Class	Index Number	Name
17		

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

PHYSICS, Higher 1 **8867/01**

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 **16** printed pages including this page.

Data

speed of light in free space,	c =	3.00×10^{8} m s^{-1}
elementary charge,	e =	-1.60×10^{-19} C
unified atomic mass constant	u =	1.66×10^{-27} kg
rest mass of electron,	m_e =	9.11×10^{-31} kg
rest mass of proton,	m_p =	1.67×10^{-27} kg
the Avogadro constant,	N_A =	6.02×10^{23} mol^{-1}
gravitational constant,	G =	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g =	9.81 m s^{-2}

Formulae

uniformly accelerated motion,	s =	$u t + \frac{1}{2} a t^2$
	v^2 =	$u^2 + 2 a s$
resistors in series,	R =	$R_1 + R_2 + ...$
resistors in parallel,	$1 / R$ =	$1 / R_1 + 1 / R_2 + ...$

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 $m^2 s^{-1} A^{-1}$

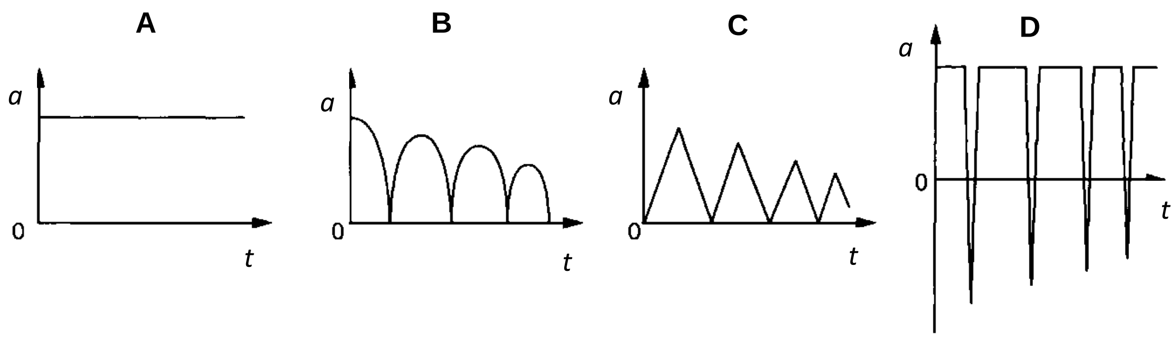
C W A^{-1} **D** A Ω

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 steel ball held above a horizontal table is released so that it falls on the table and rebounds several times. If the collisions are inelastic, which graph best represents the acceleration *a* of the ball with time, *t* ? Effects of air resistance may be neglected.



4 A ball is thrown vertically upwards and air resistance is not negligible**.** Which of the following statement is false?

A At the maximum height, acceleration is zero.

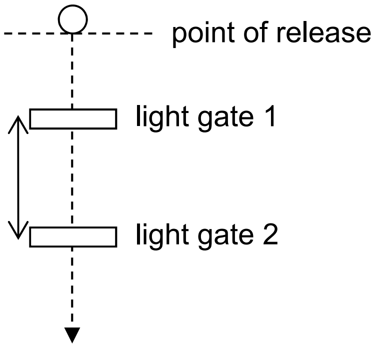
B The time taken for the ball to travel up is shorter than time taken for the downward motion.

C The distance travelled for the upward and downward motions are the same.

D The magnitude of the acceleration for the upward motion is always greater than 9.81 m s^{-2}.

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

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



What is the acceleration of free fall?

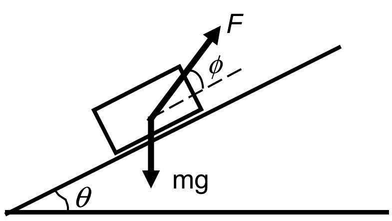
A $\frac{2h}{(t_2 - t_1)}$ **B** $\frac{2h}{(t_2 - t_1)^2}$ **C** $\frac{2h}{(t_2^2 - t_1^2)}$ **D** $\frac{2h}{\left(\frac{t_2 + t_1}{2}\right)^2}$

6 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 $\mathrm{m\,s^{-2}}$, what is the force exerted on the tractor by the trailer?

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

7 A force F is applied to a body of mass m on a smooth inclined plane as shown. The body moves up along the inclined plane with uniform acceleration. The magnitude of the resultant force acting on the body upwards along the incline is



A F sin ϕ – mg sin θ

B F cos ϕ – mg sin θ

C mg cos θ – mg sin θ

D –F cos ϕ + mg sin θ

8 Which statement shows an *incorrect* understanding of Newton's Third Law?

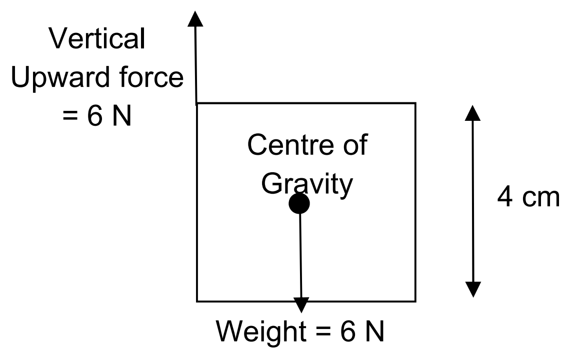
A The reason why a person is unable to move a heavy box when he pushes it is because the box pushes back on him with an equal force.

B When boy A punches boy B with a force of 100 N, boy A will experience a force of 100 N due to boy B.

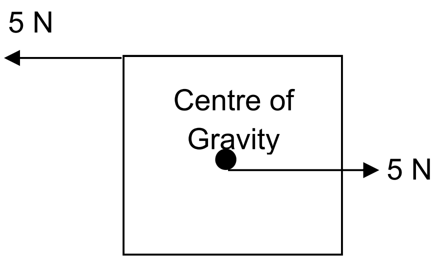
C The weight of the book and the normal force which is acting on the book when placed on a table is not an action-reaction pair.

D The pull of the Earth on you and the pull you exert on the Earth is an action-reaction pair.

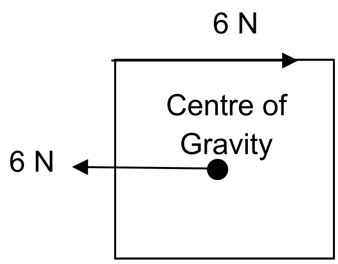
9 The diagram below shows two forces acting on a uniform square plate of metal.



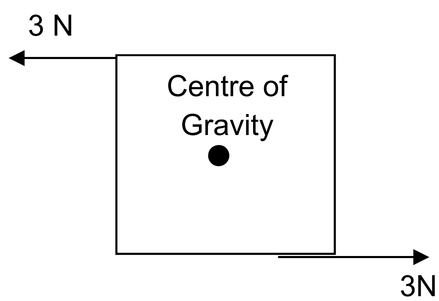
Which of the following force(s) would ensure equilibrium when added to the setup above?



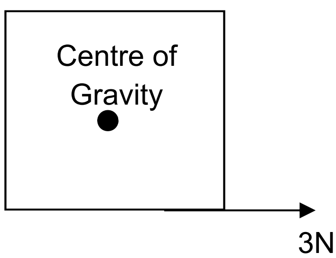
A



B

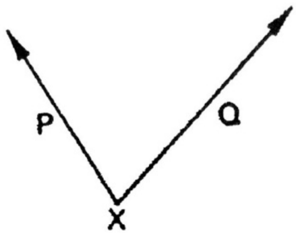


C



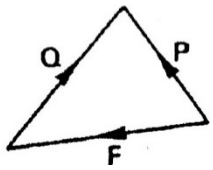
D

10 Two forces P and Q act at a point X as shown in the vector diagram below.

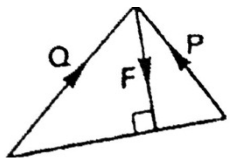


In which of the following diagrams does the vector *F* represent the force which must be applied at X to maintain equilibrium?

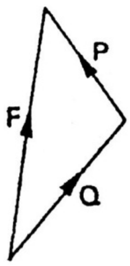
A



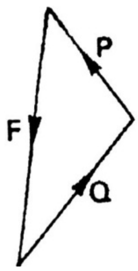
B



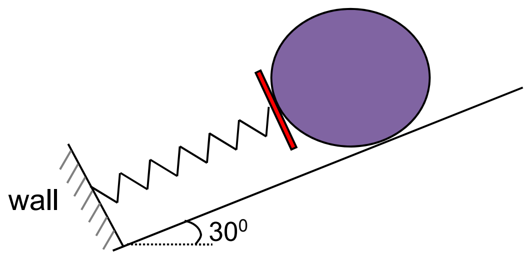
C



D



11 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

12 Wind powered generators have been known to operate at 45% efficiency. If such a generator generates 1000 MW of electrical power, what is the input power and what is the wasted power?

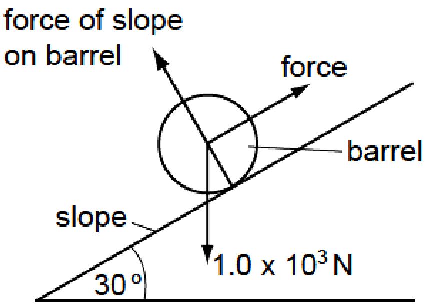
	Input power/MW	Wasted power/MW
A	1000	450
B	1000	550
C	1450	450
D	2200	1200

13 An object of weight 50 N is dragged up an inclined plane at constant speed, through a vertical height of 12 m. The total work done is 1500 J.

The work done against friction is

A 600 J **B** 900 J **C** 1500 J **D** 2100 J

14 The diagram shows a barrel of weight 1.0×10^3 N on a frictionless slope inclined at 30° to the horizontal.



A force is applied to the barrel to move it up the slope at constant speed. The force is parallel to the slope.

What is the work done in moving the barrel a distance of 5.0 m up the slope?

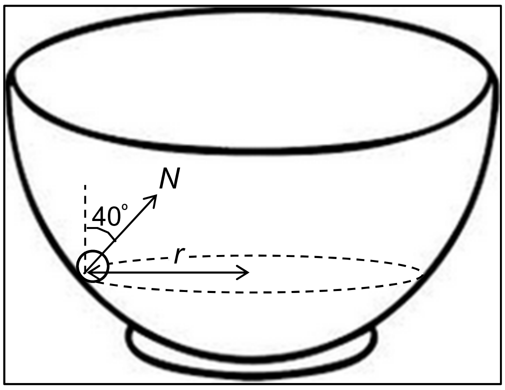
A 1.0×10^4 J

B 2.5×10^3 J

C 4.3×10^3 J

D 5.0×10^3 J

15 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?



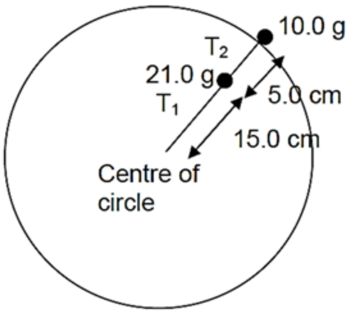
A 0.070 m

B 0.090 m

C 0.11 m

D 0.13 m

16 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?

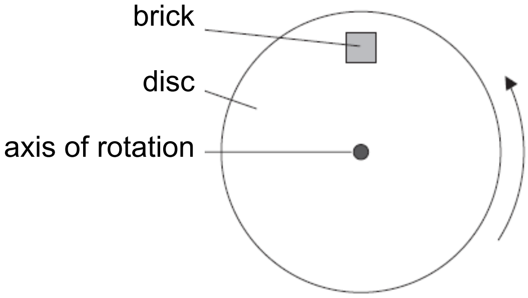
A 1.0

B 1.6

C 2.1

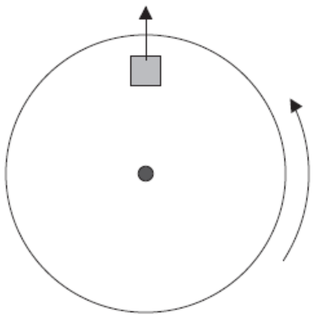
D 2.6

17 A brick is placed on the surface of a flat horizontal disc as shown in the diagram below. The disc is rotating at constant speed about a vertical axis through its centre. The brick does not move relative to the disc.

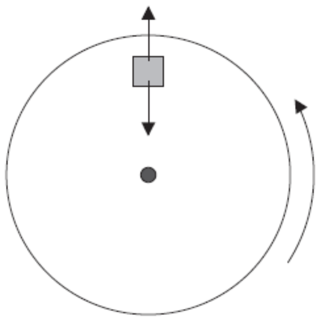


Which of the diagrams below correctly represents the **horizontal** force or forces acting on the brick?

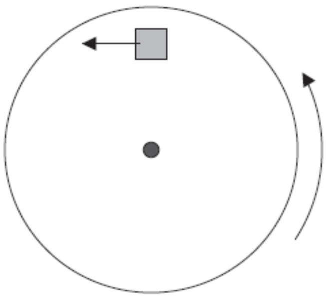
A



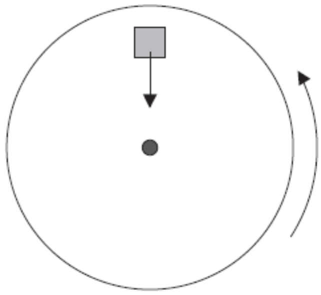
B



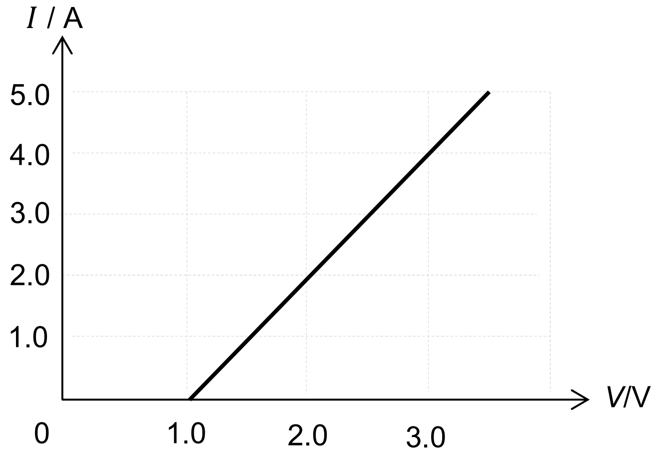
C



D

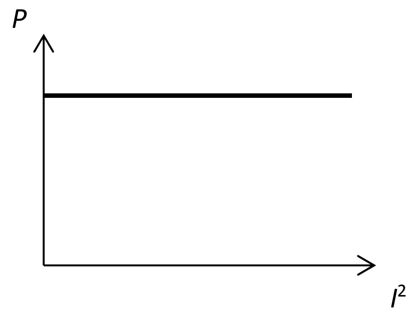


18 The graph below shows the I-V characteristic of a conductor.

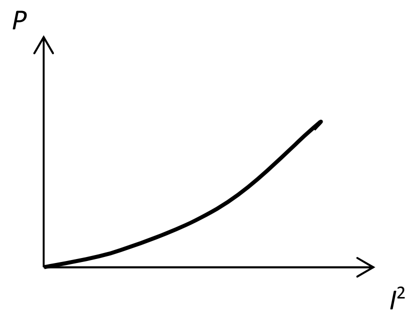


Which of the following graphs best represents the variation of power P dissipated in the same conductor with I^2 ?

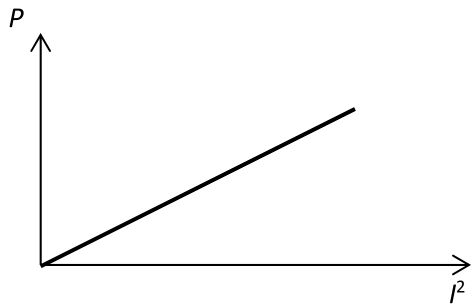
A



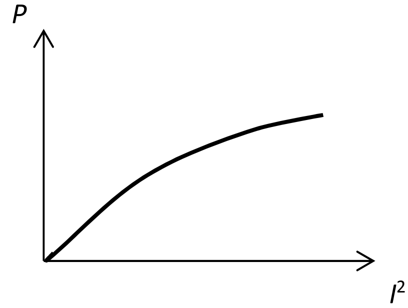
C



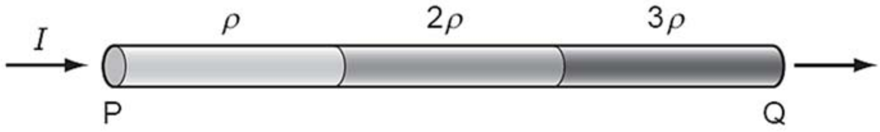
B



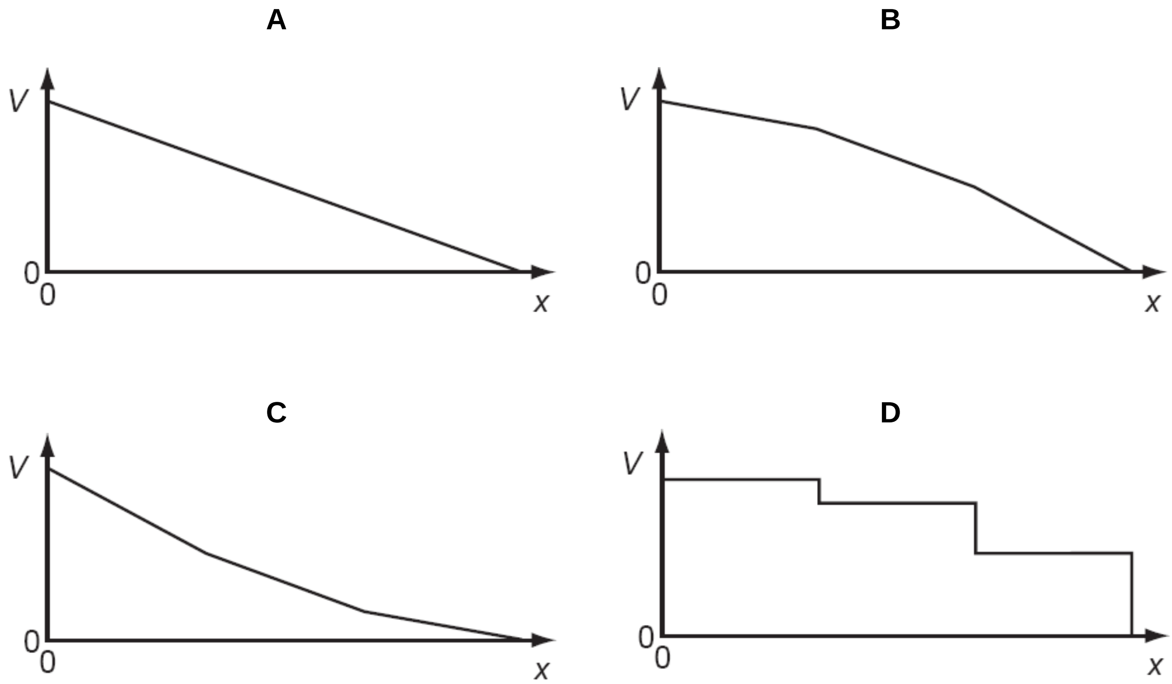
D



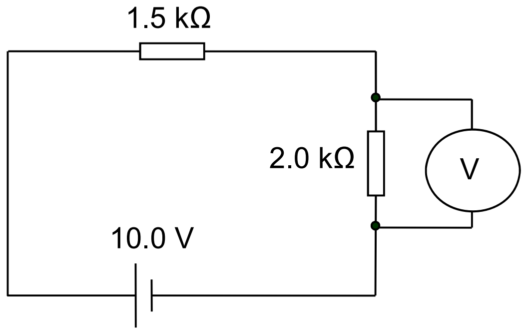
19 A wire PQ is made of three different materials, with resistivities ρ, 2ρ and 3ρ. There is a current I in this composite wire, as shown.



Which graph best shows how the potential V along the wire varies with distance x from P?



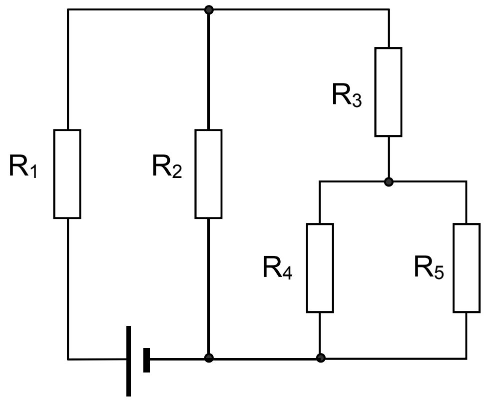
20 A 10.0 V cell of negligible internal resistance is connected to two resistors of resistances 2.0 kΩ and 1.5 kΩ. A voltmeter of resistance 1.0 kΩ is connected across the 2.0 kΩ resistor.



What is the voltmeter reading?

A 2.7 V **B** 3.1 V **C** 4.3 V **D** 5.7 V

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



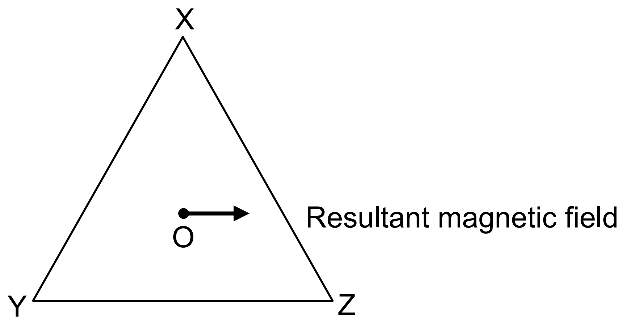
Which resistor dissipates the most power?

A R_1 **B** R_2 **C** R_3 **D** R_4

22 When a 4 Ω resistor is connected between the terminals of a certain cell, a 2 A current flows. When the 4 Ω resistor is replaced by one of 2 Ω, the current is 3 A. The e.m.f. and internal resistance of the cell are respectively

A 15 V, 4 Ω **B** 12 V, 2 Ω **C** 10 V, 1 Ω **D** 8 V, zero

23 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?

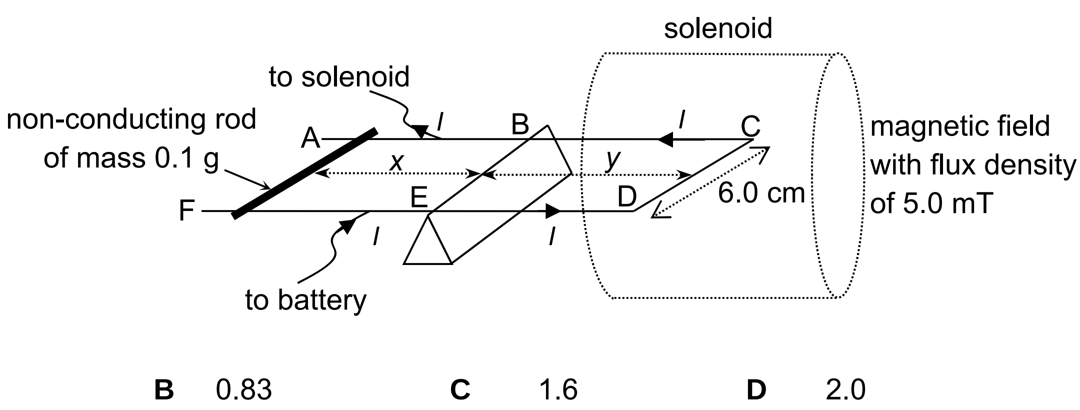


	Into page	**Out of page**
A	X	Y and Z
B	Z	X and Y
C	Y and Z	X
D	X, Y and Z	None

24 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.

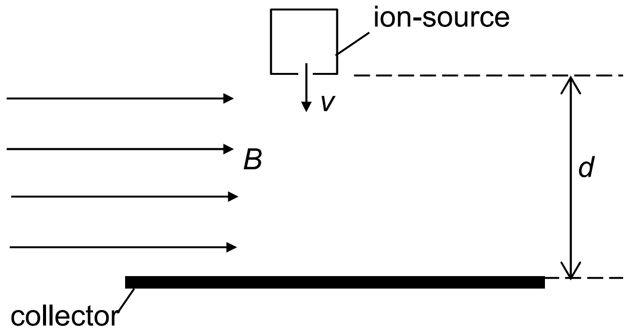
A current I of 2.0 A is then passed through the frame as shown and the position of the non-conducting rod of mass 0.10 g is adjusted so that the frame is oriented horizontally.

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

25 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?

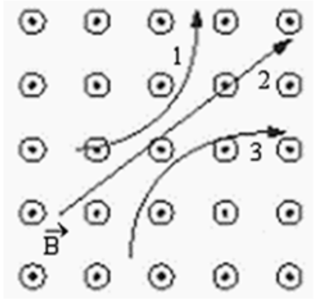
A $v > \sqrt{\dfrac{2Bq}{m}}$

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

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

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

26 Three particles travel through a region of space where the magnetic field is out of the page, as shown in the figure below.



Which statement about their charges is correct?

A 1 is neutral, 2 is negative, and 3 is positive.

B 1 is negative, 2 is neutral, and 3 is positive.

C 1 is positive, 2 is negative, and 3 is neutral.

D 1 is positive, 2 is neutral, and 3 is negative.

27 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

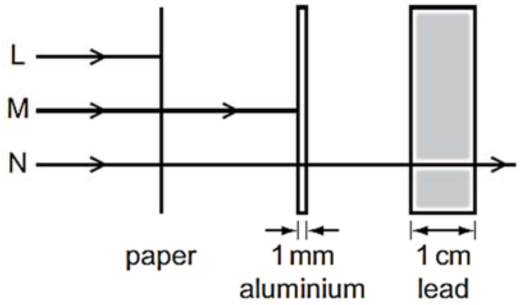


diagram 2

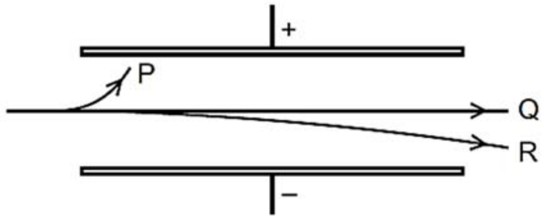
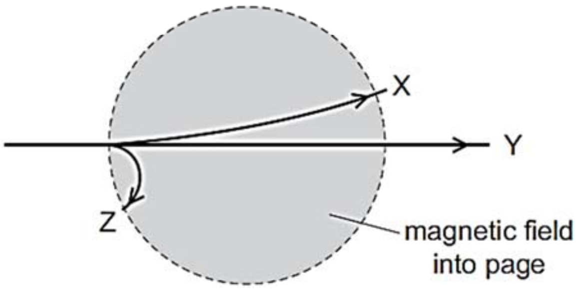


diagram 3



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

28 A radioactive nucleus decays to form an isotope of the original nucleus.

What could be the other products of this radioactive decay?

A one α-particle and four β-particles

B one α-particle and two β-particles

C two α-particles and two β-particles

D four α-particles and one β-particle

29 A parent nucleus, initially at rest, decays into two particles of masses m_1 and m_2, moving away from each other in opposite directions.

If E is the total energy of the two particles, what is the energy associated with the particle of mass m_1?

A $\frac{m_1}{m_2}E$

B $\frac{m_2}{m_1}E$

C $\frac{m_2}{m_1 + m_2}E$

D $\frac{m_1}{m_1 + m_2}E$

30 Which of the following statements concerning nuclear reactions, the mass differences and energies released is always true?

A The greater the binding energy of a nucleus, the more stable it is.

B When a stationary nucleus decays to produce an alpha particle, the alpha particle and daughter nucleus always move off in opposite directions so as to conserve linear momentum.

C If the total mass of the products of a reaction is lesser than its initial reactants, this reaction cannot be spontaneous.

D In a nuclear fusion, the reactant's nuclei have lesser mass and the product nuclei have greater mass.

END OF PAPER

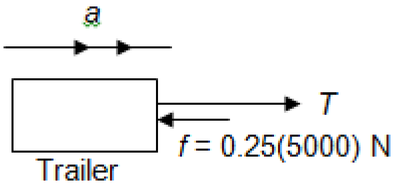
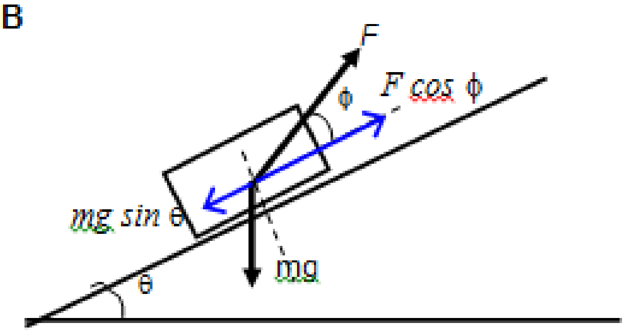
JC2 Preliminary Exam 2018 (H1 Physics)
Paper 1 Solutions

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

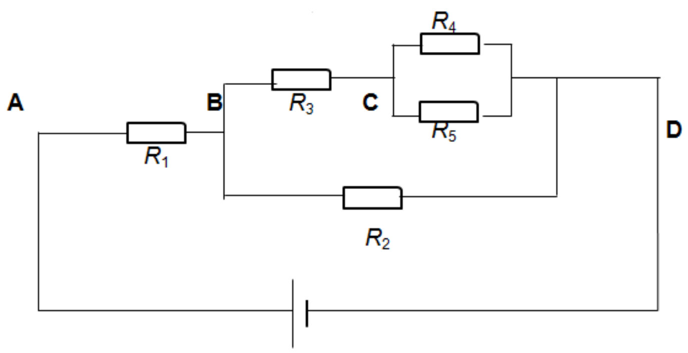
Qn	11	12	13	14	15	16	17	18	19	20
Ans	B	D	B	B	D	D	D	D	B	B

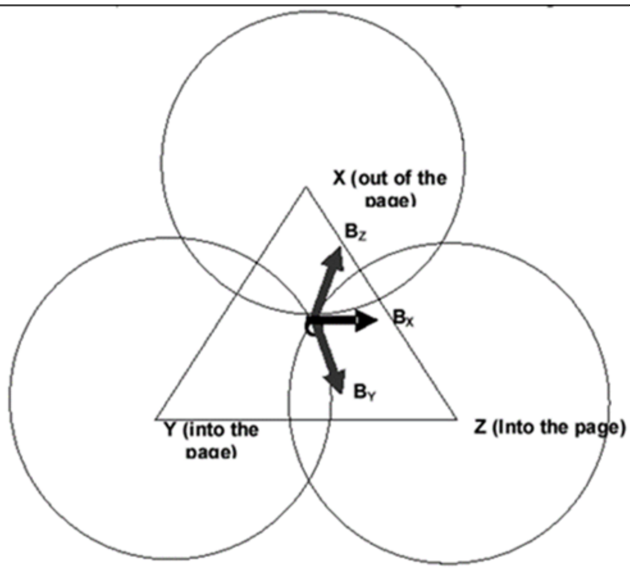
Qn	21	22	23	24	25	26	27	28	29	30
Ans	A	B	C	A	C	B	C	B	C	B

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 Acceleration of the ball is constant at 9.81 m s^{-2} while the ball is in the air; but acceleration is negative (i.e. pointing upwards) due to the large net force (= Normal contact force – weight) when the ball is on the table.
4	Ans: A At the point of maximum height, the speed is zero and air resistance is zero. Hence, the acceleration at that point is 9.81 m s^{-2} downwards.
5	Ans: C $s_1 = 0 + \frac{1}{2}gt_1^2$ ----(1) , $s_2 = 0 + \frac{1}{2}gt_2^2$ ----(2) (2) – (1) $\Rightarrow$ $h = s_2 - s_1 = \frac{1}{2}g(t_2^2 - t_1^2)$ $g = \frac{2h}{\left(t_2^2 - t_1^2\right)}$

6	Ans: B $T - f = ma$ $T - 0.25(5000) = 1500(1.0)$ $T = 2750\ \text{N}$ 
7	Ans: B B 
8	Ans: A It is a fact that the box will push back on the person with the same force he pushes on the box, however, the reason why the box does not move is perhaps due to friction between the box and the ground.
9	Ans: C For equilibrium, There must be rotational equilibrium and translational equilibrium. The original setup has attained translational equilibrium already. The additional forces to be added must have translational equilibrium as well. In addition, the original setup has a resultant clockwise moment of 6 x 0.02 = 0.12 Nm. Hence, option C, which gave a resultant anticlockwise moment of 3 x 0.04 = 0.12 Nm, will be the required option.
10	Ans: D The three force vectors P, Q and F must form a closed triangle when drawn in a continuous manner.
11	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.*

	$mg\sin\theta = ke$ or $e = \dfrac{(3.00)(9.81)\sin 30^0}{500} \approx 0.0294\text{ m}$ $= 29.4\text{ mm}$
12	Ans: D Efficiency = $\dfrac{\text{Output power}}{\text{Input power}} \times 100\%$ $0.45 = \dfrac{1000}{\text{Total input}} \Rightarrow$ Input power = $\dfrac{1000}{0.45} = 2200$ MW. Hence, wasted power will be 2222 – 1000 = 1200 MW.
13	Ans: B Total work done = W.D. against Friction + W.D. against gravity 1500 = W.D. against Friction + (50 x 12) W.D. against Friction = 900 J
14	Ans: B Work done = force x displacement in the direction of the force At constant speed, the force applied = component of weight down the slope Work done = $1.0 \times 10^3 \sin 30^o \times 5.0 = 2500$ N
15	Ans: D ω = 10 (2 x 3.14) / 8 = 7.85 rad s^{-1} Resolve vertically: N cos θ = mg ----(1) Resolve horizontally: N sin θ = m r ω^2----(2) (2)/(1) tan θ = r ω^2 / g r = g tan θ / ω^2 = 0.13 m
16	Ans: D Considering 10.0 g alone, T_2 provides the centripetal force for it. T_2 = m r ω^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
17	Ans: D Friction is the only force acting on the brick. It provides the centripetal force.
18	Ans: D For the *I-V* graph given, the resistance decreases as the current increases. Using $P = I^2R$, the gradient, representing the resistance, decreases with increasing current *I*.

19	Ans: B V = RI, R=ρx/A. So, V = (ρI /A) x. For graph of V against x, ρI /A is the gradient. Since I & A are constant, when ρ is greater, gradient is steeper.
20	Ans: B The voltmeter and the 2.0 kΩ resistor has a combined equivalent resistance of 0.667 kΩ. The p.d. across the equivalent resistor can be determined using the potential divider principle, = $\frac{0.667}{0.667+1.5}$ x 10 = 3.07 V.
21	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)] = 3*R*/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.
22	Ans : B E = I x (R + r) = 2 x (4 + r) = 3 x (2 + r) 8 + 2r = 6 + 3r ⇒ r = 2 E = 2 x (4 + 2) = 12 V
23	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.

	
24	Ans: A mg (x) = BIL (y) $(0.10\times10^{-3})(9.81)(x) = (5.0\times10^{-3})(2.0)(6.0\times10^{-2})(y)$ $\frac{x}{y} = 0.61$
25	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*. i.e. $\frac{mv}{Bq} > d \quad \Rightarrow v > \frac{dBq}{m}$
26	Ans: B Particle 2 is neutral since its path is straight and not affected by the magnetic field. Using Fleming's Left Hand Rule, the curved paths of the particles 1 and 3 indicates that particle 1 is negatively charged whereas particle 3 is positively charged.
27	Ans: C L: alpha M: beta N: gamma P: beta Q: gamma R: alpha X: alpha Y: gamma Z: beta
28	Ans: B Isotopes are atoms of the same element whose nuclei have the same number of protons (but different number of neutrons). Only option B allows for the atomic numbers of the original nucleus and the isotope to be equal. (See sample below) $parent_{150}^{200} \rightarrow daughter_{150}^{196} + \alpha_2^4 + 2\beta_{-1}^0$

29	Ans: C By conservation of momentum, $m_1 v_1 = m_2 v_2$ $\Rightarrow \frac{v_1}{v_2} = \frac{m_2}{m_1}$ …. (1) Energy of m_1 , $E_1 = \frac{1}{2} m_1 v_1^2$ …. (2) Energy of m_2 , $E_2 = \frac{1}{2} m_2 v_2^2$ …. (3) $E = E_1 + E_2$ $\frac{(2)}{(3)}$: $\frac{E_1}{E_2} = \frac{m_1 v_1^2}{m_2 v_2^2} = \frac{m_2}{m_1}$ $\Rightarrow \frac{E_1}{E - E_1} = \frac{m_2}{m_1}$ $\Rightarrow E_1 = \frac{m_2}{m_1 + m_2} E$
30	Ans: B The nucleus is initially stationary, initial momentum of the system is zero. When it decays into its products, total momentum must be conserved, hence the products move in opposite directions (with equal and opposite momenta).

End of solutions

Civic Group	Index Number	Name
17		

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

PHYSICS, Higher 1 **8867/02**

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.

Section **A**
Answer **all** questions.

Section **B**
Answer any **one** question

You are advised to spend about one hour and 30 minutes on Section A and about 30 minutes 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	/ 5
2	/ 9
3	/ 10
4	/ 11
5	/ 8
6	/ 17
Section B	
7	/ 20
8	/ 20
Total	/ 80

This question paper consists of 26 printed pages including this page.

Data

speed of light in free space,	c =	3.00×10^{8} m s^{-1}
elementary charge,	e =	-1.60×10^{-19} C
unified atomic mass constant	u =	1.66×10^{-27} kg
rest mass of electron,	m_e =	9.11×10^{-31} kg
rest mass of proton,	m_p =	1.67×10^{-27} kg
the Avogadro constant,	N_A =	6.02×10^{23} mol^{-1}
gravitational constant,	G =	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g =	9.81 m s^{-2}

Formulae

uniformly accelerated motion,	s =	$u\,t + \frac{1}{2}\,a\,t^2$
	v^2 =	$u^2 + 2\,a\,s$
resistors in series,	R =	$R_1 + R_2 + ...$
resistors in parallel,	$1 / R$ =	$1 / R_1 + 1 / R_2 + ...$

Section A

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

1 **(a)** 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 what is meant by work done.

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

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

(b) Two forces, each of magnitude F, form a couple acting on the edge of a disc of radius r, as shown in Fig. 2.1.

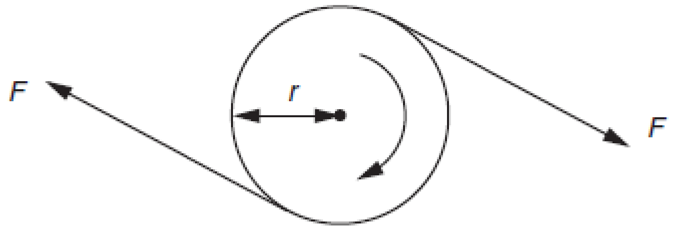


Fig 2.1

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) and the work done by one of the two forces.

work done = ………………………………. [1]

(c) Using your answer to **(b)**, 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]

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

output power = ……………………………W [2]

(e) The efficiency of the car engine in **(c)** is 20%. Determine the input power required to the engine.

input power = ……………………………W [2]

3 Tides are caused by the gravitational forces exerted by the Sun and the Moon on the water in the Earth's oceans. Fig. 3.1 shows the distances from the Earth to the Sun and from the Earth to the Moon. The mass of the Sun is 2.0 x 10^{30} kg and mass of the Moon is 7.0 x10^{22} kg.

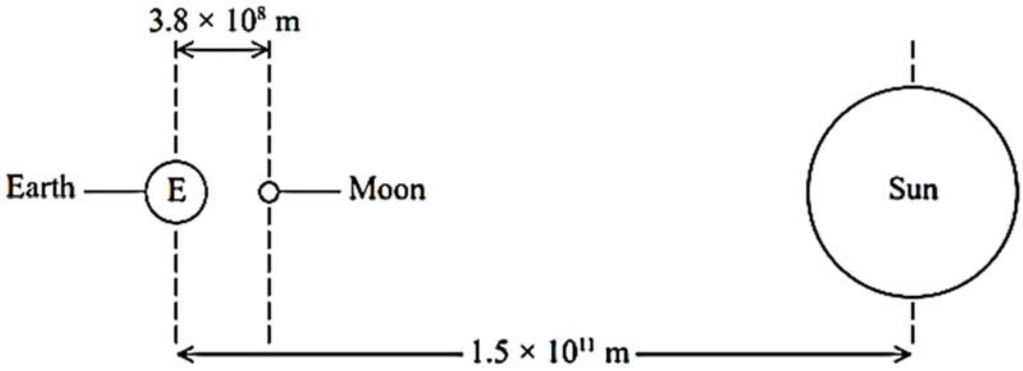


Fig. 3.1

(a) 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]

(b) 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]

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

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

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

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

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

mass = ... kg [3]

(e) 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]

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

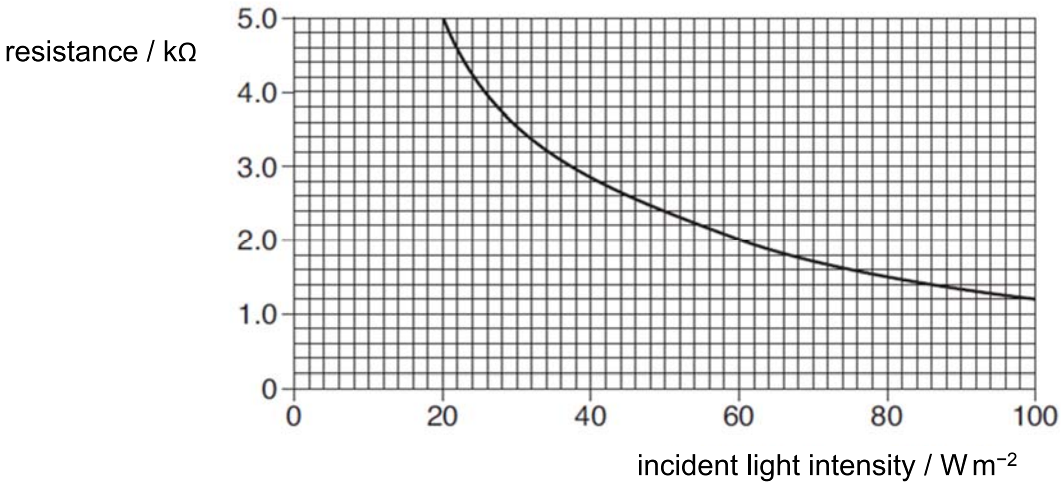


Fig 4.1

(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. 4.2, which should show a light-sensing circuit where the potential difference across the LDR, with characteristics shown in Fig. 4.1, 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.

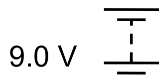


Fig. 4.2

[2]

(iii) Use Fig. 4.1 and Fig. 4.2 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. 4.3 shows a close-up of the LDR device used in the circuit in Fig. 4.2. The LDR consists of a uniform strip of 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.

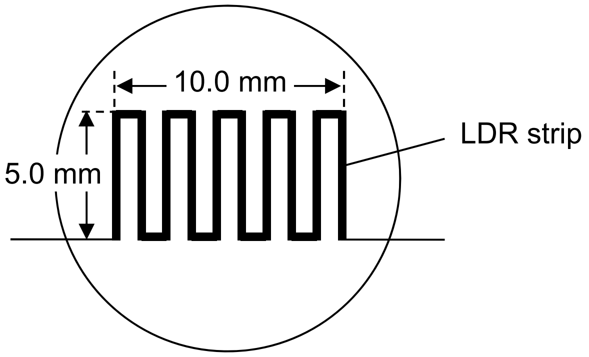


Fig. 4.3

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

resistivity = …………………….. Ω m [2]

(b) Fig. 4.4 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.

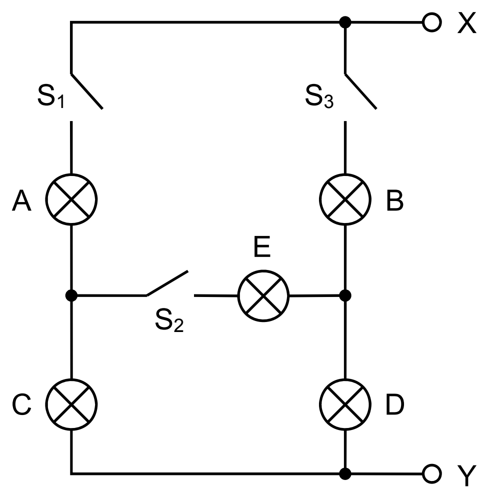


Fig. 4.4

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. 4.5 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. 4.5

Identify the faulty lamp, and the nature of the fault.

faulty lamp = ……..……………………[1]

nature of fault = ……..……………………[1]

5 **(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 an uniform electric field strength between the plates of 2.0×10^{4} N C^{-1}, as shown in Fig. 5.1.

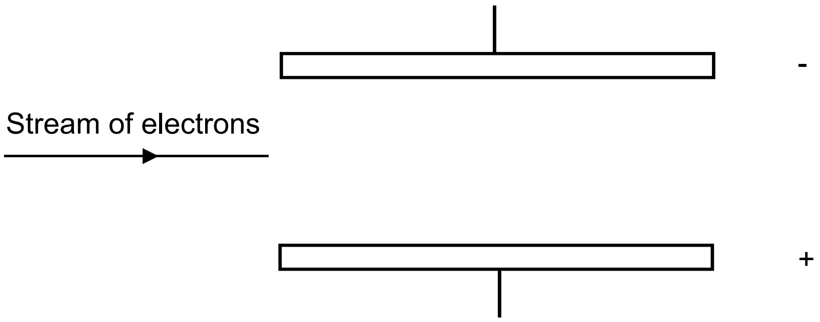


Fig. 5.1

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

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

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

[3]

(iii) Hence, in Fig. 5.1 draw the path of the stream of electrons between and beyond the plates (if applicable). [1]

(b) When an electric current flows through a thin metallic conductor in a magnetic field, the moving charges will accumulate at the sides of the conductor. The voltage measured across both sides is known as the Hall voltage.

Fig. 5.2 shows a metallic conductor of thickness *d* and width *w*, placed perpendicularly to a magnetic field, *B*.

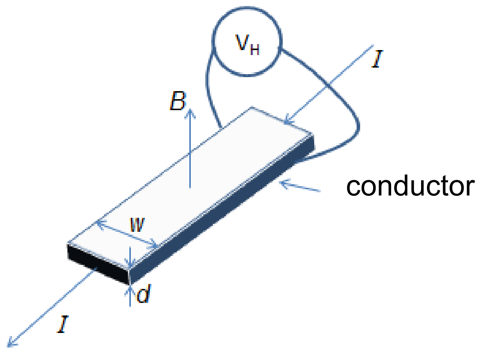


Fig. 5.2

An electric current, I, has been passed through the metallic conductor in the direction shown until a steady voltage reading, V_H, is obtained.

(i) Indicate on Fig. 5.2 the polarity of the respective edges of the conductor. [1]

(ii) Explain how your answer in **(i)** is obtained.

………………………………………………………………………………………………

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

6 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. 6.1.

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	284 000	3400	876	8000	155 400	13 500	362
Airbus A340-600	4	276	365 000	3200	902	9800	195 600	13 900	437
Boeing 777-200	2	343	247 000	3100	900	7700	117 300	9000	430
Boeing 747-400	4	264	397 000	3600	925	14 160	216 800	13 500	525
DC10-40	3	236	251 700	2800	965	10 800	138 700	9300	339
MD-11	3	270	273 900	3100	945	9000	146 000	12 600	339

Fig. 6.1

(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. 6.1 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. 6.1 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. 6.2 shows the relationship between maximum take-off mass *M* and wing area *A* for all six aircraft in the table.

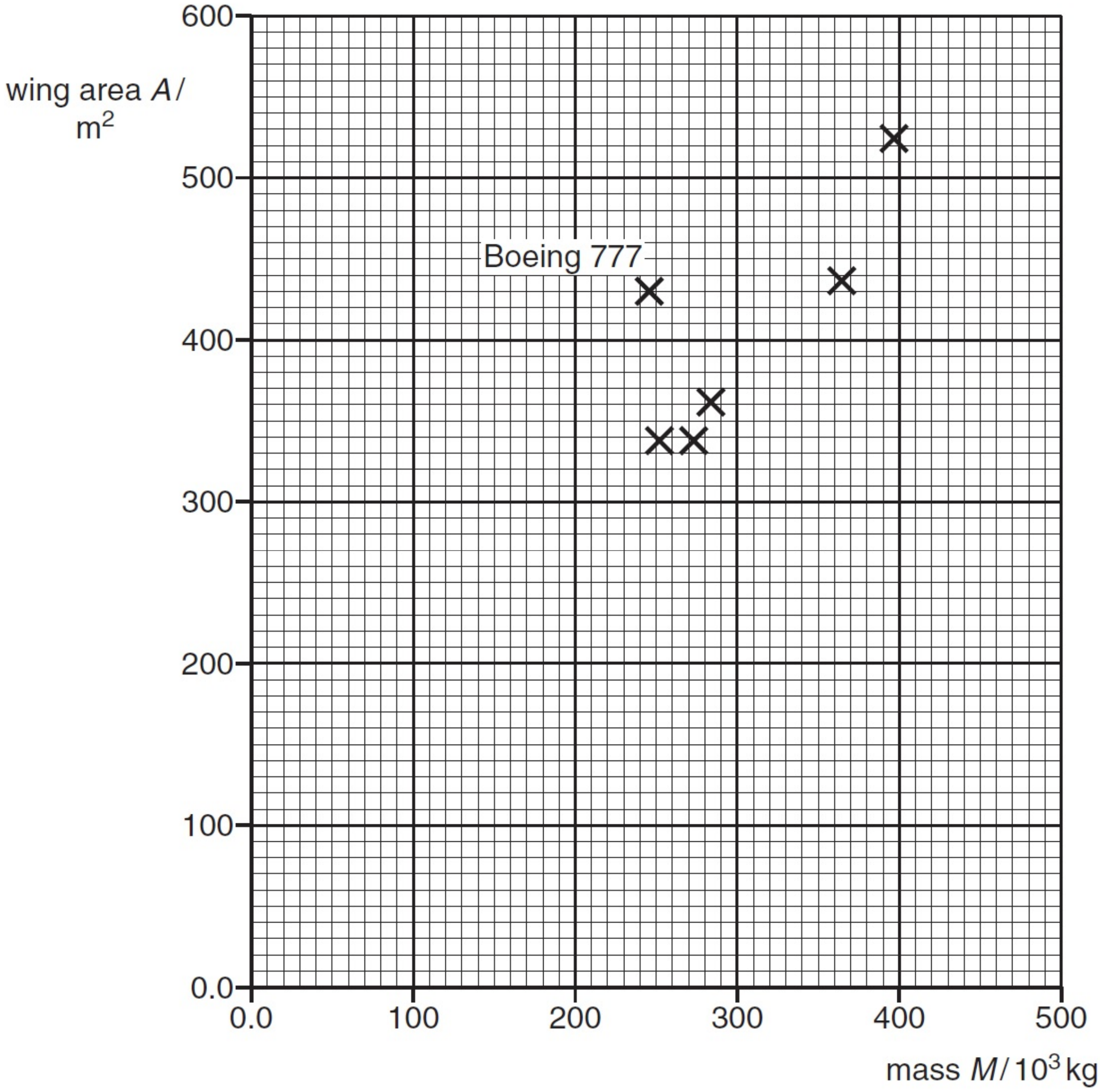


Fig. 6.2

Draw a straight line of best fit on Fig. 6.2.

Discuss what the graph suggests about the design of these six aircraft.

....

....

....

.... [4]

Section B

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

7 **(a)** 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. 7.1. It reaches the maximum height at point H and finally lands on the ground at B. Assume air resistance is negligible.

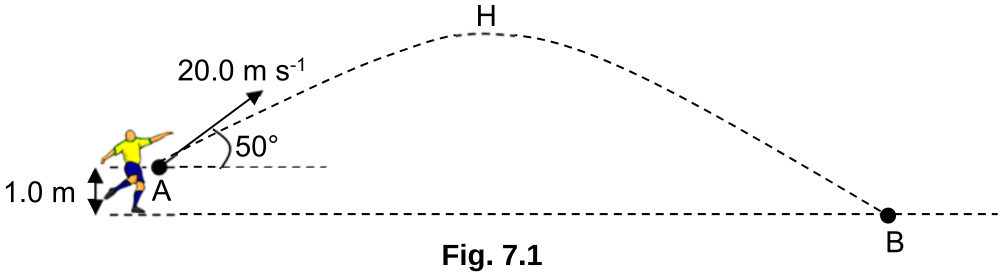


Fig. 7.1

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

time = ……..…………..……….. s [3]

(ii) On Fig. 7.2, sketch the variation with time t of the vertical component of the ball's velocity v_y.

[2]

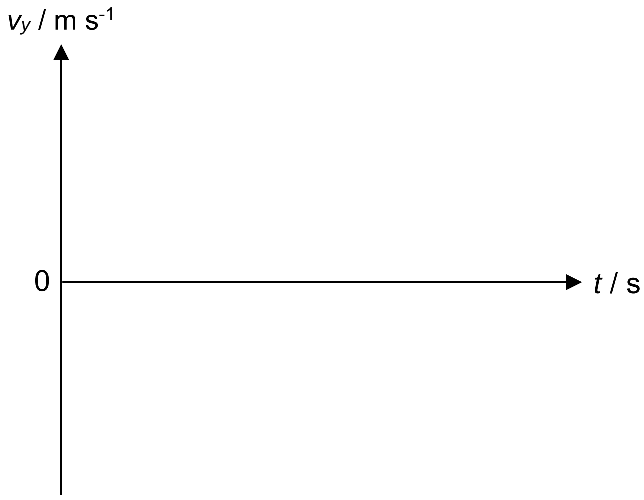


Fig. 7.2

(iii) On Fig. 7.3, sketch the variation with time t of the kinetic energy E_k of the ball. [2]

Fig. 7.3

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

……

……

……

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

(c) State the relation between force and momentum.

……

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

(d) 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. 7.4.

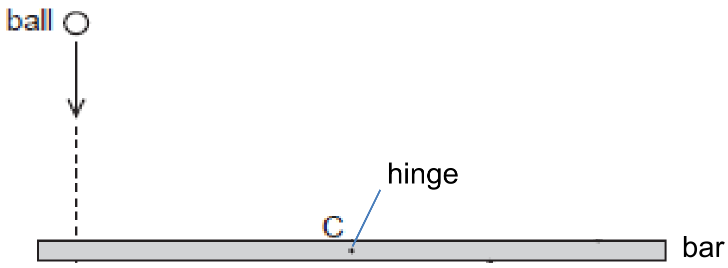


Fig. 7.4

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. 7.5.

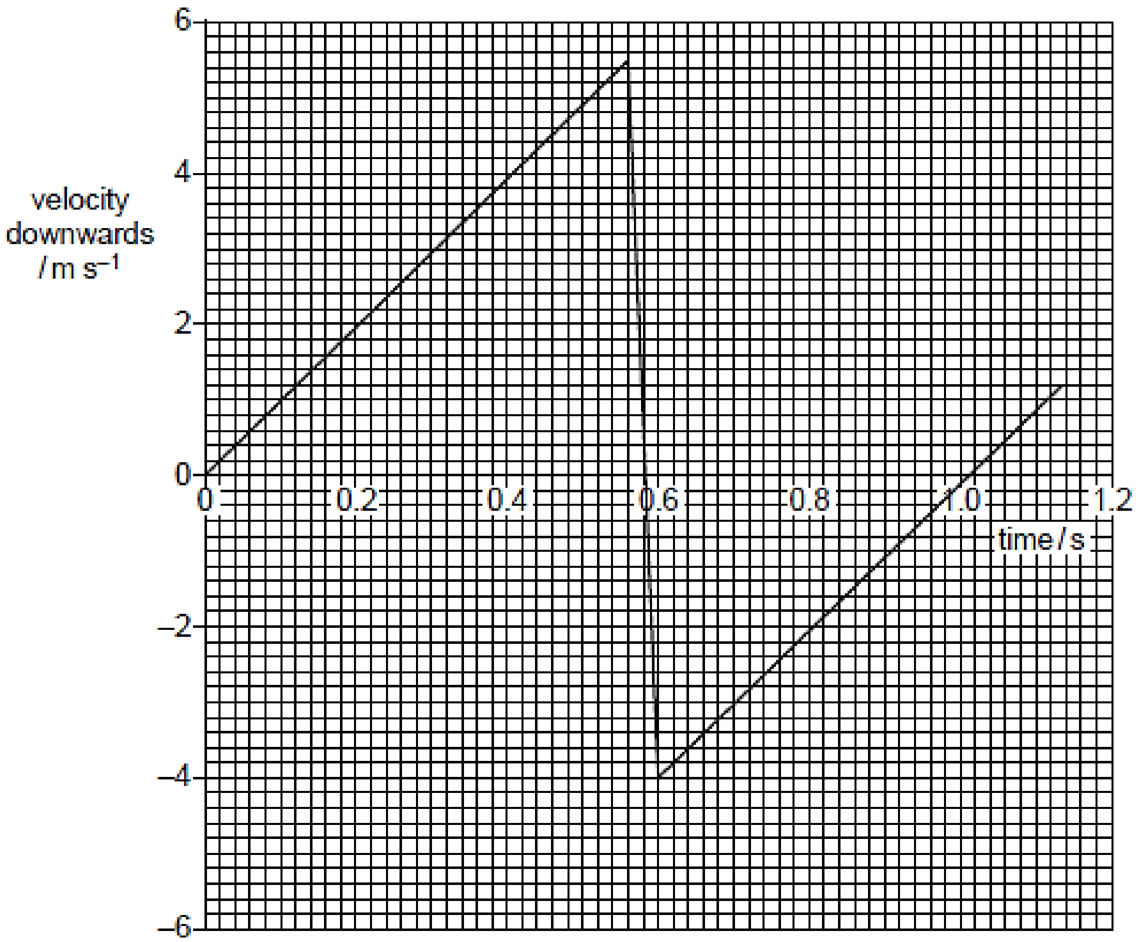


Fig. 7.5

For the time that the ball is in contact with the bar, use Fig. 7.5 to determine

(i) the change in momentum of the ball,

change in momentum = …………………… 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]

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

…………………………………………………………………………………………...

…………………………………………………………………………………………...

…………………………………………………………………………………………...

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

8 **(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 $^{16}_{8}\mathrm{O}$.

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]

(iv) Fig. 8.1 shows the variation with nucleon number *A* of the binding energy per nucleon *E* of nuclei.

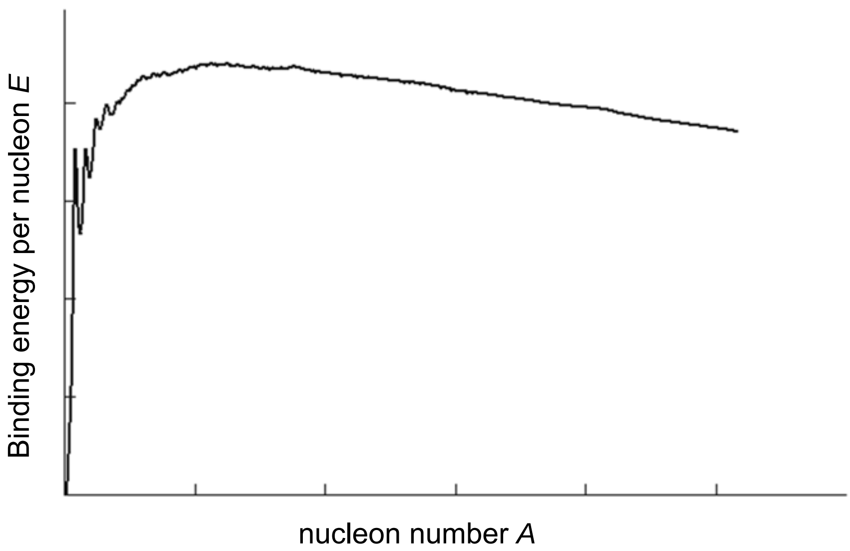


Fig. 8.1

1. With the aid of **Fig. 8.1**, explain why more energy per nucleon is released in fusion than in fission.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………[2]

2. Even though fusion generates more energy per nucleon than a fission reaction, suggest why it is not viable to build a fusion reactor to simulate the fusion reactions happening in the sun.

……….…………………………………………………………………………………

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

(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.

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

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

(ii) On Fig. 8.2, 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. 8.2

(iii) In one rock sample the scientists found 1.50 μg of argon-40 and 0.10 μg of potassium-40. Half-life of potassium-40 is 1.4 x 10^9 years. Calculate the age of the rock sample in years.

age = ... years [2]

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

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

END OF PAPER

JC2 Preliminary Exam 2018 (H1 Physics)

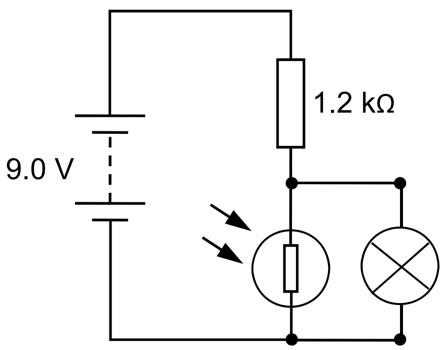
Paper 2 Solutions

1(a)(i)	vernier calipers zero error (do not accept parallax)	[1] [1]
(ii)	$V = \pi\left(\frac{d^2}{4}\right)h$ $= 964.665 \text{ cm}^3$ $\frac{\Delta V}{V} = \frac{2\Delta d}{d} + \frac{\Delta h}{h}$ $\Delta V = \left(\frac{2 \times 0.01}{8.50} + \frac{0.1}{17.0}\right) \times 964.665$ $= 8 \text{ cm}^3$ $V = (965 \pm 8) \text{ cm}^3$	 [1] [1] [1]

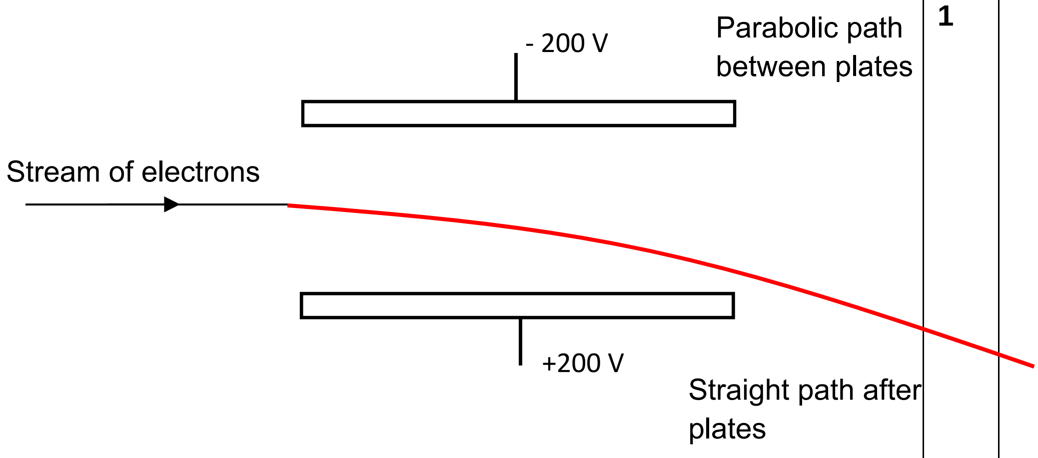
2 (a)	Work done by a force is the product of the force and the displacement (of its point of application) in the direction of the force.	[1]
(b)(i)	distance = $n \times 2\pi r = 2\pi nr$	[1]
(ii)	work done = $F \times 2\pi nr$ (ecf allowed)	[1]
(c)	total work done by couple = 2 x F x $2\pi nr$ Since $\tau = 2Fr$ Hence work done = $\tau \times 2\pi n = 2\pi n\tau$	[1] [1]
(d)	Output power = work done / time = $2\pi n\tau$ / time = (2π x 2900 x 450) / 60 = **1.37 x 10^5** W	 [1] [1]
(e)	Efficiency = output P / input P x 100% 0.20 = 1.37 x 10^5 / input P Input power = **6.85 x 10^3 W**	 [1] [1]

3(a)	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)	The separation is much greater than the diameter/radius of the Moon and the Earth and the Sun.	**1**
(c)	Since the Moon has a linear/tangential velocity perpendicular to gravitational force,	**1**

	the gravitational force is <u>just sufficient</u> to provide the centripetal acceleration for the Moon to orbit about the Earth.	1
(d)	$\omega = 2\pi / T$ $= 2\pi / (27.3 \times 24 \times 60 \times 60) = 2.66 \times 10^{-6}$ rad s^{-1} $mr\omega^2 = GMm / r^2$ $M = (3.8 \times 10^8)^3 (2.66 \times 10^{-6})^2 / (6.67 \times 10^{-11})$ $= 5.8 \times 10^{24}$ kg	 1 1 1
(e)	As orbital radius increases, angular velocity decreases Since $\omega = 2\pi / T$, orbital period increases OR By T^2 proportional to r^3, orbital period increases	1 1 1 1

4 (a) (i)	If R is inversely proportional to intensity, R x intensity = k, $(5)(20) \neq (100)(1.2)$ or any 2 points. Products not equal. Hence, no	1 1
(ii)	 [1] – correct symbols [1] – correct diagram	1 1
(iii)	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. 4.1, light intensity = 24 W m^{-2}	1 1 1
(iv)	Length of strip, $\lambda = (10 \times 5.0 \times 10^{-3}) + (10.0 \times 10^{-3}) = 0.060$ m Using $R = \frac{\rho \lambda}{A}$, $\rho = \frac{RA}{l} = \frac{4200 \times \pi \times (4.0 \times 10^{-4})^2}{0.060} = 3.5 \times 10^{-2}\ \Omega\ \text{m}$	1 1

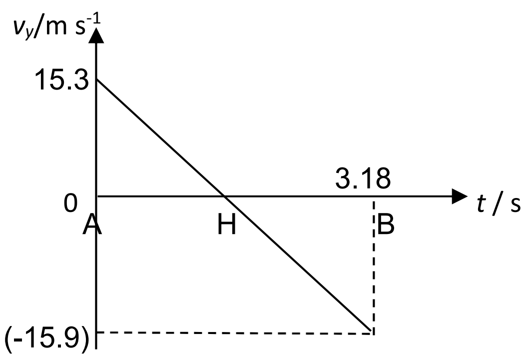
	ECF allow for wrong length	
b	nature of fault: lamp fused (open circuit) faulty lamp: lamp E	1 1

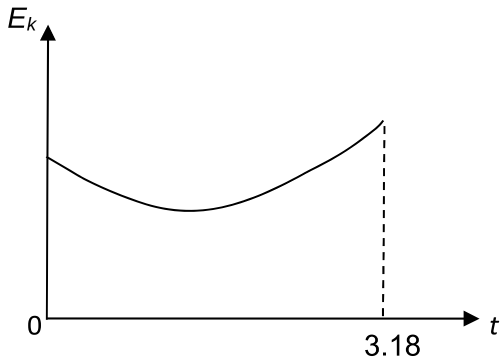
5 (a)(i)	F = qE $= (1.6\times10^{-19})(2.0\times10^{4})$ $= 3.2 \times 10^{-15}$ N $a = \frac{F}{m_e}$ $= \frac{3.2\times10^{-15}}{9.11\times10^{-31}}$ $=3.51 \times 10^{15}$ m s^{-2} (downwards)	1 1
(ii)	Time interval that the electron is inside the electric field = $\frac{s_x}{u_x}$ $= \frac{0.05}{1.0\times10^{8}}$ $= 5.0 \times 10^{-10}$ s Vertical distance travelled by the stream of electrons is given by $s_y = \frac{1}{2}a_y t^2$ $= \frac{1}{2}(3.51\times10^{15})(5.0\times10^{-10})^2$ $= 4.39 \times 10^{-4}$ m Since the vertical distance travelled by the stream of electrons in the region between the parallel plates is <u>shorter than half the distance (< 0.01 m) between the two plates, the stream of electrons will NOT hit any of the parallel plates.</u>	1 1 1
(iv)		1
(b)(i)	(+) to the right of conductor, (-) to the left of conductor	1
(ii)	Using Fleming's Left Hand Rule, induced magnetic force act on the	1

	electrons, resulting in polarity indicated in **(a)(i)**	

6(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.: more fuel needed at take-off; work done in accelerating/overcoming turbulence/denser air at ground level	**1** **1**
(ci)	$F = 3 \times 270\,000 = 810\,000$ N $a = F/m = 810\,000 \text{ N}/273\,900 \text{ kg} = 2.96 \text{ m s}^{-2}$	**1**
(cii)	$s = v^2/2a$ $= (81 \text{ m s}^{-1})^2/2\times 2.96 \text{ m s}^{-2}$ = 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 /	**1**

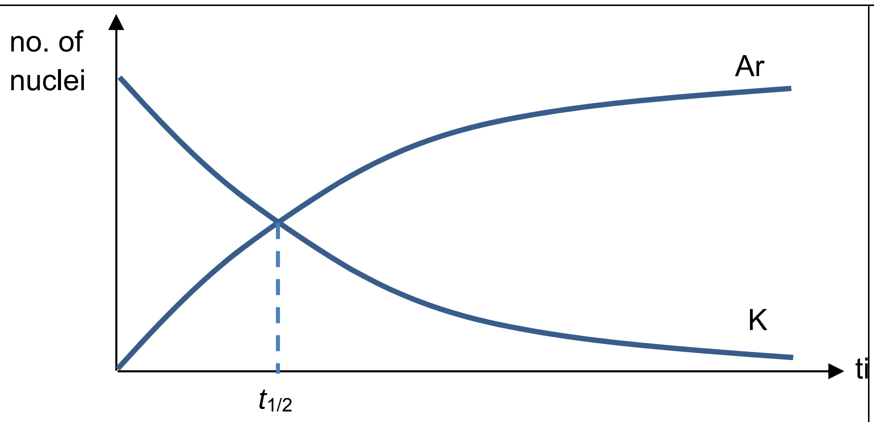
	turbulence If *v* not reached, plane would crash /need space to slow down/brake to a halt	 **1**
(d)	Lift must equal weight weight = (mass)(g) so Lift is proportional to mass	**1** **1**
(e)	Best-fit line excluding Boeing 777 (Line should obviously exclude Boeing 777 and should be reasonable best fit 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**

7(a)(i)	$u_y = 20 \sin 50^o = 15.3$ taking upwards as positive, $s_y = u_y t + ½ gt^2$ $-1 = 20 \sin 50^o t + ½(-9.81)t^2$ $-1 = 15.3 t – 4.91 t^2$ $t = \frac{15.3 \pm \sqrt{15.3^2 - 4 \times 4.91 \times (-1.0)}}{2 \times 4.91}$ $= \frac{15.3 \pm 15.9}{2 \times 4.91}$ $= 3.18$ s	[1] [1] [1]
(ii)		

	Correct shape: inclined straight line with + or – gradient {Shape must be correct before awarding the second mark.} Show: HB > AH , 15.3 and 3.18	[1] [1]
(iii)	 Correct "U" shape not touching t-axis. {Shape must be correct before awarding the second mark.} Show the tail end higher than the start point.	[1] [1]
(b)	Maximum height decreases due to work done against air resistance / greater deceleration caused by air resistance when moving upwards. Horizontal range also decreases due to work done against air resistance.	[1] [1]
(c)	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]
(d)(i)	$\Delta p = m\,\Delta v = (0.140)(-4.0 - 5.5)$ $= -$**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 = $\Delta p / \Delta t$ = 1.33 / 0.04 = **33.3** N	 [1]
(e)(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	[1] [1]

	upward <u>force by hinge on bar/ gravitational force</u> acting on the ball & bar.	
(ii)	According to Newton's 3rd law, <u>force</u> on bar (due to ball) is <u>equal in magnitude and opposite in direction to force</u> on ball (due to bar) Since time (of contact) (*t*) is <u>same</u> for both **AND** <u>Impulse = *Ft*</u> Impulse on ball is <u>equal in magnitude and opposite in direction</u> to impulse on bar	[1] [1] [1]

8(a)(i)	nucleus is <u>small in comparison to size of atom</u>	**1**
(ii)	nucleus is massive/heavy/dense and (positively) charged	**1** **1**
(b)(i)	Energy supplied to completely separate the nucleus into its individual nucleons	**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 ${}^{17}_{8}O = \frac{126.43}{17} = 7.43\,\text{MeV}$ Binding energy per nucleon for ${}^{16}_{8}O = \frac{127.6}{16} = 7.98\,\text{MeV}$ Since ${}^{16}_{8}O$ has a higher binding energy per nucleon, it would be more stable.	**1 for both values** **1**
(iv)1	Energy released in a nuclear reaction is equal to <u>the difference in binding energies between the products and the original reactants</u>. From graph, the <u>steeper slope of the binding energy curve for lighter nuclei</u> indicates that the <u>change in binding energy in fusion is larger</u> , compared to that for fission reactions.	**1** **1**
(iv)2	A very <u>high temperature</u> is required to enable fusion to occur AND <u>High pressure</u> to overcome electrostatic repulsion. They must be within 1x10^{-15} meters of each other to fuse.	**1**
(c)(i)	${}^{40}_{19}K \rightarrow {}^{40}_{18}Ar + {}^{0}_{1}\beta$	**1**
(ii)		**3**

	 [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	
(iii)	Since the molar mass of the nuclides are the same, the number of nuclei is proportional to the mass of the sample. $N = N_o(1/2)^n$ $M = M_o(1/2)^n$ $0.1 = (0.1+1.50)(1/2)^n$ $n = 4$ Years = $4 \times 1.4 \times 10^9 = 5.6 \times 10^9$ years	**1** **1**
(iv)	All the argon-40 is formed from the decay of potassium-40. No argon is lost.	**1** **1**