Candidate's Name ………………………………….……… CTG ……….……

YISHUN JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS 2018

PHYSICS **8867/1**
HIGHER 1 **14th September 2018**
1 hour

Paper 1 Multiple Choice

Additional Material:
Optical Mark Sheet

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READ THESE INSTRUCTIONS FIRST

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

Write your name and CTG on the Optical Mark Sheet in the spaces provided.
Shade your NRIC in the space 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 Optical Mark Sheet.

Read the instructions on the Optical Mark Sheet carefully.

INFORMATION FOR CANDIDATES

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.

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	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
resistors in series,	R	=	$R_1 + R_2 + \ldots\ldots\ldots$
resistors in parallel,	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + \ldots\ldots$

1 To find the resistivity of a copper wire, a student makes the following measurements.

Length = 30 ± 2 mm

Diameter = 0.45 ± 0.01 mm

Resistance = 60 ± 1 Ω

How should the uncertainty be expressed?

A $(3.18 \pm 0.04) \times 10^{-4}$ Ω m

B $(31.8 \pm 4) \times 10^{-5}$ Ω m

C $(3.2 \pm 0.4) \times 10^{-4}$ Ω m

D $(3.2 \pm 0.4) \times 10^{-5}$ Ω m

2 An aircraft flies with an airspeed of 600 km h^{-1} through a 200 km h^{-1} jet-stream wind towards the west. The pilot wishes to fly directly south.

To achieve this, the pilot points the aircraft away from the south direction.

What is the speed of the aircraft in the direction of south relative to the ground?

A 400 km h^{-1} **B** 570 km h^{-1} **C** 630 km h^{-1} **D** 800 km h^{-1}

3 Which pair of physical quantities has the same base units?

A Acceleration and angular speed

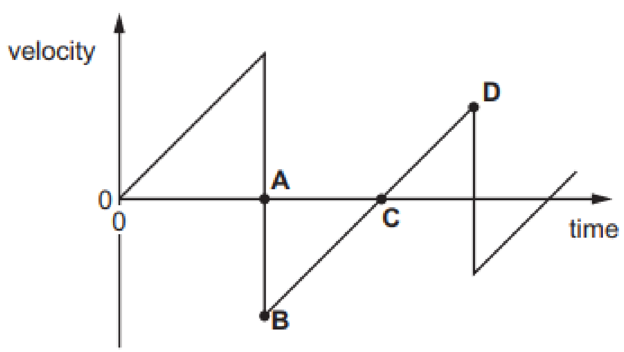
B Impulse and momentum

C Energy and power

D Charge and current

4 A ball is released from rest above a hard, horizontal surface. The graph shows how the velocity of the bouncing ball varies with time.

At which point on the graph does the ball reach its maximun height after the first bounce?

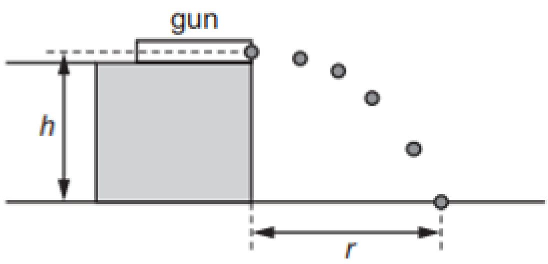


5 An elevator is moving upwards with an acceleration of 5.8 m s^{-2}. A ball is held 1.0 m above the floor of the elevator and at rest with respect to the elevator and released.

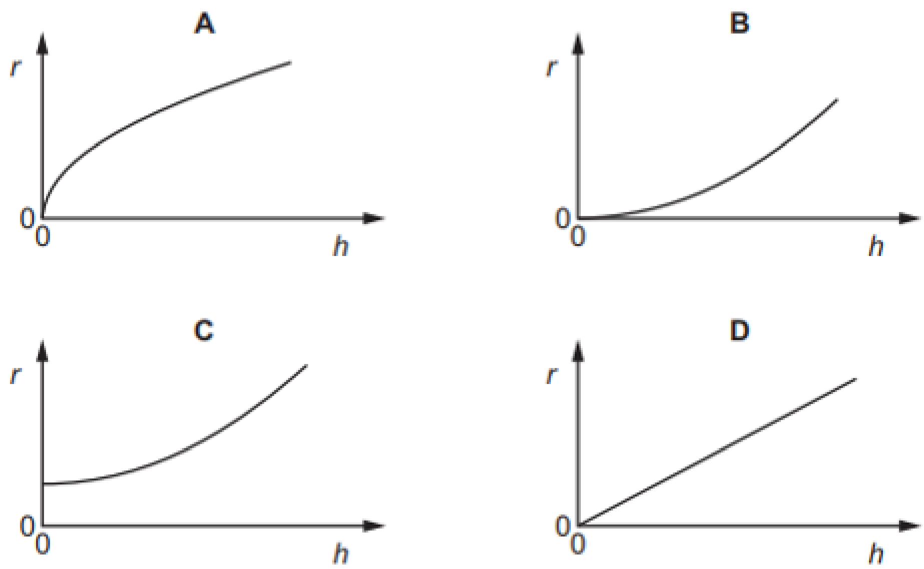
How long does it takes for the ball to reach the floor of the elevator?

A 0.36 s **B** 0.45 s **C** 0.71 s **D** 1.00 s

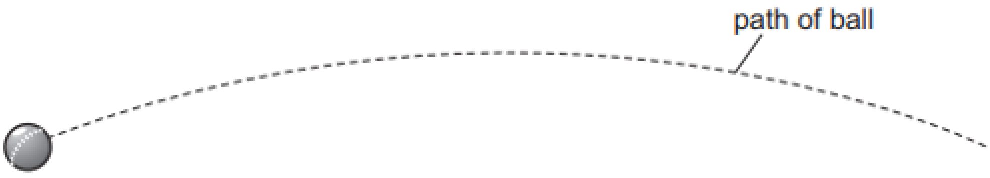
6 A student uses a spring gun to lauch a steel ball with a constant horizontal velocity. He varies the height *h* of the gun and measures the horizontal displacement *r* of the ball when it hits the ground.



Which graph shows the variation with height *h* of the horizontal displacement *r* ?



7 A ball is thrown across a flat field.



Which statement describes the motion of the ball, when the effects of air resistance are ignored?

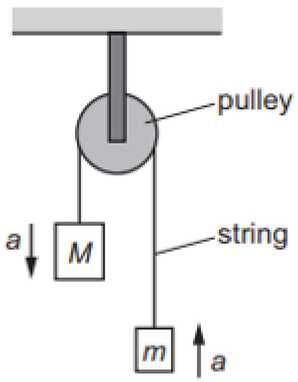
A The ball lands with the same velocity at which it is thrown.

B The kinetic energy of the ball is zero at the highest point of motion.

C The horizontal and vertical components of the acceleration remains constant throughout the motion.

D The horizontal and vertical components of acceleration are both zero at the highest point of the motion.

8 Two blocks of masses *M* and *m* are joined by a thin massless string which passes over a frictionless pulley as shown.



The acceleration of free fall is *g*.

What is the acceleration *a* of the two blocks?

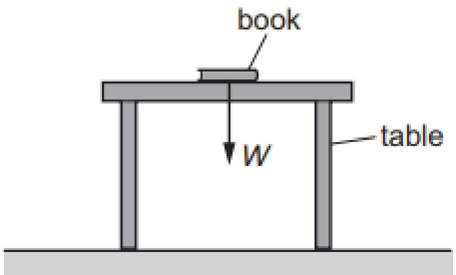
A $\frac{(M+m)}{(M-m)}g$ **B** $\frac{(M-m)}{(M+m)}g$ **C** $\frac{M}{m}g$ **D** $\frac{m}{M}g$

9 Two railway trucks of mass 2*m* and 3*m* move towards each other in opposite directions with speeds *v* and 2*v* respectively. These trucks collide and stick together.

What is the speed of the trucks after the collison?

A $\frac{v}{4}$ **B** $\frac{4}{5}v$ **C** $\frac{5}{4}v$ **D** zero

10 A book of weight *W* is at rest on a table. A student attempts to state Newton's third law of motion by saying that 'action equals reaction'.



If the weight of the book is the 'action' force, what is the 'reaction' force?

A The force acting downwards on Earth from the table.

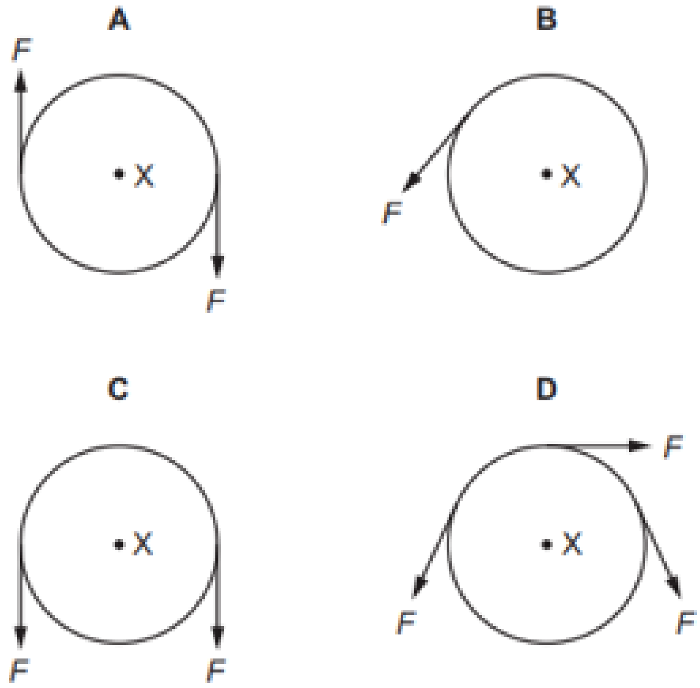
B The force acting upwards on the book from the table.

C The force acting upwards on the Earth from the book.

D The force acting upwards on the table from the floor.

11 A rigid circular disc of radius *r* has its centre at X. A number forces of equal magnitude *F* act at the edge of the disc. All the forces are in the plane of the disc.

Which arrangement of forces provides a arrangment of rotational equilibrium but not translational equilibrium.

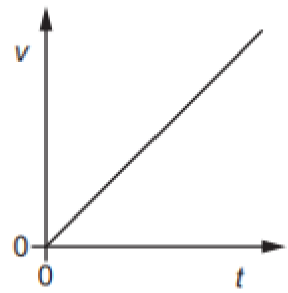


12 A spring obeying Hooke's law is stretched by a distance of 2.8 cm. The elastic potential energy stored in the spring at this length is 0.060 J. It is then further stretched by a further of 5.4 cm.

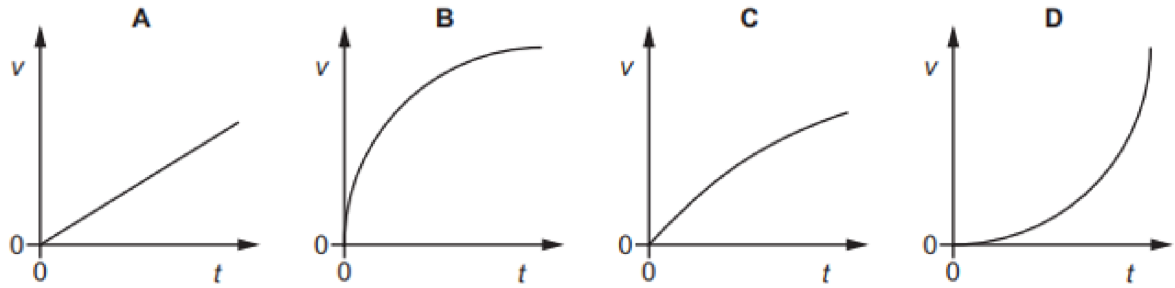
How much work needs to be done to cause this further stretching?

A 0.12 J **B** 0.45 J **C** 0.51 J **D** 0.57 J

13 An object falls freely from rest in a vacuum. The graph shows the variation with time *t* of the velocity *v* of the object.



Which graph represents the object falling in air?



14 A car engine accelerates the car of mass 1000 kg from rest to a speed of 80 km h^{-1}.

How much useful work must be done on the car to reach this speed?

A 12 kJ **B** 250 kJ **C** 320 kJ **D** 3200 kJ

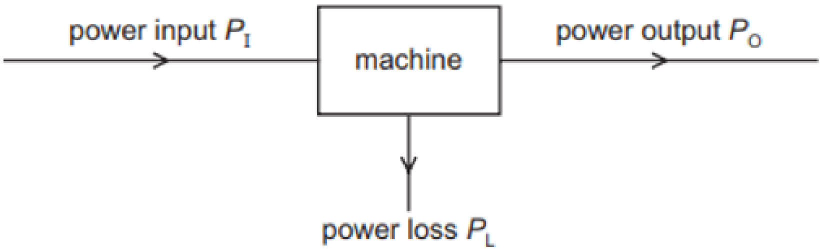
15 A cyclist travelling at a constant speed up a hill. The frictional force acting against the cyclist's motion is 9.0 N.

The cyclist uses 500 J of energy to travel a distance of 25 m.

What is the increase in gravitational potential energy of the cyclist?

A 225 J **B** 275 J **C** 500 J **D** 725 J

16 Power is tranferred through a machine as shown.



What is the efficiency of the machine?

A $\frac{P_I}{P_o+P_L}$ **B** $\frac{P_L}{P_I}$ **C** $\frac{P_L}{P_o}$ **D** $\frac{P_o}{P_I}$

17 An object of mass 3.0 kg rotates at constant speed in a horizontal circle radius of 5.0 m. The time it takes to complete 10 oscillations is 30 s.

What is the magnitude of the resultant force acting on the object?

A $\frac{20}{3}\pi^2$ **B** $\frac{10}{3}\pi^2$ **C** $\frac{2}{3}\pi^2$ **D** $\frac{1}{3}\pi^2$

18 A geostationary satellite which is in orbit around the earth is replaced by a new satellite which has half the mass of the old one.

What is the value of $\frac{\text{radius of orbit of new satellite}}{\text{radius of orbit of old satellite}}$?

A 0.50 **B** 1.0 **C** 1.5 **D** 2.0

19 On the ground, the gravitational force on a satellite is W.

What is the gravitational force acting on the satellite when it is at a height of $2R$ above the ground. The radius of the Earth is R.

A $\frac{1}{2}W$ **B** $\frac{1}{3}W$ **C** $\frac{1}{4}W$ **D** $\frac{1}{9}W$

20 A direct current is reduced uniformly from 100 mA to 20 mA in a period of 5.0 s.

What is the total charge that flows during this time?

A 0.016 C

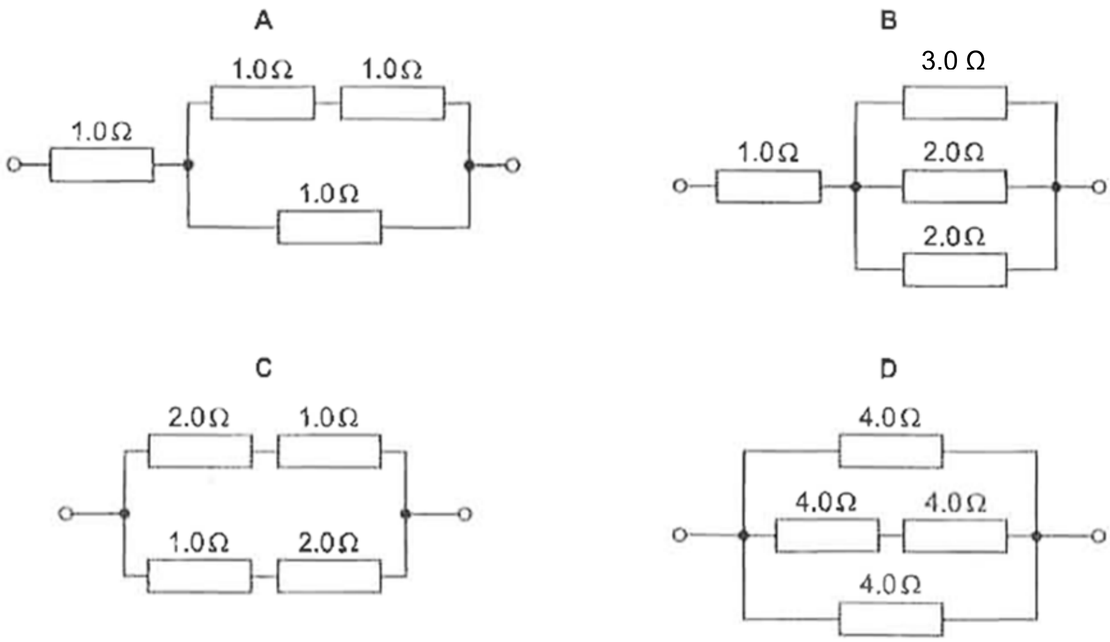
B 0.20 C

C 0.30 C

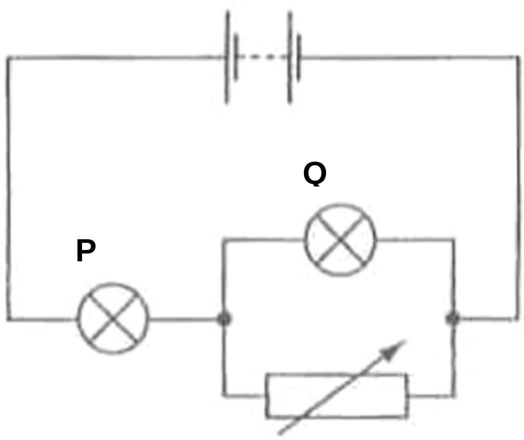
D 0.60 C

21 Four resistors, with resistances as shown, are connected in series and parallel combinations.

Which combination has the **largest** total resistance?



22 A circuit consists of a battery, two identical light bulbs P and Q, and a variable resistor.



The resistance of the variable resistor is **increased.**

What will happen to the brightness of the light bulbs?

	Light bulb P	Light bulb Q
A	Brighter	Brighter
B	Brighter	Less bright
C	Less bright	Brighter
D	Less bright	Less bright

23 A cell of emf *E* and internal resistance *r* is connected to a variable resistor *R* as shown in Fig. 23a. Fig. 23b shows the variation of the ammeter reading *I* with the voltmeter reading *V* as *R* is varied.

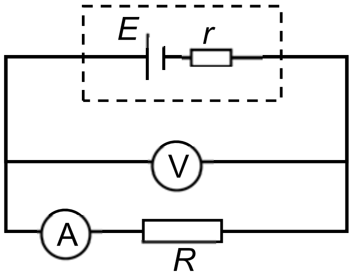


Fig. 23a

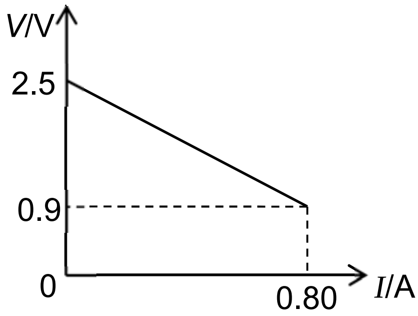
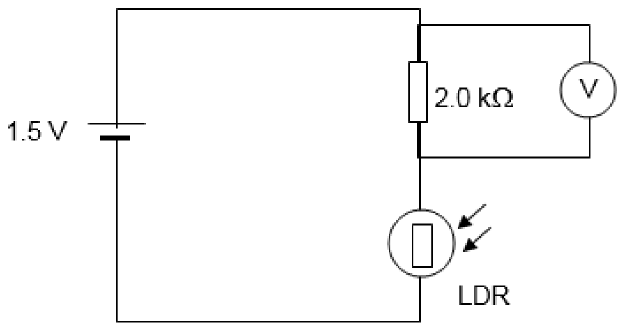


Fig. 23b

Assuming that both the voltmeter and ammeter are ideal, what is the internal resistance *r* of the cell?

A 2.0 Ω **B** 1.7 Ω **C** 1.3 Ω **D** 1.1 Ω

24 A light dependent resistor (LDR) is connected in series with a 2.0 kΩ resistor and a 1.5 V battery of negligible internal resistance.



If the resistance of the LDR in daylight is 500 Ω, what is the voltmeter reading in daylight?

A 1.5 V **B** 1.2 V **C** 0.30 V **D** 0.0060 V

25 A 240 V electric heater uses a current of 2.0 A. It is to be rewound with resistance wire of diameter 6.0×10^{-4} m.

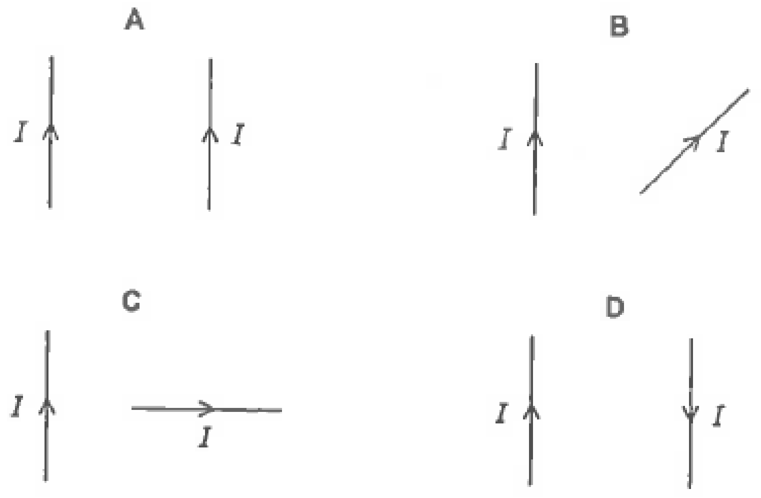
At working temperature, the resistance wire has resistivity of 1.4×10^{-6} Ω m.

What length of wire is required?

A 6.0 m **B** 24 m **C** 51 m **D** 97 m

26 In each diagram, to wires are shown, each carrying a constant current I.

In which diagram will the attractive force between the wires, due to the currents, be maximum in magnitude?



27 Different charged ions of several nuclides enter into a region of uniform magnetic field at right angles to their initial paths.

If the ions have the same initial speed, which one will travel in a circular path of the largest radius?

A Singly charged oxygen-16 ions

B Singly charged lithium-6 ions

C Doubly charged carbon-12 ions

D Doubly charged magnesium-24 ions

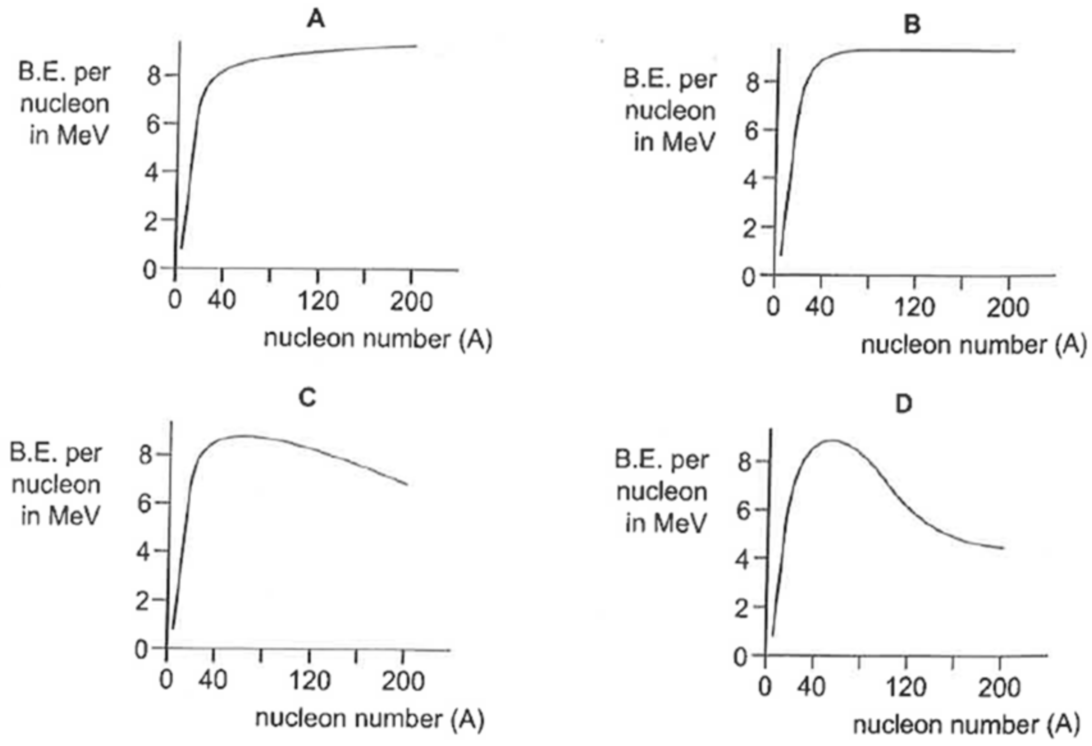
28 What is the binding energy of the nucleus of the following nuclide?

$$^{238}_{92}U$$

Given that the mass of a proton is 1.00728 *u*, mass of a neutron is 1.00867 *u* and mass of the nucleus is 238.05076 *u*.

A 3.13×10^{-27} J **B** 3.02×10^{-19} J **C** 2.70×10^{-10} J **D** 2.82×10^{-10} J

29 The binding energy (B.E.) per nucleon is a useful measure of the stability of a nucleus.



Which graph shows how the B.E. per nucleon varies with the nucleon number (A)?

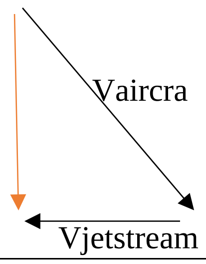
30 A Geiger-Muller (GM) tube detects a background count rate of 35 counts per second.

A radioactive source is placed near the GM tube and the reading is 835 counts per second.

What will be the reading after three half-lives of the source?

A 100 **B** 104 **C** 135 **D** 278

End of Paper

S/N	Answer	Explanation
1	C	$\rho = \frac{\pi}{4}\frac{Rd^2}{l} = \frac{\pi}{4}\frac{(60)(0.45\times10^{-3})^2}{30\times10^{-3}}$ = 3.18 x 10^{-4} $\frac{\Delta\rho}{\rho} = \frac{\Delta R}{R} + 2\frac{\Delta d}{d} + \frac{\Delta l}{l} = \frac{1}{60} + 2\frac{0.01}{0.45} + \frac{2}{30}$ $\Delta\rho$= 4 x 10^{-5} Ω m $\rho + \Delta\rho$ =(3.2 ± 0.4) x 10^{-4} Ω m
2	B	$V^2_{\text{aircraft relative to ground}} = V^2_{\text{aircraft}} - V^2_{\text{jetstream}}$ $V_{\text{relative}} = \sqrt{600^2 - 200^2}$ = 566 km h^{-1} 
3	B	Impulse = change in momentum
4	C	After dropping from rest, when ball first hits the ground, its velocity is greatest (downward-positive), after hits the ground, its velocity drops to zero and changes direction (upward-negative) at maximum height, the ball velocity is zero.
5	A	Acceleration $_{\text{effective}}$ = 9.81 + 5.8 = 15.61 m s^{-2} The effective acceleration is greater than 9.81 as it will take a shorter time for the ball to reach the ground. s=ut + ½ at^2 1.0 = 0 + ½ (15.61) t^2 t = 0.36 s
6	A	Horizontal : r = u_x t Vertical : h = 0 + ½ g t^2 Substitute t = u_x/r into vertical We get $r^2 = \left(\frac{2}{g}u^2\right)h$ after rearranging to make r the subject. Equation is in the form y^2 = kx
7	C	The horizontal component of acceleration is always zero The vertical component of acceleration is always 9.81 m s^{-2}.

8	**B**	F_{net} = ma (M-m) g = (M+m) a $a = \frac{(M-m)}{(M+m)} g$
9	**B**	Pi = (3m)(2v) – (2m)(v) Pf = (2m +3m) $V_{combined}$ $V_{combined}$ = 4/5 v
10	**C**	Action reaction pair are of the same nature, acting on different bodies.
11	**C**	A: rotate clockwise, Net force = 0 B: rotate anticlockwise, Net force = F C: rotational equilibrium, Net force = 2F D: rotate clockwise, Net force = F
12	**B**	E.PE (2.8)= ½ K x^2 = 0.060 K = $\frac{2(0.060)}{0.028^2} = 153$ E.P.E (8.2) = ½ (153)$(0.082)^2$ = 0.51 J Additional work to be done = 0.51 – 0.06 = 0.45 J
13	**C**	The object experiences air resistance and hence rate of increase of velocity will be less with time. Difference between option B and C is the starting acceleration.
14	**B**	Useful work done = gain in the KE of car = ½ mv^2 $\frac{1}{2}(1000)\left(\frac{80x1000}{3600}\right)^2$ = 246,914 J = 250 kJ
15	**B**	Energy supplied = Gain in G.P.E + Work done against friction 500 = Gain in GPE + (25 x 9) Gain in GPE = 275 J
16	**D**	Efficiency = $\frac{Power\ output}{Power\ input}$
17	**A**	F= $mr\omega^2 = (3)(5)\frac{4\pi^2}{3^2} = \frac{20}{3}\pi^2$
18	**B**	Force on satellite = $\frac{GMm}{r^2}$= mr ω^2 Hence $r^3 \omega^2$ = GM = constant (where G is gravitational constant and M is mass of earth) Since both are in geostationary orbit, hence 24 hours, same angular speed $\frac{radius\ of\ orbit\ of\ new\ satellite}{radius\ of\ orbit\ of\ old\ satellite}$ = 1.0

19	**D**	Force on satellite (ground, R) = $\frac{GMm}{R^2}$ = W Force on satellite (2R +R) = $\frac{GMm}{(R+2R)^2} = \frac{1}{9}W$
20	**C**	Q = area under I-t graph = [(100 + 20) / 2] 10^{-3} x 5.0 = 0.30 C
21	**B**	A: R_{eff} = 1.0 + (1/2.0 + 1/1.0)$^{-1}$ = 1.67 Ω B: R_{eff} = 1.0 + (1/3.0 + 1/2.0 + 1/2.0)$^{-1}$ = 1.75 Ω C: R_{eff} = 1.0 + (1/3.0 + 1/3.0)$^{-1}$ = 1.5 Ω D: R_{eff} = (1/4.0 + 1/8.0 + 1/4.0)$^{-1}$ = 1.6 Ω
22	**C**	If resistance of variable resistor increases, effective resistance across Q and variable resistor increases. The p.d. across Q increases hence Q becomes brighter (P=V^2 / R). P will become less bright.
23	**A**	V = E – Ir 0.9 = 2.5 – 0.80 r r = 2.0 Ω
24	**B**	Using potential divider rule, V = [2000 / (2000 + 500)] x 1.5 = 1.2 V
25	**B**	*R = ρL / A , R = V / I* *V/I = ρL / A* *L = VA / Iρ* *= 240 [π(3.0x10^{-4})^2] / (2.0 x 1.4 x 10^{-6})* = *24* m
26	**A**	
27	**A**	$F_{net} = ma_c$ Bqv = mv^2 /r r = mv / Bq
28	**D**	Mass defect = 92 x 1.00728 u + (238-92) x 1.00867 u – 238.05076 u = 1.88482 u E = mc^2 = 1.88482 x 1.66 x 10^{-27} x (3.00 x 10^8)^2 = 2.82 x 10^{-10} J
29	**C**	

30	**C**	C_o = 835 – 35 = 800 $(1/2)^3 = C / C_o$ C = 100 Reading of GM tube = 100 + 35 = 135

Candidate's Name …………………………………….………… CTG ………..……

YISHUN JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATIONS 2018

PHYSICS **8867/2**

HIGHER 1 **28th August 2018**

2 hours

Paper 2 Structured Questions

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

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READ THESE INSTRUCTIONS FIRST

Write your name and CTG in the spaces provided on this cover page.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer any **one** question.

Write your answers in the spaces provided on the question paper.
For numerical answers, **all** working should be shown clearly.

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

For Examiner's Use	
Paper 2 (67%)	
Section A	
1	**/9**
2	**/12**
3	**/8**
4	**/6**
5	**/10**
6	**/15**
Section B	
7	**/20**
8	**/20**
Penalty	
Total	
	/ 80

This question paper consists of 24 printed pages.

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	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
resistors in series,	R	=	$R_1 + R_2 + \ldots\ldots\ldots$
resistors in parallel,	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + \ldots\ldots$

Section A

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

1 A ball of mass 20 g moves along a curved track, as shown in Fig. 1.1.

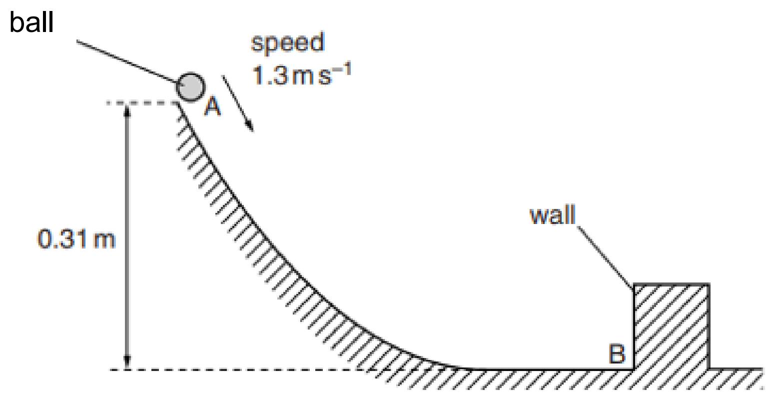

Fig. 1.1

The speed of the ball is 1.3 m s^{-1} when it is at point **A** at height of 0.31 m. The ball moves down the track and collides with a vertical wall at point **B**. The ball then rebounds back up the track. It may be assumed that fricitional forces are negligible.

(a) Show that the ball hits the wall at **B** with a speed of 2.8 m s^{-1}.

[2]

(b) The change in momentum of the ball due to the collision with the wall is 0.096 kg m s^{-1}. The ball is in contact with the wall for a time of 15 ms.

Determine, for the ball colliding with the wall,

(i) the speed immediately after the collision, and

speed = ……………………….. m s^{-1} [2]

(ii) the magnitude of the average force on the ball by the wall.

magnitude of average force = ………………………N [1]

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

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(d) In practice, frictional effect on the track is significant so that the actual increase in kinetic energy of the ball in moving from **A** to **B** is 56 mJ. The length of the track between **A** and **B** is 0.40 m.

Determine the average frictional force acting on the ball as it moves from **A** to **B** when frictional effect is significant.

average frictional force = ………………………N [2]

2 (a) A binary star system consists of two stars **A** and **B** orbiting about their common centre of mass, point **P**, is shown in Fig. 2.1.

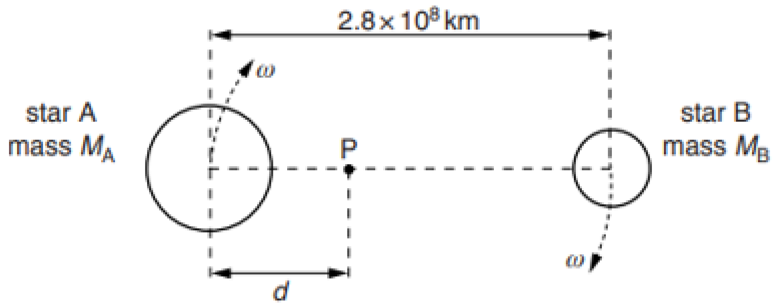

Fig. 2.1

The stars are in circular orbits with the centres of both orbits at point **P**, a distance *d* from the centre of star A.

(i) Explain why the centripetal force acting on both stars has the same magnitude.

....

....

.... [1]

(ii) The period of the orbit of the stars about point **P** is 4.0 years. Calculate the angular speed of the stars.

angular speed = ...rad s^{-1} [2]

(b) The separation of the centres of the stars is 2.8 × 10^8 km. The mass of star **A** is M_A. The mass of star **B** is M_B. The ratio of $\frac{M_A}{M_B}$ is 3.0.

(i) Determine the distance *d*.

d = ...km [3]

(ii) **1.** Explain why star **A** experiences acceleration although it is moving at constant speed in circular orbit. State the direction of this acceleration.

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

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

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

2. Calculate the magnitude of the acceleration of the star **A**.

acceleration = …………………..m s^{-2} [1]

(iii) By considering the force(s) on star **A**, or otherwise, determine the mass M_B of star **B**. Explain your working.

M_B = …………………..kg [3]

3 Fig 3.1 shows the current-voltage (I-V) characteristic of a resistor R and a thermistor.

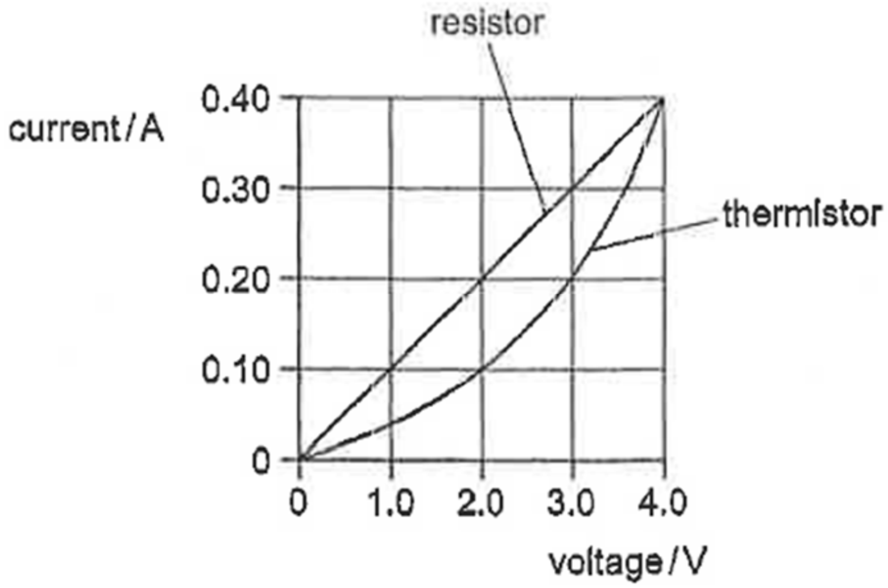

Fig. 3.1

The resistor, R, and thermistor are connected in parallel to a battery of e.m.f. of 4.0 V and with internal resistance of *r*, as shown in Fig. 3.2.

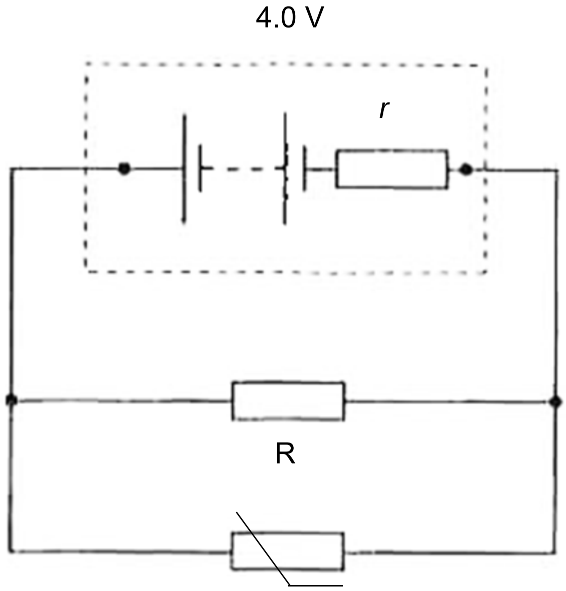

Fig. 3.2

Given that a current of 0.20 A flows through the thermistor, determine

(a) the resistance of the thermistor,

resistance = ………………… Ω [2]

(b) the resistance of the resistor R,

resistance = ………………… Ω [2]

(c) the total power used by the thermistor and resistor R, and

power = ………………… W [2]

(d) the internal resistance of the battery *r*.

resistance = ………………… Ω [2]

4 An electron is projected horizontally at an initial speed of 4.2×10^7 m s^{-1} into the vertical electric field in the space between two horizontal charged plates as shown in Fig. 4.1. It experiences an electrostatic force of 3.0×10^{-13} N in the electric field. Assume that weight of electron is negligible.The plates are 2.0 cm apart. The electron emerges from the electric field region at angle.

(a) In Fig. 4.1, sketch the path of the electron in the electric field. [2]

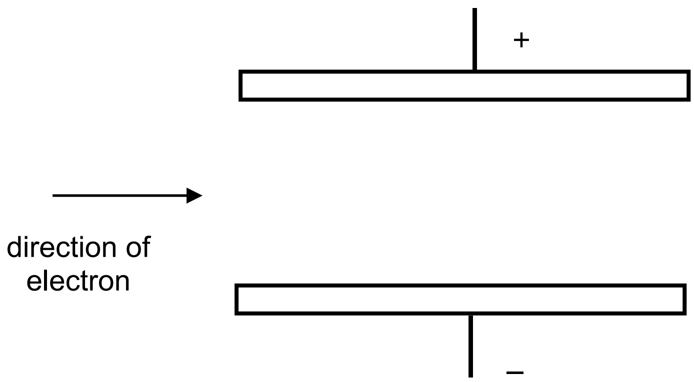

Fig. 4.1

(b) Calculate the potential difference between the two plates.

potential difference = ………………… V [2]

(c) In order for the electron to emerge undeviated from the region of field, a magnetic field perpendicular to the electric field is applied in the same region.

Calculate the magnitude of the magnetic flux density of the magnetic field.

magnetic flux density = ………………… T [2]

5 **(a)** Describe the experimental evidence for a small charged nucleus in the atom. You may include a diagram if you wish.

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……………………………………………………………………………………………

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

(b) **(i)** The decay of radioactive nuclei is said to be a random and spontaneous phenomenon. Explain what is meant by spontaneous decay.

……………………………………………………………………………………

…………………………………………………………………………………… [1]

(ii) A sample of radioactive nuclide, iodine-131 ($^{131}_{53}\mathrm{I}$), decay by the emission of a β-particle to xenon (Xe).

1. Complete the nuclear equation for the decay of iodine-131.

$$^{131}_{53}\mathrm{I} \longrightarrow$$

[2]

2. The count rate from the sample of iodine-131 at two different times is shown in Fig. 5.1.

time / h	count rate / s^{-1}
35.0	2500
478.0	508

Fig. 5.1

Use the information in Fig. 5.1 to calculate the half-life of iodine-131.

half-life = ………………… h [3]

6 When a car has a brake test, two sets of measurements are made:

1. the maximum braking force on the wheels produced by operating the foot brake,
2. the maximum braking force produced by operating the hand brake.

Typical data for a car of mass 900 kg are as follows in Fig. 6.1.

	Maximum braking force / N
1. Foot brake	6700
2. Hand brake	2000

Fig. 6. 1

In order to determine whether or not the brakes are satisfactory, the data are applied to a chart (called a nomogram) like the one shown in Fig. 6.2. This chart has three vertical lines, marked with scales.

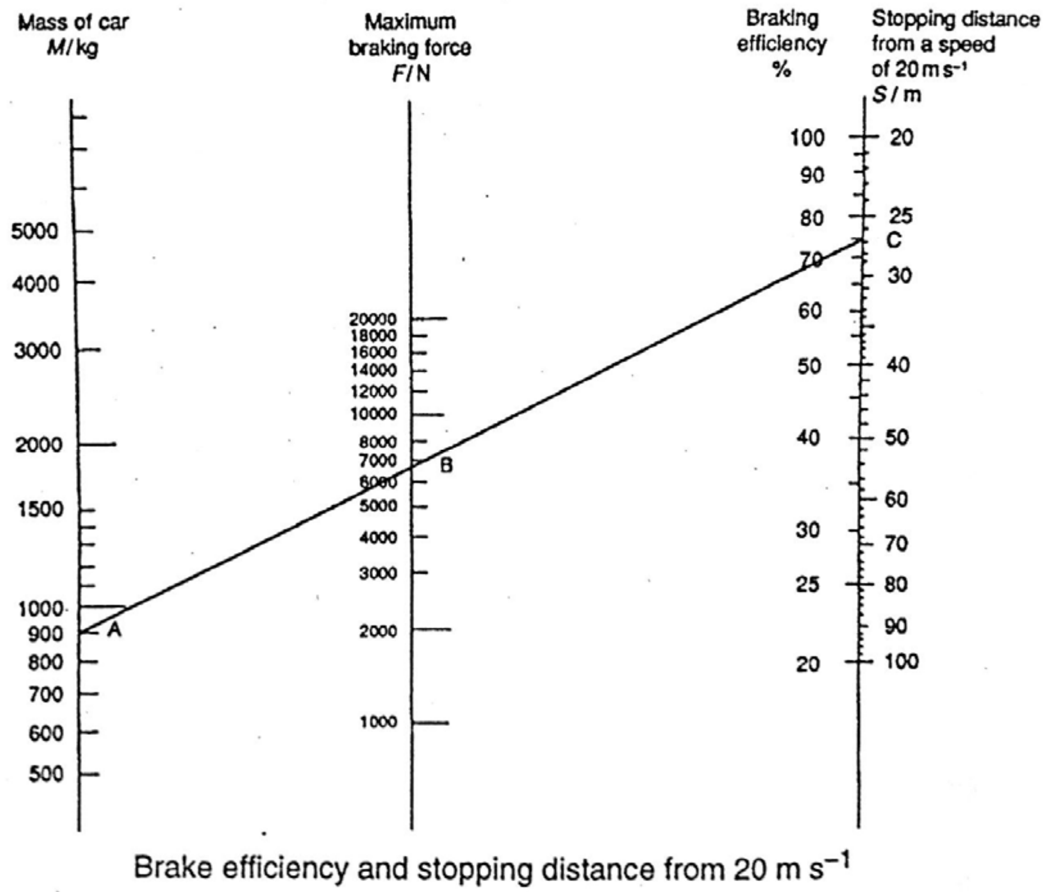


Fig. 6.2

The central vertical line is for the maximum braking force.

The left line is for the mass of the car.

The right hand line is for the braking efficiency and also for the stopping distance from an initial speed of 20 m s^{-1}. The braking efficiency E is defined by the equation

$$E = \frac{\text{Deceleration of the car}}{\text{Acceleration of free fall}} \times 100$$

As an example of the use of this chart for the car of mass 900 kg, the values in Fig. 6.2 show a maximum braking force for the foot brake of 6700 N. The point **A** corresponding to the mass and the point **B** corresponding to the braking force are joined to give a straight, sloping line. This line is extended to cut the braking efficiency scale at the point **C**, and shows that in this particular case, the stopping distance *S* from a speed of 20 m s^{-1} is about 27 m.

(a) Describe the motion of the car when it undergoes deceleration.

…………………………………………………………………………………………

…………………………………………………………………………………………

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

(b) Read from Fig. 6.2, the braking efficiency corresponding to point **C**.

braking efficiency = ………………… % [1]

(c) Using the definition of braking efficiency given above, find the deceleration corresponding to this value of braking efficiency.

deceleration = ………………… m s^{-2} [2]

(d) Show, by calculation from the equations of motion, that the deceleration you obtained in **(c)** gives a stopping distance of 27 m from an initial speed of 20 m s^{-1}.

[3]

(e) **(i)** Draw a line in Fig. 6.2 to represent the results of the hand brake test on the car of mass 900 kg. [1]

(ii) Using the hand brake alone, determine

1. the stopping distance from a speed of 20 m s^{-1}, and

stopping distance = ………………… m [1]

2. the braking efficiency.

braking efficiency = ………………. % [1]

(f) Use Fig. 6.2 to estimate the deceleration for a car of mass 1300 kg if the maximum braking force was 14 000 N. Explain your answer.

…………………………………………………………………………………………

…………………………………………………………………………………………

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

(g) State and explain one other physical factor which might affect the stopping distance of a car.

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………………… [2]

Section B

Answer **one** question in this section.

7 A car used in a crash test first accelerates from rest to a speed of 26 m s^{-1}.

(a) The table in Fig. 7.1 shows how the speed of the car varies over the first 30 seconds of motion.

Time/ s	0	5.0	10.0	15.0	20.0	25.0	30.0
Speed/ m s^{-1}	0	16.5	22.5	24.5	25.5	26.0	26.0

Fig. 7.1

(i) Draw a graph of speed against time in Fig. 7.2.

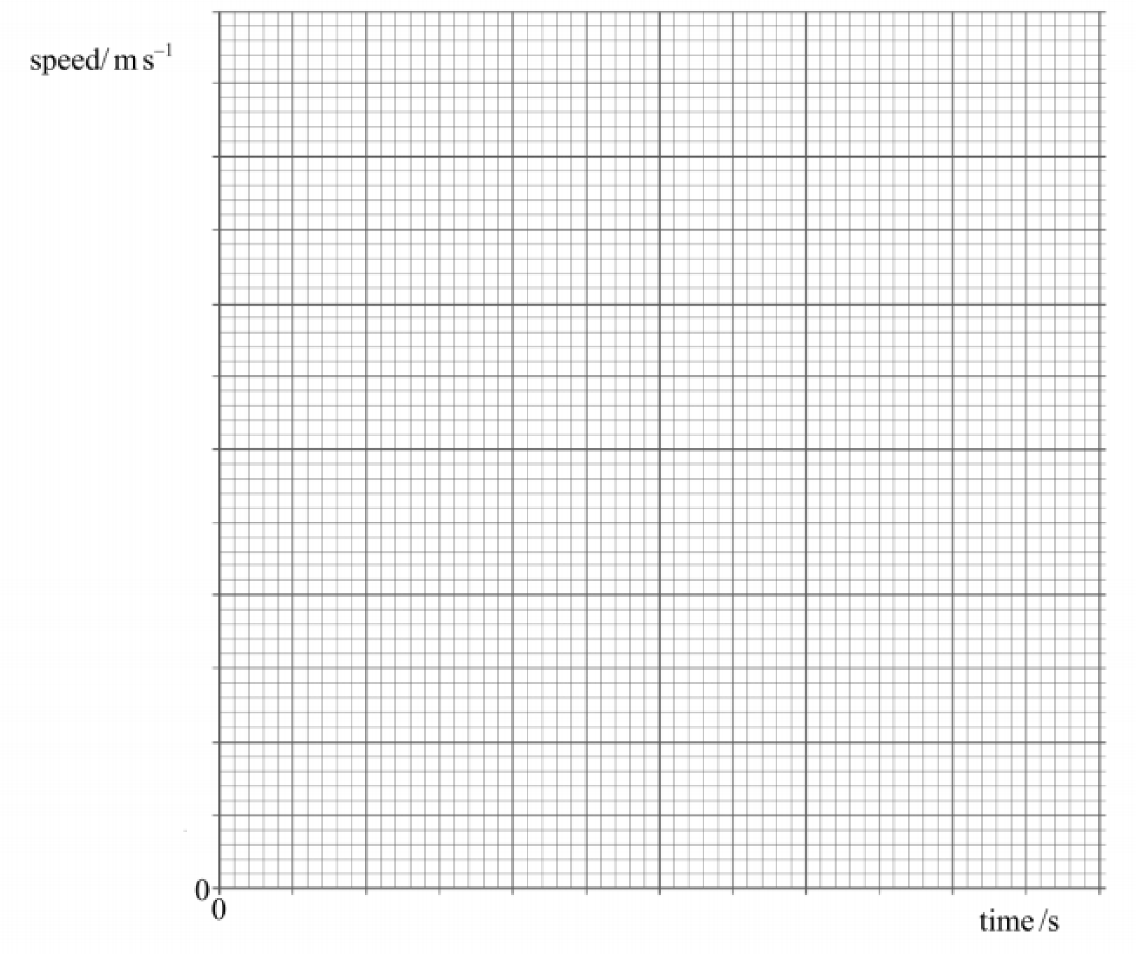


Fig. 7.2

[2]

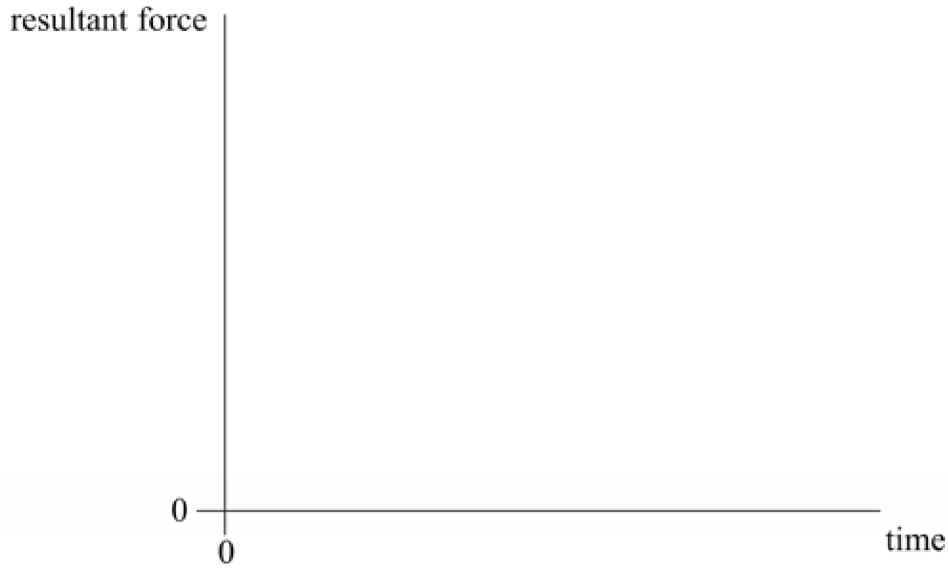
(ii) Calculate the average acceleration of the car over the first 25 s.

average acceleration = …………………. m s^{-2} [1]

(iii) Use your graph in Fig. 7.2 to estimate the distance travelled by the car in the first 25 s.

distance travelled = ……………………………m [3]

(iv) Using the axes below in Fig.7.3, sketch a graph to show how the resultant force acting on the car varies over the first 30 s of motion.



[2]

Fig. 7.3

(v) Explain the shape of the graph you have sketch in **(a)(iv)**.

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

……………………………………………………………………………...……………

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

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

(b) During the crash test, the car used in the crash test collided with a truck.

(i) Show how the conservation of momentum can be deduced from Newton's third law.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

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…………………………………………………………………………………………

…………………………………………………………………………………………

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

(ii) Fig. 7.4 shows the momentum against time graphs for the truck and the car during the collision.

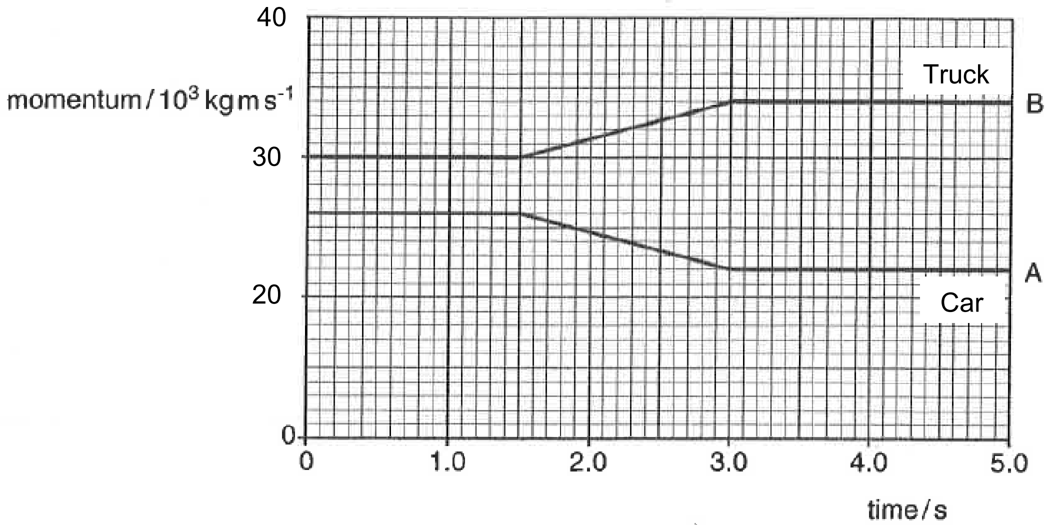


Fig. 7.4

The masses of the car is 1000 kg and truck is 3000 kg.

1. Explain why the gradients of the graph during the collision have opposite sign.

……………………………………………………………………………………….

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

2. Show that momentum is conserved when the two vehicles collide.

[2]

3. Calculate the force acting on the truck during the collision.

force = ……………………. N [2]

(c) Some makes of car have, as a safety feature, regions at the front and rear which are designed to collapse on impact. Briefly explain how this design may help to protect the passengers from serious injury in the event of a collision.

…………………………………………………………………………………………

…………………………………………………………………………………………

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

8 A student wound insulated wire of around a copper tube to make a solenoid of 1200 turns and diameter 2.8 cm as shown in Fig. 8.1.

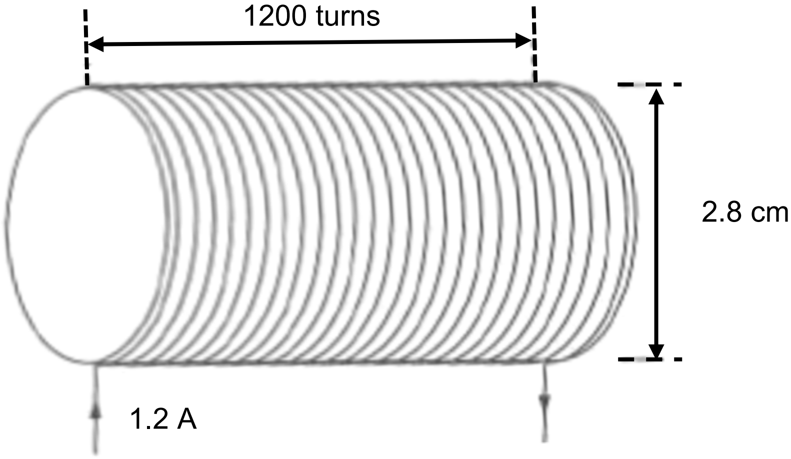


Fig. 8.1

The solenoid is connected to a voltage supply of 6.0 V and a current of 1.2 A follows through it.

(a) **(i)** Calculate, for the solenoid, the resistance of the wire.

resistance = ………………… Ω [1]

(ii) Calculate the total length of the wire of the solenoid.

length = …………………m [2]

(iii) Given that the radius of the wire is 0.30 mm, calculate the resistivity of the wire.

resistivity of wire = …………………Ω m [2]

(b) When current flows through the solenoid, a magnetic field is set up around it.

(i) In Fig. 8.2, sketch the magnetic field pattern within and outside the solenoid.

[3]

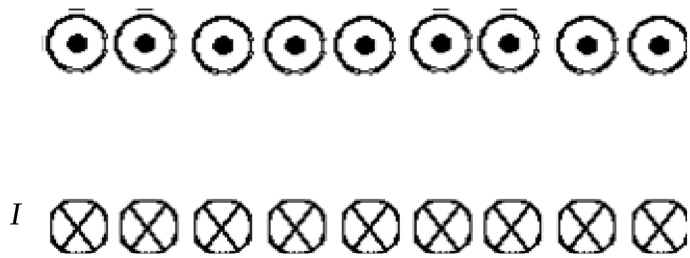


Fig. 8.2

(ii) State and explain the effect on the magnetic field strength inside the solenoid when an iron core is inserted into the solenoid.

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

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

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

(c) A current balance made of wire frame **ACDF**, pivoted at **B** and **E**, is placed in the solenoid to measure the magnetic flux density of the solenoid, as shown in Fig. 8.3. Pivots **B** and **E** have electrical connections so that current can flow through the frame.

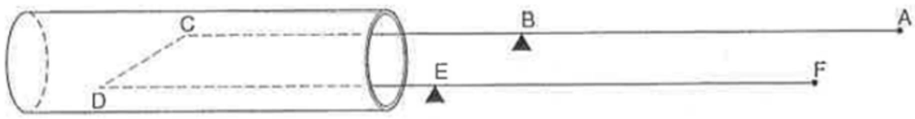


Fig. 8.3

(i) Define *magnetic flux density*.

………………………………………………………………………….……..

………………………………………………………………………….…...

………………………………………………………………………….…... [2]

(ii) The wire frame is balanced when there is no current in it.

When a current of 3.2 A flows through the wire frame, a mass of 0.0045 g has to be positioned 3.0 cm from pivots **BE** for the frame to be at equilibrium as shown in Fig. 8.4.

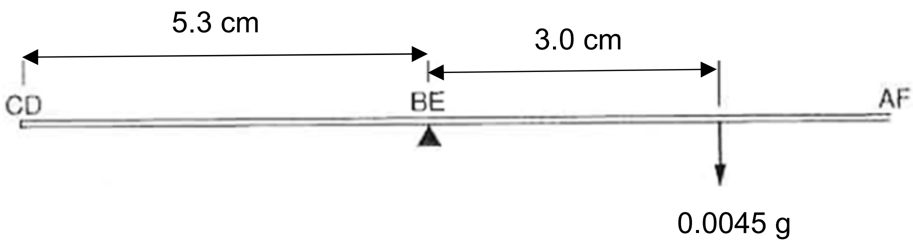


Fig. 8.4

1. Explain why the current in CD causes a turning effect.

………………………………………………………………………..…………..

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

………………………………………………………………………..…..………

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

2. State the direction of the current in CD.

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

3. Given that the length of CD is 2.0 cm, calculate the magnetic flux density in the solenoid.

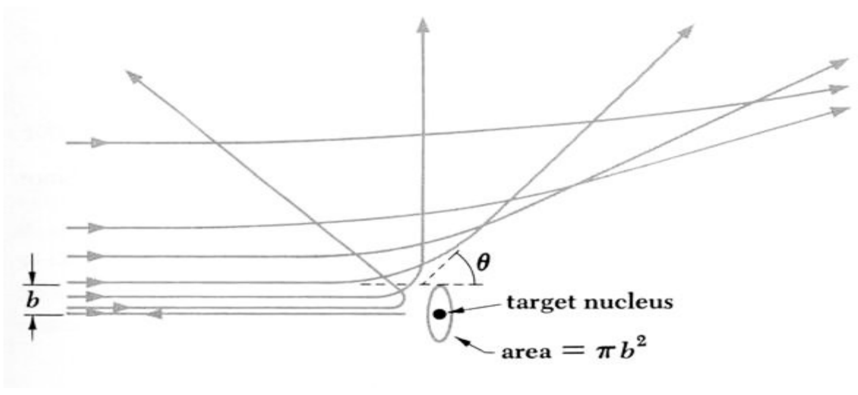
magnetic flux density = …………………T [4]

End of Paper

Solution
Section A

1	**(a)**		Loss in G.P.E = Gain in K.E mg (0.31) = ½ m v^2 – ½ m (1.3^2) v = 2.8 m s^{-1}	**1** **1**
	(b)	**(i)**	Δp = m (Δv) = 0.020 [v – (-2.8)] V = 0.096/0.020 – 2.8 = 2.0 ms^{-1}	**1** **1**
		(ii)	F= $\frac{\Delta p}{\Delta t} = \frac{0.096}{0.015} = 6.4\ N$	**1**
	(c)		The kinetic energy of the ball and wall decreases, so inelastic collision Note: it is incorrect to just state the KE of ball decreases. The system consist of ball and wall.	**1** **1**
	(d)		ΔG.P.E = mgh = (0.020)(9.81)(0.31) = 0.061 J Work done by friction = Frictional force x displacement 0.061 – 0.056 = F (0.40) F = 0.0125 N	**1** **1**
2	**(a)**	**(i)**	Gravitational force provides / is the centripetal force Same gravitational force (by Newton Third Law)	**1**
		(ii)	ω = $\frac{2\pi}{4\times365\times24\times3600}$= 5.0 (4.98) x 10^{-8}	**2**
	(b)	**(i)**	Same magnitude of centripetal force M_A d w_A^2 = M_B (2.8 x 10^8 –d) w_B^2 Since w_A= w_B $\frac{M_A}{M_B} = \frac{2.8\times10^8 - d}{2.8\times10^8} = 3.0$ d = 7.0 x 10 ^{7} km	 **1** **1** **1**
		(ii)	1. The gravitational force acting on the star causes the direction of the velocity to change (perpendicular) to the direction of motion. Hence it experience an acceleration acting towards point P.	**1** **1**
			2. a_A= (7.0x10^7)(1000) (4.98 x 10^{-8})^2 =1.74 x 10^{-4} m s^{-2}	**1**
		(iii)	The gravitational force on star A provides for centripetal acceleration of star A. F_G= $M_A a_A$ $\frac{GM_AM_B}{R^2}$ =M_A a_A	**1** **1** **1**

			M_B= (1.74x10^{-4})(2.8x10^{11})^2/ 6.67 x 10^{-11} = 2.0 x 10^{29} kg Note: all values in km must be converted to m	

3	**(a)**	From the graph, when I = 0.20 A (thermistor), V = 3.0 V R = 3.0 / 0.20 = 15 Ω	**1** **1**
	(b)	V across resistor = V across thermistor = 3.0 V From the graph, when V = 3.0 V (resistor), I = 0.30 A R = 3.0 / 0.30 = 10 Ω	**1** **1**
	(c)	P = I^2R = 0.20^2 (15) + 0.30^2 (10) = 1.5 W	**1** **1**
	(d)	Current through r = 0.20 + 0.30 = 0.50 A V = E - Ir 3.0 = 4.0 – (0.50) r r = 2.0 Ω	**1** **1**
4	**(a)**	1 mark – parabolic path 1 mark – path curves upwards	**2**
	(b)	F = qE & E = V /d V = (3.0 x 10^{-13}) (2.0 x 10^{-2}) / (1.6 x 10^{-19}) = 3.8 x 10^4 V	**1** **1**
	(c)	Using Newton's second law, F_B - F_E = 0 Bqv = qE B = E / v = [(3.0 x 10^{-13}) / (1.6 x 10^{-19})] / 4.2 x 10^7 = 0.045 T	**1** **1**
5	**(a)**	 From the Rutherford's alpha-scattering experiment, it was found that most of the alpha particles pass through the gold foil undeflected. [1]	**4**

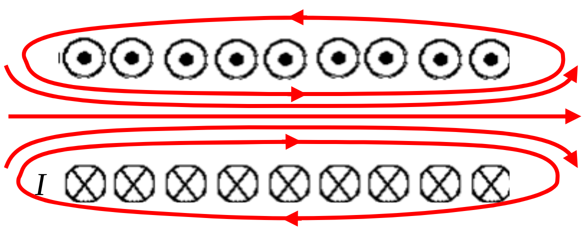
		The deduction is that the nucleus is very small relative to an atom. [1] Some alpha particles are scattered at a large angle away from the gold foil, with a few even experiencing back-scatter. [1] The deduction is that the nucleus in the atom is positively charged which causes the alpha particles to repel from the foil. [1]		
	(b)	**(i)**	It is unaffected by environmental factors such as temperature and pressure.	**1**
		(ii)	**1.** $^{131}_{53}\mathbf{I} \rightarrow ^{131}_{54}\mathbf{Xe} + ^{0}_{-1}\mathbf{e}$ 1 mark – correct Xe 1 mark – correct e	**2**
			2. $(1/2)^n = 508 / 2500$ n = 2.3 (no. of half-lives) 478 – 35 = 2.3 $t_{1/2}$ $t_{1/2}$ = 193 h	 **1** **1** **1**
6	**(a)**	Velocity of car is in opposite direction to its acceleration OR slowing down		**1**
	(b)	75%		
	(c)	Deceleration = E x acceleration of free fall / 100 = 75 x 9.81 / 100 = 7.36 m s^{-2}		 **1** **1**
	(d)	Using $v^2 = u^2 + 2as$ Where v = 0, since car comes to a stop. $0 = 20^2 + 2(-7.36)s$ S = 27 m		**1** **1** **1**
	(e)	**(i)** Straight line joining m = 900 kg and Maximum braking = 2000 N (given max hand brake in Fig. 6.1.)		**1**
		(ii) 1. 90 m		**1**
		(ii) 2. 22.5 %		**1**

	(f)	On Fig. 6.2, drawing a straight line joining mass 1300 kg and braking force 1400 N, braking efficiency E = 100% Since Deceleration = E x acceleration of free fall / 100, deceleration of the car is 9.81 m s^{-2}.	**1** **1** **1**
	(g)	Surface of the road / wheel. Rougher surfaces means more friction, shorter stopping distance.	**1** **1**

Section B

7	**(a)(i)**	Appropriate Scales Six points plotted correctly Trendline	**1** **1**
	(ii)	Average acceleration = 26/ 26 = 1.0 (4) ms^{-2}	**1**
	(iii)	Area under the graph = 510 ± 30 m	**3**
	(iv)	Graph to show forces starting from y-axis, decreasing (not a straight line) To zero (at the end of graph)	**1** **1**
	(v)	Since the gradient of velocity time graph gives the magnitude of the acceleration, acceleration decreases to zero.m	**1** **1**
	(b)(i)	By Newton;s third law, the force on body A by B is equal and opposite to the force on body B by A. These forces are proportional to the rate of change of momentum of each body. $F_{A\ by\ B} = \frac{dP_A}{dt}$ $F_{B\ by\ A} = \frac{dP_B}{dt}$ Since $F_{A\ by\ B} = - F_{B\ by\ A}$. Assuming the duration of the force applied on both bodies are the same, The change in momentum of A is equal to the change in momentum of B. $\Delta P_B = - \Delta P_A$ P_B(final) – P_B (initial) = P_A(final) – P_A(initial) Rearranging, we get the conservation of momentim. P_A(initial) + P_B (initial) = P_A (final) + P_B(final) Total sum of initial momentum of closed system = Total sum of final momentum of closed system.	**1** **1** **1**
	(b)(ii)1	The gradient of the graph gives the magnitude of the force experienced by the vehicles. Since the force on the truck by car is opposite in direction to the force on car by truck, the gradients have opposite sign.	**1**

	2.	Sum of initial momentum = (30 + 26) x 10^3 = 56 x 10 ^{3} kg m s^{-1} Sum of final momentum = (22 + 24) x 10^3 = 56 x 10 ^{3} kg m s^{-1} Since sum of initial momentum = sum of final momentum Momentum of closed system of car and truck is conserved.	**1** **1**
	3.	$F = \frac{dp}{dt} = gradient\ of\ the\ momemtum\ time\ graph\ during\ the\ collision$ Gradient of truck = $\frac{(34-30)\times 10^3}{3-1.5}$= 2667 = 2700 N	**1** **1**
	(c)	The crash regions increases the time of impact during the collision. As the change in momentum remains constant Δp = mΔv = FΔt The impact force exerted on the passengers will be reduced.	**1** **1**

8	**(a)**	(i) R = 6.0 / 1.2 = 5.0 Ω		**1**
		(ii) L = 1200 (π) (2.8 x 10^{-2}) = 106 m		**1** **1**
		(iii) ρ = AR / L = [5.0 (π) (0.30 x 10^{-3})^2] / 106 = 1.3 x 10^{-8} Ω m		**1** **1**
8	**(b)**	**(i)**  1 – uniform field inside soleniod 1 – field lines outside soleniod 1 – correct direction of field lines		**3**
		(ii)	Inserting the iron core should give rise to an increased flux density, Hence magnetic field strength is increased. *Do not accept “concentrating” the existing flux into a smaller area.	**1** **1**
	(c)	**(i)**	The magnetic flux density of a magnetic field is defined as the **force** exerted on a **unit length** of conductor carrying a **unit current** [1] placed at **right angles** to the field. [1]	**2**
		(ii)	**1.** When a current *I* passes through CD, a magnetic field is set up around CD. This magnetic field due to the current in CD interacts with the magnetic field due to the current in the solenoid.	**1** **1**

			Hence, a downward magnetic force acts on CD, causing a turning effect.	1
		(ii)	**2.** DC	1
		(ii)	**3.** Principle of moments, F_B (5.3 x 10^{-2}) = W (3.0 x 10^{-2}) F_B = 0.0045 x 10^{-3} (3.0 x 10^{-2}) / (5.3 x 10^{-2}) = 2.55 x 10^{-6} N F_B = BIL B = 2.55 x 10^{-6} / (3.2 x 2.0 x 10^{-2}) = 4.0 x 10^{-5} T	1 1 1 1