Name	Class	Index Number

PIONEER JUNIOR COLLEGE
JC2 Preliminary Examination

PHYSICS **8867/01**
Higher 1

Paper 1 Multiple Choice

21 September 2018

Additional Material: Multiple Choice Answer Sheet **1 hour**

READ THESE INSTRUCTIONS FIRST

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

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

Read the instructions on the Answer Sheet very carefully.

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

This document consists of **14** printed pages.

Data

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

Formulae

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

1 Which of the derived unit below consists of less than three different SI base units?

A newton (N)

B joule (J)

C ampere (A)

D pascal (Pa)

2 A resistor is marked as having a resistance value *R* of 4.7 Ω ± 2%. The current in the resistor is measured as (2.50 ± 0.05) mA.

Given that the power *P* dissipated in the resistor is $P = I^2R$, what is the percentage uncertainty in the calculated value of *P*?

A 2%

B 4%

C 6%

D 8%

3 A particular equation relates the quantities *W*, *X*, *Y* and *Z* as shown below.

$$W = Z^2 + XY$$

Which statement must be correct for the equation to be homogeneous?

A *W*, *X*, *Y* and *Z* all have the same units.

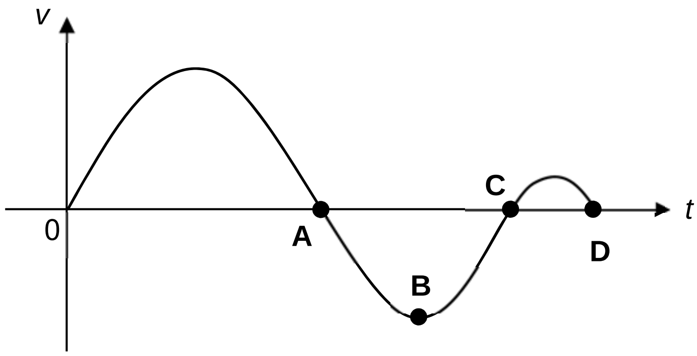
B $\frac{W}{Z}$ must have the same unit as *X.*

C The square root of *XY* has the same unit as *Z*.

D *X* has the same unit as *Y.*

4 A graph showing the variation of the velocity v of a body with time t is as shown.

At which point is the body furthest away from its starting position?



5 The velocity of a car which is decelerating uniformly from 25 m s^{-1} to 12 m s^{-1} in 65 m.

After what further distance will it come to rest?

A 19 m

B 33 m

C 60 m

D 84 m

6 A body is projected at an angle to the horizontal in a gravitational field and it follows a parabolic path, PQRST. The points are positions of the object after successive equal time intervals, T being the highest point reached.

Which of the following is true about the displacements PQ, QR, RS and ST?

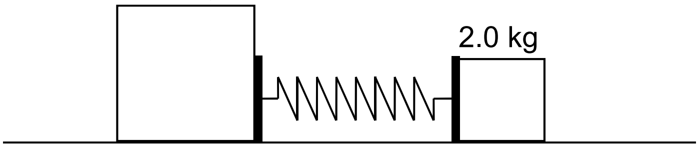
A They are equal.

B They decrease at a constant rate.

C They have equal vertical components.

D They have equal horizontal components.

7 A light spring is connected between two blocks of wood, of masses 5.0 kg and 2.0 kg, on a frictionless horizontal surface. The spring is compressed and the blocks are released simultaneously from rest.



When the acceleration of the heavier block is 10 m s^{-2}, what is the acceleration of the lighter block?

A 5.0 m s^{-2}

B 10 m s^{-2}

C 20 m s^{-2}

D 25 m s^{-2}

8 Water is pumped through a hose at a rate of 20 kg per minute. It emerges from the hose horizontally with a speed of 5.0 m s^{-1}.

What is the force that a person, who is holding the hose, require to prevent it from moving backwards?

A 1.7 N

B 4.0 N

C 100 N

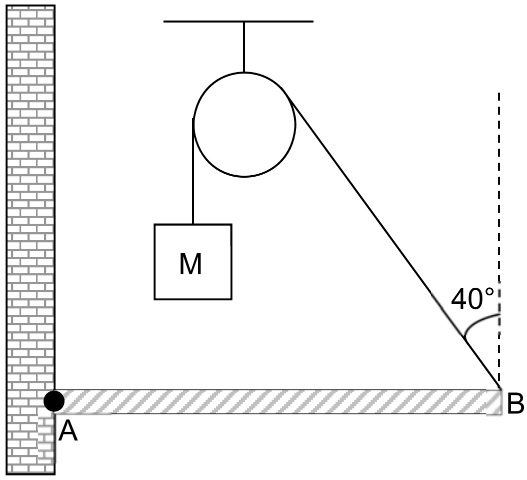
D 6000 N

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

What is the speed of the trucks after the collision?

A $\frac{v}{4}$ **B** $\frac{v}{2}$ **C** v **D** $\frac{5v}{4}$

10 A uniform rod AB of mass 4.0 kg is suspended by a string attached at B. The string is connected to a block M and passed over a smooth pulley. The other end of the rod is hinged at A. When the rod is horizontal, the string makes an angle of 40^{o} with the vertical.



What is the weight of M required to maintain equilibrium?

A 20 N

B 26 N

C 31 N

D 39 N

11 A wire that obeys Hooke's law is of length x_1 when it is in equilibrium under a tension T_1 . Its length becomes x_2 when the tension is increased to T_2 .

What is the extra energy stored in the wire as a result of this process?

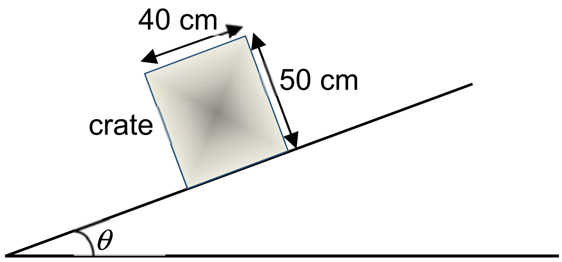
A $\frac{1}{2}(T_2 + T_1)(x_2 - x_1)$

B $\frac{1}{2}(T_2 - T_1)(x_2 + x_1)$

C $(T_2 + T_1)(x_2 - x_1)$

D $(T_2 - T_1)(x_2 + x_1)$

12 A uniform rectangular block of mass m rests on an inclined plane.



What is the maximum angle of tilt θ before the block topples over? Assume that sliding does not occur before tilting occurs.

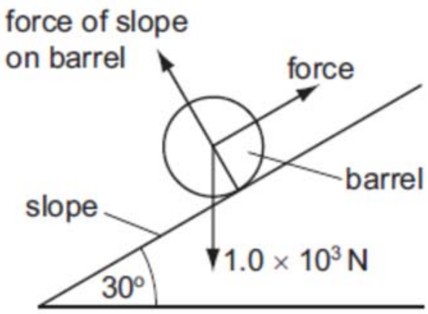
A 37°

B 39°

C 51°

D 53°

13 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 2.5×10^3 J

B 4.3×10^3 J

C 5.0×10^3 J

D 1.0×10^4 J

14 A motor using electrical energy at a rate of 400 W raises a block of mass 12 kg vertically at a constant speed of 2.0 m s^{-1}. The block is raised by a vertical distance of 25 m.

What is the efficiency of the motor?

A 6.0 %

B 16 %

C 59 %

D 65 %

15 The forward thrust provided by the engine of a car moving horizontally with constant velocity of 12 m s^{-1} on a straight road is 500 N.

Which of the following statements is correct?

A The net force on the car is 500 N.

B The average power of the engine is 3.0 kW.

C The rate of work done by the engine is 6.0 kW.

D The power of the engine is zero as the car is moving at constant velocity.

16 Which statement is incorrect for a particle moving in a horizontal circle with constant angular velocity?

A The centripetal force is not constant.

B The speed and the linear momentum are constant.

C The kinetic energy is constant but the velocity varies.

D The kinetic energy is constant but the linear momentum varies.

17 A circular disc is rotating about a vertical axis through its centre. Two objects of mass 3.0 kg and 6.0 kg are placed on the rough surface of the rotating disc at 2.0 m and 5.0 m from its centre respectively.

What is the ratio of the centripetal force on the 3.0 kg mass to the 6.0 kg mass?

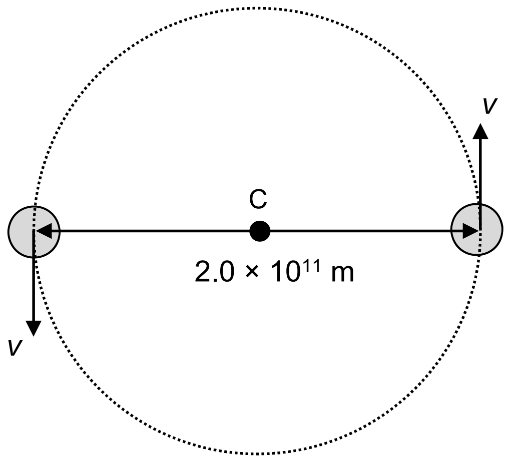
A 0.20

B 0.80

C 5.0

D 1.3

18 A binary star system consists of two identical stars each of mass 4.0×10^{30} kg orbiting about their common centre of mass C. The stars are moving with a constant speed *v* and their centres are separated by a distance of 2.0×10^{11} m.



What is the speed *v* of each star?

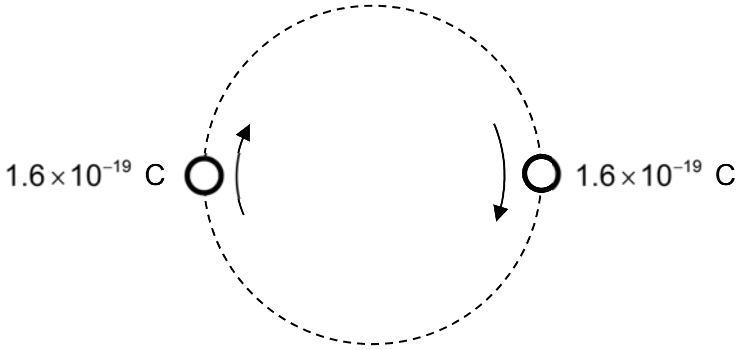
A 1.8×10^4 m s^{-1}

B 2.6×10^4 m s^{-1}

C 3.7×10^4 m s^{-1}

D 5.2×10^4 m s^{-1}

19 Two charged particles, each of charge 1.6×10^{-19} C, are moving in a circular path due to an external magnetic field as shown. The period of the motion for each particle is 2.0×10^{-10} s.



What is the current caused by the motion of the two particles?

A 1.6×10^{-29} A

B 3.2×10^{-29} A

C 8.0×10^{-10} A

D 1.6×10^{-9} A

20 A cell of internal resistance *r* is connected in series to a variable resistor and an ammeter. When the variable resistor is set to 5.0 Ω, the ammeter reads 1.5 A. The variable resistor is then set to 2.0 Ω, and the ammeter reads 3.5 A.

What is *r*?

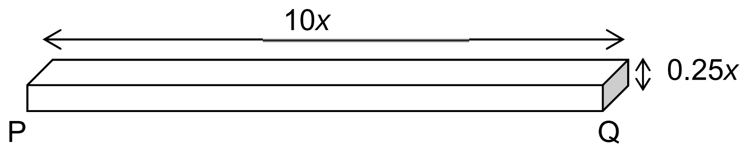
A 0

B 0.25 Ω

C 0.32 Ω

D 0.50 Ω

21 A uniform block of resistive material has length 10x and thickness 0.25x, as shown.



For a given width, how does the resistance of the block across the two ends P and Q vary with x?

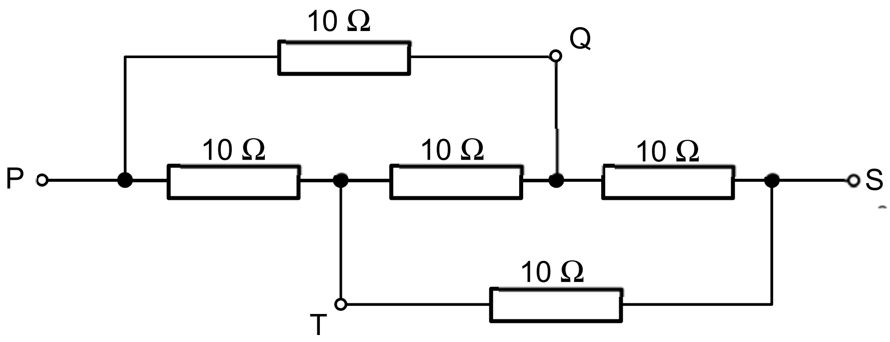
A proportional to x^2

B proportional to x

C independent of x

D inversely proportional to x

22 A network of resistors each of resistance 10 Ω are shown.



What is the effective resistance between Q and T?

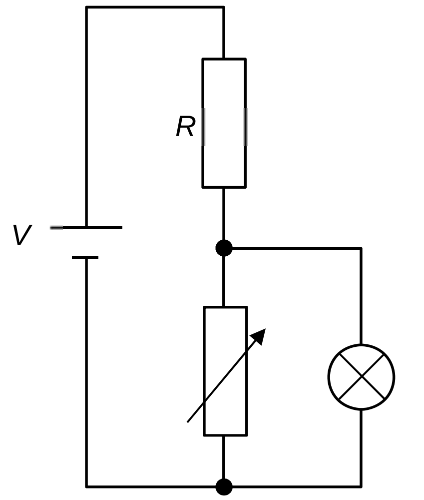
A 2.0 Ω

B 5.0 Ω

C 10 Ω

D 12 Ω

23 A battery of e.m.f. *V* and negligible internal resistance is connected to a resistor of resistance *R*, a variable resistor and a lamp as shown.



What happens to the brightness of the lamp as the resistance of the variable resistor is increased?

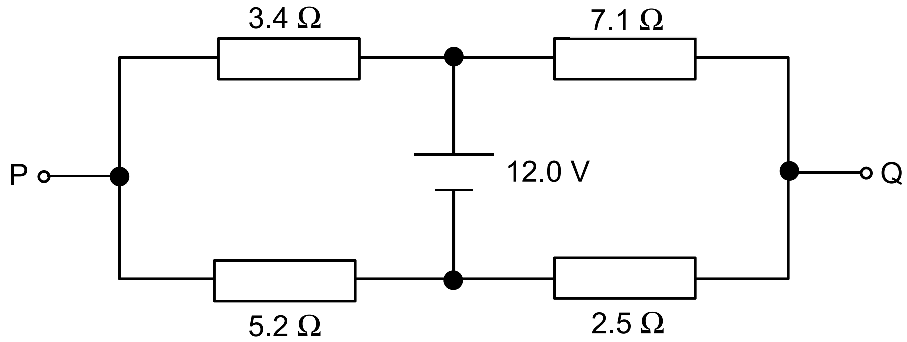
A The bulb becomes dimmer.

B The bulb becomes brighter.

C The brightness remains the same.

D The bulb becomes brighter initially, and then becomes dimmer.

24 Four fixed resistors are connected to a cell as shown.



What is the potential difference across P and Q?

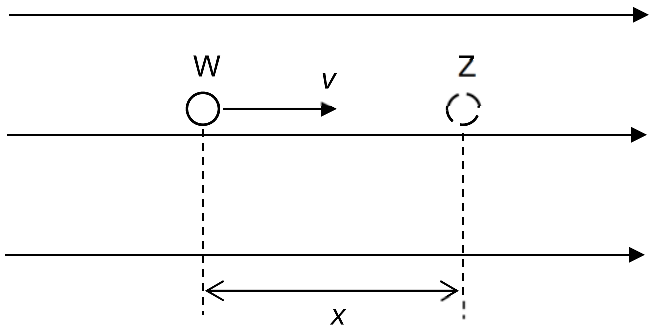
A 0

B 1.6 V

C 4.1 V

D 10 V

25 An electron with charge *e* and mass *m* travels from point W to point Z within a uniform electric field of strength *E*. At point W, the particle has a velocity of *v*. It comes to a stop at point Z. The distance between point W and Z is *x*.

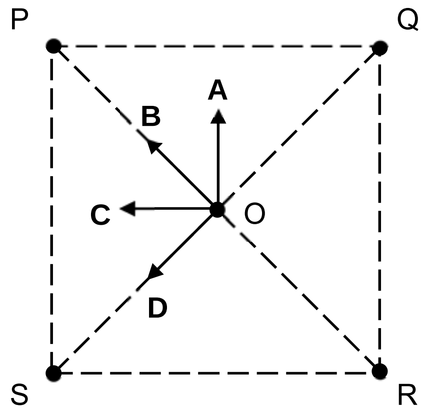


Which expression gives the value of *x*?

A $\frac{mv}{E}$ **B** $\frac{mv}{Ee}$ **C** $\frac{mv^2}{2E}$ **D** $\frac{mv^2}{2Ee}$

26 The figure below shows four long, straight current-carrying wires, P, Q, R and S which are perpendicular to the plane of the paper. They pass through the corners of a square. Point O is the point of intersection of the diagonals of the square. The currents in all four wires have the same magnitude. The currents in wires P, Q and R flow into the plane of the paper while that in S flows out of the plane of the paper.

Which arrow shows the direction of the resultant magnetic field at O?



27 An electron moves across Earth's equator in a south-easterly direction. At this point, the Earth's magnetic field has a direction due north and is parallel to the Earth's surface.

What is the direction of the force acting on the electron at this instant?

A towards the north-east

B towards the south-east

C into the Earth's surface

D out of the Earth's surface

28 In the α-particle scattering experiment, a beam of α-particles is aimed at a thin gold foil. Most of the α-particles go straight through or are deflected by a small angle. A very small proportion are deflected through more than 90°, effectively rebounding towards the source of the α-particles.

Which conclusion about the structure of atoms cannot be drawn from this experiment alone?

A The nucleus is charged.

B Most of the atom is empty space.

C The nucleus contains both protons and neutrons.

D Most of the mass of an atom is concentrated in the nucleus.

29 A radioactive nuclide X disintegrates by emitting gamma radiation and a single α-particle, forming a daughter nuclide Y.

Which of the following statements is correct?

A X has more protons in its nucleus than Y.

B X and Y are isotopes of the same element.

C The atomic number of X is less than that of Y.

D The mass number of X is one less than that of Y.

30 A Geiger-Muller tube recorded an average count-rate of 20 min^{-1} in the absence of any radioactive source. When it is moved near a radioactive source of half-life 48 hours, the average count-rate rises to 100 min^{-1}.

What is average count rate recorded of the source 12 hours later?

A 67 min^{-1} **B** 84 min^{-1} **C** 87 min^{-1} **D** 94 min^{-1}

End of paper

PJC Answers to JC2 Preliminary Examination Paper 1 (H1 Physics)

1	**C**	**6**	**D**	**11**	**A**	**16**	**B**	**21**	**C**	**26**	**B**
2	**C**	**7**	**D**	**12**	**B**	**17**	**A**	**22**	**B**	**27**	**C**
3	**C**	**8**	**A**	**13**	**A**	**18**	**B**	**23**	**B**	**28**	**C**
4	**A**	**9**	**A**	**14**	**C**	**19**	**D**	**24**	**C**	**29**	**A**
5	**A**	**10**	**B**	**15**	**C**	**20**	**B**	**25**	**D**	**30**	**C**

Suggested Solutions:

1 It is a matter of routine to work out the base units of N (kg m s^{-2}), J (kg m^2 s^{-2}) and Pa (kg m^{-1} s^{-2}). All three consist of three base units. Ampere is an SI base unit.

Answer: C

2 $P = I^2R$

$$\frac{\Delta P}{P} = \frac{2\Delta I}{I} + \frac{\Delta R}{R} = \frac{2(0.05)}{2.50} + \frac{2}{100}$$
$$= 0.06$$

Therefore, percentage uncertainty is 6%.

Answer: C

3 Z^2 has same units as W and XY
Therefore, Z has the same unit as square root of XY.

Answer : C

4 The displacement is determined from the area underneath the graph. The point where the area underneath the graph is the largest is A.

This means that the body is moving towards the starting position from A to C, and then away from the starting position from C to D.

Answer: A

5 $v^2 = u^2 + 2as$

$12^2 = 25^2 + 2a(65)$

$a = -3.7 \text{ m s}^{-2}$

Accounting for the rest of the trip,

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

$0 = 12^2 + 2(-3.7)s'$

$s' = 19 \text{ m}$

Answer: A

6 In projectile motion of a body in a gravitational field, the body experiences a net force downwards towards the ground. Therefore, the acceleration of the body acts downwards. This only affects the vertical component of the velocity and not its horizontal component, thus the displacements will have equal horizontal components.

Answer: D

7 Let F on 5 kg = (5)(10) = 50 N

50 = 2a
a = 25 m s^{-2}

Answer: D

8 $F = \frac{\Delta p}{\Delta t}$

$F = \frac{(20)(5.0-0)}{60} = 1.7$ N

Answer: A

9 By conservation of linear momentum,
$m(-2v) + 3m(v) = 4mV$

$V = \frac{v}{4}$

Answer: A

10 Taking moments about A,
$4(9.81)\left(\frac{L}{2}\right) = L(T\cos 40°)$

$T = 26$ N

Weight of M = 26 N (since pulley is smooth)

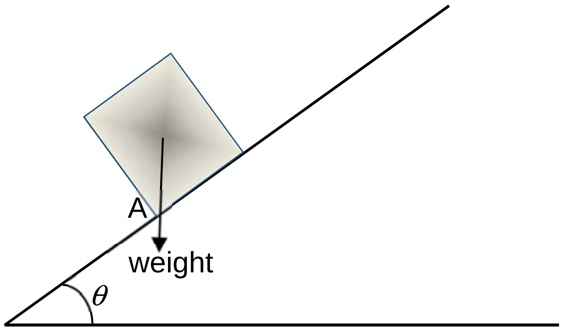
Answer: B

11 Area under the F-x graph = $\frac{1}{2}(T_2 + T_1)(x_2 - x_1)$

Answer: A

12 Tilting will take place when the line of action of the weight of the crate acts to the left of point A

When that happens,



$$\tan\theta = \frac{20}{25}$$
$$\theta = 39°$$

Answer: B

13 work done = force x displacement

$$W = 1.0\times10^{3}\sin30°(5.0)$$
$$= 2500 \text{ J}$$

Answer: A

14 $\eta = \dfrac{\text{output power}}{\text{input power}}\times100\%$

$$\eta = \frac{\text{rate of increase of GPE}}{\text{input power}}\times100\%$$
$$\eta = \frac{mgv}{\text{input power}}\times100\%$$
$$\eta = \frac{(12)(9.81)(2.0)}{400}\times100\% = 59\%$$

Answer: C

15 $P = Fv$

$$P = (500)(12)$$
$$= 6000 \text{ W}$$

Answer: C

16 The speed is constant but the linear momentum is not because it is a vector quantity and the direction of the velocity is always changing.

Answer: B

17 Frictional force on the masses provides the centripetal force for their motion

$$F_c = f = mr\omega^2$$
$$f_{3kg} = (3.0)(2.0)\omega^2$$
$$f_{6kg} = (6.0)(5.0)\omega^2$$
$$\frac{f_{3kg}}{f_{6kg}} = \frac{6.0}{30} = 0.20$$

Answer: A

18 Gravitational force = centripetal force

$$\frac{GM^2}{r^2} = \frac{Mv^2}{\left(\frac{r}{2}\right)}$$
$$v = \sqrt{\frac{GM}{2r}}$$
$$= \sqrt{\frac{(6.67\times10^{-11})(4.0\times10^{30})}{2(2.0\times10^{11})}}$$
$$= 2.6\times10^4 \text{ m s}^{-1}$$

Answer: B

19 Since current is the rate of flow of charge at a point,

$$I = \frac{dQ}{dt} = \frac{1.6\times10^{-19}}{0.5(2.0\times10^{-10})} = 1.6\times10^{-9} \text{ A}$$

Answer: D

20 $E = IR_{total} = 1.5(r + 5.0) = 3.5(r + 2.0)$
$r = 0.25\ \Omega$

Answer: B

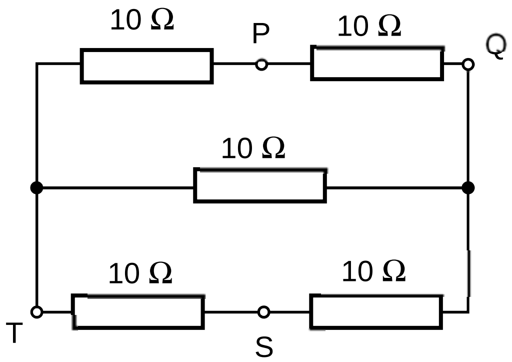
21 Resistance is directly proportional to length and inversely proportional to area

$$R \propto \frac{L}{A}$$
$$R \propto \frac{10x}{(0.25x)(\text{width})} = \frac{10}{(0.25)(\text{width})}$$

Hence, resistance is independent of x.

Answer: C

22 The given circuit is similar to the circuit below.



Thus, calculating the effective resistance across QT,

$$R_{QT} = \left(\frac{1}{10+10} + \frac{1}{10} + \frac{1}{10+10} \right)^{-1} = 5.0\ \Omega$$

Answer: B

23 When the resistance across the variable resistor increases, the effective resistance across the variable resistor and the lamp increases. By potential divider rule, this will increase the p.d. across the lamp and the variable resistor. Thus, the brightness of the lamp increases, assuming the resistance of the lamp is constant.

Answer: B

24 Let the negative terminal of the cell be O.

$$\text{p.d. across OP} = \frac{5.2}{5.2+3.4} \times 12 = 7.26\ \text{V}$$

$$\text{p.d. across OQ} = \frac{2.5}{2.5+7.1} \times 12 = 3.13\ \text{V}$$

$$\begin{aligned}\text{p.d. across PQ} &= 7.26 - 3.13 \\ &= 4.13\ \text{V} \\ &\approx 4.1\ \text{V}\end{aligned}$$

Answer: C

25 By conservation of energy,
Work done by electric field on electron = loss in kinetic energy

$$(qE)(x) = \frac{1}{2} m v^2$$

$$x = \frac{mv^2}{2Ee}$$

Answer: D

26 By right hand grip rule, magnetic flux density at O due to P and Q points in direction of C. Magnetic flux density due to R and S points in direction of A.
Hence, resultant magnetic flux density at point O is in direction of B.

Answer: B

27 The component of the velocity of the electron pointing to the east will lead to a magnetic force acting on the electron. By using Fleming's left hand rule, the force will act into the Earth's surface.

Answer: C

28 Answer: C

29 ${}^{A}_{Z}X \rightarrow {}^{A-4}_{Z-2}Y + {}^{4}_{2}He + \gamma$

Answer: A

30 Actual count-rate of the source, $C_0 = 100 - 20 = 80 \text{ min}^{-1}$

After 12 hours, actual count-rate, $C = C_0\left(\frac{1}{2}\right)^{\frac{t}{t_{\frac{1}{2}}}} = 80\left(\frac{1}{2}\right)^{\frac{12}{48}} \approx 67 \text{ min}^{-1}$

Observed count-rate $= 67 + 20 = 87 \text{ min}^{-1}$ (Need to add background radiation)

Answer: C

Name	Class	Index Number

PIONEER JUNIOR COLLEGE
JC2 Preliminary Examination

PHYSICS **8867/02**
Higher 1

Paper 2 Structured Questions

14 September 2018

2 hours

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

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Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer any **one** question.

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		/	6
2		/	6
3		/	7
4		/	6
5		/	7
6		/	8
7		/	8
8		/	12
Section B			
9		/	20
10		/	20
Total		/	80

This document consists of **23** printed pages.

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Section A

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

1 **(a)** Distinguish between *accuracy* and *precision*.

....

....

.... [1]

(b) A steel ball is dropped from rest in a vacuum and is timed to determine g, the acceleration of free fall. The percentage uncertainty of H, the distance of fall is measured to 3% due to *random errors*. The time taken t is accurate to only 0.01 s. The readings obtained are as follows:

H = 1.315 m
t = 0.50 s

(i) Explain what is meant by *random error* and suggest how it can be reduced.

....

....

.... [2]

(ii) Calculate the percentage uncertainty in g.

percentage uncertainty in g = …………… % [3]

2 A rugby player attempts to kick a rugby ball over the crossbar of a rugby goal posts which is at a point 36 m horizontally from him. The crossbar of the goal posts is 3.0 m high. The ball leaves the ground at a speed of 20 m s^{-1} and at an angle of 53° to the horizontal.

(a) Show that the ball will pass above the crossbar.

[4]

(b) State and explain whether the ball crosses the crossbar while rising or falling.

....

....

.... [2]

3 (a) Define *work done*.

....

.... [1]

(b) A trolley of mass 400 g is moving at a constant speed of 2.5 m s^{-1} to the right as shown in Fig. 3.1.

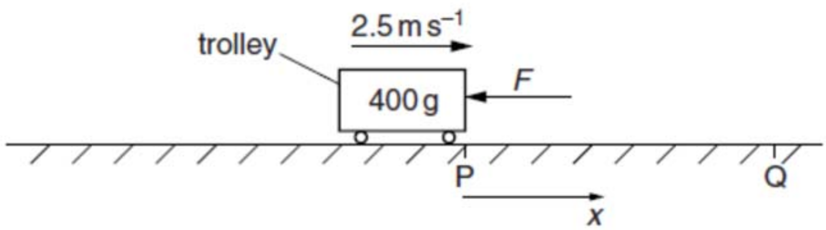


Fig. 3.1

A variable force F acts to the left on the trolley as it moves between points P and Q. The variation of F with displacement x from P is shown in Fig. 3.2.

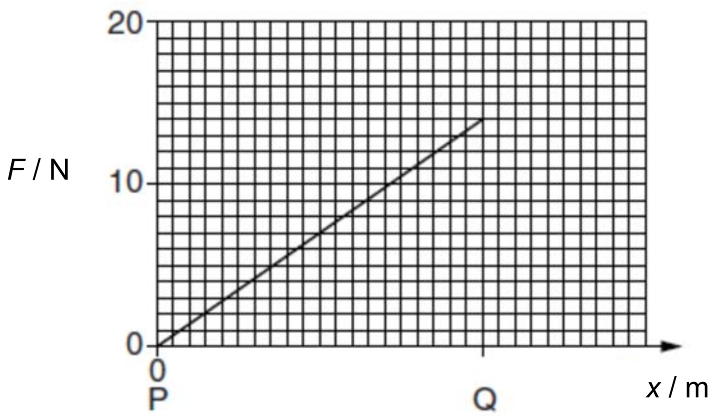


Fig. 3.2

The trolley comes to rest at point Q.

(i) Calculate the distance PQ.

distance = ... m [2]

(ii) On Fig. 3.3, sketch, with appropriate values, the variation with *x* of work done on trolley by *F*.

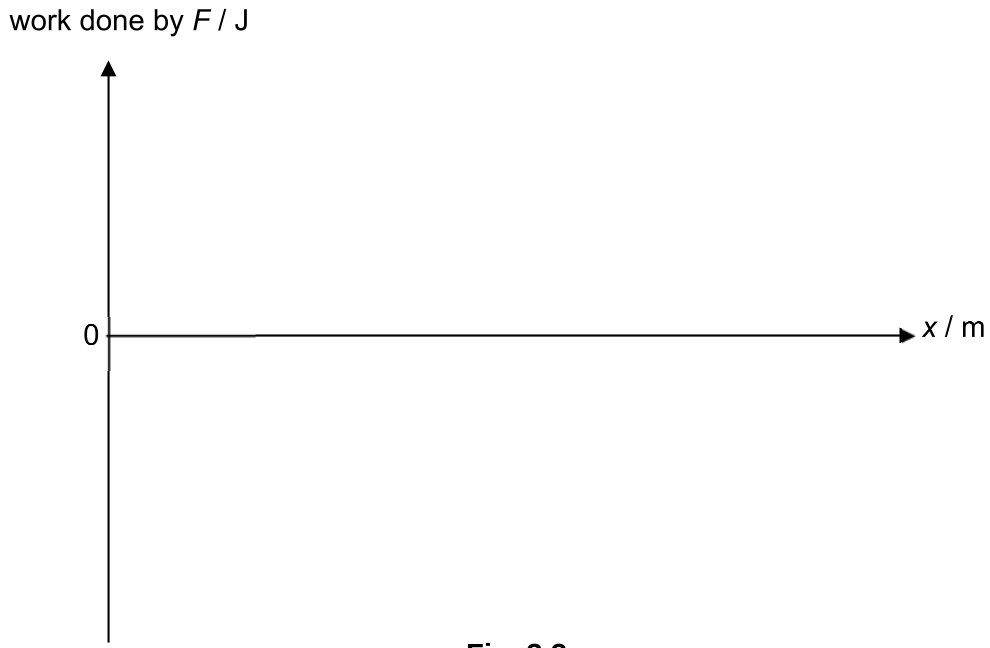


Fig. 3.3

[3]

(iii) In order to maintain a constant speed of 2.5 m s^{-1}, an electric motor attached to the trolley is switched on.

On Fig. 3.4, sketch the variation with *x* of the power supplied by motor while the trolley moves from point P to Q. No numerical value is required.

Fig. 3.4

[1]

4 The variation with the potential difference V across a filament wire of current I is as shown in Fig. 4.1.

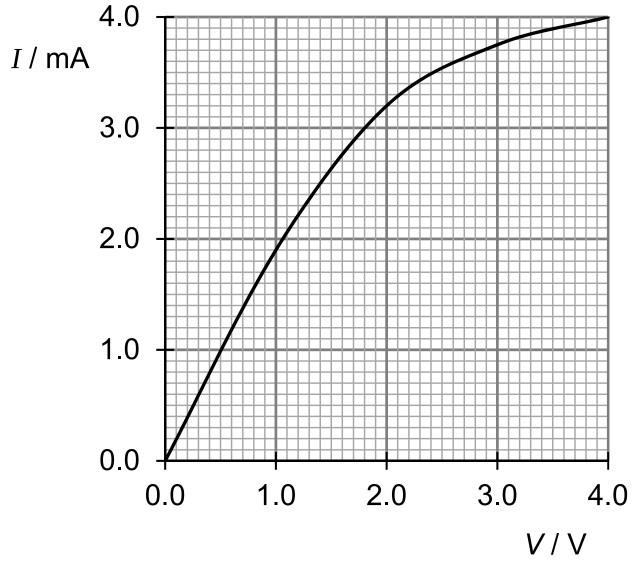


Fig. 4.1

(a) Explain how Fig. 4.1 shows that the resistance of the filament wire increases with potential difference.

....

....

.... [2]

(b) Using Fig. 4.1, determine the minimum value of the resistance of the filament wire.

minimum resistance = ... Ω [2]

(c) The filament wire is 2.0 m long and has a diameter of 0.046 mm.

Determine the resistivity of the wire when V is 4.0 V.

resistivity = ... Ω m [2]

5 A cell P, a fixed resistor R and a uniform resistance wire AB are connected in a circuit as shown in Fig. 5.1.

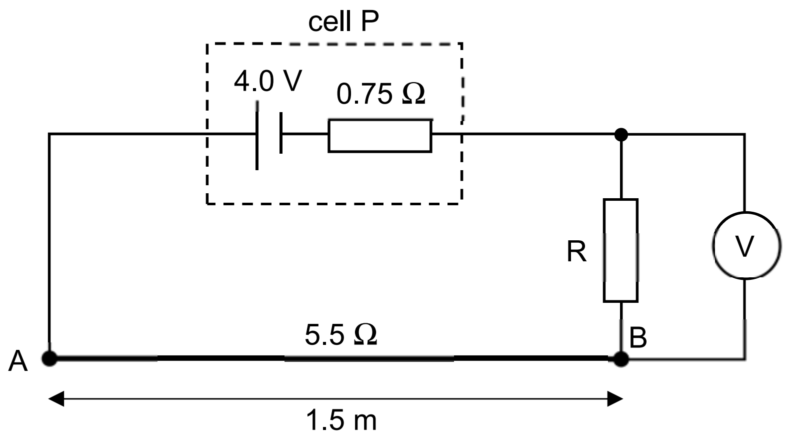


Fig. 5.1

Cell P has e.m.f. 4.0 V and internal resistance 0.75 Ω. Wire AB has length 1.5 m and resistance 5.5 Ω. The voltmeter reads 1.3 V.

(a) Show that the potential difference across AB is 2.4 V.

[3]

(b) A resistor of resistance 1.0 Ω is connected to the circuit in Fig. 5.1, as shown in Fig. 5.2. A crocodile clip C is attached to the wire AB, such that the length of AC is 0.56 m.

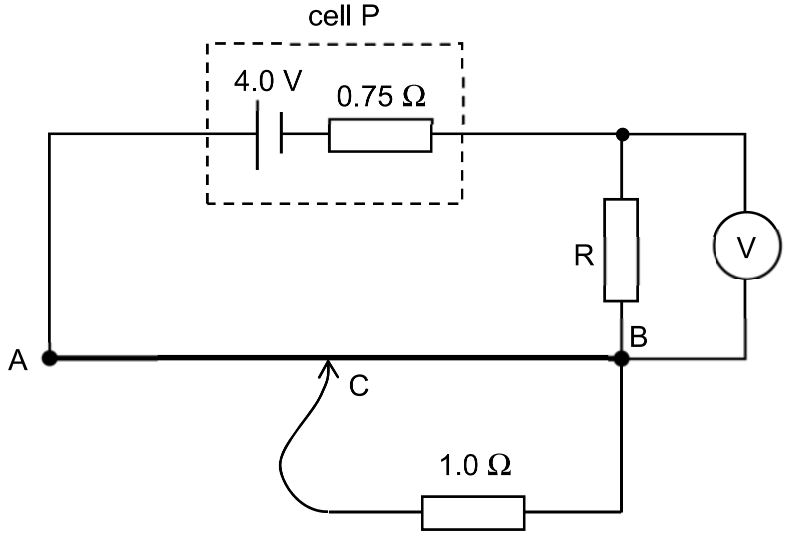


Fig. 5.2

(i) Determine the effective resistance across AB.

effective resistance = ... Ω [2]

(ii) State and explain how the reading in the voltmeter will change as C is shifted closer to A.

....

....

.... [2]

6 (a) (i) Write down the equation defining *magnetic flux density* in terms of *F* the force it produces on a long, straight conductor of length *L* carrying a current I at an angle θ to the field.

[1]

(ii) Draw a diagram to illustrate the direction of the force relative to the current and magnetic field.

[1]

(b) Fig. 6.1 shows a small square coil of *N* turns and sides of length *L.* It is mounted so that it can pivot freely through the centre of the coil, about a horizontal axis PQ parallel to one pair of sides of the coil.

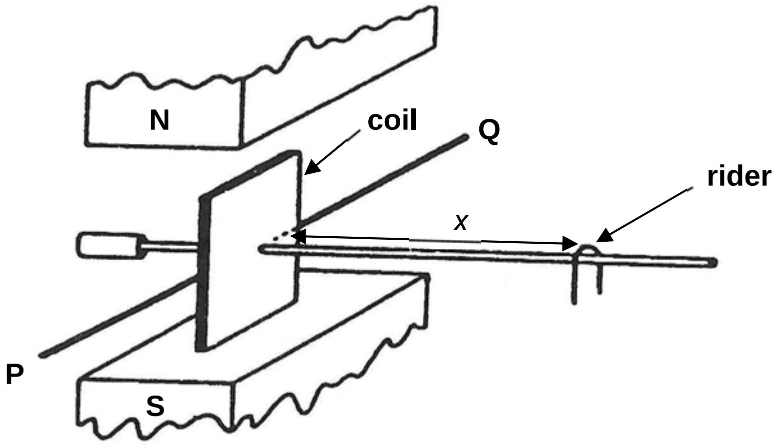


Fig. 6.1

The coil is situated between the poles of a magnet which produces a uniform vertical magnetic field of flux density *B*. The coil is maintained in a vertical plane by moving a rider of mass *M* along a horizontal beam attached to the coil. When a current I flow through the coil, equilibrium is restored by adjusting *x,* the distance of the rider from the coil.

(i) Starting from the definition of magnetic flux density, show that B is given by the expression

$$B = \frac{Mgx}{IL^2N}.$$

[3]

(ii) Current I is supplied by a battery of constant e.m.f. and negligible internal resistance. Discuss the effect on x if the coil is replaced by one wound with wire of same material and diameter, but forming a coil of N turns with sides of length $\frac{L}{2}$.

....

....

....

.... [3]

7 **(a)** Define *half-life.*

....

....

.... [1]

(b) A new 'superheavy' nucleus X, with 118 protons and 175 neutrons, was created by firing very high energy Krypton-86 nuclei $\left({}^{86}_{36}Kr\right)$ at a Lead-208 $\left({}^{208}_{82}Pb\right)$ target.

(i) Write down the nuclear equation for this fusion reaction.

.... [1]

(ii) Suggest a possible reason why X is unstable.

....

.... [1]

(iii) The nucleus X decays by the emission of a series of six high-energy alpha-particles. Determine the number of protons and neutrons of the product nucleus.

number of protons = ...

number of neutrons = ... [2]

(c) The half-life of X is such that 82% of a given quantity decays in 15 seconds.

Determine the half-life of X.

half-life = ... s [3]

8 Fig. 8.1 shows a bubble chamber which consists of a sealed chamber filled with a liquefied gas. The coils around the chamber provide a magnetic field. The pressure inside the chamber can be reduced quickly by an adjustable piston. The liquid is originally at a temperature just below its boiling point. When the pressure is reduced, the boiling point of the liquid becomes lower, so that it is less than the original temperature of the liquid, leaving the liquid superheated.

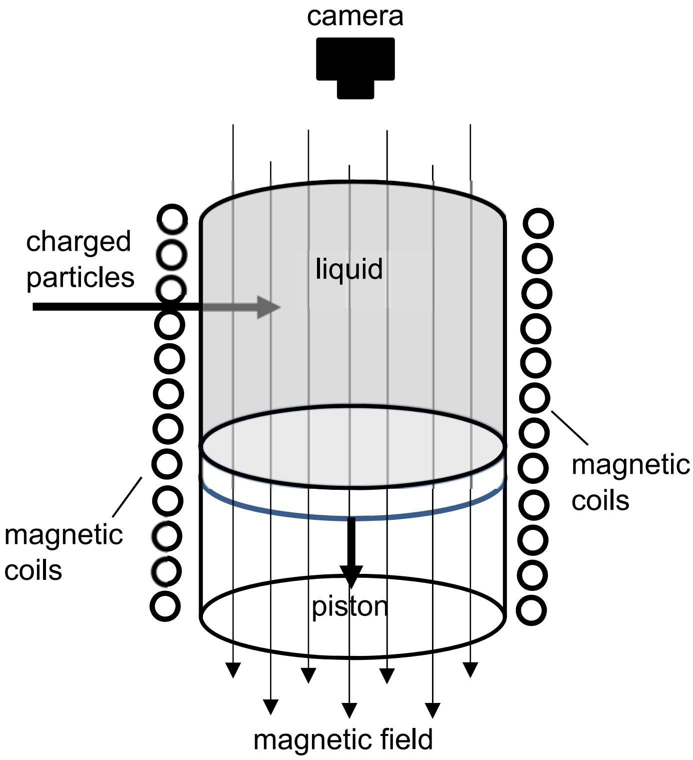


Fig. 8.1

As beams of charged particles pass through the liquid, they deposit energy by ionising the liquid atoms. This causes the liquid to boil and tiny gas bubbles are formed along the paths of the charged particles.

Some charged particles may also collide with an atomic nucleus of the liquid and form products which are charged too. These charged products will move on and ionise the liquid, causing more trails of bubbles to form.

The chamber is illuminated so that the tracks of the charged particles can be photographed. By analyzing the tracks, the charged particles can be identified and any complex events involving the particles can be studied.

In the presence of a magnetic field, the tracks of the charged particles will be curved. The degree of curvature depends on the mass, speed, and charge of each particle.

Neutral particles can be detected indirectly by applying various conservation laws to the events recorded in the bubble chamber or by observing their decay into pairs of oppositely charged particles.

Fig. 8.2 is a picture taken by the camera from a bubble chamber that is filled with liquid hydrogen. The lines show the path of the particles entering the chamber from one of the sides.

A parallel beam of K^- particles, each with an energy of 8.2 GeV and a charge of $-e$ enters from the bottom of Fig. 8.2.

The radius of any circular path made by a moving charged particle in the bubble chamber is proportional to the momentum and inversely proportional to the charge of the particle.

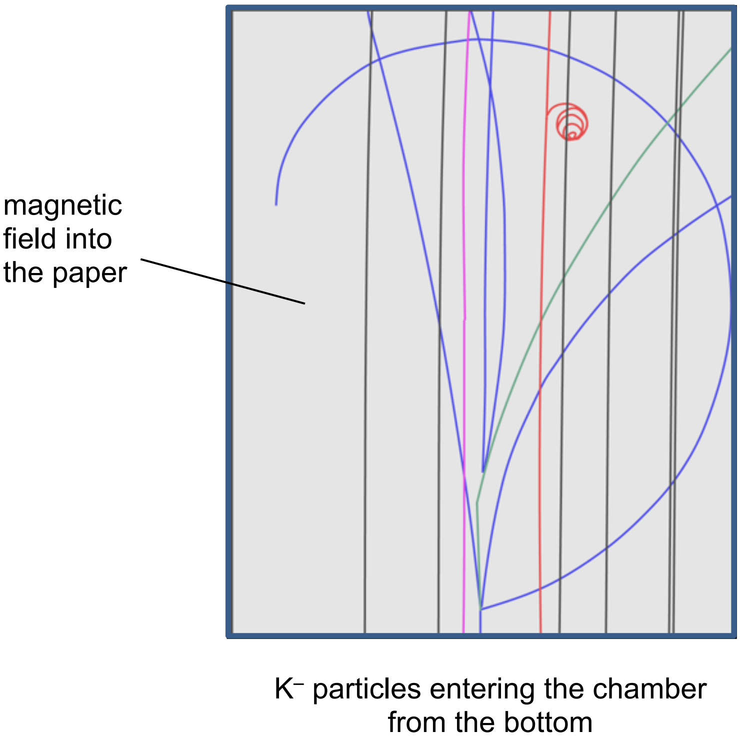


Fig. 8.2

(a) Fig. 8.3 shows the enlarged picture of the little curly track at the top right quadrant of Fig. 8.2.

It has been proposed that this track is produced by an electron which is knocked out of the hydrogen atom by a passing K^- particle.

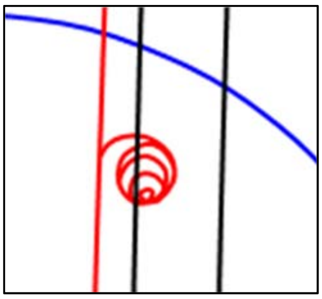


Fig. 8.3

(i) By comparing the curly path in Fig. 8.3 with paths made by other particles in Fig. 8.2, explain whether this proposal is possible.

....

....

.... [2]

(ii) Suggest why is this path a spiral.

....

....

.... [2]

(b) Fig. 8.4 shows a K^- particle colliding with the positively charged nucleus of a hydrogen atom at point A. The collision produced four charged particles as illustrated by the four outgoing tracks, numbered 1 to 4.

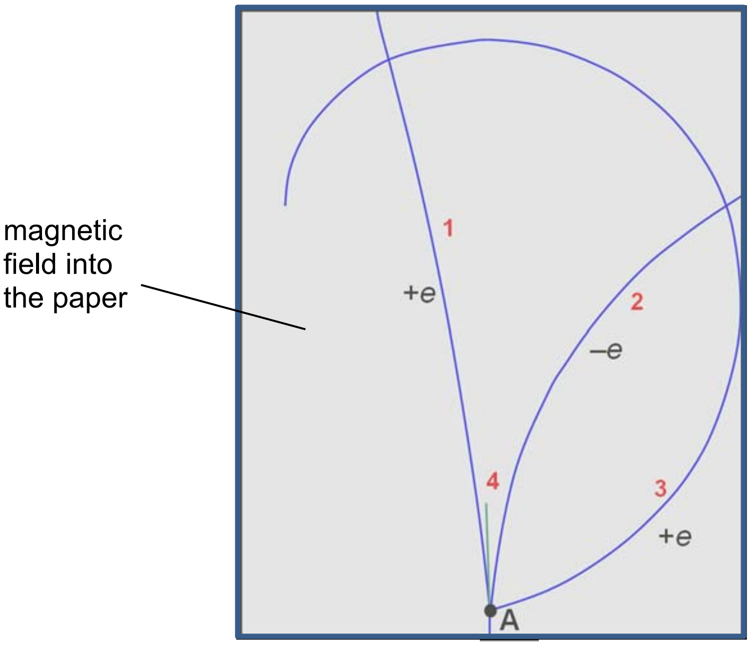


Fig. 8.4

The charges of three of the four outgoing particles after the collision are indicated beside their tracks.

Deduce the charge of the fourth outgoing particle. Justify your answer.

....

.... [2]

(c) The bubble chamber is used to study the collision between a K^- particle and a stationary proton p. The total energy E and momentum in three dimensions p_x, p_y, p_z of each particle produced in a collision is governed by the formula

$$E^2 = (p_x{}^2 + p_y{}^2 + p_z{}^2)c^2 + m^2c^4$$

where m is the mass of the particle and c is the speed of light.

In a particular collision, three additional particles Ω^-, Ω^+ and K^0 are formed and the data collected are shown in Fig. 8.5 below.

Before collision

particle	p_x / 10^{-20} N s	p_y / 10^{-20} N s	p_z / 10^{-20} N s	E / 10^{-12} J
K^-	438.05	-13.24	0.81	1317.12
p	0.00	0.00	0.00	150.13
sum				

After collision

particle	p_x / 10^{-20} N s	p_y / 10^{-20} N s	p_z / 10^{-20} N s	E / 10^{-12} J
K^-	79.03	1.48	11.95	252.50
Ω^-	7.98	-0.60	2.07	33.38
Ω^+	2.02	-6.52	-1.21	30.51
p	80.46	6.85	-3.76	285.22
K^0	189.10	-8.69	-13.07	574.78
sum				

Fig. 8.5

(i) Complete Fig. 8.5 to show

1. the sum of the momentum in all the dimensions for the particles before and after the collision, [1]

2. the sum of the energy for the particles before and after the collision. [1]

(ii) The sum of the total energies E before and after the collision are not equal, implying that more particles are formed but have gone undetected.

Assuming that there is only one undetected particle, determine

1. the components of its momentum p_x, p_y, p_z and its total energy E,

p_x = ...N s

p_y = ...N s

p_z = ...N s

E = ...J [2]

2. its mass *m*.

m = ...kg [2]

Section B

Answer **one** question from this section.

9 **(a)** **(i)** Define *linear momentum*.

....

.... [1]

(ii) State the relation between force and momentum.

....

.... [1]

(b) In a car factory, a collision test is carried out to test the safety features of a car. Fig. 9.1 shows a car colliding into a solid wall with a speed of 30 km h^{-1}. The dummy in the car jerks forward and collides with the steering wheel as it was not fastened with the seat-belt.

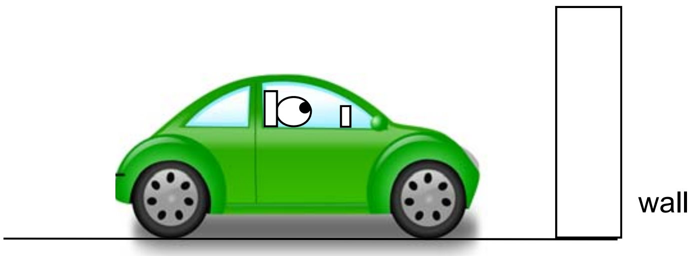


Fig. 9.1

(i) By considering the forces acting on the dummy, explain why the dummy jerks forward when the car stops upon hitting the wall.

....

....

....

.... [2]

(ii) The duration of impact between the dummy and the steering wheel is recorded to be 0.10 s. The mass of the car and dummy are 1250 kg and 80 kg respectively.

1. State the speed that the dummy is moving just before hitting the steering wheel.

.... [1]

2. Calculate the magnitude of the average force exerted on the dummy.

average force = ... N [2]

3. The collision test is repeated with a heavier dummy. Explain whether the extent of damage to this heavier dummy will be bigger.

....

....

.... [2]

(c) Fig. 9.2 shows a block A of mass 40 kg resting on a horizontal frictionless surface with a block B of mass 10 kg resting on top. The frictional force between the blocks is 40 N if B slides over A.

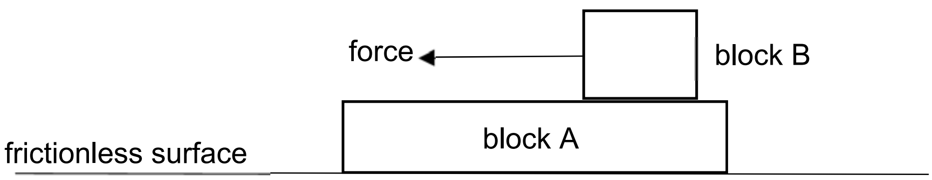


Fig. 9.2

(i) Block B is acted upon by a horizontal force of 100 N in the leftwards direction.

Calculate

1. the acceleration of block A,

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

direction of acceleration: .... [2]

2. the acceleration of block B.

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

direction of acceleration: .... [2]

(ii) The system of blocks A and B is placed on a rough surface and the maximum frictional force between block A and the rough surface is 80 N.

State and explain whether block A will slide when block B is acted upon by the same horizontal force of 100 N in the leftwards direction.

....

....

.... [2]

(d) (i) Define *moment* of a *force.*

....

.... [2]

(ii) Fig. 9.3 shows a uniform plank of length 14 m and mass 20 kg being supported at pivots A and B. Two boys X and Y, with masses 20 kg and 50 kg respectively, stand at A and B respectively.

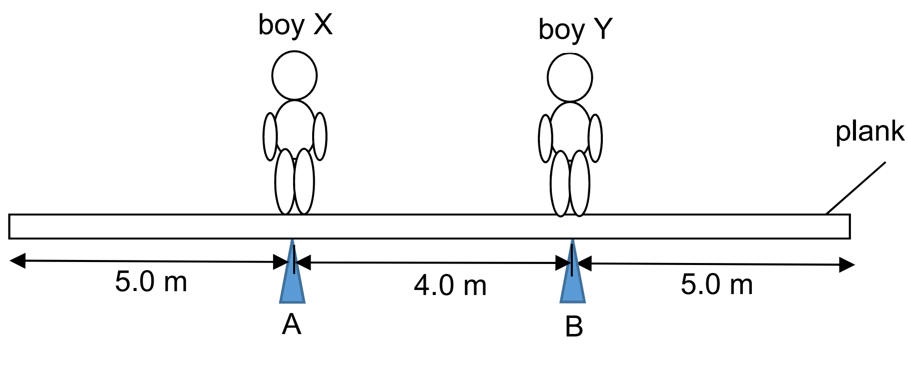


Fig. 9.3

At a particular instant, boy X starts to walk towards the left end of the plank and boy Y starts to walk towards the right end of the plank with the same speed of 1.0 m s^{-1}.

Calculate the time when the plank begins to overturn. Explain your working.

time = ... s [3]

10 (a) (i) State Newton's law of gravitation.

....

....

.... [2]

(ii) By relating the gravitational force on a planet to the centripetal acceleration it causes, show that, for a circular orbit,

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

[2]

(iii) Using the expression in **(ii)**, explain why geostationary satellites are all at the same height above the surface of the Earth.

....

....

.... [2]

(b) A satellite of mass 2400 kg is placed in a geostationary orbit at a distance of 4.23×10^7 m from the centre of the Earth.

Calculate

(i) the angular velocity of the satellite,

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

(ii) the speed of the satellite,

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

(iii) the acceleration of the satellite,

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

(iv) the force of attraction between the Earth and the satellite,

force = ... N [2]

(v) the mass of the Earth.

mass = ... kg [2]

(c) Explain why a geostationary satellite

(i) must be placed vertically above the equator,

....

....

.... [2]

(ii) must move from west to east.

....

....

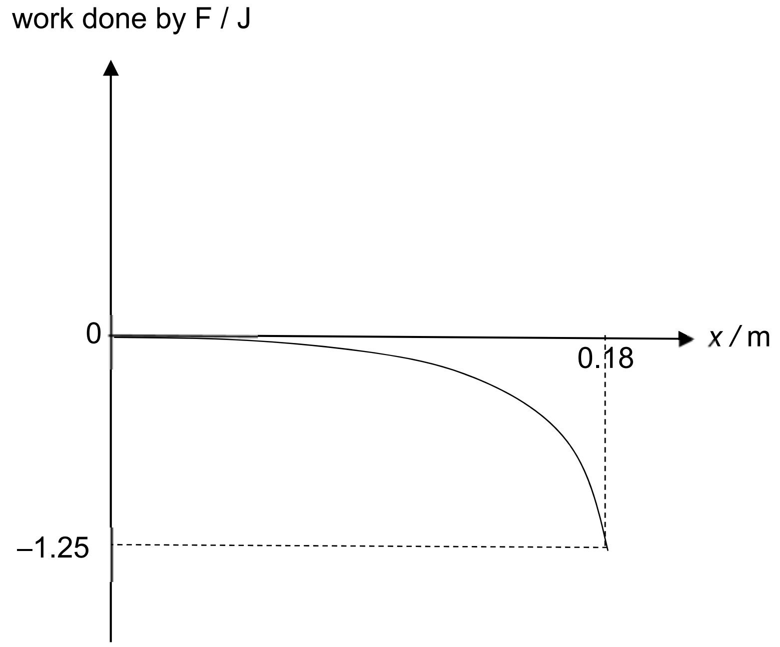
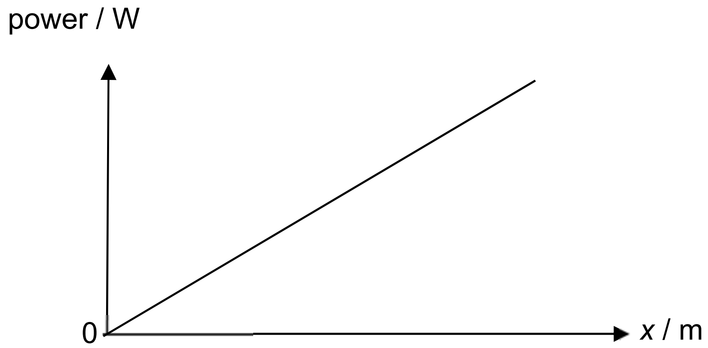
.... [2]

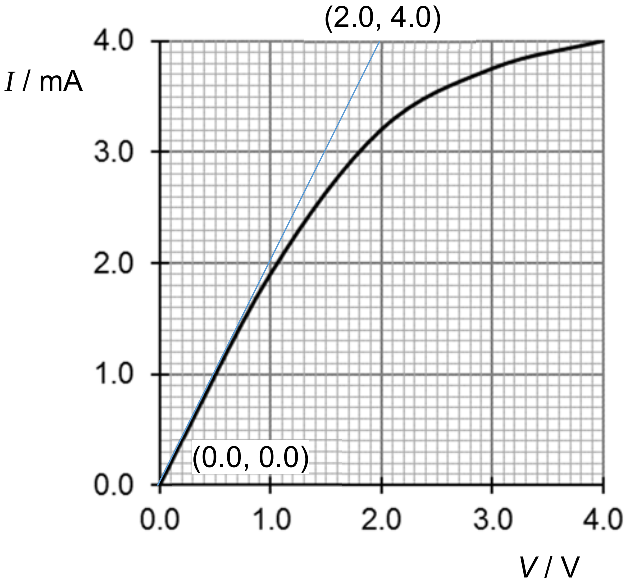
End of paper

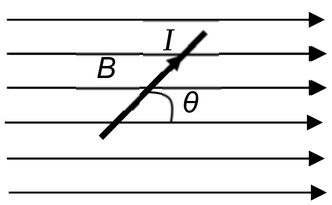
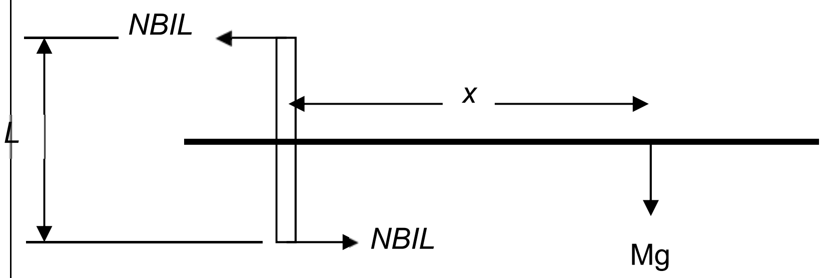
Answers to 2018 JC2 Preliminary Examination Paper 2 (H1 Physics)

Suggested Solutions:

No.	Solution	Remarks
1(a)	Accuracy is how close the experimental mean is to the true value. Precision is where the various experimental readings are found to be close to one another.	
1(b)(i)	Random error refers to the **error occurring in 2 directions where the experimental reading could be more or less than the true value.** It can be reduced by **taking average of all experimental readings**	
1(b)(ii)	Using $H = \frac{1}{2}gt^2$ Making g the subject, $g = \frac{2H}{t^2}$ $\frac{\Delta g}{g} = \frac{\Delta H}{H} + 2\frac{\Delta t}{t}$ Percentage uncertainty in g = $\frac{\Delta g}{g} \times 100 = 3\% + (2(\frac{0.01}{0.50}) \times 100) = 7\%$	
2(a)	Considering horizontal motion, s_x = 36 m, u_x = 20 cos 53°. Using '$s_x = u_x t$' $t = \frac{36}{20\cos 53^o} = 2.99$ s Considering vertical motion, u_y = 20 sin 53o Using '$s_y = u_y t + \frac{1}{2}a_y t^2$' $s_y = 20 \sin 53°(2.99) + (-9.81)(2.99)^2$ $= 3.89$ m As the crossbar is 3.0 m high, the ball will clear it above it.	
2(b)	For vertical motion, Using '$v_y = u_y + a_y t$', $v_y = 20 \sin 53° + (-9.81)(2.99)$ $= -13.4 \text{ m } s^{-1}$ As the vertical velocity is negative, the ball is still falling.	

No.	Solution	Remarks
3(a)	The work done by a force on an object particle is defined as the product of the magnitude of the force and the component of the displacement in the direction of the force.	
3(b)(i)	Change in KE = Net work done $0-\frac{1}{2}mu^2=-\frac{1}{2}F_{max}x$ $(0.400)(2.5)^2=(14)x$ $x=0.18\text{ m}$	
3(b)(ii)		
3(b)(iii)		
4(a)	The gradient of the line joining the origin and each point of the curve decreases with increasing potential difference. Since the gradient represents the inverse of the resistance of the filament lamp, the resistance increases.	

4(b)	 The minimum resistance can be determined by drawing the tangent of the graph at the origin. $\text{gradient} = \frac{(4.0-0.0)\times10^{-3}}{2.0-0.0} = 2.0\times10^{-3}$ Hence, $\text{resistance} = \frac{1}{2.0\times10^{-3}} = 500\ \Omega$	
4(c)	resistance of wire $R = \frac{4.0}{4.0\times10^{-3}} = 1000\ \Omega$ resistivity $\rho = \frac{RA}{L}$ $= \frac{(1000)\left(\frac{\pi}{4}\times(0.046\times10^{-3})^2\right)}{2.0}$ $= 8.3\times10^{-7}\ \Omega\text{ m}$	
5(a)	p.d. across R = 1.3 V Let R_R be the resistance across R. Using potential divider rule, $\frac{R_R}{0.75+R_R+5.5}\times4.0 = 1.3$ $R_R = 3.0\ \Omega$ Hence, $\text{p.d. across AB} = \frac{5.5}{0.75+3.0+5.5}\times4.0$ $= 2.38$ $= 2.4\text{ V (2 s.f.)}$	

5(b)(i)	resistance of wire BC $= \dfrac{1.5 - 0.56}{1.5} \times 5.5\ \Omega$ $= 3.45\ \Omega$ effective resistance across AB $= (5.5 - 3.45) + \dfrac{1.0 \times 3.45}{1.0 + 3.45}$ $= 2.8\ \Omega$	
5(b)(ii)	As C is shifted closer to A, the effective resistance across AB becomes smaller. This decreases the total resistance across the circuit. Thus the current in the circuit increases (OR by potential divider rule), increasing the potential difference across R and the voltmeter reading.	
6(a)(i)	$B = \dfrac{F}{IL\sin\theta}$	
6(a)(ii)	 Direction of force: into plane of paper.	
6(b)(i)	From $B = \dfrac{F}{BIL\sin\theta}$ where θ = 90° Force on opposite sides of the coil perpendicular to the field, *F = BIL x N*  Taking moments about the axis of rotation Sum of clockwise moment = sum of anti-clockwise moment 2 (*NBIL x L/*2) = Mg *x* $B = \dfrac{Mgx}{IL^2N}$	
6(b)(ii)	- with sides of *L*/2, length of wire making the coil is halved, - resistance is halved, so current is doubled (since emf is constant) - L^2 is now ¼ of its original value, so x is halved.	
7(a)	The half-life $t_{\frac{1}{2}}$ of a radioactive nuclide is the <u>average time taken for the active nuclide to disintegrate to half its initial value.</u>	

<table>
<tr><td>7(b)(i)</td><td>$^{208}_{82}Pb + ^{86}_{36}Kr \rightarrow ^{293}_{118}X + ^{1}_{0}n$</td><td></td></tr>
<tr><td>7(b)(ii)</td><td>The superheavy nucleus is expected to have low binding energy per nucleon and is thus unstable.</td><td></td></tr>
<tr><td>7(b)(iii)</td><td>After 6 α-decay, the nucleus is $^{269}_{106}Y$.
The nucleus has 106 protons and 163 neutrons.</td><td></td></tr>
<tr><td>7(c)</td><td>After t = 15 s, amount undecayed is $(1-0.82)N_0 = 0.18N_0$.
If n is the number of half-life,
$0.18N_0 = \left(\frac{1}{2}\right)^n N_0 \Rightarrow n = 2.47$
therefore $2.47t_{\frac{1}{2}} = 15\text{ s} \Rightarrow t_{\frac{1}{2}} = 6.1\text{ s}$</td><td></td></tr>
<tr><td>8(a)(i)</td><td>$r \alpha \frac{p}{q}$
Compared to other tracks, the radius of the track in Fig. 8.3 is the smallest. The mass of electron is small. Its momentum and the radius will be small.

Hence the proposal is possible.</td><td></td></tr>
<tr><td>8(a)(ii)</td><td>The electron loses energy as it travels through the chamber.
Its momentum and hence its radius decreases, resulting in a spiral.</td><td></td></tr>
<tr><td>8(b)</td><td>Conservation of charge gives
(Charge of K–) + (proton charge) = Total charge after collision
(-e) + (+e) = (+e) + (–e) + (+e) + q4
$\Rightarrow$ q4 = –e</td><td></td></tr>
<tr><td>8(c)(i)</td><td>
<table>
<tr><th>particle</th><th>p_x / 10^{-20} N s</th><th>p_y / 10^{-20} N s</th><th>p_z / 10^{-20} N s</th><th>E / 10^{-12} J</th></tr>
<tr><td>K^-</td><td>438.05</td><td>-13.24</td><td>0.81</td><td>1317.12</td></tr>
<tr><td>p</td><td>0.00</td><td>0.00</td><td>0.00</td><td>150.13</td></tr>
<tr><td>sum</td><td>438.05</td><td>-13.24</td><td>0.81</td><td>1467.25</td></tr>
</table>
<table>
<tr><th>particle</th><th>p_x / 10^{-20} N s</th><th>p_y / 10^{-20} N s</th><th>p_z / 10^{-20} N s</th><th>E / 10^{-12} J</th></tr>
<tr><td>K^-</td><td>79.03</td><td>1.48</td><td>11.95</td><td>252.50</td></tr>
<tr><td>Ω^-</td><td>7.98</td><td>-0.60</td><td>2.07</td><td>33.38</td></tr>
<tr><td>Ω^+</td><td>2.02</td><td>-6.52</td><td>-1.21</td><td>30.51</td></tr>
<tr><td>P</td><td>80.46</td><td>6.85</td><td>-3.76</td><td>285.22</td></tr>
<tr><td>K^0</td><td>189.10</td><td>-8.69</td><td>-13.07</td><td>574.78</td></tr>
<tr><td>sum</td><td>358.59</td><td>-7.48</td><td>-4.02</td><td>1176.39</td></tr>
</table>
</td><td></td></tr>
<tr><td>8(c)(ii)1</td><td>p_x = (438.05 - 358.59) x 10^{-20} = +79.46 x 10^{-20} N s

p_y = (-13.24 + 7.48) x 10^{-20} = -5.76 x 10^{-20} N s

p_z = (0.81 + 4.02) x 10^{-20} = +4.83 x 10^{-20} N s</td><td></td></tr>
</table>

	E = (1467.25 - 1176.36) x 10^{-12} = 290.86 x 10^{-12} J	
8(c)(ii)2	$m=\sqrt{\dfrac{E^2-(p_x{}^2+p_y{}^2+p_z{}^2)c^2}{c^4}}$ $=\sqrt{\dfrac{(290.87\times10^{-12})^2-((79.46\times10^{-20})^2+(5.77\times10^{-20})^2+(4.83\times10^{-20})^2)c^2}{c^4}}$ = 1.835 x 10-27 kg	
9(a)(i)	The linear momentum *p* of a body is the product of its mass *m* and instantaneous linear velocity *v*.	
9(a)(ii)	The rate of change of momentum of a body is proportional to the net force that acts on it and has the same direction as the net force.	
9(b)(i)	When car is moving at 30 km h^{-1}, the dummy will travel with the same velocity. When car hits the wall, there is a large decelerating force to slow the car down due to contact with the wall. The dummy, without the presence of any decelerating force, will continue its motion forward.	
9(b)(ii)1.	30 km h^{-1}	
9(b)(ii)2.	$\langle F\rangle=\dfrac{\Delta p}{\Delta t}$ $=\dfrac{80\left(\dfrac{30000}{3600}-0\right)}{0.10}$ $\langle F\rangle=6700$ N	
9(b)(ii)3.	The rate of change of momentum is proportional to the mass of the dummy if the time of collision and the speed of car remains unchanged. Thus, a larger mass will result in a larger average force acting on dummy and a larger extent of damage.	
9(c)(i)1.	Using $F = ma$ $40=40a$ $a=1.0$ m s^{-2} Leftwards	
9(c)(i)2.	Using $F = ma$ $100-40=10a$ $a=6.0$ m s^{-2} Leftwards	
9(c)(ii)	The maximum friction force acted on A by surface of 80 N in the rightward direction exceed the friction force of 40 N acted by B on A towards the left.	

	Thus when A starts sliding on B, the friction force by surface on A has not reached its maximum value yet. Block A will not slide.	
9(d)(i)	The moment of a force about a pivot is the product of the force and the perpendicular distance from the pivot to the line of action of the force.	
9(d)(ii)	Since boy Y is heavier than boy X, the plank will tend to rotate clockwise. When the plank rotate clockwise, the normal contact force at A will be zero first. Taking moment about B, Clockwise moments = anticlockwise moments $50g(x)=20g(2.0)+20g(4.0+x)$ $x = 4.0$ m $t=\frac{4.0}{1.0}=4.0$ s	
Qn	Solution	
10(a)(i)	Newton's law of gravitation states that the force of attraction between two point masses is directly proportional to the product of the masses and inversely proportional to the square of the distance between them.	
10(a)(ii)	Gravitational force on orbiting mass provides centripetal force $\frac{GMm}{r^2}=mr\omega^2$ $GM=r^3\left(\frac{4\pi^2}{T^2}\right)$ $T^2=\frac{4\pi^2r^3}{GM}$	
10(a)(iii)	All geostationary satellites have period of 24 hrs. Since they are orbiting about the same mass (Earth), they must have the same orbital radius and hence are at the same height above surface of the Earth.	
10(b)(i)	$\omega=\frac{2\pi}{T}=\frac{2\pi}{24\times60\times60}$ $=7.27\times10^{-5}$ rad s^{-1}	
10(b)(ii)	$v=r\omega=(4.23\times10^{7})(7.27\times10^{-5})$ $=3.08\times10^{3}$ m s^{-1}	
10(b)(iii)	$a=r\omega^2=(4.23\times10^{7})(7.27\times10^{-5})^2$ $=0.224$ m s^{-2}	
10(b)(iv)	$F=ma=(2400)(0.224)$ $=537$ N	

10(b)(v)	$F = \dfrac{GM_1M_2}{r^2}$ $537 = \dfrac{\left(6.67\times10^{-11}\right)\left(2400\right)M_E}{\left(4.23\times10^{7}\right)^2}$ $M_E = 6.0\times10^{24}$ kg	
10(c)(i)	The orbital plane of the satellite must contain the gravitational force which acts towards the centre of the Earth. For the satellite to be always above the same point on Earth's surface, its orbital plane must coincide with the equatorial plane.	
10(c)(ii)	The Earth rotates in a west to east direction hence for the satellite to be always above the same point on the surface of the Earth, it must also move from west to east.	