Class	Index Number	Name
17S		

ST. ANDREW'S JUNIOR COLLEGE
JC 2 2018
Preliminary Examination

PHYSICS, Higher 2 **9749/01**

Paper 1 Multiple Choice **18th September 2018**
1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

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

There are **thirty** questions in 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.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

For Examiner's Use	
Total	**/ 30**

This document consists of **14** printed pages including this page.

Data

speed of light in free space,	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space,	$\mu_o = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	$\varepsilon_o = 8.85 \times 10^{-12}$ 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,	$\phi = -\dfrac{Gm}{r}$
temperature,	$T/\text{K} = T/°\text{C} + 273.15$
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,	$E = \dfrac{3}{2}kT$
displacement of particle in s.h.m.,	$x = x_o \sin \omega t$
velocity of particle in s.h.m.,	$v = v_0 \cos \omega t$
	$v = \pm\omega\sqrt{x_0^2 - x^2}$
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,	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage,	$x = x_o \sin \omega t$
magnetic flux density due to a long straight wire,	$B = \dfrac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil,	$B = \dfrac{\mu_0 N I}{2r}$
magnetic flux density due to a long solenoid,	$B = \mu_0 n I$
radioactive decay,	$x = x_o \exp(-\lambda t)$
decay constant,	$\lambda = \dfrac{\ln 2}{t_{1/2}}$

1 Which of the following correctly expresses the volt in terms of SI base units?

A kg m^2 s^{-3} A^{-1} **B** kg m^2 s^{-1} A^{-1}

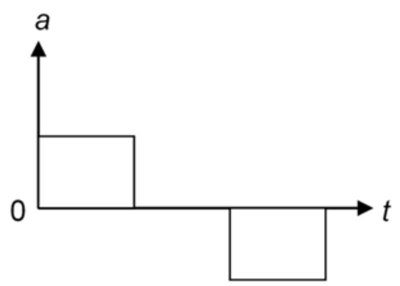
C W A^{-1} **D** A Ω

2 In a simple electrical circuit, the potential difference across a resistor is measured as (3.20 ± 0.01) V. The resistor is marked as having a value of 6.3 Ω ± 5 %.

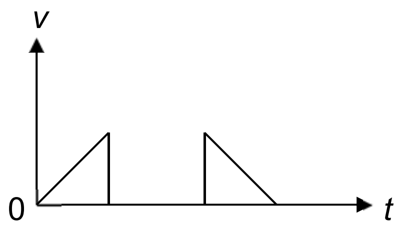
If these values were used to calculate the power dissipated in the resistor, what would be the percentage uncertainty in the value obtained?

A 5.3 % **B** 5.6 % **C** 6.0 % **D** 6.3 %

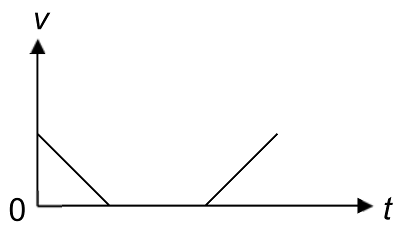
3 A car is accelerated from rest following the acceleration-time graph shown below. Which graph shows the variation of velocity of the car with time?



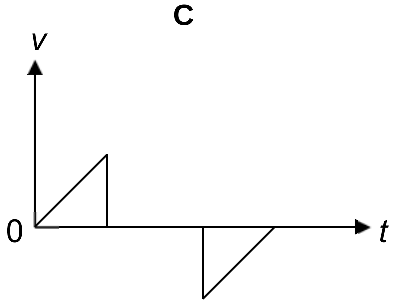
A



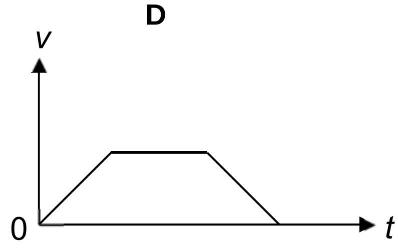
B



C

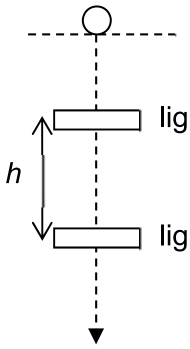


D



4 To determine the acceleration of free fall, a steel ball is dropped above two light gates as shown.

The ball passes light gate 1 and 2 at times t_1 and t_2 after release.



What is the acceleration of free fall?

A $\dfrac{2h}{(t_2 - t_1)}$

B $\dfrac{2h}{(t_2 - t_1)^2}$

C $\dfrac{2h}{(t_2^2 - t_1^2)}$

D $\dfrac{2h}{\left(\dfrac{t_2 + t_1}{2}\right)^2}$

5 A tractor of mass 3500 kg pulls a trailer of mass 1500 kg. The total resistance to motion has a constant value of 5000 N. One quarter of this resistance acts on the trailer.

When they are moving with an acceleration of 1.0 m s^{-2}, what is the force exerted on the tractor by the trailer?

A 1500 N **B** 2750 N **C** 5250 N **D** 8000 N

6 A proton (mass 1u) travelling with velocity +0.100 *c* collides elastically head-on with a helium nucleus (mass 4u) travelling with speed 0.050 *c* as shown below.

What are the velocities of each particle after the collision?

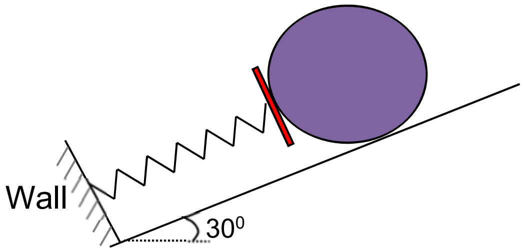
	proton	helium nucleus
A	-0.140 *c*	+0.010 *c*
B	+0.140 *c*	+0.010 *c*
C	+0.233 *c*	-0.083 *c*
D	-0.233 *c*	+0.083 *c*

7 In the Pixar movie, *Up*, an old man lifted his house using about 20000 helium balloons. Assuming that the average volume of each balloon used is 0.17 m^3, determine the maximum weight of the old man's house.

(density of air = 1.2 kg m^{-3}, density of helium = 0.18 kg m^{-3})

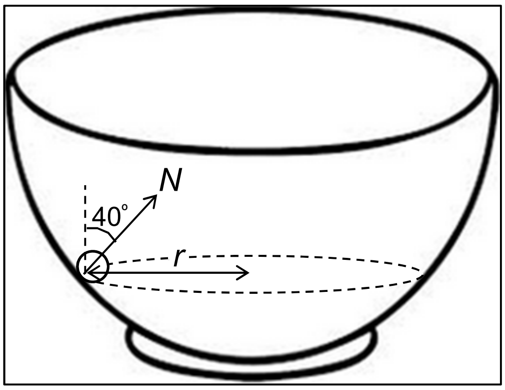
A 20000 N
B 34000 N
C 40000 N
D 46000 N

8 A sphere of mass 3.00 kg rests on a frictionless slope inclined at 30^0 above the horizontal as shown below. The spring constant is 500 N m^{-1}. Determine the compression of the spring.



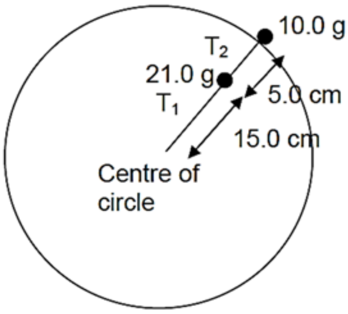
A 7.67 mm **B** 29.4 mm **C** 34.3 mm **D** 51.0 mm

9 A small glass marble is moving in a horizontal circle round the inside surface of a smooth bowl. It is observed to make 10 complete rounds in 8 s. The normal reaction *N* acting on the marble inclined at 40° to the vertical as shown. What is the radius *r* of the horizontal circle?



A 0.070 m **B** 0.090 m
C 0.11 m **D** 0.13 m

10 Two blocks of mass 10.0 g and 21.0 g are tied together and performing a uniform horizontal circular motion on a smooth table, at an angular speed of 6.28 rad s^{-1}, as shown below.



Tension T_1 is the tension in the string connecting the 21.0 g mass to the centre and T_2, the tension in the string connecting the 10.0 g mass to the 21.0 g mass. What is the ratio T_1 to T_2?

A 1.0
B 1.6
C 2.1
D 2.6

11 A kinetic theory formula relating the pressure p and the volume V of the gas to the mean-square speed $<c^2>$ of its molecules is

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

In this formula, what does the product Nm represent?

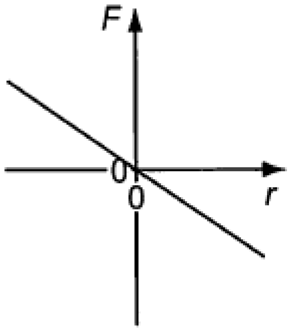
A the mass of gas present in volume V
B the number of molecules in unit volume of the gas
C the total number of molecules in one mole of gas
D the total number of molecules present in volume V

12 The temperature of a hot liquid in a container of negligible heat capacity falls at a rate of 3 K per minute just before it begins to solidify. The temperature then remains steady for 15 minutes by which time the liquid has all solidified.

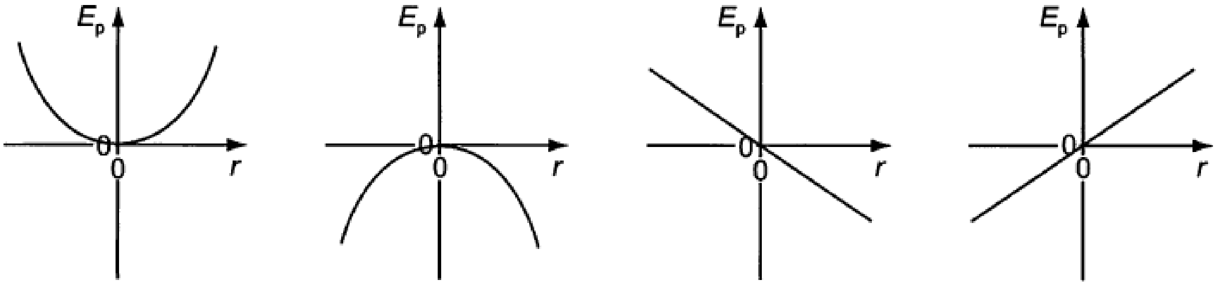
What is the value of the ratio $\frac{\text{specific heat capacity of liquid}}{\text{specific latent heat of fusion}}$?

A $\frac{1}{45}$ K^{-1} **B** $\frac{1}{5}$ K^{-1}
C 5 K^{-1} **D** 45 K^{-1}

13 A particle is moving such that the force F on it changes with the distance r from a fixed point as shown.



Which graph shows the relationship between the potential energy E_p of the particle and the distance r?



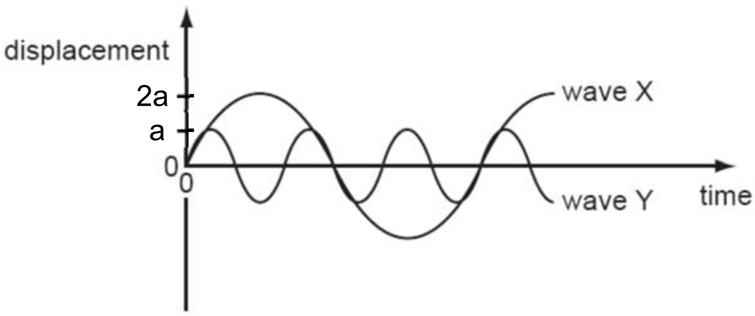
14 A particle oscillates with simple harmonic motion along a line with a maximum speed v_0.

When the displacement of the particle is half of its amplitude, its speed is

A $\frac{1}{4}v_0$ **B** $\frac{1}{2}v_0$ **C** $\frac{3}{4}v_0$ **D** $\frac{\sqrt{3}}{2}v_0$

15 The intensity of a progressive wave, besides being dependent on the amplitude of the wave, is also proportional to the square of the frequency.

The diagram shows two waves X and Y.

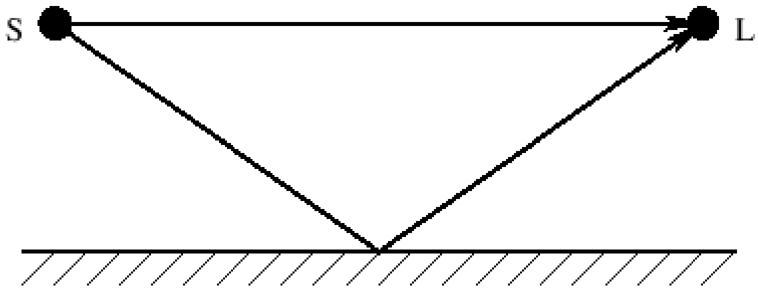


The intensity of wave X is I_0.

What is the intensity of wave Y?

A 0.028 I_0 **B** 0.11 I_0 **C** 0.44 I_0 **D** 2.25 I_0

16 A loudspeaker at position S emits sound of a single frequency. The sound travels to Leo who is at position L, both through a straight path and after reflection from a wall as shown.



As Leo walks directly towards the wall, the sound alternates between loud and soft. Which of the following changes would result in an increase in the distance between loud and soft sounds?

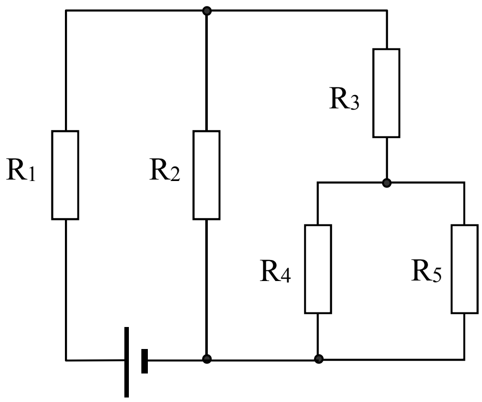
A Increase the frequency emitted by the loudspeaker.

B Move the loudspeaker closer to the wall.

C Move the loudspeaker towards L.

D Increase the loudness of the sound emitted by the loudspeaker.

17 Five identical resistors are connected to a dry cell of negligible internal resistance as shown below.



Which resistor dissipates the most power?

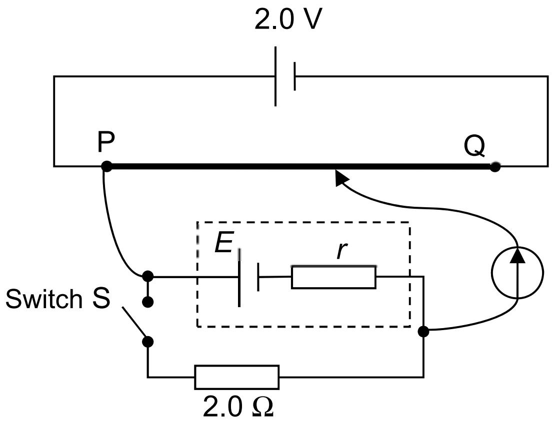
A R_1

B R_2

C R_3

D R_4

18 The diagram below shows a potentiometer circuit used to determine the internal resistance *r* of a cell of e.m.f. *E*. The driver cell has an e.m.f. of 2.0 V with negligible internal resistance and the resistance wire PQ is 1.0 m long. The cell is connected in parallel with a resistor of 2.0 Ω. When the switch is open, the balance length is 0.70 m and when the switch is closed, the balance length is 0.50 m. Determine *r*.



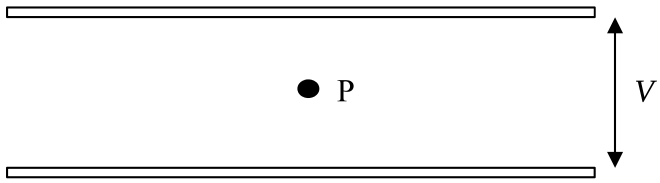
A 0.15 Ω

B 0.40 Ω

C 0.50 Ω

D 0.80 Ω

19 A small negatively charged particle P is balanced halfway between two horizontal plates where a potential difference of *V* is applied between the plates.



When *V* is increased, P rises towards the upper plate.
When *V* is decreased, P falls towards the lower plate.

Which statement is correct?

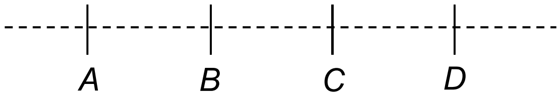
A The change of electric potential energy of the particle must equal the change in gravitational potential energy of the particle.

B Increasing *V* increases both the gravitational and electric potential energy of the particle.

C Decreasing *V* decreases both the gravitational and electric potential energy of the particle.

D Decreasing *V* decreases the gravitational potential energy and increases the electric potential energy of the particle.

20 *A*, *B*, *C*, *D* are four points on a straight line as shown below.



A point charge +*Q* is fixed at *A*. When another point charge -*Q* is moved from *B* to *C*, which of the following quantities is false?

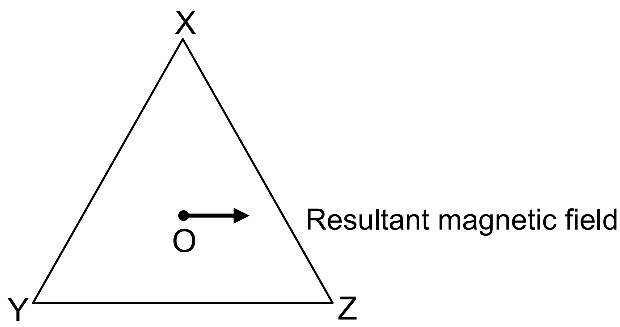
A The electric potential energy of the system of charges will increase.

B The magnitude of the electric field strength at the point *D* will increase.

C The electric potential at the point *D* will increase.

D The electric force acting on a positive charge placed at *D* will increase.

21 Three parallel conductors, carrying equal currents, pass vertically through the three corners of an equilateral triangle XYZ. It is required to produce a resultant magnetic field at O in the direction shown. What must be the directions of the currents?

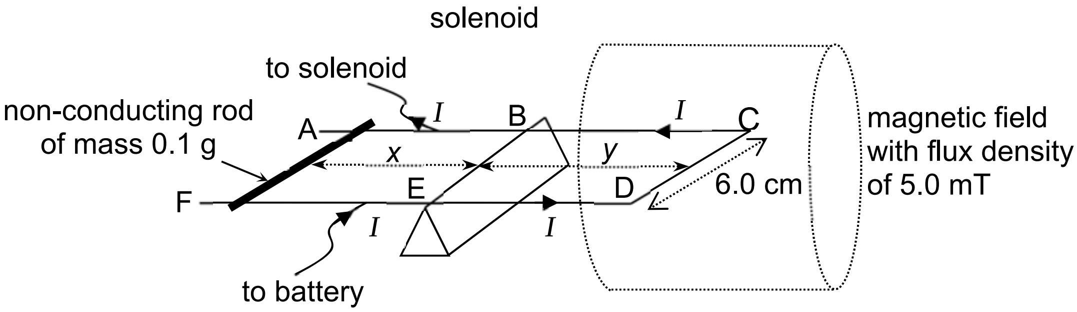


	Into page	Out of page
A	X	Y and Z
B	Z	X and Y
C	Y and Z	X
D	X, Y and Z	None

22 The figure shows a wire frame ACDF that is supported on a sharp edge at B and E such that section BCDE lies within a solenoid that provides a magnetic field of flux density 5.0 mT.

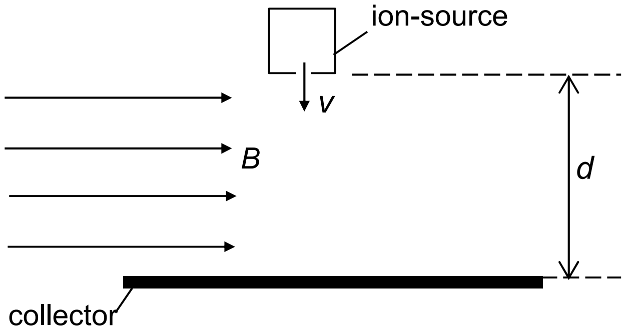
A current I of 2.0 A is then passed through the frame as shown and the position of the non-conducting rod of mass 0.10 g is adjusted so that the frame is oriented horizontally.

Given that CD = 6.0 cm, what is the ratio of the distances $\frac{x}{y}$ to ensure the frame is horizontal?



A 0.61 **B** 0.83 **C** 1.6 **D** 2.0

23 An ion-source is at distance *d* from a flat, horizontal collector at the same potential as the source. A magnetic field of flux density *B* acts horizontally as shown in the diagram. The field is uniform throughout the region between the source and the collector.



An ion of charge *q* and mass *m* is emitted vertically downwards at a speed *v*. Under what conditions will the ion reach the collector?

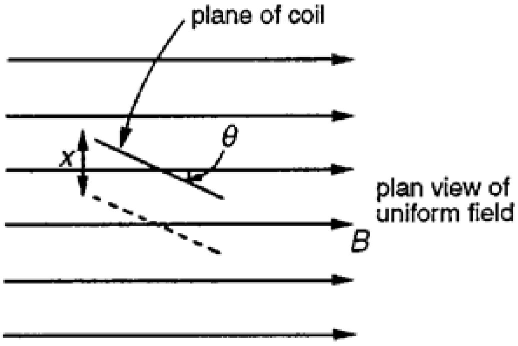
A $v > \sqrt{\frac{2Bq}{m}}$

B $v < \sqrt{\frac{2Bq}{m}}$

C $v > \frac{dBq}{m}$

D $v < \frac{dBq}{m}$

24 A plane coil of wire containing N turns each of area A is placed so that the plane of the coil makes an angle θ with the direction of the uniform magnetic field of flux density B. The coil is now moved through a distance x in time t to the position shown dotted.



What is the e.m.f. induced in the coil?

A zero **B** $NAB\frac{x}{t}$ **C** $NABx\frac{\cos\theta}{t}$ **D** $NABx\frac{\sin\theta}{t}$

25 A transformer steps up 120 V at the primary coil to 240 V at the secondary coil. If the current in the primary coil is 2.0 A and the power loss in the windings and core of the transformer is 48 W, what is the current in the secondary coil?

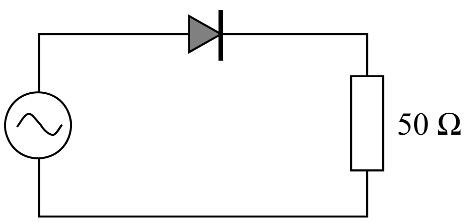
A 0.2 A

B 0.8 A

C 1.0 A

D 1.2 A

26 In the given circuit, if the sinusoidal a.c. source has a peak-to-peak voltage of 20 V, the r.m.s. current through the 50 Ω resistor is



A 0.07 A

B 0.10 A

C 0.14 A

D 0.20 A

27 Charged particles of mass *m* are accelerated from rest by a potential difference *V*. If *V* and *m* are doubled, the de Broglie wavelength of the charged particles is

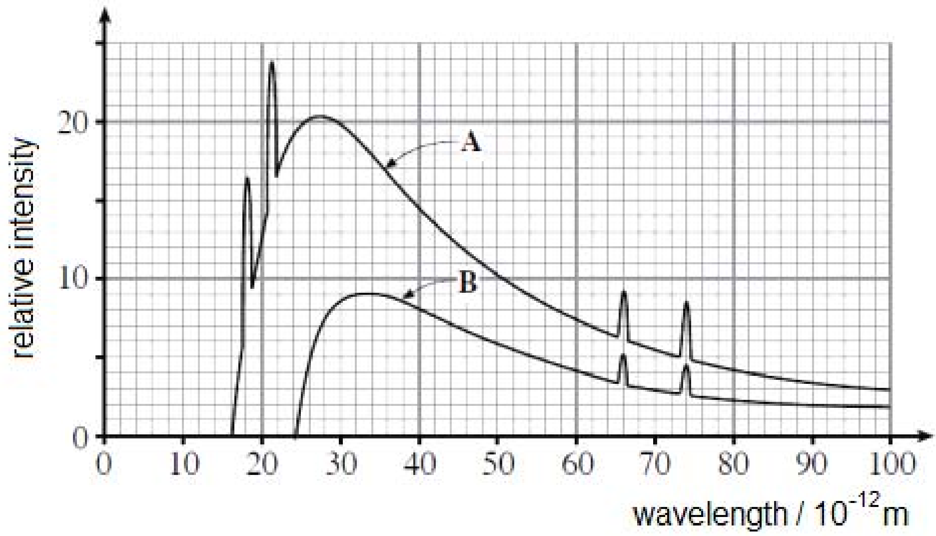
A halved.

B doubled.

C unchanged.

D decreased by a factor of $\sqrt{2}$.

28 The diagram shows two spectra of X-rays from an X-ray tube.



From the graph, it can be deduced that

A the accelerating voltage to produce spectrum B is higher than spectrum A.

B spectrum B has a continuous spectrum but no discrete spectrum.

C the target material to produce spectrum A has a higher mass number.

D the same target material is used to produce spectra A and B.

29 Alpha, beta and gamma radiations

1. are absorbed to different extents in solids,
2. behave differently in an electric field,
3. behave differently in a magnetic field.

The diagrams illustrate these behaviours.

diagram 1

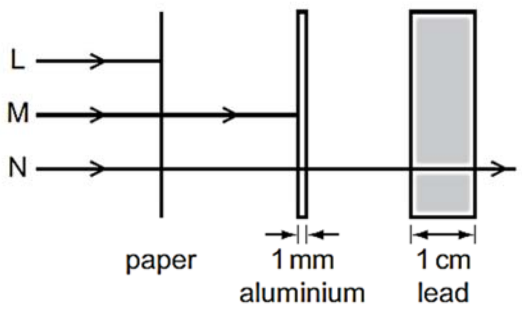


diagram 2

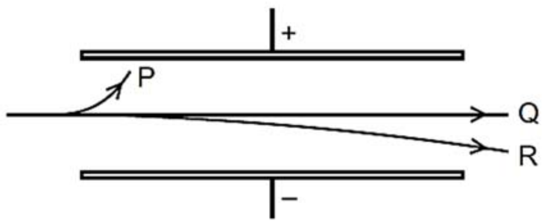
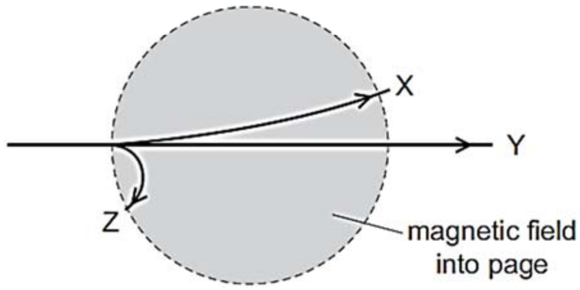


diagram 3



Which three labels on these diagrams refer to the same kind of radiation?

A L, P, X **B** L, P, Z **C** M, P, Z **D** N, Q, X

30 Each of the nuclei below is accelerated from rest through the same potential difference. Which one completes the acceleration with the lowest speed?

A ${}^{1}_{1}H$ **B** ${}^{4}_{2}He$ **C** ${}^{7}_{3}Li$ **D** ${}^{9}_{4}Be$

End of paper

JC2 Preliminary Exam 2018 (H2 Physics)

Paper 1 Solutions

Qn	1	2	3	4	5	6	7	8	9	10
Ans	A	B	D	C	B	A	B	B	D	D

Qn	11	12	13	14	15	16	17	18	19	20
Ans	A	A	A	D	D	B	A	D	D	C

Qn	21	22	23	24	25	26	27	28	29	30
Ans	C	A	C	A	B	B	A	D	C	C

Average score: /30

1 **Ans: A**

$[V] = \frac{[W]}{[q]} = \frac{[F\ s]}{[It]}$

$= \frac{kg\ m\ s^{-2}\ m}{A\ s}$

$= kg\ m^2\ s^{-3}\ A^{-1}$

2 **Ans: B**

$P = \frac{V^2}{R}$

$\frac{\Delta P}{P} \times 100\% = \left(2\frac{\Delta V}{V} + \frac{\Delta R}{R}\right) \times 100\%$

$= \left(2\frac{0.01}{3.20} + 0.05\right) \times 100\%$

$\approx 5.6\%$

3 **Ans: D**

The gradient of the v-t graph represents the acceleration.

4 **Ans: C**

$s_1 = 0 + \frac{1}{2}gt_1^2$ ----(1) , $s_2 = 0 + \frac{1}{2}gt_2^2$ ----(2)

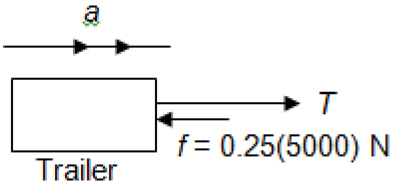
(2) – (1) $\Rightarrow$ $h = s_2 - s_1 = \frac{1}{2}g(t_2^2 - t_1^2)$

$g = \frac{2h}{(t_2^2 - t_1^2)}$

5 **Ans: B**

$T - f = ma$

$T - 0.25(5000) = 1500(1.0)$
$T = 2750$ N



6 **Ans: A**

Do note that if rightwards is taken to be positive, u_2 = -0.050c, the negative sign is essential. In this case, it is also an elastic collision, hence, the relative speed of approach/separation equation can still be used.
PCLM : $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$
(1u)(0.100c) + (4u)(-0.050c) = (1u) v_1 + (4u)v_2

Relative : $v_2 - v_1 = u_1 - u_2$
$v_2 - v_1$ = 0.100c – (-0.050c)

Solving, v_1 = -0.140c, v_2 = +0.010c

7 **Ans: B**

Upthrust = Weight of balloons + Weight of house
$\rho_{air} g V_{helium} = \rho_{helium} g V_{helium}$ + Weight of house
Weight of house
= 1.2 x 9.81 x 0.17 x 20000 – 0.18 x 9.81 x 0.17 x 20000
= 34000 N

8 **Ans: B**

By Hooke's Law, the component of the sphere's weight down the incline causes the spring to compress by a value *e.*

$$mg \sin\theta = ke$$

$$\text{or } e = \frac{(3.00)(9.81)\sin 30^0}{500} \approx 0.0294 \text{ m}$$

$$= 29.4 \text{ mm}$$

9 **Ans: D**
ω = 10 (2 x 3.14) / 8 = 7.85 rad s^{-1}
Resolve vertically: $N \cos\theta = mg$ ----(1)
Resolve horizontally: $N \sin\theta = m r \omega^2$----(2)
(2)/(1) $\tan\theta = r\omega^2 / g$
$r = g \tan\theta / \omega^2 = 0.13$ m

10 Ans: D

Considering 10.0 g alone, T_2 provides the centripetal force for it.

$T_2 = m\,r\,\omega^2$

$= (0.010)\ (0.150 + 0.050)\ 6.28^2 = 0.079$ N

Considering 21.0 g alone, $(T_1 - T_2)$ provides the centripetal force for it.

$T_1 - T_2 = (0.021)\ (0.150)\ 6.28^2 = 0.124$ N

$T_1 = 0.203$ N

Ratio = 0.203 / 0.079 = 2.6

11 Ans: A

N is the number of molecules in the container of volume *V*. *m* is the mass of one molecule. Therefore, *Nm* is the mass of gas present in volume *V.*

12 Ans: A

By conservation of energy, neglecting energy losses to the surroundings,

<u>rate</u> of electrical energy supplied = <u>rate</u> of heat absorbed by the liquid

$IV = \frac{mc\Delta\theta}{t_1} = \frac{mL}{t_2}$

$c\left(\frac{3}{60}\right) = \frac{L}{15\text{x}60}$

$\frac{c}{L} = \frac{1}{45}\ K^{-1}$

13 Ans: A

This is an SHM question and the E_p graph is **A**, lowest at the equilibrium and maximum at the amplitudes (opposite from the KE-r graph).

14 Ans: D

$$v = \omega\sqrt{x_0{}^2 - \frac{x_0{}^2}{4}}$$

$$v = \frac{\sqrt{3}}{2}\omega x_0 = \frac{\sqrt{3}}{2}v_0$$

15 Ans: D

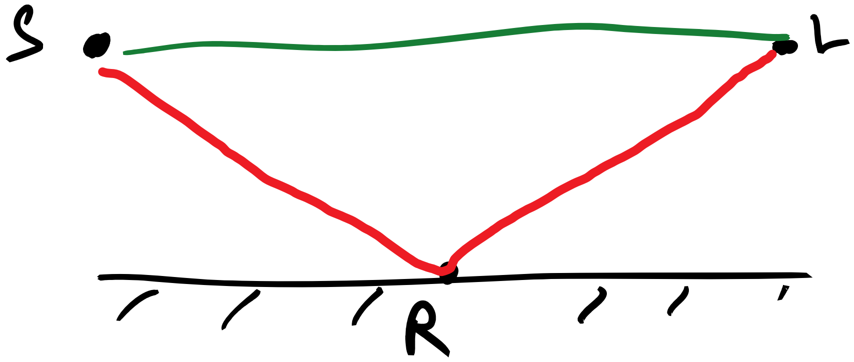
Amplitude of X = 2 x Amplitude of Y

Period of X = 3 x Period of Y ➔ Frequency of X = 1/3 Frequency of Y

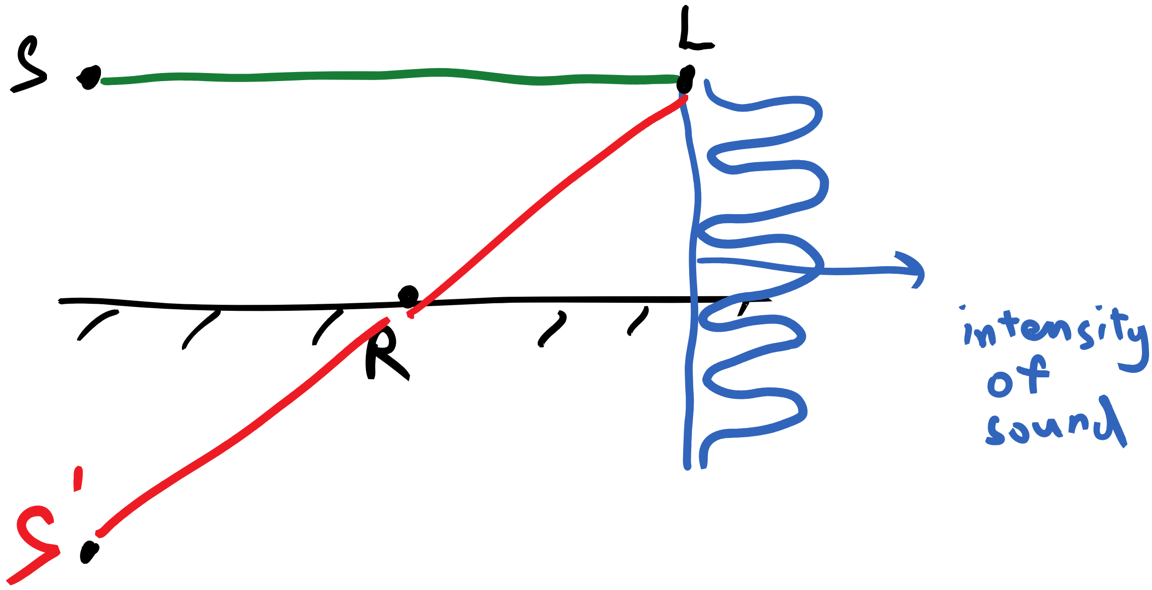
Hence, $I_X / I_Y = (2)^2(1/3)^2$

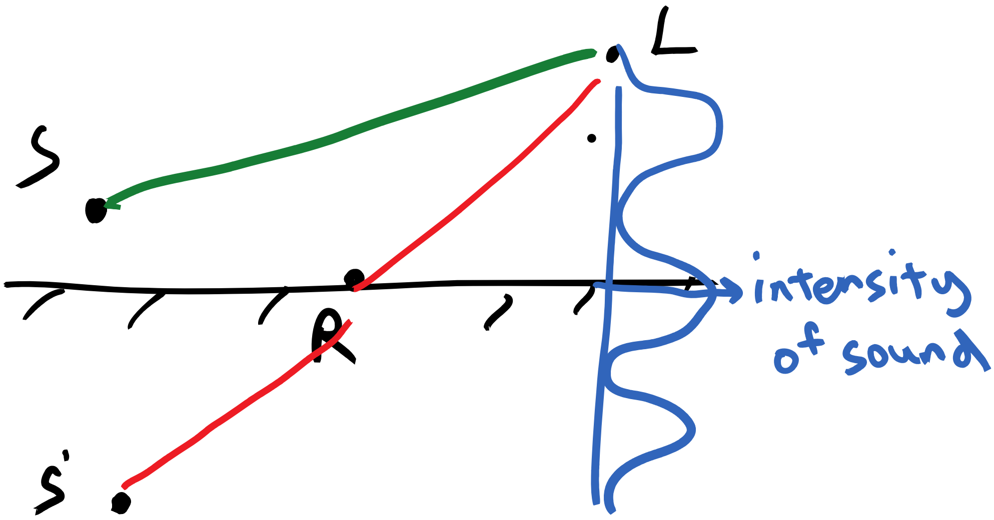
$I_Y = 9/4\ I_X = 2.25\ I_0$

16 (L3) Ans: B



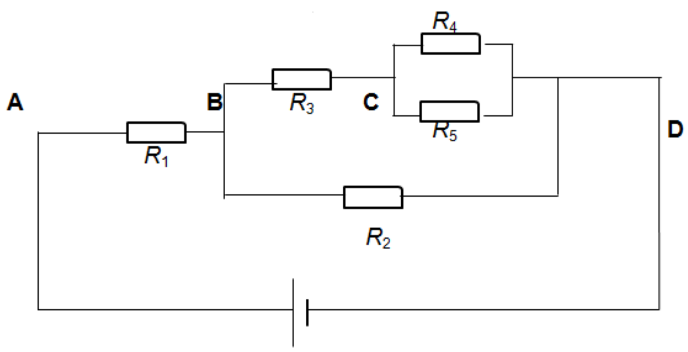
We can simplify the arrangement to look like the one below, where the reflected wave is now considered to be coming from a "virtual" source, S'. So now this looks like a "2-source" interference situation.





So if S and S' is now closer together, the distance between loud and soft sounds would be further apart ($ax = \lambda D$).

17 **Ans: A**



Redrawing:
Effective resistance across AB = R
Effective Resistance across CD = $R/2$
Effective Resistance across BD = $1/[1/R + 1/(R + R/2)] = 3R/5$
Hence p.d across AB is greater than pd across BD since resistance across AB is greater than resistance across BD. Thus p.d. is the largest across R_1. Since power is proportional to the square of the potential difference, R_1 has the largest power.

18 Ans: D

When the switch is open, at balance position, there is no current passing through the unknown emf cell.

$$E = \frac{0.70}{1.0} \times 2.0 = 1.4 \text{ V}$$

When switch is closed, at balance position, there is current flowing in the secondary circuit below.

$$E - Ir = \frac{0.50}{1.0} \times 2.0$$

$$1.4 - \left(\frac{1.4}{2.0 + r}\right) r = 1.0$$

$$r = 0.80\ \Omega$$

19 Ans: D

In order for the particle to stay balanced, the electric force must be acting upwards and the weight downwards.

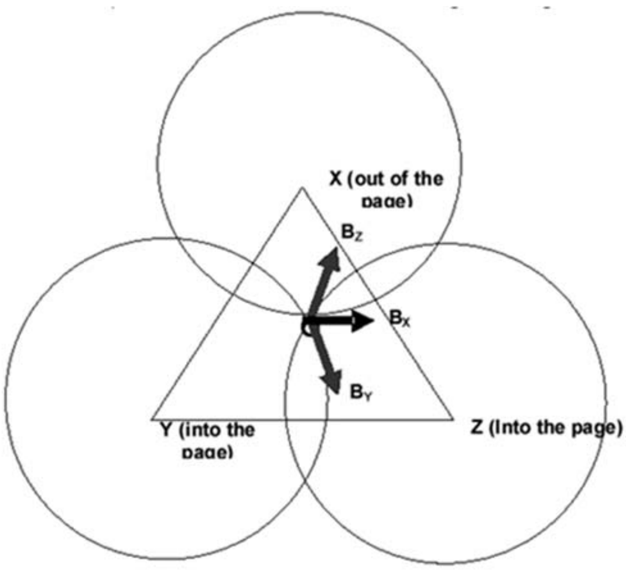
When V decreases, the particle moves downwards which is opposite to the direction of the electric force. Work done by electric force is negative and hence work done by the external force is positive. Hence the EPE increases.

20 Ans: C

As negative charge moves nearer to D, potential will become more negative and thus decrease.

21 Ans: C

Vertical components B_Y and B_Z cancel each other.
The directions of B_X, B_Y and B_Z are determined using the Right Hand Grip Rule.



22 **Ans: A**

$$mg\,(x) = BIL\,(y)$$
$$(0.10\times10^{-3})(9.81)(x) = (5.0\times10^{-3})(2.0)(6.0\times10^{-2})(y)$$
$$\frac{x}{y} = 0.61$$

23 **Ans: C**

magnetic force = centripetal force

$$Bqv = m\frac{v^2}{r} \quad \Rightarrow r = \frac{mv}{Bq}$$

To reach the collector, *r* must be greater than *d*.

$$\text{i.e. } \frac{mv}{Bq} > d \quad \Rightarrow v > \frac{dBq}{m}$$

24 **Ans: A**

There is no change of flux linkage

25 **Ans: B**

Since there is energy loss in the transformer, secondary coil current is not 1.0 A.

$P_{\text{primary}} = P_{\text{secondary}} + P_{\text{loss}}$

$120 \times 2.0 = 240I + 48$

$I = 0.8$ A

26 **Ans: B**

V_0 = 20/2 = 10 V

For half wave rectified circuit, $V_{rms} = V_0 / 2 = 5$ V

$I_{rms} = V_{rms} / R = 5 / 50 = 0.10$ A

27 Ans: A

Using loss in EPE = gain in KE,

$$\frac{1}{2}mv^2 = qV$$
$$\frac{1}{2}\frac{\rho^2}{m} = qV$$
$$\lambda = \sqrt{\frac{h^2}{2mqV}}$$

When V and m are doubled,

$$\lambda_{new} = \sqrt{\frac{h^2}{2(2m)q(2V)}} = \frac{1}{2}\lambda$$

28 Ans: D

Same target atom since the K_α and K_β have the same wavelengths showing the same set of energy levels.

29 Ans: C

L: alpha	M: beta	N: gamma
P: beta	Q: gamma	R: alpha
X: alpha	Y: gamma	Z: beta

30 Ans: C

Gain in KE = ½ m v^2 – 0 = q V
v = $(2 \text{ V q/m})^{1/2}$
Nucleus with lowest q/m will have the lowest speed. Charge is determined from the proton number while mass is determined from the mass number.

End of solutions

Class	Index Number	Name
17S		

ST. ANDREW'S JUNIOR COLLEGE
JC 2 2018
Preliminary Examination

PHYSICS, Higher 2 **9749/02**

Paper 2 Structured Questions **13th September 2018**
2 hours

Candidates answer on the Question Paper.
No additional materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, index number and Civics Group on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a 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	/ 6
2	/ 11
3	/ 6
4	/ 13
5	/ 15
6	/ 12
7	/ 17
Total	**/ 80**

This document consists of **23** printed pages including this page.

Data

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

Formulae

uniformly accelerated motion,	$s = u t + \frac{1}{2} a t^2$
	$v^2 = u^2 + 2 a s$
work done on/by a gas,	$W = p \Delta V$
hydrostatic pressure,	$p = \rho g h$
gravitational potential,	$\phi = -\frac{Gm}{r}$
temperature,	T / K = T / °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.,	$x = x_o \sin \omega t$
velocity of particle in s.h.m.,	$v = v_0 \cos \omega t$
	$v = \pm \omega \sqrt{x_0^2 - x^2}$
electric current	$I = Anvq$
resistors in series,	$R = R_1 + R_2 + ...$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + ...$
electric potential,	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage,	$x = x_o \sin \omega t$
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,	$x = x_o \exp(-\lambda t)$
decay constant,	$\lambda = \frac{\ln 2}{t_{1/2}}$

1 **(a)** Explain what is meant by random error.

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

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

(b) A cylindrical thermos flask is used to store hot water. The internal diameter and depth of the thermos flask are measured to be (8.50 ± 0.01) cm and (17.0 ± 0.1) cm respectively.

(i) State the instrument used to measure its diameter and a systematic error that can occur with the use of this instrument.

....……………………………………………………………………………………

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

(ii) Calculate the volume of the thermos flask and its associated uncertainty.

volume = …………….……………………………… cm^3 [3]

2 **(a)** State the relation between force and momentum.

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

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

(b) A uniform wooden bar of mass 450 g is held in position horizontally by a hinge at C, which also allows for rotation of the bar, as shown in Fig. 2.1.

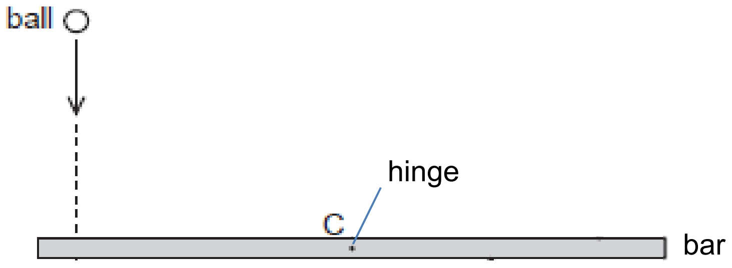


Fig. 2.1

A ball of mass 140 g falls vertically from rest onto the bar such that it hits the bar at a position to the left of C. The variation with time t of the velocity v of the ball before, during and after hitting the ball is shown in Fig. 2.2.

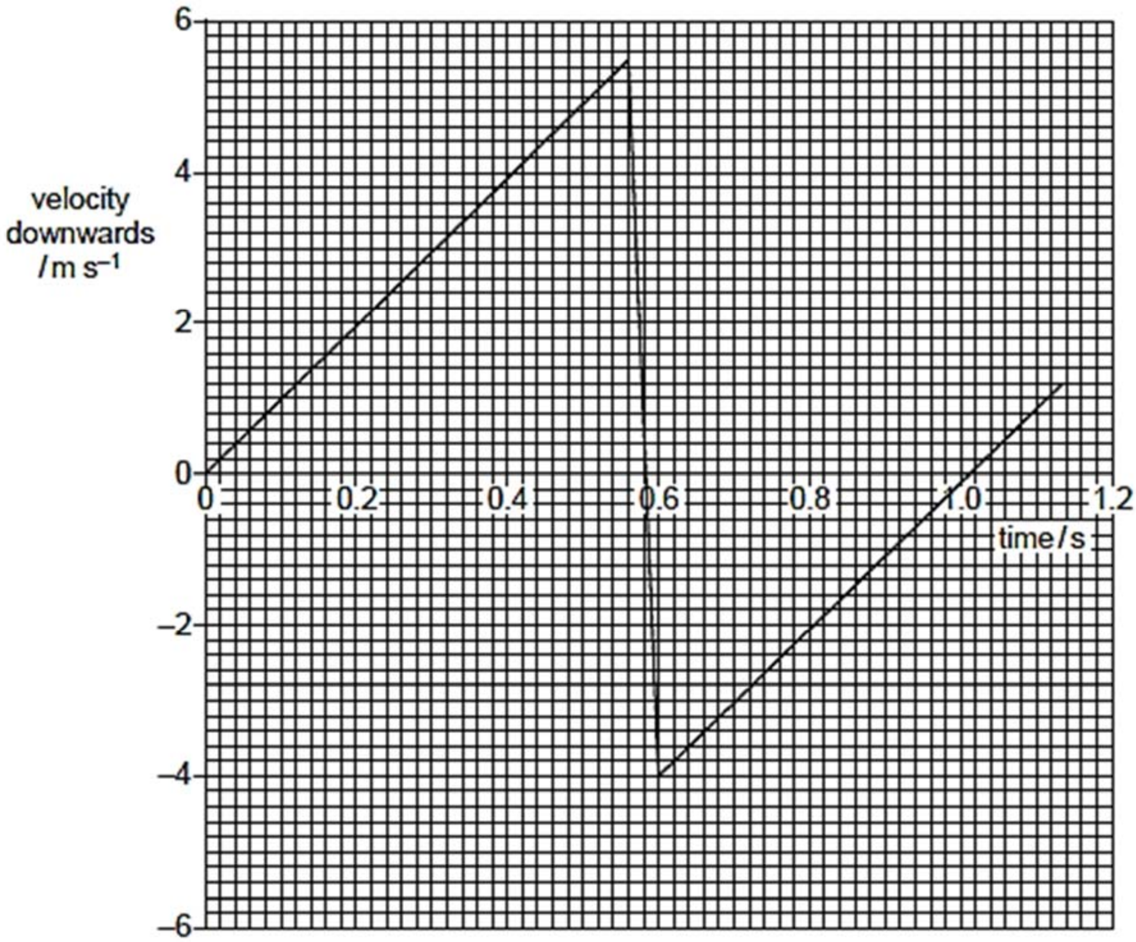


Fig. 2.2

For the time that the ball is in contact with the bar, use Fig. 2.2 to determine

(i) the change in momentum of the ball,

change = …………………… kg m s^{-1} [2]

(ii) the impulse delivered to the bar,

impulse = ………………………Ns [1]

(iii) the magnitude of the force exerted by the ball on the bar,

force = …………………… N [1]

(c) **(i)** State and explain whether the principle of conservation of momentum can be applied for the collision of the ball with the bar.

……………………………………………………………………………………...

……………………………………………………………………………………...

……………………………………………………………………………………...

……………………………………………………………………………………..[2]

(ii) Explain, using Newton's third law of motion, the relationship between the impulse experienced by the ball and the impulse experienced by the bar during impact.

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

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

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

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

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

3 Two forces, each of magnitude F, form a couple acting on the edge of a disc of radius r, as shown in Fig. 3.1.

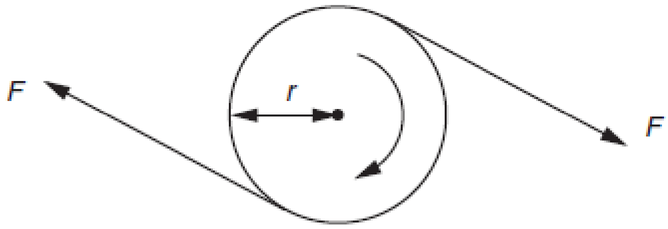


Fig 3.1

(a) The disc is made to complete n revolutions about an axis through its centre, normal to the plane of the disc. Write down an expression for

(i) The distance moved by a point on the circumference of the disc,

distance = ………………………………. [1]

(ii) the work done by one of the two forces.

work done = ………………………………. [1]

(b) Using your answer to **(a)**, show that the work done W by a couple producing a torque τ when it turns through n revolutions is given by

$$W = 2\pi n\tau.$$ [2]

(c) A car engine produces a torque of 450 N m at 2900 revolutions per minute. Calculate the output power of the engine.

power = ……………………………W [2]

4 A block of wood of mass *m* floats in still water, as shown in Fig. 4.1 below.

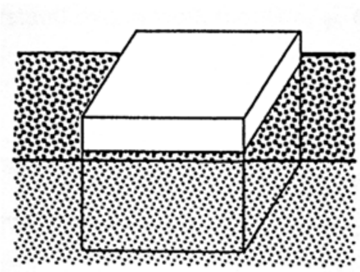


Fig. 4.1

When the block is pushed into the water, without totally submerging it, and is then released, it bobs up and down in the water in simple harmonic motion.

Surface water waves of speed 1.2 m s^{-1} and wavelength 0.35 m are then incident on the block. These cause *resonance* in the oscillation of the block.

The vertical displacement *y* of the block varies with time *t* according to the relation:

$$y = -0.015\,cos\left(\sqrt{\frac{28}{m}}\right)t\,,$$ where *m* is measured in kg.

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

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

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

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

(b) **(i)** Calculate period of the water waves T_0 during which resonance is achieved.

T_0 = ………………………..s [1]

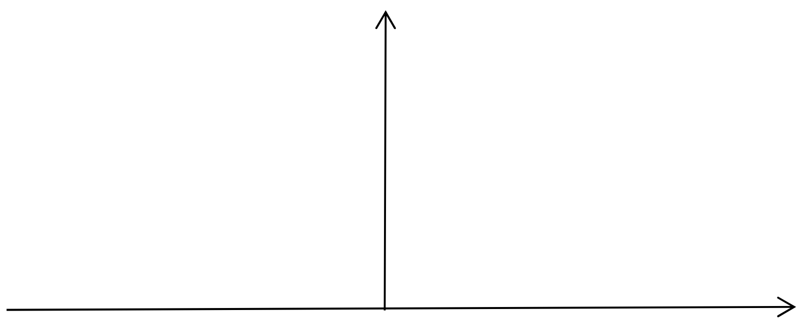
(ii) Determine the mass of the block,

mass = ………………………kg [2]

(iii) Determine the maximum acceleration during the oscillation.

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

(iv) Sketch a graph of the kinetic energy of the block against displacement in the vertical direction. [2]



(c) Fig. 4.2 shows how the amplitude of oscillation of the block varies with the period of the surface water waves, while keeping the amplitude of the water waves constant.

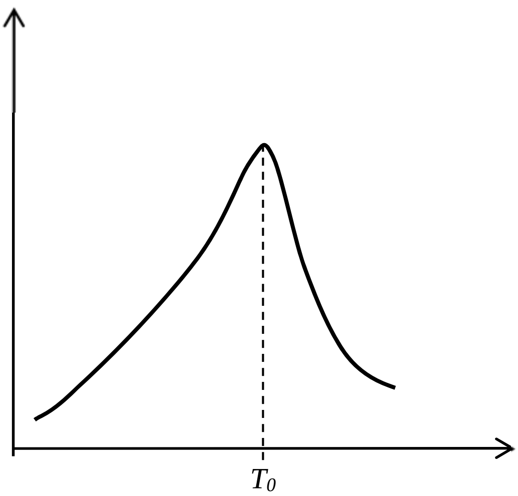


Fig. 4.2

(i) With respect to energy, explain how the peak amplitude of oscillation of the block is achieved.

………………………………………………………………………………………...

………………………………………………………………………………………...

………………………………………………………………………………………...

……………………………………………………………………………………….[2]

(ii) The block is replaced with another one with a larger cross-sectional area but of the same mass. Sketch a graph on Fig. 4.2 to show how the amplitude of oscillation of the block varies with the period of the water waves. [2]

5 **(a)** Fig. 5.1 shows how the resistance of a light-dependent resistor (LDR) varies with the intensity of the light incident on it.

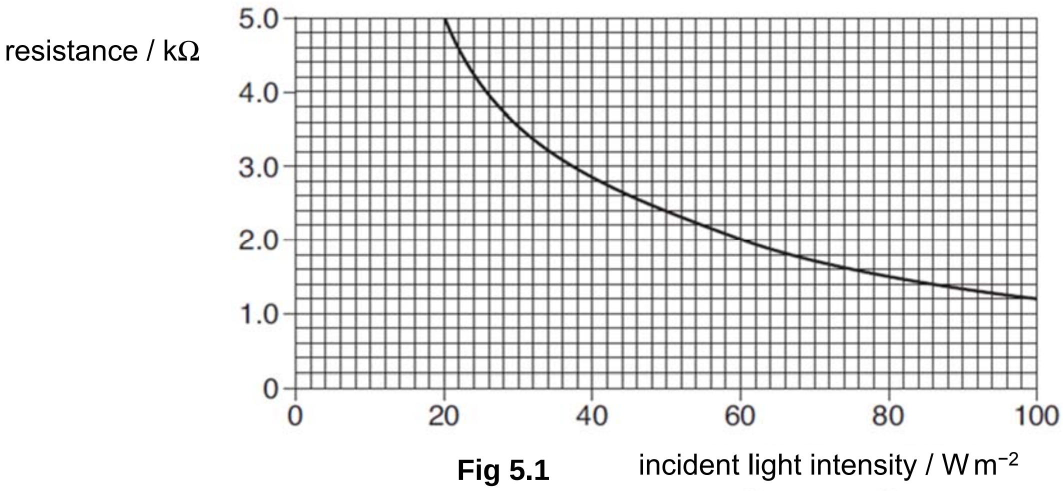


Fig 5.1

(i) State and explain *quantitatively*, if the resistance of the LDR is inversely proportional to the intensity of the light incident on it, by using the end-points of the graph.

……………………………………………………………………………………………

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

(ii) Complete the circuit diagram in Fig. 5.2, which should show a light-sensing circuit where the potential difference across the LDR, with characteristics shown in Fig. 5.1, can be used to control the brightness of a bulb rated 6.0 V, 1.5 W in a room.

The bulb is to be arranged in parallel with the LDR while a 1.2 kΩ resistor made of carbon is to be arranged in series with the LDR-bulb combination. The 9.0 V e.m.f. battery has negligible internal resistance.

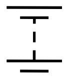
9.0 V 

Fig. 5.2

[2]

(iii) Use Fig. 5.1 and Fig. 5.2 to show that the light intensity in the room is 24 W m^{-2} when the potential difference across the LDR is 7.0 V and the bulb is removed.

[3]

(iv) Fig. 5.3 shows a close-up of the LDR device used in the circuit in Fig. 5.2. The LDR consists of a uniform strip of an intrinsic semiconductor whose resistivity is dependent on the intensity of the light incident on it. The strip has a diameter of 8.0×10^{-4} m.

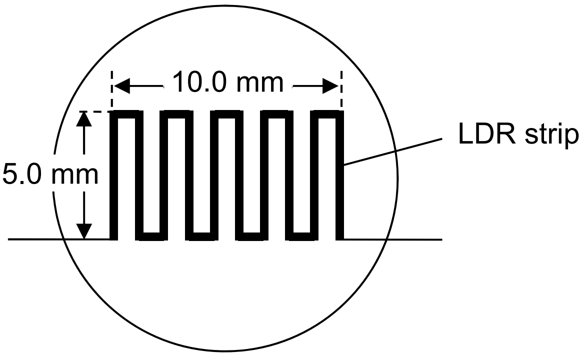


Fig. 5.3

Determine the resistivity of the LDR when it has a resistance of 4.2 kΩ.

resistivity = ……………….. Ω m [2]

(b) **(i)** Fig. 5.4 shows a circuit containing five identical lamps A, B, C, D and E. The circuit also contains three switches S_1, S_2 and S_3.

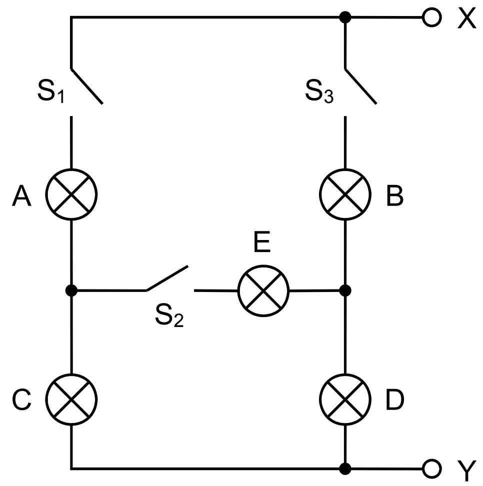


Fig. 5.4

One of the lamps is faulty. In order to detect the fault, an ohm-meter (a meter that measures resistance) is connected between terminals X and Y. When measuring resistance, the ohm-meter causes negligible current in the circuit.

Fig. 5.5 shows the readings of the ohm-meter for different switch positions.

The resistance of the non-faulty lamps can be assumed to be constant.

switch			ohm-meter reading / Ω
S_1	S_2	S_3	
open	open	open	∞
closed	open	open	30.0
closed	closed	open	30.0
closed	closed	closed	15.0

Fig. 5.5

(1) Identify the faulty lamp, and the nature of the fault.

faulty lamp = ……..……………………[1]

nature of fault = …………………………[1]

(2) Suggest why it is advisable to test the circuit using an ohm-meter that causes negligible current rather than with a power supply across terminals X and Y.

…………………………………………………………………………………

…………………………………………………………………………………

…………………………………………………………………………………[1]

(3) State the resistance of one of the non-faulty lamps, as measured using the ohm-meter.

resistance = …………………Ω [1]

(4) After replacing the faulty lamp in the circuit in Fig. 5.4 with a similar working lamp, the ohm-meter is connected between terminals X and Y.
On Fig. 5.6, complete the readings of the ohm-meter for different switch positions.

switch			ohm-meter reading / Ω
S_1	S_2	S_3	
open	open	open	∞
closed	open	open	
closed	closed	open	
closed	closed	closed	

Fig. 5.6 [2]

6 When light illuminates a clean surface of potassium, electrons can be emitted. This is the photoelectric effect. Fig 6.1 shows a section of the surface at a microscopic scale.

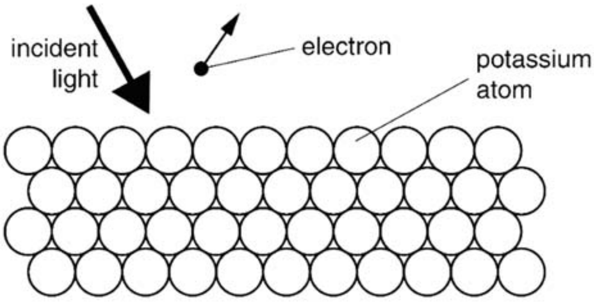


Fig. 6.1

(a) Electrons are emitted when the incident light is violet, but not when the incident light is red. Increasing the intensity of violet light causes more electrons to be emitted. Increasing the intensity of red light has no effect.
Explain how this is evidence for the quantum behaviour of light.

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

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

(b) Einstein explained the photoelectric effect by suggesting that there is a minimum energy ϕ, the work function, which must be supplied to remove an electron from the surface of a metal.

The work function for potassium is 3.7×10^{-19} J.

Show that photons of frequency less than 5.6×10^{14} Hz cannot remove electrons from a potassium surface. [2]

(c) One early device using the photoelectric effect was the photoelectric cell. This cell sets up a current in an external circuit when light falls on it.

Suggest one use for a photoelectric cell containing a potassium surface and any limitations it may have in practice.

....

....

....

....[2]

(d) The variation with frequency *f* of the maximum kinetic energy E_k of the emitted electrons is shown in Fig. 6.2.

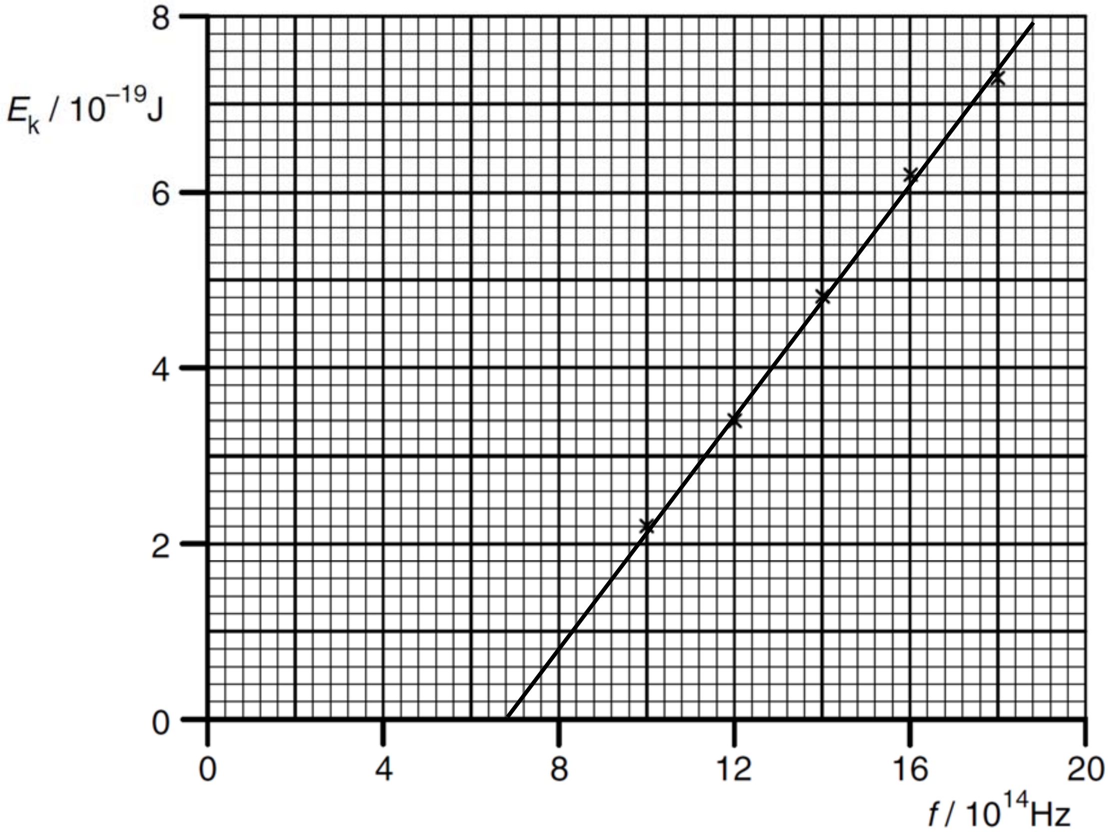


Fig. 6.2

(i) Explain the shape of the graph in Fig. 6.2.

....

....

.... [2]

(ii) Use Fig. 6.2 to determine a value for the Planck constant.

Planck constant = ... J s [2]

7 This question is about the performance of commercial jet aircraft.

Although much criticised for their carbon footprint, modern jet aircraft have been developed to carry the largest load they can, at the greatest speed possible, for the smallest amount of fuel. This is basic economic good sense. However, some of these factors do compete with each other: the fastest commercial jet aircraft, Concorde, proved uneconomic to run, as it could not carry enough passengers to make its journeys profitable. It was taken out of service in 2003.

More recent jet aircraft are designed to carry many more passengers and their luggage than Concorde could. They also need to travel a quarter of the way around the world without refuelling. This means that they need to carry a lot of fuel, which can be over a third of the total weight of the plane! The planes themselves are necessarily larger, which further increases the weight to be carried.

In level flight, lift is produced by pressure differences produced by airflow across the wings, with lift depending on the speed and on the surface area of the wings. Cruising speeds of many jet aircraft are all rather similar, being just less than the speed of sound, so differences in lift are likely to depend mainly on the surface area and shape of the wings.

Aircraft use fuel very rapidly at take-off, when the engines have to deliver maximum thrust. The aircraft must accelerate fast enough to reach the speed needed to take off, usually about 240 – 290 km h^{-1} in a distance well within the length of the runways available. Because take-off speeds and runway lengths are all rather similar, the acceleration of most jet aircraft down the runway is similar, whatever their mass and total engine thrust.

After take-off, jet aircraft are required to climb steeply to avoid excessive noise nuisance. If the angles of climb are similar, this also requires maximum thrust to be related to total aircraft take-off weight.

Data on six aircraft are given in the table of Fig. 7.1.

type	number of engines	maximum thrust per engine / kN	maximum take-off mass /kg	take-off distance /m	cruising speed km/h	fuel consumption litre/h	fuel capacity /litre	range /km	wing surface area /m^2
Airbus A340-300	4	152	284000	3400	876	8000	155400	13500	362
Airbus A340-600	4	276	365000	3200	902	9800	195600	13900	437
Boeing 777-200	2	343	247000	3100	900	7700	117300	9000	430
Boeing 747-400	4	264	397000	3600	925	14160	216800	13500	525
DC10-40	3	236	251700	2800	965	10800	138700	9300	339
MD-11	3	270	273900	3100	945	9000	146000	12600	339

Fig. 7.1

(a) Suggest and explain why the Concorde could not carry as many passengers as other commercial jet aircraft.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(b) Use the data on the Airbus A340-600 in Fig. 7.1 to answer the following questions.

(i) Show that the plane takes about 15 hours to travel the range at its cruising speed. [1]

(ii) Show that the fuel consumed in travelling the range at cruising speed is less than 80% of the maximum fuel carried. [2]

(iii) Suggest and explain why the aircraft carries more fuel than that needed to travel its range at its cruising speed.

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

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

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

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

(c) Use the data on the MD-11 in Fig. 7.1 to answer the following questions.

(i) Show that the initial acceleration of the MD-11, with maximum thrust and maximum take-off mass, is approximately 3 m s^{-2}. [1]

(ii) Use your answer to **(c)(i)** to calculate the distance required for the MD-11 to reach a take-off speed of 81 ms^{-1}.

distance = …………………………….m [1]

(iii) The distance calculated in **(c)(ii)** is substantially less than the quoted take-off distance of 3100 m.
Suggest and explain a reason for this.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

……………………………………………………………………………………[2]

(d) In level flight, the lift required is directly proportional to the *mass* of the aircraft. Explain why.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

……………………………………………………………………………………[2]

(e) The graph of Fig. 7.2 shows the relationship between maximum take-off mass *M* and wing area *A* for all six aircraft in the table.

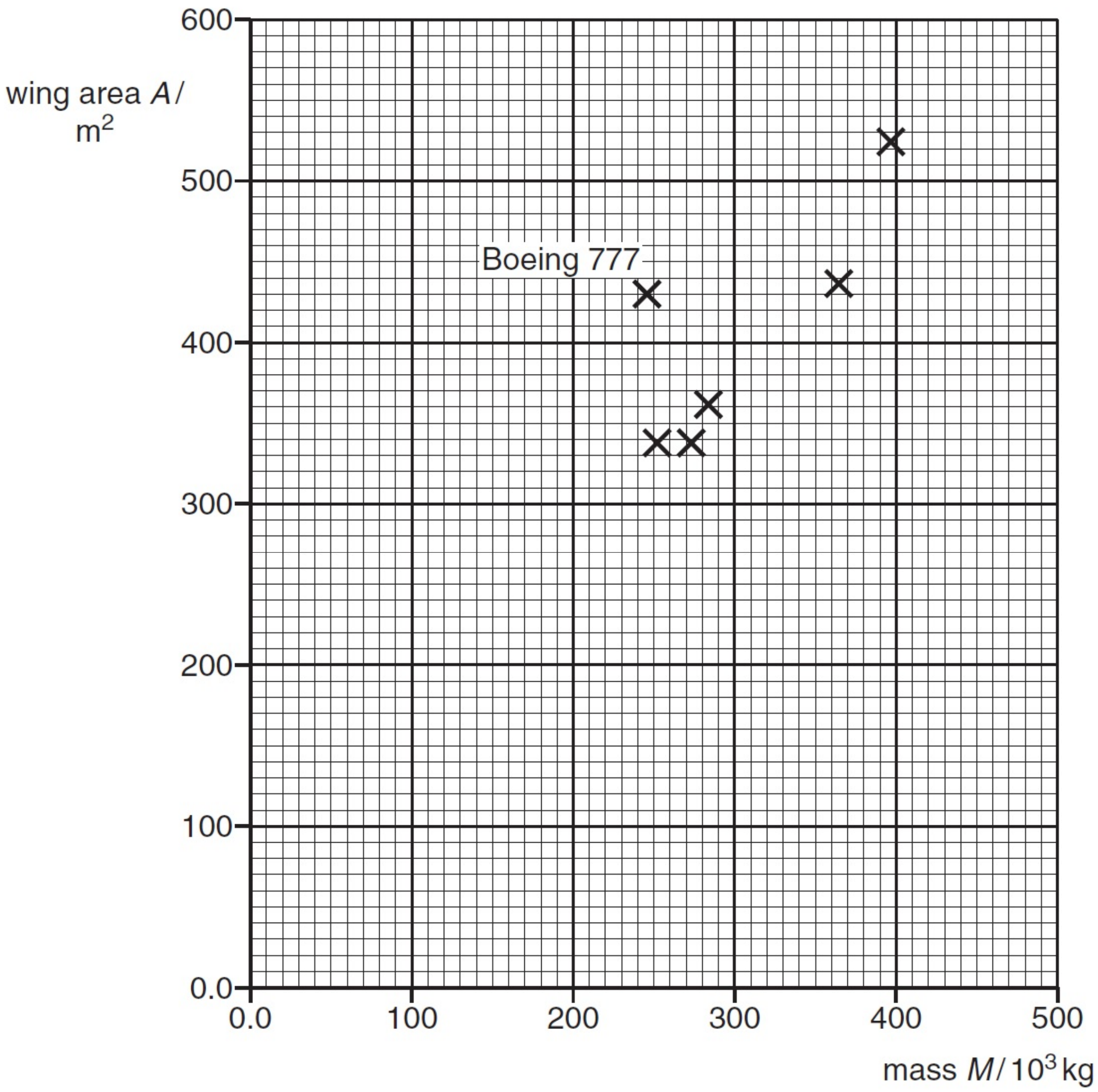


Fig. 7.2

Draw a straight line of best fit on Fig. 7.2.
Discuss what the graph suggests about the design of these six aircraft.

……

……

……

……

…… [4]

End of paper

Solution for 2018 SAJC H2 Physics Prelim Paper 2

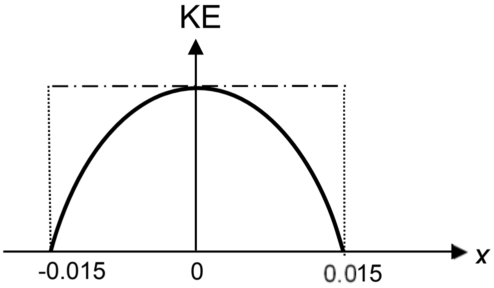
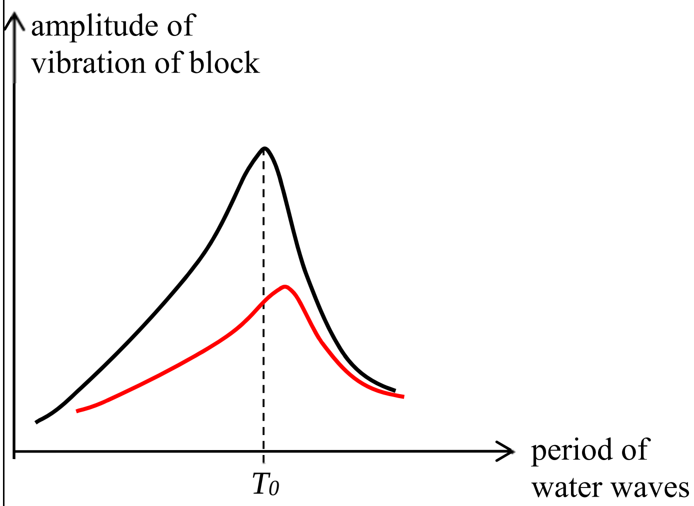
1 (a)	Random error is an error which causes measurements to be sometimes larger than the true value and sometimes smaller than the true value.	**1**
(b)(i)	vernier calipers zero error (do not accept parallax)	**1** **1**
(ii)	$V = \pi\left(\frac{d^2}{4}\right)h$ $= 964.665\ \text{cm}^3$ $\frac{\Delta V}{V} = \frac{2\Delta d}{d} + \frac{\Delta h}{h}$ $\Delta V = \left(\frac{2\times 0.01}{8.50} + \frac{0.1}{17.0}\right)\times 964.665$ $= 8\ \text{cm}^3$ $V = (965 \pm 8)\ \text{cm}^3$ {ECF for wrong V or ΔV}	**1** **1** **1**

2 (a)	Force = rate of change of momentum (allow symbols if defined) and it acts in the direction of the change in momentum**.** {Note: this qn appeared in N2012 P3 Q6a, 2m}	**1** **1**
(b)(i)	Δp = m Δv = (0.140)(–4.0 – 5.5) = **–1.33** kg m s^{-1} (must be –ve)	**1** **1**
(ii)	Impulse to bar = negative of the Δp of ball = + **1.33** Ns (give ecf corr to above ans)	**1**
(iii)	force = Δp / Δt = 1.33 / 0.04 = **33.3** N {give ecf for wrong impulse}	**1**
(c)(i)	If the system considered consists of only the ball, Not applicable, since there is net/resultant force acting, due to gravitational force / contact force on ball. OR If the system considered consists of both the ball and bar, Not applicable, since there is net/resultant force acting, due to the upward force by hinge on bar/ gravitational force acting on the ball & bar.	**2 or 0** **2 or 0**

(ii)	According to Newton's 3rd law, force on bar (due to ball) is equal in magnitude and opposite in direction to force on ball (due to bar) Since time (of contact) (*t*) is same for both **AND** Impulse = *Ft* Impulse on ball is equal in magnitude and opposite in direction to impulse on bar	**1** **1** **1**

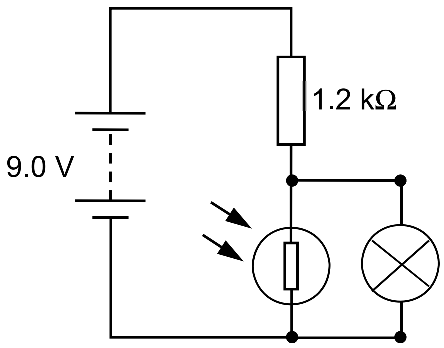
3 (a)(i)	distance = $n \times 2\pi r = 2\pi nr$	**1**
(ii)	work done = $F \times 2\pi nr$ (ecf allowed)	**1**
(b)	total work done by couple = $2 \times F \times 2\pi nr$ Since $\tau = 2Fr$ Hence work done = $\tau \times 2\pi n$	**1** **1**
(c)	Power = work done / time = $(450 \times 2\pi \times 2900) / 60$ $= 1.37 \times 10^5$ W	**1** **1**

4 (a)	Simple harmonic motion is a periodic oscillation with its acceleration proportional to its displacement from the equilibrium position ("origin" not acceptable) and is always directed towards the equilibrium position/ opposite in direction to the displacement from the equilibrium position.	**1** **1**
(b)(i)	T_o = 1/ driver frequency = 1/ (speed / wavelength) = 0.35 / 1.2 = 0.292 s	**1**
(ii)	frequency of water waves = speed / wavelength = 1.2 / 0.35 = **3.43** Hz $\omega = \sqrt{\frac{28}{m}}$ $\Rightarrow 2\pi f = \sqrt{\frac{28}{m}}$ $\Rightarrow m = \frac{28}{(2\pi(3.4))^2}$ = 0.0603 kg	**1** **1**

(iii)	Max acceleration = $a_o = x_o\omega^2$ = 0.015 x (2π x 3.43)^2 = **6.96** m s^{-2}	**1** **1**
(iv)		**1 - shape** **1- amplitude**
(c)(i)	When driver frequency (of water waves) is equal to the natural frequency (of block), there is a maximum transference of energy from the waves to the block, hence increasing the total energy of the driven oscillating system and its amplitude.	**1** **1**
(ii)	 [1] for lower overall amplitudes [1] for peak shifted to the right of T_o (note that x-axis is period, not driving frequency as in lect notes!)	**2**

<table>
<tr><td>5 (a)
(i)</td><td>If R is inversely proportional to intensity, R x intensity = constant,

$(5)(20) \neq (100)(1.2)$ or any 2 points. Products not equal. Hence, not inversely proportional.</td><td>1

1</td></tr>
<tr><td>(ii)</td><td>

[1] – correct symbols

[1] – correct diagram</td><td>1

1</td></tr>
<tr><td>(iii)</td><td>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

From Fig. 5.1, light intensity = 24 W m^{-2}</td><td>1

1

1</td></tr>
<tr><td>(iv)</td><td>Length of strip, $\lambda = (10 \times 5.0 \times 10^{-3}) + (10.0 \times 10^{-3}) = 0.060\ m$

Using $R = \frac{\rho \lambda}{A}$,

$\rho = \frac{RA}{l} = \frac{4200 \times \pi \times (4.0 \times 10^{-4})^2}{0.060} = 3.5 \times 10^{-2}\ \Omega\ m$
{ECF allowed for wrong length}</td><td>1

1</td></tr>
<tr><td>b(i)(1)</td><td>nature of fault: lamp fused (open circuit)

faulty lamp: lamp E</td><td>1

1</td></tr>
<tr><td>(2)</td><td>If there is a short circuit, it could cause <u>excessive current</u> to flow in the circuit that could cause <u>damage to the power supply / other lamps / blow fuse in power supply</u>.</td><td>1</td></tr>
<tr><td>(3)</td><td>Resistance of one non-faulty lamp = 30.0 / 2 = 15.0 Ω</td><td>1</td></tr>
<tr><td>(4)</td><td><table><tr><td>switch</td><td>ohm-meter reading</td></tr></table></td><td>2
-1
for</td></tr>
</table>

	S_1	S_2	S_3	/ Ω		1 mistake
	open	open	open	∞		
	closed	open	open	30.0		
	closed	closed	open	25.0		
	closed	closed	closed	15.0		

6(a)	violet photons are energetic enough to liberate electrons, while red are not OR Frequency of violet (photons) is higher than threshold frequency, while red (photons) is not	**1**
	Higher frequency/lower wavelength means higher energy photons OR E = hf greater intensity = more photons one photon liberates one electron more photons per unit time (incident on potassium leads to) more electrons produced in wave model, there will be photoelectric emission for all wavelengths/frequencies but this does not happen (so wave model is wrong)	**Any 3**
(b)	$E = hf = 6.6 \times 10^{-34}$ J s × 5.6×10^{14} Hz = 3.7×10^{-19} J comparison of calculated value with given threshold E.g. Photons with frequency less than 5.6×10^{14} Hz will have less energy than the work function, so these photons cannot remove electrons from potassium surface OR $f_o = 3.7 \times 10^{-19}$ J/6.6×10^{-34} J s = 5.6×10^{14} Hz Photons with frequency below the threshold frequency of 5.6×10^{14} Hz will have less energy than the work function of potassium, and cannot remove electrons from potassium surface	**1** **1**
(c)	Any reasonable application/use involving detection of light or measurement of its intensity E.g. solar panel, measuring light level, automatic switch. Limitation: e.g. limited range of wavelengths detectable (not red end of spectrum), need for clean potassium surface, very low amount of power generated, very little current generated (thus requiring the need for very sensitive micro-ammeters)	**1** **1**

(di)	E_k is 0 for f below the threshold frequency 6.8×10^{14} Hz (allow ±0.4×10^{14} Hz) OR no electrons produced OR energy of photon is less than the work function $E_k = hf - \phi$, so a graph of constant gradient/straight line is obtained (after threshold frequency) {note: cannot say "directly proportional"}	**1** **1**
(dii)	Attempt at finding gradient (either seen from gradient triangle on graph, or calculations shown to find gradient) Working shown to give 6.6 × 10^{-34} J s (Allow ±0.2×10^{-34} J s) e.g. $h = \frac{(7.8-0)\times10^{-19}}{(18.9-6.8)\times10^{14}}$ = 6.5 ×10^{-34} J s	**1** **1**

7(a)	Plausible suggestion Explains effect of suggestion on passenger capacity E.g.: Concorde travels at higher speeds so higher air resistance Need to carry more fuel (instead of carrying passengers) to do more work against air resistance E.g. Concorde travels at higher speeds so higher air resistance needs to have a small cross sectional area, so carry fewer passengers	**1** **1**
(bi)	Time = distance/ speed = 13 900 km/ 902 km h^{-1} = 15.4 h	**1**
(bii)	fuel used = 15.4 h × 9800 L h^{-1} = 151 000 L 80% of 195 600 = 156 000 L (> 151 000 L) {allow use of 15 hours: fuel used = 15 h × 9800 L h^{-1} = 147 000 L 80% of 195 600 = 156 000 L (> 147 000 L) }	**1** **1**
(biii)	Plausible suggestion Explains effect of suggestion on fuel needed – must have correct physics reasoning E.g.: head winds / diversion from route / delays in landing; so plane must stay longer in the air E.g.:	**1** **1**

	more fuel needed at take-off; work done in accelerating/overcoming turbulence/denser air at ground level	
(ci)	$F = 3 \times 270\ 000 = 810\ 000$ N $a = F/m = 810\ 000$ N/273 900 kg = 2.96 m s^{-2}	**1**
(cii)	$s = v^2/2a$ = (81 m s^{-1})^2/2×2.96 m s^{-2} = 1100 m	**1**
(ciii)	Plausible suggestion Explains effect of suggestion on take-off distance – must have correct physics reasoning e.g. May not reach required *v* due to wind / other traffic on runway / turbulence If *v* not reached, plane would crash /need space to slow down/brake to a halt	 **1** **1**
(d)	Lift must equal weight weight = (mass)(g) <u>so</u> Lift is proportional to mass	**1** **1**
(e)	Best-fit line excluding Boeing 777 (Line should obviously exclude Boeing 777 and should be reasonable best fit of other points by eye, i.e. have points on each side) Larger mass planes have larger wing area Identifying Boeing 777 as different from others (e.g. Boeing 777 is an anomalous plot) Suggestion for odd position of Boeing 777 on the graph e.g. Boeing 777 has a relatively low mass because of its low fuel capacity (because of its good fuel effiency)	**1** **1** **1** **1**

Class	Index Number	Name
17S		

ST. ANDREW'S JUNIOR COLLEGE
JC 2 2018
Preliminary Examination

PHYSICS, Higher 2 **9749/03**

Paper 3 Longer Structured Questions **17th September 2018**
2 hours

Candidates answer on the Question Paper.
No additional materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, index number and Civics Group on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a 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 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	
Section A	
1	/ 17
2	/ 13
3	/ 10
4	/ 20
Section B	
5	/ 20
6	/ 20
Total	/ 80

This document consists of **21** printed pages including this page.

Data

speed of light in free space,	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space,	$\mu_o = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	$\varepsilon_o = 8.85 \times 10^{-12}$ 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,	$\phi = -\dfrac{Gm}{r}$
temperature,	$T/\text{K} = T/^{\circ}\text{C} + 273.15$
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,	$E = \dfrac{3}{2}kT$
displacement of particle in s.h.m.,	$x = x_o \sin \omega t$
velocity of particle in s.h.m.,	$v = v_0 \cos \omega t$
	$v = \pm\omega\sqrt{x_0^2 - x^2}$
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,	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage,	$x = x_o \sin \omega t$
magnetic flux density due to a long straight wire,	$B = \dfrac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil,	$B = \dfrac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid,	$B = \mu_0 nI$
radioactive decay,	$x = x_o \exp(-\lambda t)$
decay constant,	$\lambda = \dfrac{\ln 2}{t_{1/2}}$

Section A

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

1 **(a)** In the following list, underline **all** the scalar quantities.

acceleration pressure kinetic energy mass power weight

[1]

(b) Define displacement.

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

(c) A ball is kicked from point A, 1.0 m above the ground with a velocity of 20.0 m s^{-1} at an angle 50° to the horizontal as shown in Fig. 1.1. It reaches the maximum height at point H and finally lands on the ground at B.

Assume air resistance is negligible.

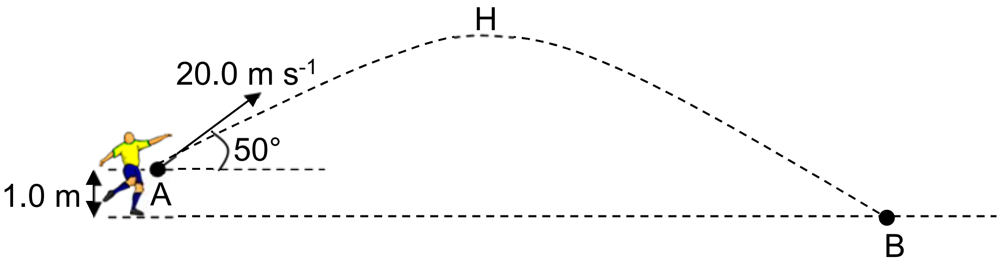


Fig. 1.1

(i) Determine the time of flight of the ball.

time = …………………………….. s [3]

(ii) Calculate the horizontal distance the ball travelled from A to B.

distance = ………………………….. m [1]

(iii) Calculate the speed of the ball when it hits the ground at B.

speed = ……………………….. m s^{-1} [2]

(iv) State the magnitude and direction of the acceleration of the ball at H.

magnitude and direction = …………………………………………… [1]

(v) **1.** On Fig. 1.2, sketch the variation with time t of the vertical component of the ball's velocity v_y.

[2]

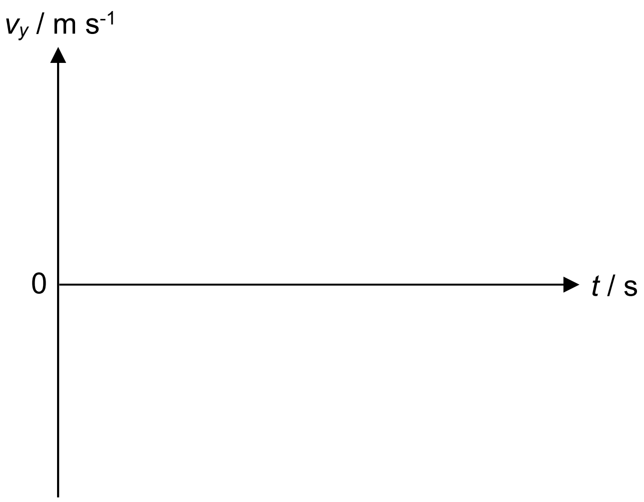


Fig. 1.2

2. On Fig. 1.3, sketch the variation with time *t* of the distance *d* travelled along its path.

[2]

Fig. 1.3

3. On Fig. 1.4, sketch the variation with time *t* of the kinetic energy E_k of the ball.

[2]

Fig. 1.4

(vi) Explain the effects on the trajectory (path) of the ball if air resistance is not negligible.

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

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

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

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

2 **(a)** Explain what is meant by an ideal gas.

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

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

(b) An ideal gas is enclosed in a cylinder by a gas-tight, frictionless piston as shown in Fig. 2.1.

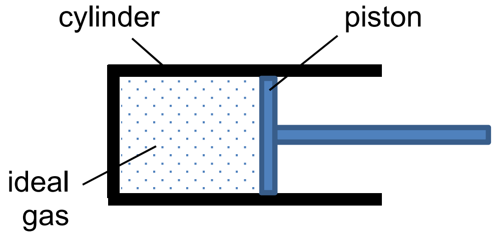


Fig. 2.1

Use the *molecular model* of a gas to explain the following phenomena.

(i) The pressure rises if the volume containing a given mass of gas is reduced, the temperature remaining constant.

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

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

…………………………………………………………………………………….…[2]

(ii) The temperature rises if the gas is compressed.

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

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

…………………………………………………………………………………….…[2]

(c) A fixed mass of monatomic ideal gas in a cylinder undergoes a cycle of changes of pressure, volume and temperature as shown in Fig. 2.2. Line **AB** and line **CD** represent two isothermal processes. The pressure at **A** and **B** are 2.7 x 10^5 Pa and 12 x 10^5 Pa respectively. The volume at **A** is 2.00 x10^{-3} m^3 and that at **B** is 0.45 x 10^{-3} m^3.

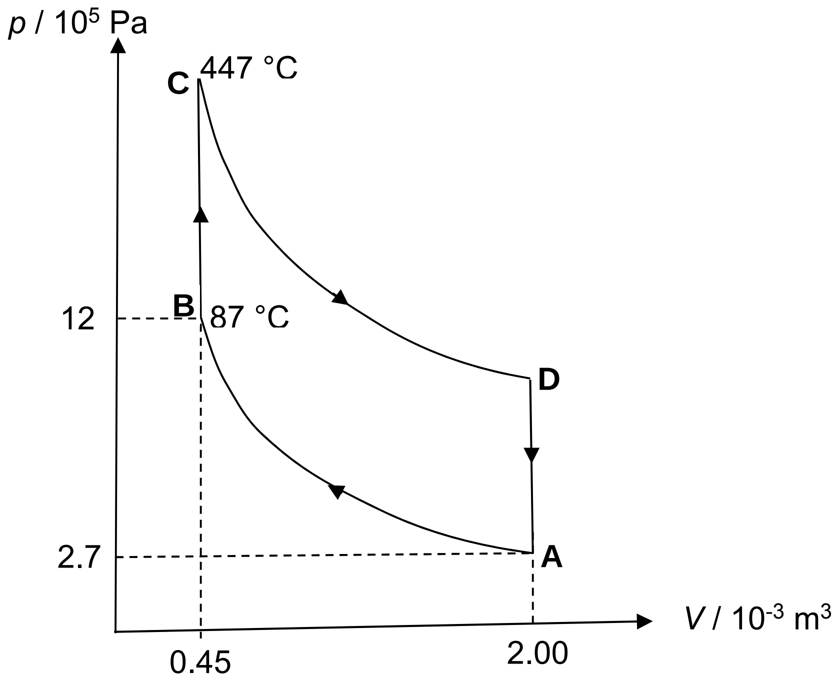


Fig. 2.2

(i) Determine the number of moles of the gas.

number of moles = ………………….. mol [1]

(ii) Calculate the heat supplied in the change from **B** to **C**, where the temperature of the gas rises from 87 °C to 447 °C.

heat supplied = ………………….. J [3]

(iii) Determine the net work done on the gas for a complete cycle. The magnitudes of heat transfer from **A** to **B** and from **C** to **D** are 8.1×10^2 J and 1.6×10^3 J respectively.

net work done = …….…………….. J [4]

3 Waves on water are usually produced by wind blowing across the surface.
Under certain conditions, standing waves called *seiches* can be produced on a shallow lake. Antinodes occur at opposite ends of the lake.
Fig. 3.1. shows the cross-section of a lake where a seiche is occurring, at equal intervals of time.

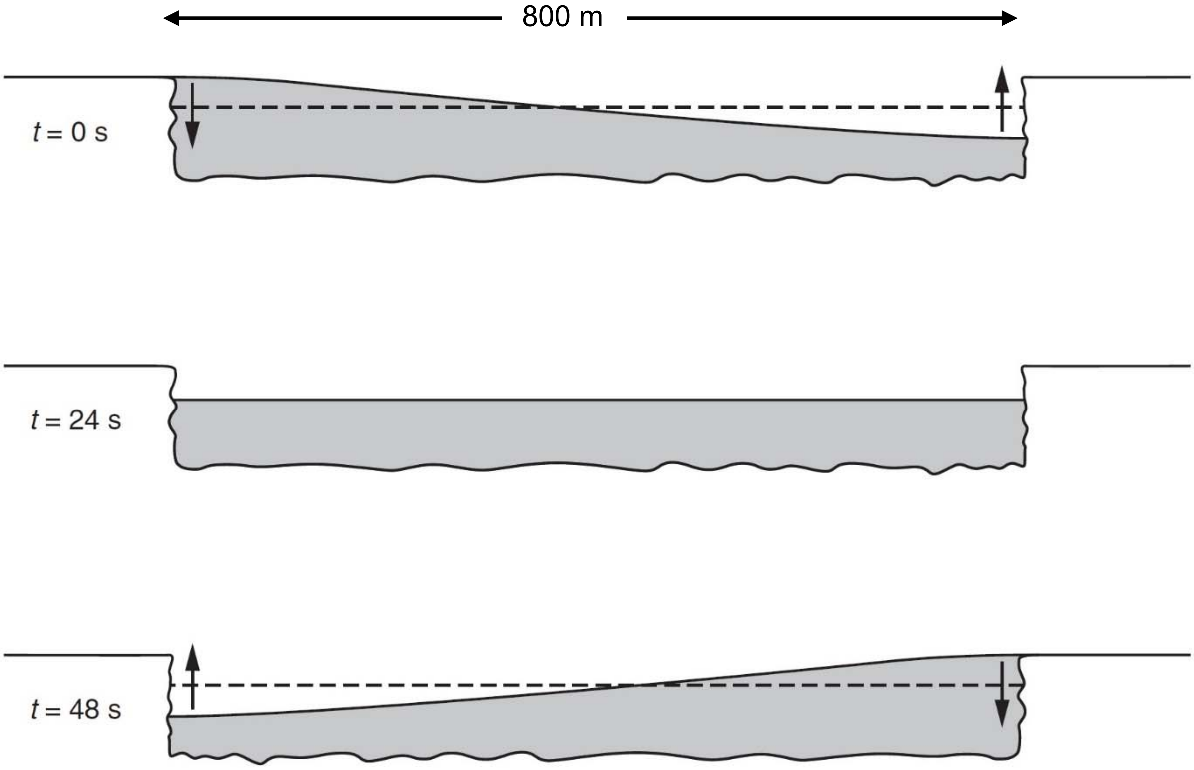


Fig. 3.1

(a) The standing waves shown in Fig. 3.1 occur in a small lake, 800 m long. They have a period of 96 s and amplitude of 1 m.

(i) Describe how someone viewing the lake might be aware that there were *standing waves* on the lake.

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

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

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

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

(ii) For the standing wave, label each antinode **A** and each node **N** on the bottom diagram of Fig. 3.1. With the aid of the labels, show that the wavelength of the water waves is 1600 m. [2]

(iii) Explain why Fig. 3.1 shows that the period of the waves is 96 s. Use this to calculate the speed of water waves in the lake.

speed = …………………………….m s^{-1} [2]

(b) Explain why standing waves of period 48 s might also be observed on this lake.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

(c) In another lake, the longest period of seiche standing waves observed is about 14 hours, not 96 s. Suggest and explain *one* way in which this other lake may differ from the one in Fig. 3.1.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

4 **(a)** The α-particle scattering experiment provided evidence for the existence of a nuclear atom.

State what could be deduced from the fact that

(i) most α-particles were deviated through angles of less than 10°,

....

.... [1]

(ii) a very small proportion of the α-particles was deviated through angles greater than 90°.

....

.... [2]

(b) **(i)** Define the term binding energy.

....

.... [1]

(ii) Use the data below to calculate the binding energy in MeV of a nucleus of ${}^{16}_{8}O$.

Data:	mass of proton	=	1.007 276 u
	mass of neutron	=	1.008 665 u
	mass of oxygen nucleus	=	15.990 527 u

binding energy = ... MeV [3]

(iii) The binding energy of $^{17}_{8}\mathrm{O}$ is 126.43 MeV.

State and explain which of these two isotopes of oxygen would be more stable.

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

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

(c) Scientists have worked out the age of the Moon by dating rocks brought back by the Apollo missions. They use the decay of potassium $^{40}_{19}\mathrm{K}$ to argon $^{40}_{18}\mathrm{Ar}$, which is stable. The decay constant of potassium-40 is 5.3×10^{-10} per year.

(i) Write a full nuclear equation for this decay.

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

(ii) Explain what is meant by the decay constant of potassium-40 being 5.3×10^{-10} per year.

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

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

(iii) On Fig. 4.1, sketch 2 labelled graphs to show how the number of $^{40}_{19}\mathrm{K}$ nuclei and $^{40}_{18}\mathrm{Ar}$ changes with time. Label the half-life with $t_{1/2}$.

[3]

Fig. 4.1

(iv) In one rock sample the scientists found 0.84 μg of argon-40 and 0.10 μg of potassium-40. Calculate the age of the rock sample in years.

age = ... years [2]

(v) State two assumptions that you have made for the calculation in **(iv).**

....

....

.... [2]

(vi) Calculate the activity of the potassium-40 in the rock sample. Hence, explain if it is necessary for the scientists who handled the rock sample to take special safety precautions.

activity = ... Bq [1]

....

.... [1]

Section B

Answer **one** question from this Section in the spaces provided.

5 **(a)** State what is meant by a gravitational field.

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

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

(b) Tides are caused by the gravitational forces exerted by the Sun and the Moon on the water in the Earth's oceans. Fig. 5.1 shows the distances from the Earth to the Sun and from the Earth to the Moon. The mass of the Sun is 2.0×10^{30} kg and mass of the Moon is 7.0×10^{22} kg.

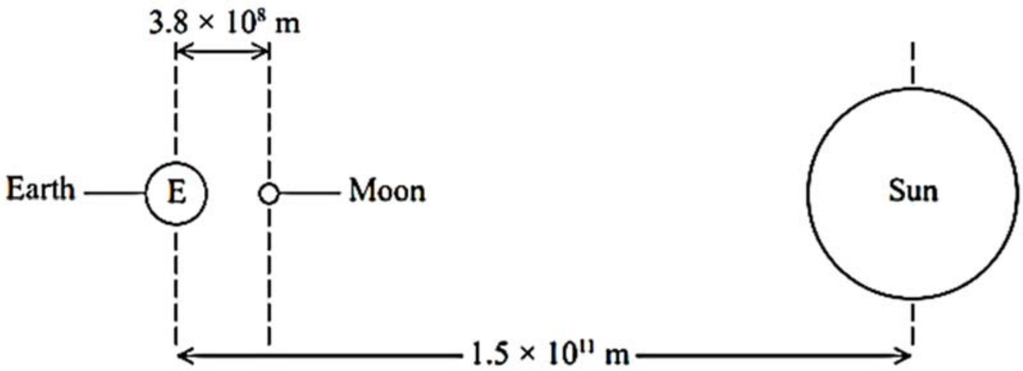


Fig. 5.1

(i) Calculate the ratio of the gravitational force acting on the Earth by the Sun to the gravitational force acting on the Earth by the Moon.

ratio = ……………………………………… [2]

(ii) Explain why, although the Earth, the Moon and the Sun are not point masses, the Newton's Law of Gravitation also applies to them.

………………………………………………………………………………………………

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

(iii) Explain why, although gravitational forces are attractive, the Moon does not accelerate and crash into the Earth.

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(iv) The Moon takes 27.3 days to make one complete orbit of the Earth. Determine the mass of the Earth.

mass = ... kg [3]

(v) The Moon is gradually moving further away from the Earth because of the action of the tides. Explain how this increasing distance affects the Moon's orbital period.

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(vi) In 200 years, the radius of the Moon's orbit is predicted to increase by 8 m. The rate of increase of the orbital radius is due to tidal action. However, in practice, this rate of increase is not constant.

Suggest and explain how this rate of increase might have been different in the very distant past.

……………………………………………………………………………………………

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

(vii) The tides depend on the difference in the gravitational field strength produced by the Sun (mass M_S) and the Moon (mass M_M) on opposite sides of the Earth (mass M_E). Fig. 5.2 shows the Earth and the Sun.

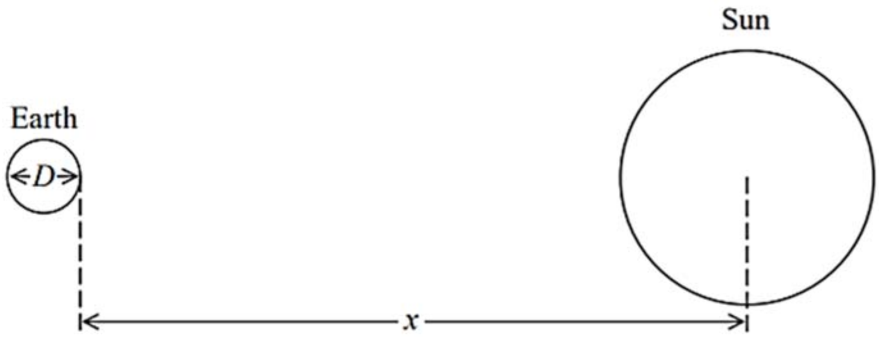


Fig. 5.2

1. State two expressions for the gravitational field strength due to the Sun at opposite sides of the Earth.

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

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

2. Hence explain why the Sun has a relatively small effect on the tides.

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

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

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

(c) **(i)** The Earth may be assumed to be an isolated sphere of radius 6.4 x 10^3 km. A rocket is projected vertically from the surface of the Earth so that it reaches an altitude of 1.3 x 10^4 km.
With reference to **(b)(iv)**, calculate the minimum speed of projection from the Earth's surface.

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

(ii) State the assumption made for the calculation in **(c)(i)**.

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

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

(iii) State why the equation

$$v^2 = u^2 + 2as$$

is not appropriate for the calculation in **(c)(i)**.

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

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

6 **(a)** A stream of electrons, travelling at 1.0×10^8 m s^{-1}, enters a region half-way between two parallel plates of the same length of 0.050 m and with a potential difference, as shown in Fig. 6.1.

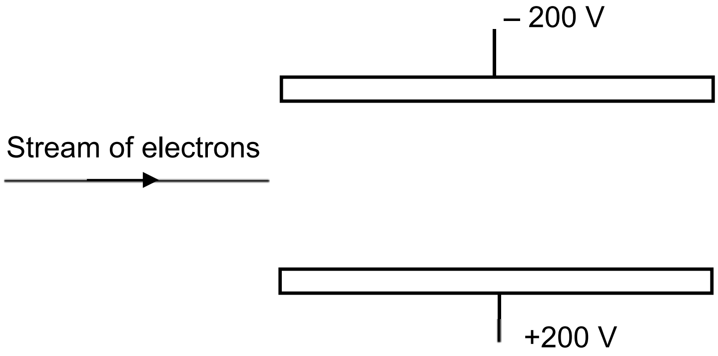


Fig. 6.1

(i) Calculate the separation between the plates given that the electric field strength between the plates is 2.0×10^4 N C^{-1}.

separation = ... m [1]

(ii) Calculate the magnitude of the acceleration of the electrons between the plates.

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

(iii) Explain whether the stream of electrons will hit the plate.

[3]

(iv) Hence, in Fig. 6.1 draw the path of the stream of electrons between and beyond the plates. [1]

(b) The EZ-link card is a contact-less smartcard used for payment purposes in Singapore. The card has a thin wire coil with 3 turns each of area 4.00×10^{-3} m^2 printed along its edge. It also has a circuit which includes a transmitter and receiver that can communicate with external devices but it has no internal energy source.

The card obtains its energy from external devices like the card reader/writer located near the doors of the public buses and the MRT/LRT gantries. When the card reader/writer detects a card within range, it produces a changing magnetic field which affects the card thus allowing the information in the card to be read and updated. The magnetic flux density *B* from the card reader/writer is

$$B = B_0 \sin(2\pi ft)$$

(i) State the laws of electromagnetic induction.

………...…………………………………………………………………………………

………...…………………………………………………………………………………

………...…………………………………………………………………………………

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

(ii) Hence explain how the EZ-link card obtains its energy from the card reader/writer.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(iii) Explain whether the EZ-link card can still be used if it is bent until the embedded coil is broken.

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(iv) Given that the frequency of the magnetic flux density B from the card reader/writer is 13.56×10^6 Hz, show that the magnitude of the peak e.m.f. induced in the card is $1.02 \times 10^6\ B_0$.

[2]

(v) Calculate the value of B_0 if the card needs a peak voltage of 15.0 mV to operate.

B_0 = ………………………T [2]

(vi) The Earth's magnetic field is constant at about 30 μT. Suggest whether the Earth's magnetic field will disrupt the operation of the card reader/writer.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

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

(vii) Calculate the root-mean-square voltage that the card needs to operate.

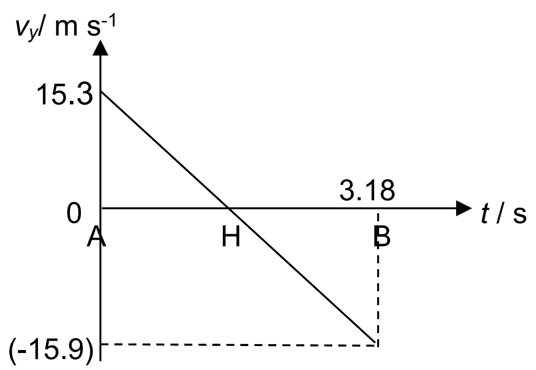
root-mean-square voltage =……………………V [1]

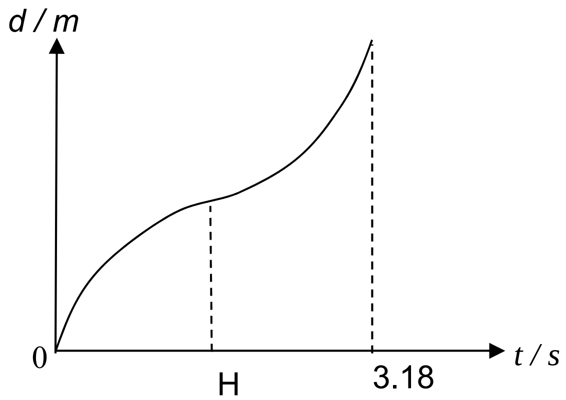
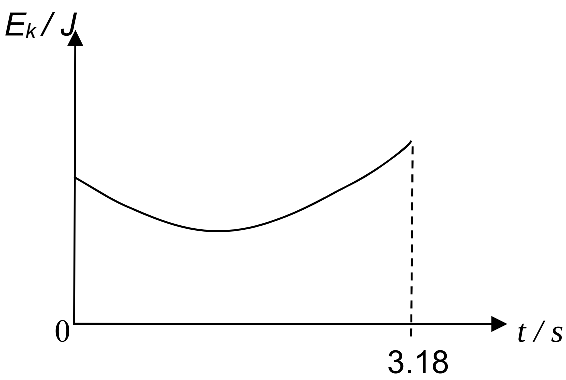
(viii) Given that the effective resistance of the circuit embedded within the card is 0.20 Ω, calculate the mean power that the card needs in order to operate.

mean power =………………………W [1]

End of paper

Solution for 2018 SAJC H2 Physics Prelim Paper 3

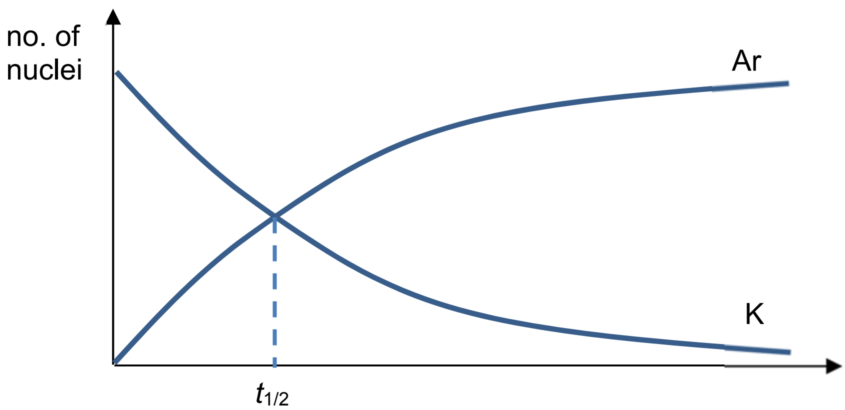
1 (a)	<u>pressure</u> <u>kinetic energy</u> <u>mass</u> <u>power</u>	**1**
(b)	<u>distance moved in a specific direction</u>	**1**
(c)(i)	$u_y = 20 \sin 50^o = 15.3$ taking upwards as positive, $s_y = u_y t + ½ gt^2$ $-1 = 20 \sin 50^o t + ½(-9.81)t^2$ $-1 = 15.3 t – 4.91 t^2$ $t = \frac{15.3 \pm \sqrt{15.3^2 - 4 \times 4.91 \times (-1.0)}}{2 \times 4.91}$ $= \frac{15.3 \pm 15.9}{2 \times 4.91}$ <u>= 3.18 s</u>	**1** **1** **1**
(ii)	$s_x = 20 \cos 50^o t$ $= 20 \cos 50^o (3.18)$ = <u>40.9 m</u> {allow ecf for wrong time}	**1**
(iii)	$v_x = 20 \cos 50^o = 12.9$ m s^{-1} $v_y^2 = u_y^2 + 2as_y$ $= (20 \sin 50^o)^2 + 2(-9.81)(-1)$ $v_y = \pm 15.9$ m s^{-1} $v = \sqrt{(v_x^2 + v_y^2)} = \sqrt{[(12.9)^2 + (-15.9)^2]}$ = <u>20.5 m s^{-1}</u> Alternative method: Initial KE + GPE = Final KE v = <u>20.5 m s^{-1}</u>	**1** **1** **OR** **1** **1**
(iv)	<u>9.81 m s^{-2}</u> and <u>downwards</u>	**1**
(v)1.	 Correct shape: inclined straight line with + or – gradient [1]	

	{Shape must be correct before awarding the second mark.} Show: HB > AH , 15.3 and 3.18 [1]	
(v)2.	 Correct shape. [1] {Shape must be correct before awarding the second mark.} Show point of inflexion having non-zero gradient and two ends having gradient ≠ ∞ [1]	
(v)3.	 Correct "U" shape not touching t-axis. [1] {Shape must be correct before awarding the second mark.} Show the tail end higher than the start point. [1]	
(vi)	Maximum height decreases and horizontal range/distance decreases {"trajectory shorter" is not accepted} due to work done against air resistance / greater deceleration caused by air resistance.	**1** **1**

2 (a)	An ideal gas is one that obeys the equation $p\ V = n\ R\ T$ for all values of pressure, volume and temperature.	**1**
(b)(i)	As volume is reduced, frequency of collision between molecules and walls of container increases. Hence, pressure rises. As the temperature remains constant, there is no increase in average KE of molecules, thus having no effect on pressure. OR Change in momentum per collision remains constant. {No mark for correct answers using the 1st law.}	**1** **1**
(ii)	During the compression, the piston transfers momentum to the colliding molecules. Hence, the velocity of every molecule which bounces off the piston increases. Average KE of molecules increases ($1/2mv^2 = 3/2kT$) which means temperature rises. {No mark for correct answers using the 1st law.}	**1** **1**
(c)(i)	Applying pV = nRT to either **A** or **B**, n = 0.18 mol	**1**
(ii)	$\Delta U = Q + W$ $w_{b\to c} = 0$ (no change in volume) OR $\Delta U = Q$ ideal gas : $U = \frac{3}{2} n\ RT \rightarrow \Delta U = 3/2\ n\ R\Delta T$ $\Delta U = \frac{3}{2}(0.18)(8.31)(447 - 87)$ $= 8.1 \times 10^2$ J {allow ecf for n} $\rightarrow Q = \Delta U = 8.1 \times 10^2$ J	**1** **1** **1**
(iii)	$W_{net} = W_{A\to B} + W_{B\to C} + W_{C\to D} + W_{D\to A}$ where $W_{B\to C} = 0 = W_{D\to A}$ (since $\Delta V = 0$ in these 2 processes) $\Delta U_{A\to B} = 0$ (isothermal) Thus $W_{A\to B} = -Q_{A\to B} = +8.1 \times 10^2$ J (for compression) $\Delta U_{c\to D} = 0$ (isothermal process) Thus $W_{C\to D} = -Q_{C\to D} = -1.6 \times 10^3$ J (expansion) Thus $W_{net} = (+8.1 \times 10^2) + 0 + (-1.6 \times 10^3) + 0$ $= -7.9 \times 10^2$ J {no ecf if W_{net} is positive. Students should be able to conclude by inspection that W_{by} is more than W_{on} and hence, W_{net} is negative.} {Can accept "table method"}	**1** **1** **1** **1**

L2	3(ai)	some parts don't move at all No movement (of wave profile) along surface OR The wave does not move/advance/travel left-to-right	1 1
L2	(aii)	Labelled on Fig 3.1 : A at ends and N in centre length (of lake) = ½ wavelength {second mark can be awarded if positions of A and N are interchanged} 800 m = ½ wavelength Wavelength = 2 × 800 m = 1600 m	1 1 0
	(aiii)	From Fig. 3.1, ½ T = 48 s, so T = 2 × 48 = 96 s (as it would take another 48 s for the wave to return to the original position at t = 0 s) $v = f\lambda = (1/T)\lambda = (1/96)(1600)$ $= 16.7 \text{ m s}^{-1}$	1 1
L3	(b)	different wind speed may produce different standing wave pattern OR Stronger wind results in higher frequency Period of 48s is half of 96s OR frequency is doubled OR Frequency of wind matches one of the natural frequencies of the lake Wavelength is ½ (1600) to 800m OR Stationary/standing waves will fit (in the lake) OR Period of 48s will form a stationary wave with antinodes on both sides of the lake	1 1 1
L3	(c)	Lake (is very much) longer/bigger , so distance from antinode-node-antinode is longer, so wavelength is longer, so frequency is lower (assuming v unchanged), so period is longer OR Lake is different in depth, so waves travel slower	1

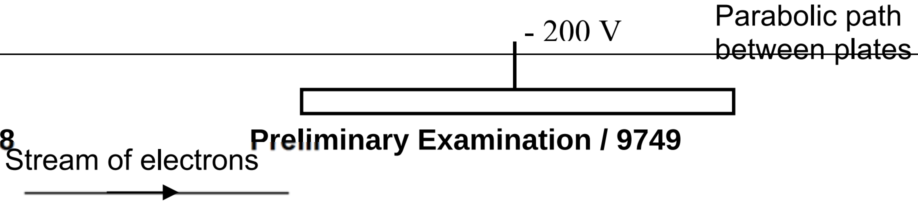
4(a)(i)	nucleus is small in comparison to size of atom (do not accept atom is mostly empty space)	1
(ii)	nucleus is massive/heavy/dense OR	1

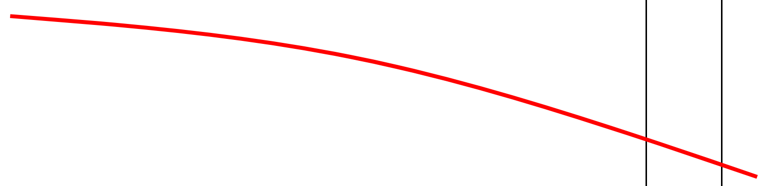
	mass is concentrated at the nucleus and (positively) charged	 1
(b)(i)	Energy supplied to completely separate the nucleus (atom) into its individual nucleons (and electrons) OR Energy released when the nucleus(atom) is formed from its constituent nucleons (and electrons)	1
(ii)	Mass defect, Δm = 8(1.007276 u) + 8(1.008665 u) – 15.990527 u = 0.137001 u Binding energy, $\Delta mc^2 = (0.137001 \times 1.66 \times 10^{-27})(3.00 \times 10^8)^2$ $= 2.04 \times 10^{-11}$ J $= 127.6$ MeV $= 128$ MeV	1 1 1
(iii)	Binding energy per nucleon for $^{17}_{8}O = \frac{126.43}{17} = 7.43$ MeV Binding energy per nucleon for $^{16}_{8}O = \frac{127.6}{16} = 7.98$ MeV Since $^{16}_{8}O$ has a higher binding energy per nucleon, it would be more stable. {allow ECF from b(ii)}	1 for both values 1
(c)(i)	$^{40}_{19}K \rightarrow ^{40}_{18}Ar + ^{0}_{1}\beta + \nu$ OR $^{40}_{19}K \rightarrow ^{40}_{18}Ar + ^{0}_{1}e + \nu$	1
(ii)	The probability that a particular potassium-40 nucleus will decay within a year is 5.3 x 10^{-10}.	1
(iii)	 [1] for K graph [1] for Ar graph intersect at half of initial no. of nuclei, mirror image of K [1] for labelling half-life at intersection point {if graphs are curving in the wrong way, do not award the third mark}	3
(iv)	Since the molar mass of the nuclides are the same, the number of nuclei is proportional to the mass of the sample.	1

	$M = M_0 e^{-\lambda t}$ $0.1 = (0.1 + 0.84)e^{-(5.3\times10^{-10})t}$ $\Rightarrow t = 4.23\times10^{9}\ years$	1
(v)	All the argon-40 is formed from the decay of potassium-40. No argon is lost.	1 1
(vi)	$A = \lambda N = \frac{5.3\times10^{-10}}{365\times24\times60\times60}\left(\frac{0.1\times10^{-6}}{40}\times6.02\times10^{23}\right)$ $= 0.025\,Bq$ Since the activity is quite low, not necessary. {ECF given for getting very high activity}	1 1

5(a)	Region of space in which a mass experiences a force	1
(b)(i)	F = GMm / r^2 $\frac{F_{sun}}{F_{moon}} = \frac{\frac{2.0\times10^{30}}{(1.5\times10^{11})^2}}{\frac{7.0\times10^{22}}{(3.8\times10^{8})^2}}$ = 183	1 1
(b)(ii)	The separation is much greater than the diameter/radius of the Moon and the Earth and the Sun.	1
(b)(iii)	Since the Moon has a linear/tangential velocity perpendicular to gravitational force, the gravitational force is just sufficient to provide the centripetal acceleration for the Moon to orbit about the Earth.	1 1
(b)(iv)	ω = 2π / T = 2π / (27.3 x 24 x 60 x 60) = 2.66 x 10^{-6} rad s^{-1} $mr\omega^2$ = GMm / r^2 M = (3.8 x $10^8)^3$ (2.66 x $10^{-6})^2$ / (6.67 x 10^{-11}) = 5.8 x 10^{24} kg	 1 1 1
(b)(v)	As orbital radius increases, angular velocity decreases (GM = $r^3\omega^2$) Since ω = 2π / T, orbital period increases OR By T^2 proportional to r^3, orbital period increases	1 1 1 1
(b)(vi)	In the past, since orbital radius is small, gravitational force is stronger. As tidal action is due to gravitational force, tidal action is stronger. Hence there is greater rate of increase in the past.	1
(b)(vii)1	$g_1 = GM_s / x^2$ $g_2 = GM_s / (x + D)^2$	1 for both
(b)(vii)2	Since x is much greater than D, Difference between gravitational field strength on opposite sides is very small / zero.	1 1

(c)(i)	Total Initial energy = Total Final energy ½ mv_{min}^2 + (- GMm / (6.4 x 10^6)) = 0 + (- GMm / (6.4 x 10^6 + 1.3 x 10^7) v_{min} = 9000.6 m s^{-1} OR use loss in KE = gain in GPE Note: Use M from (b)(iv)	**1** **1** **1**
(c)(ii)	Negligible air resistance	**1**
(c)(iii)	Acceleration (due to gravity) is not constant	**1**

6(a)(i)	$E = \frac{V}{d}$ $\Rightarrow d = \frac{V}{E}$ $= \frac{400}{2.0 \times 10^4}$ = 0.02 m	**1**
(ii)	F = qE $= (1.6 \times 10^{-19})(2.0 \times 10^4)$ = 3.2 x 10^{-15} N $a = \frac{F}{m_e}$ $= \frac{3.2 \times 10^{-15}}{9.11 \times 10^{-31}}$ =3.51 x 10^{15} m s^{-2} (downwards)	**1** **1**
(iii)	Time interval that the electron is inside the electric field = $\frac{s_x}{u_x}$ $= \frac{0.05}{1.0 \times 10^8}$ = 5.0 x 10^{-10} s Vertical distance travelled by the stream of electrons is given by $s_y = \frac{1}{2} a_y t^2$ $= \frac{1}{2}(3.51 \times 10^{15})(5.0 \times 10^{-10})^2$ = 4.39 x 10^{-4} m Since the vertical distance travelled by the stream of electrons in the region between the parallel plates is shorter than half the distance (< 0.01 m) between the two plates, the stream of electrons will NOT hit any of the parallel plates.	**1** **1** **1**
(iv)		**1**

	 Straight path after plates	
(b)(i)	Faraday's law of electromagnetic induction states that the magnitude of induced electromotive force in a coil is directly proportional to the rate of change of magnetic flux linkage through the coil. Lenz's law states that the direction of induced e.m.f. opposes the change causing it	1 1
(ii)	When the card is brought close enough to the card reader/writer, the **changing** magnetic field causes a **changing** magnetic flux linkage through the thin wire loops inside the card. Using Faraday's law, e.m.f. is induced in the loop, which results in a current due to a closed circuit**.** Thus the card obtains electrical energy which can be used to operate its transmitter and receiver.	1 1
(iii)	It cannot be used anymore since the breakage in the coil will cause an open circuit**.**	1
(iv)	Magnitude of e.m.f. induced $=\frac{d\Phi}{dt}=\frac{d(NBA)}{dt}=NA\frac{dB}{dt}=NA\frac{d(B_0\sin 2\pi ft)}{dt}=NAB_0\frac{d(\sin 2\pi ft)}{dt}$ $=2\pi fNAB_0\cos(2\pi ft)$ Magnitude of peak e.m.f. induced $= 2\pi(13.56 \times 10^6)(3)(4.00 \times 10^{-3})B_0$ $= 1.02 \times 10^6\ B_0$	1 1
(v)	Peak e.m.f. induced in card = peak voltage supplied to card $1.02 \times 10^6\ B_0 = 15.0 \times 10^{-3}$ $B_0 = 1.47 \times 10^{-8}$ T	1 1
(vi)	The Earth's magnetic field will not disrupt the operation of the card reader/writer since it is not a changing field.	2 or 0
(vii)	$V_{rms}=\frac{V_0}{\sqrt{2}}=\frac{15.0\times10^{-3}}{\sqrt{2}}=1.06\times10^{-2}$ V	1
(viii)	$\text{Power}=\frac{V_{rms}^{\ 2}}{R}=\frac{(10.6\times10^{-3})^2}{0.20}$ = 5.62×10^{-4} W	1