replaced by bulb Z, the power drawn from the cell is maximum. Determine the maximum current that can be drawn from the cell.

maximum current = ... A [2]

7. **(a)** A copper pipe has an internal diameter of 4.00 cm and an external diameter of 7.00 cm. The resistivity of copper is 1.68×10^{-8} Ω m.

Determine the resistance of 15.0 m of this pipe.

resistance = ... Ω [3]

(b) A number of resistors are connected to a 6.0 V cell in an electrical circuit as shown in Fig. 7.

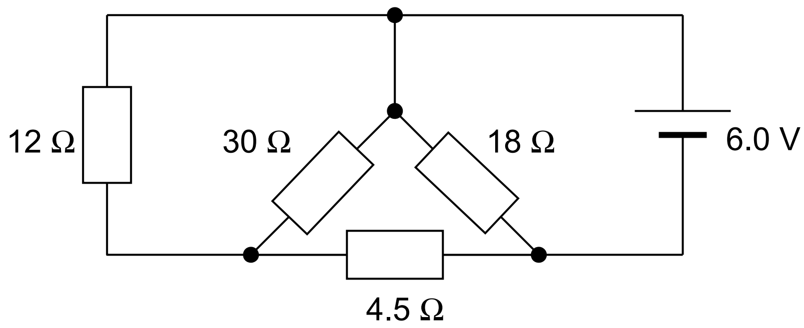


Fig. 7

With reference to Fig. 7,

(i) show that the equivalent resistance of the circuit is 7.6 Ω.

[1]

(ii) determine the current in the 18 Ω resistor.

current = ... A [1]

(iii) determine the power dissipated in the 4.5 Ω resistor.

power = ... W [3]

Section B

Answer **any one** question in this Section.

8. **(a)** **(i)** State two assumptions of the kinetic theory of gases.

1. ______________________________

____

2. ______________________________

______________________________ [2]

(ii) A sealed container holds a mixture of nitrogen-14 and helium-4 gas molecules at at temperature of 290 K.

1. Determine the average kinetic energy of a helium molecule.

average kinetic energy = ______________ J [2]

2. Explain whether it is possible for the mean square speed of the nitrogen molecules to be different from the helium molecules at the same temperature.

____

______________________________ [1]

(b) **(i)** State what is meant by the internal energy of a system.

____

____

______________________________ [1]

(ii) In Fig. 8.1 below, place a tick (√) against those changes where the internal energy of a system is increasing.

Water freezing at constant temperature	
A stone falling under gravity in a vacuum	
Water evaporating at constant temperature	
Stretching a wire at constant temperature.	

Fig. 8.1

[2]

(iii) A cylinder of gas at constant volume is placed under the sun so that its temperature rises.

Explain the changes to the internal energy of the gas.

[2]

(iv) The volume occupied by 1.00 mol of water at 100 ^oC is 1.87×10^{-5} m^3. When the water is vaporised at an atmospheric pressure of 1.03×10^5 Pa, the water vapour has a volume of 2.96×10^{-2} m^3.

The latent heat required to vaporise 1.00 mol of water at 100 ^oC and 1.03×10^5 Pa is 4.05×10^4 J.

Determine, for this change of state,

1. the work done on the system,

work done = ______________ J [2]

2. the increase in internal energy of the system.

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

(c) **(i)** A student states wrongly that temperature measures the amount of thermal energy in a body.

State and explain two observations that show why the statement is incorrect.

....

....

....

.... [2]

(ii) Some crushed ice at 0 °C is placed in a funnel together with an electric heater, as shown in Fig. 8.2 below.

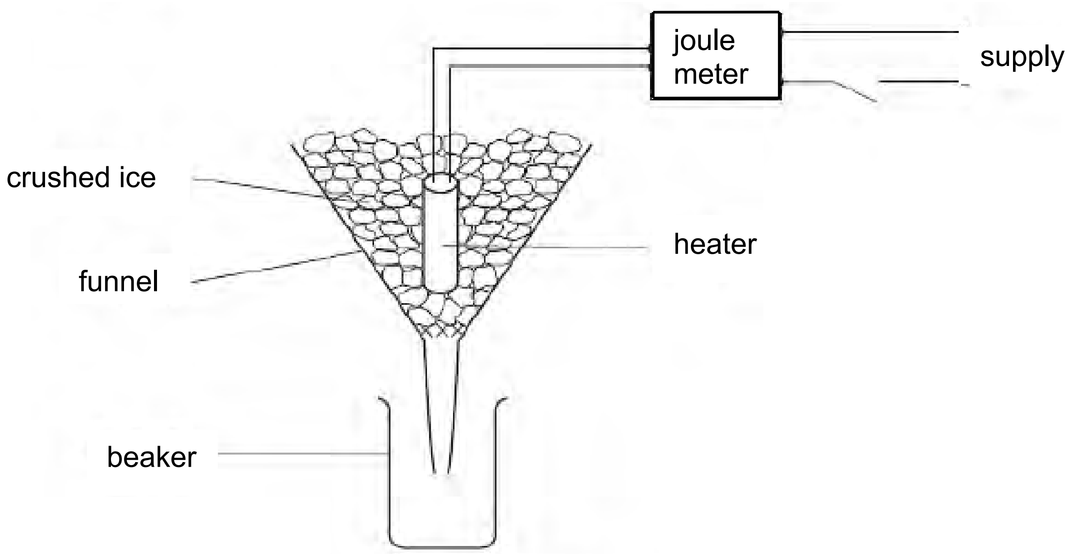


Fig. 8.2

The mass of water collected in the beaker in a measured interval of time is determined with the heater switched off. The mass is then found with the heater switched on. The energy supplied to the heater is also measured.

For both measurements of the mass, water is not collected until melting occurs at a constant rate.

The data shown in Fig. 8.3 are obtained.

	mass of water / g	energy supplied to heater / kJ	time interval / min
heater switched off	8.3	0	5.0
heater switched on	64.7	18	5.0

Fig. 8.3

1. State why it is necessary to determine the mass of water with the heater switched off.

[1]

2. Suggest how it can be determined that the ice is melting at a constant rate.

[1]

3. Calculate a value for the specific latent heat of fusion of ice.

specific latent heat = ... $kJ\ kg^{-1}$ [2]

9. **(a)** Define *magnetic flux density*.

[2]

(b) Fig. 9 below shows a current carried by a square coil GHJK of 500 turns and side 5.0 cm. The coil is suspended vertically in a uniform horizontal magnetic field of flux density $B = 2.0 \times 10^{-4}$ T. The plane of the coil is at angle $\theta = 35°$ to B.

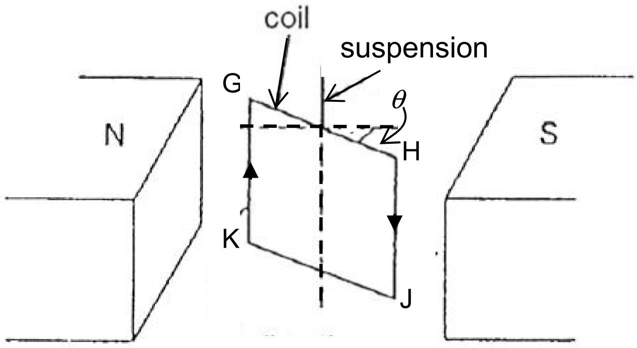


Fig. 9

(i) Indicate, in Fig. 9, the direction of the magnetic force acting on the side JK of the coil. [1]

(ii) The current in coil GHJK is 0.40 A. Calculate the magnetic force acting on side JK of the coil.

magnetic force = ... N [2]

(iii) Calculate the torque acting on the coil GHJK.

torque = ... N m [3]

(c) State the *laws of electromagnetic induction*.

....

....

....

....

.... [2]

(d) The coil GHJK in Fig. 9 is disconnected from its e.m.f. source. The plane of the coil is at angle $\theta = 35°$ to B.

(i) Calculate the magnetic flux linkage through the coil.

magnetic flux linkage = ... Wb [2]

(ii) The coil is then rotated at 100 Hz about the vertical suspension.

1. Calculate the magnitude of the maximum induced e.m.f. in the coil.

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

2. The coil is now acting as an AC generator. It is connected to a heater of resistance 5.0 Ω. Assuming the coil has negligible resistance, calculate the power generated in the heater.

power = ... W [3]

3. If the heater in **(d)(ii)2** is also connected in series with an ideal diode, determine the power generated in the heater.

power = ... W [2]

End of Paper

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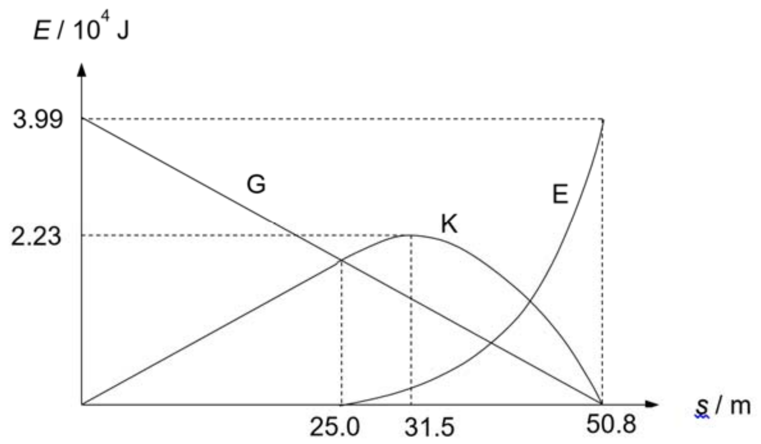
Qn	Suggested solution	Remarks
1(a)(i)	$\frac{\Delta g}{g} = \frac{0.1}{98.0} + \frac{2(0.2)}{19.8} = 0.0212$ $\Delta g = 0.0212 \times 9.869 = 0.2$ (1 s.f.) $g = (9.9 \pm 0.2)$ m s^{-2}	**[1] sub** **[1]** Δg to 1 s.f. **[1] ans**
(a)(ii)	$g = (9.9 \pm 0.2)$ m s^{-2} is more accurate but less precise. $g = (11.15 \pm 0.02)$ m s^{-2} is less accurate but more precise.	**[1]**
(b)	An estimated area of a mobile phone screen is about 6 cm by 11 cm. (Accept 5 to 12 cm by 10 to 19 cm. ±1 cm at both ends) Volume of tempered glass screen protector, $V = 0.06 \times 0.11 \times 0.0005 = 3.30 \times 10^{-6}$ m^3 (smallest = 2.5×10^{-6} m^3, largest = 1.14×10^{-5} m^3) The diameter of 1 atom is approximately 0.1 nm. Therefore, the estimated volume of a spherical atom, $V_{atom} = \frac{4}{3}\pi(\frac{d}{2})^3$ $V_{atom} = \frac{4}{3}\pi(\frac{0.1\times10^{-9}}{2})^3 = 5.23\times10^{-31}\,\text{m}^3$ Therefore, the total number of atoms in the screen protector, $n = \frac{V}{V_{atom}} = \frac{3.30\times10^{-6}}{5.23\times10^{-31}} = 6.31\times10^{24}$ (smallest = 5.97×10^{23}, largest = 2.18×10^{25})	**[1] Vol of screen protector** **[1] Vol of an atom, accept d^3** **[1] sub** **[1] No. of atoms**
2(a)(i)	Man is moving at maximum speed when resultant force acting on him is zero, hence $mg = kx$ where x is the extension of the rope at that point. $x = \frac{mg}{k} = \frac{(80.0)(9.81)}{120}$ = 6.54 m	**[1] sub**
(a)(ii)	Applying Principle of Conservation of Energy to when the man is at maximum speed, Loss of GPE = Gain in KE + Gain in Elastic PE $mg(l+x) = \frac{1}{2}mv_{max}^2 + \frac{1}{2}kx^2$ $(80.0)(9.81)(25.0+6.54) = \frac{1}{2}(80.0)v_{max}^2 + \frac{1}{2}(120)(6.54)^2$ v_{max} = 23.6 m s^{-1}	**[1] sub** **[1] ans**
(a)(iii)	Maximum KE = $\frac{1}{2}(80.0)v_{max}^2 = \frac{1}{2}(80.0)(23.6)^2$ = 2.23×10^4 J	**[1]**

Qn	Suggested solution	Remarks
(b)(i)	Applying Principle of Conservation of Energy at the lowest point, Loss of GPE = Gain in Elastic PE $mg\left(l+x_{max}\right)=\frac{1}{2}kx^2_{max}$ $(80.0)(9.81)\left(25.0+x_{max}\right)=\frac{1}{2}(120)x^2_{max}$ x_{max} = 25.8 m	**[1] sub** **[1] ans**
(b)(ii)	GPE = $mg\left(l+x_{max}\right)$ = (80.0)((9.81)(25.0 + 25.8) = 3.99 x 10^4 J	**[1]**
MC		
(c) **(i)** **(ii)** **(iii)**		**[1] G with values** **[1] E with values** **[1] K with values**
3(a)(i)	$mg=kx$ $(0.5)(9.81)=k(0.148-0.13)$ $k=$ 272.5 ≈ 273 N m^{-1}	**[1] ans**
(ii)	Above C, the weight of mass provides the centripetal force. $mg=mr\omega^2$ $9.81=0.13\omega^2$ $\omega=\sqrt{\frac{9.81}{0.13}}=8.687\approx 8.7$ rad s^{-1}	**[1] state** **[1] sub**
(iii)	$T-mg=mr\omega^2$ $(272.5)(x)-(0.50)9.81=(0.50)(0.13+x)(8.7)^2$ $234.655x=9.82485$ $x=$ 0.0418 m $L=0.13+0.0418=0.172$ m	**[1] sub** **[1] ans**
(b)(i)1.	$F_c=mr\omega^2$ $=(5)(6.4\times10^6)\left(\frac{2\pi}{(24)(3600)}\right)^2$ $=0.169$ N	**[1] sub** **[1] ans**

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Qn	Suggested solution	Remarks
2.	$N = W - F_c$ $N = (5)(9.81) - 0.169$ $= 48.9$ N	**[1] sub** **[1] ans**
(ii)	At the **poles,** the mass is **not moving in a circle**. Hence **normal contact force equals gravitational force**. ($N = F_G$) *[At the equator, some of the gravitational force is used to provide the centripetal force to move the mass in a circle. ($N = F_G - F_c$)]*	**[1]** **[1]**
4(a)	On the surface of the Earth, $\phi = -6.2\times10^{7}$ J kg^{-1} $\phi = -\frac{(6.67\times10^{-11})M}{6.4\times10^{6}} = -6.2\times10^{7}$ $M = 5.95\times10^{24}$ kg	**[1] Φ** **[1] ans**
(b)(i)	At distance R above the Earth's surface, $x = 2R$ $\phi = -3.2\times10^{7}$ J kg^{-1} By conservation of energy, U loss $= KE$ gain $m\left[0-(-3.2\times10^{7})\right] = \frac{1}{2}mv^2$ $v = 8000$ m s^{-1}	**[1] Φ** **[1] sub** **[1] ans**
(ii)	speed / velocity / acceleration would be greater. Deviates / bends from straight path	**[1]** **[1]**
5(a)	Electric field strength at a point is defined as the **electric force per unit positive charge** exerted on a **small charge** placed at that point.	**[1]**
(b) (i)	Time = $\frac{80 \times 10^{-3}}{2.50 \times 10^{7}} = 3.2 \times 10^{-9}$ s	**[1] ans**
(ii)	tan 30º = $\frac{V_y}{2.50 \times 10^{7}}$ V_y = tan 30º x 2.5 x 10^7 = 1.44 x 10^7 ms^{-1}	**[1] sub** **[1] ans**
(iii)	Acceleration = $\frac{V_y}{t} = \frac{(1.44\times10^{7})}{3.2\times10^{-9}}$ = 4.5 x 10^{15} ms^{-2}	**[1] ans**
(iv)	$a = \frac{eE}{m} = \frac{e(V/d)}{m}$ $V = \frac{adm}{e} = \frac{(4.41\times10^{15})(40\times10^{-3})(9.11\times10^{-31})}{1.6\times10^{-19}}$ = 1.02 x 10^3 V	**[1] sub** **[1] ans**

Qn	Suggested solution	Remarks
(v)	With the plate separation reduced, the electric force experienced by the charge is greater and hence the **acceleration due to the force would increase**. Therefore the vertical component of the velocity calculated **would be greater**.	
6(a)	1.6 J of energy per coulomb means the cell's emf is 1.6 V. This means that the p.d. across the internal resistor is **1.6 – 1.2 = 0.4 V.** Hence the resistance across the internal resistor is **0.4 / 0.5** = 0.8 Ω (shown)	**[1] working** **[1] working**
(b)	p.d across the bulb Y = $E - Ir$ = 1.6 – (0.3)(0.8) = 1.36 V	**[1] sub** **[1] ans**
(c)	When connected to bulb Y, Total input power = EI = 1.6 x 0.3 = 0.48 W Output power = VI = 1.36 x 0.3 = 0.408W Power lost = 0.072 W Or Power dissipated in internal resistance = I^2r= (0.3^2)(0.8) = 0.072 W	**[1] working** **[1] ans**
(d)	Maximum power drawn occurs when $R_Z = r$ (maximum power theorem) Using $E = I\,(R+r)$ 1.6 = I (0.8+0.8) I = 1 A	**[1] working** **[1] ans**
7(a)	$\mathrm{R} = \dfrac{\rho \mathrm{L}}{\mathrm{A}}$ $= \dfrac{1.68\times10^{-8}\times15.0}{\pi(0.07^2-0.04^2)/4}$ **=** 2.52 x 10^{-7} Ω m^2 ÷ 2.59 x 10^{-3} m^2 = 9.73 × 10^{-5} Ω	**[1] exp for area** **[1] sub** **[1] ans**
(b)(i)	$\mathrm{R} = \left\{\left[\left(\dfrac{1}{30}+\dfrac{1}{12}\right)^{-1}+4.5\right]^{-1}+\dfrac{1}{18}\right\}^{-1}$ = 7.6 Ω	**[1] working**
(ii)	Current in 18 Ω, = Emf ÷ 18 Ω = 6.0 ÷ 18 = 0.33 A	**[1] ans**

Qn	Suggested solution	Remarks
(iii)	Total current = Emf ÷ Total resistance, R = 6 V ÷ 7.6 Ω = 0.79 A Current through 4.5 Ω = 0.79 A– 0.33 A = 0.46 A Power dissipated in 4.5 Ω = I^2 R {or V^2/R} = $0.46^2 \times 4.5$ = 0.95 W	**[1], total current** **[1], current through** 4.5 Ω **[1], ans**
8(a)(i)	1. Any gas is made up of very **large number** of molecules. 2. The gas molecules are in **continuous random motion.** 3. The **volume** of the **gas molecules** is **negligible** compared to the volume of the container. 4. There are **no intermolecular forces** between molecules except during collisions between molecules. 5. The collision between gas molecules and between gas molecules and the wall of the container is **elastic.** 6. The **duration of collisions** is **negligible** compared with the time interval between collisions.	**[1]** **[1]** **Any 2**
(ii)1.	$E = \frac{3}{2}kT = \frac{3}{2}(1.38\times10^{-23})(290)$ $= 6.00\times10^{-21}$ J	[1] sub [1] ans
2.	**It is possible** because **their molecular masses are different**	**[1]**
(b)(i)	**Internal energy** of a system is the **sum** of a **random distribution of kinetic and potential energies** associated with the **molecules** of the system.	
(ii)	Water freezing at constant temperature: A stone falling under gravity in a vacuum: Water evaporating at constant temperature: √ Stretching a wire at constant temperature: √	**[-1] for each error**
(iii)	The **random kinetic energy of the gas molecules increases** as the temperature increases. **The potential energy of the molecules remains unchanged** since the volume is constant. → **Internal energy increases**	**[1]** **[1]**
(iv)1.	W = 1.03 x 10^5(1.87 x 10^{-5} – 2.96 x 10^{-2}) = – 3050 J	**[1] sub** **[1] ans**
2.	$U = Q + W$ $= 4.05\times10^4 - 3050$ $= 3.75\times10^4$ J	[1] sub [1] ans

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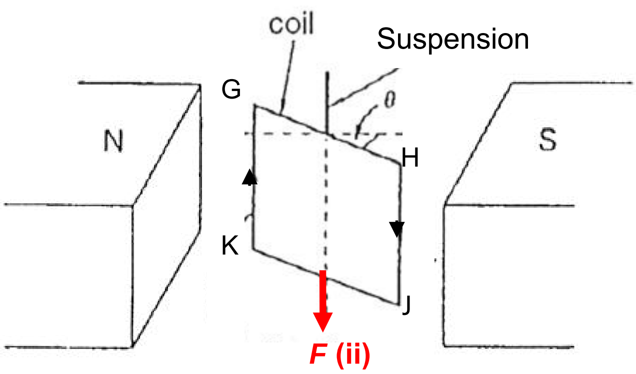
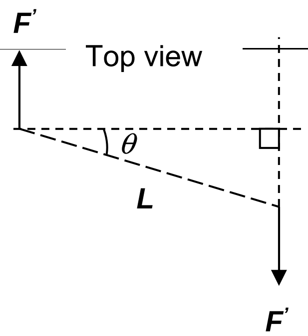
Qn	Suggested solution	Remarks
(c)(i)	• Two bodies of different masses at same temperature → same material would have different amount of internal energy • When a substance undergoes a change of state → the temperature remains unchanged although thermal energy is supplied. Temperature shows the direction of heat transfer → always from high to low temperature	[1] [1] Any 2
(ii)1.	To make allowance for heat gain from the atmosphere	[1]
2.	**Constant mass of water collected per minute in the beaker**	[1]
3.	mass melted by heater in 5 minutes = 64.7 – 8.3 = 56.4 g $56.4 \times 10^{-3}\,(L) = 18$ L = **319 kJ kg $^{-1}$**	 [1] sub [1] ans
MC	Use of m = 64.7, giving L = 278 kJ kg^{-1} no marks; Use of m = 48.1, giving L = 374 kJ kg^{-1} 1 mark	
9(a)	**Magnetic flux density** is defined as the **magnetic force per unit length per unit current** acting on **a straight conductor** placed **perpendicular** to the magnetic field.	[2]
(b)(i)		[1] – ans
(ii)	$F = NBIL \sin\theta = (500)(2.0 \times 10^{-4})(0.40)(5.0 \times 10^{-2}) \sin 35°$ $= \mathbf{1.15 \times 10^{-3}\ N}$	[1] - sub [1] - ans
(iii)	Torque = $NBIA \cos\theta$ $= (500)(2.0 \times 10^{-4})(0.40)(5.0 \times 10^{-2})^2 \cos 35°$ $= \mathbf{8.19 \times 10^{-5}\ N\ m}$ OR Torque = $\boldsymbol{F'd} = (NBIL)\,(L \cos\theta)$ 	[1] – eqn [1] - sub [1] – ans
(c)	**Faraday's law** states that the **magnitude** of the **induced e.m.f.** in a coil is **proportional** to the **rate of change of magnetic flux linkage through that coil**. **Lenz's law** states that the **polarity** of the **induced e.m.f. is such that it tends to produce a current with effects that oppose the change** causing it.	[1] [1]

Qn	Suggested solution	Remarks
(d)(i)	$\Phi = NBA \sin\theta = (500)(2.0 \times 10^{-4})(5.0 \times 10^{-2})^2 \sin 35°$ $= \mathbf{1.43 \times 10^{-4}\ Wb}$	**[1] - sub** **[1] - ans**
(ii)1.	$\varepsilon_{max} = \omega NBA = 2\pi f\ NBA$ $= 2\pi(100)(500)(2.0 \times 10^{-4})(5.0 \times 10^{-2})^2$ $= \mathbf{0.157\ V}$ OR $\Phi = \Phi_o \sin \omega t \rightarrow \varepsilon = \frac{d\Phi}{dt} = \omega\Phi_o \cos \omega t$ $\rightarrow \varepsilon_{max} = \omega\Phi_o = \omega NBA$	**[1] – exp** **[1] - sub** **[1] - ans**
2.	$V_{rms} = \frac{V_o}{\sqrt{2}} = \frac{0.157}{\sqrt{2}} = 0.111\ V$ $\langle P \rangle = \frac{V_{rms}^2}{R} = \frac{0.111^2}{5.0}$ $= \mathbf{2.46 \times 10^{-3}\ W}$ OR $P_o = \frac{V_o^2}{R} = \frac{0.157^2}{5.0} = 4.93 \times 10^{-3}\ W$ $\langle P \rangle = \frac{1}{2} P_o = \frac{1}{2}(4.93 \times 10^{-3}) = 2.46 \times 10^{-3}\ W$	**[1] - V_{rms} value** **[1] – sub** **[1] - ans**
3.	With diode, $\langle P \rangle = \frac{1}{2}(2.46 \times 10^{-3}) = \mathbf{1.23 \times 10^{-3}\ W}$ OR $V_{rms} = \frac{V_o}{2} = \frac{0.157}{2} = 0.0785\ V$ $\langle P \rangle = \frac{V_{rms}^2}{R} = \frac{0.0785^2}{5.0}$ $= \mathbf{1.23 \times 10^{-3}\ W}$	**[1] – working** **[1] – ans**