EUNOIA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION 2021
General Certificate of Education Advanced Level
Higher 1

CANDIDATE NAME

| CIVICS GROUP | 2 | 0 | - | | | REGISTRATION NUMBER | | |
|---|---|---|---|---|---|---|---|---|

# PHYSICS

**8867/02**

Paper 2 Structured Questions

**15 September 2021**

**2 hours**

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

**READ THESE INSTRUCTIONS FIRST**

| **For Examiner's Use** | | |
|---|---|---|
| **Section A** | | |
| **1** | | **9** |
| **2** | | **9** |
| **3** | | **5** |
| **4** | | **7** |
| **5** | | **8** |
| **6** | | **12** |
| **7** | | **10** |
| **Section B** | | |
| **8** | **9** | **20** |
| **S.F.** | | |
| **C.F.** | | |
| **Total** | | **80** |

Write your name, civics group and registration number on all the work you hand in.

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

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

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

**Section B**
Answer **one** question only.

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.

This document consists of **24** printed pages and **0** blank page.

**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$^{-2}$ |

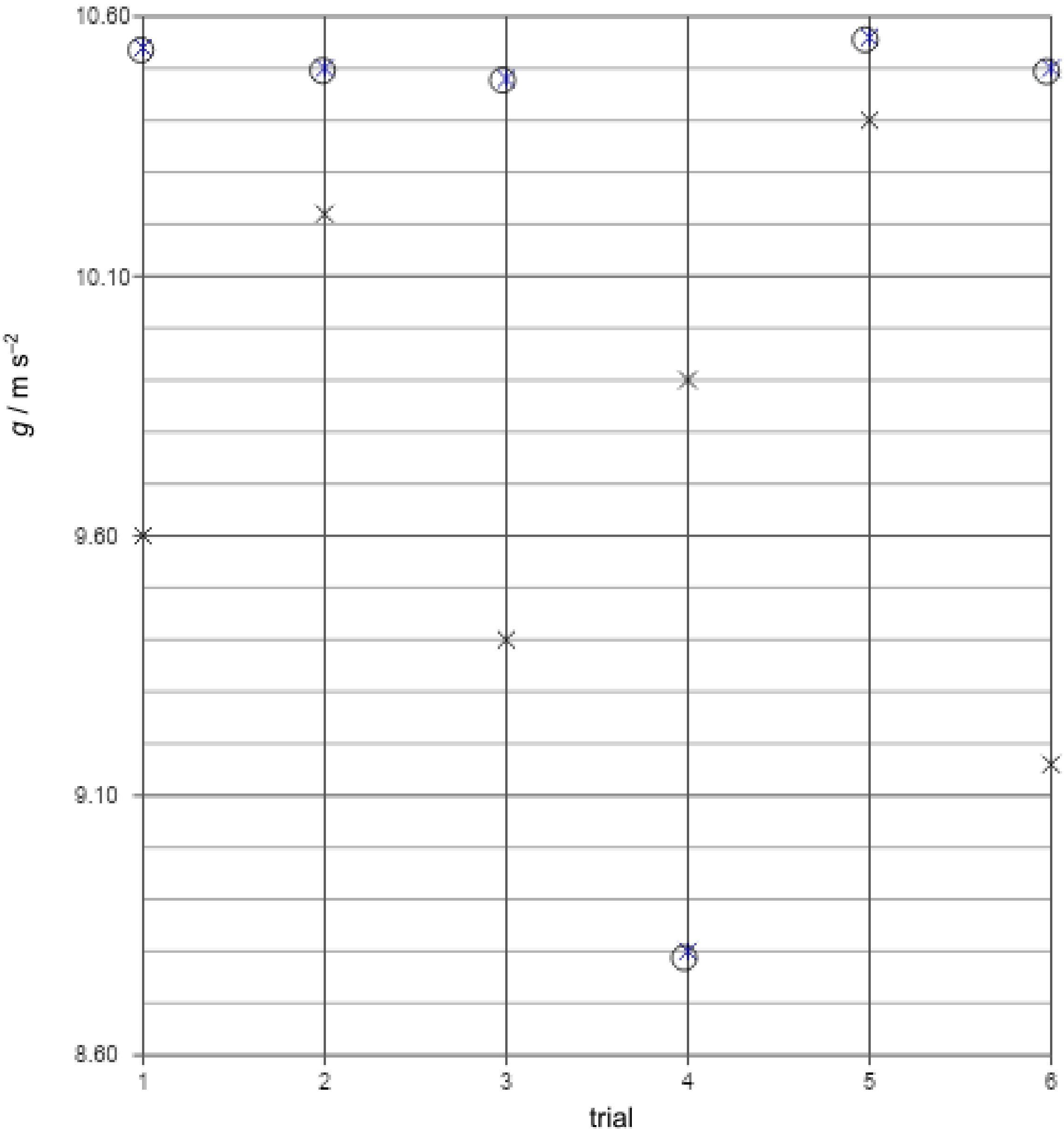
**Formulae**

| | | | |
|---|---|---|---|
| uniformly accelerated motion, | $s$ | = | $ut + ½at^2$ |
| | $v^2$ | = | $u^2 + 2as$ |
| resistors in series, | $R$ | = | $R_1 + R_2 + \ldots$ |
| resistors in parallel, | $1/R$ | = | $1/R_1 + 1/R_2 + \ldots$ |

## Section A

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

**1 (a)** Two groups of students performed similar experiments to measure the acceleration due to gravity $g$. Their results are shown in Fig. 1.1.




○

Group 1 results
Group 2 results

**Fig. 1.1**

The accepted value for $g$ is 9.81 m $s^{-2}$.

Use Fig. 1.1 to answer the following questions. You should make calculations with clear working in support of your answer.

State and explain which group of results has

**(i)** larger *systematic* errors,

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

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

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

**(ii)** larger *random* errors.

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

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

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

**(b)** A simple pendulum is used to determine the acceleration of free fall $g$. The period $T$ and the length $L$ of the pendulum are determined. The readings taken are

length of pendulum $L$ = (1.682 ± 0.005) m

time for 80 full swings of the pendulum = (207.5 ± 0.5) s.

The period $T$ is given by

$$T = 2\pi\sqrt{\frac{L}{g}}$$

Calculate $g$ and the uncertainty in its value.

Show how your answers were obtained.

g = ………………… ± …………….. m s$^{-2}$ [5]

[Total: 9]

**2** **(a)** State Newton's second law of motion.

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

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

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

**(b)** A soccer ball of mass 0.20 kg is kicked from point A of a sloping ground as shown in Fig. 2.1.

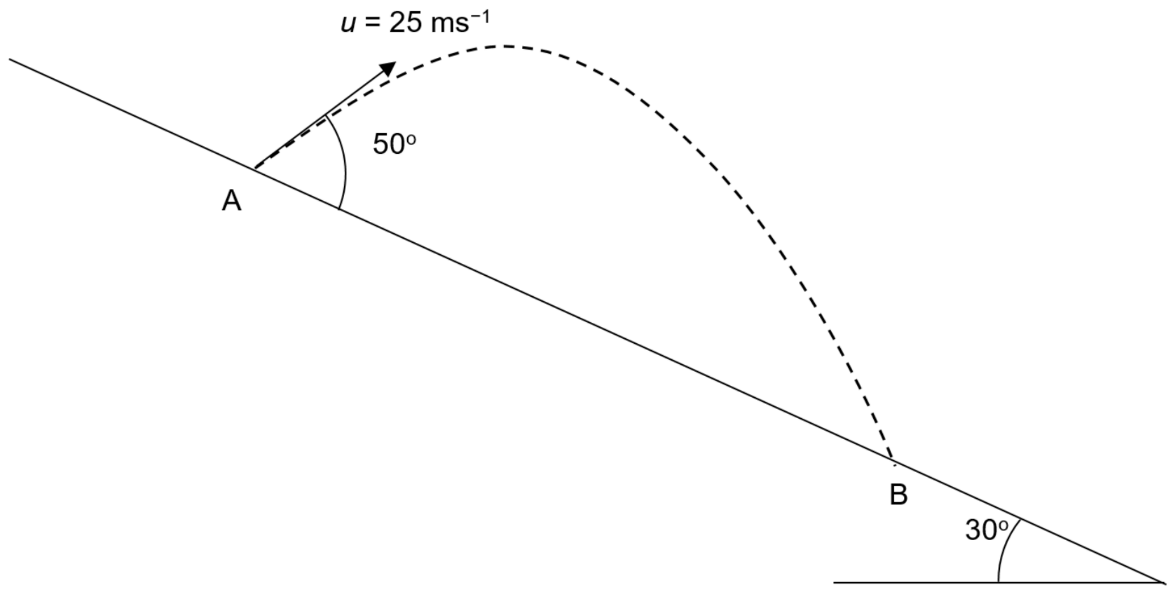



**Fig. 2.1**

**(i)** Calculate the time of travel between A and B.

time = …………………. s [3]

**(ii)** Fig. 2.2 shows the motion of the ball before and after the impact at B.

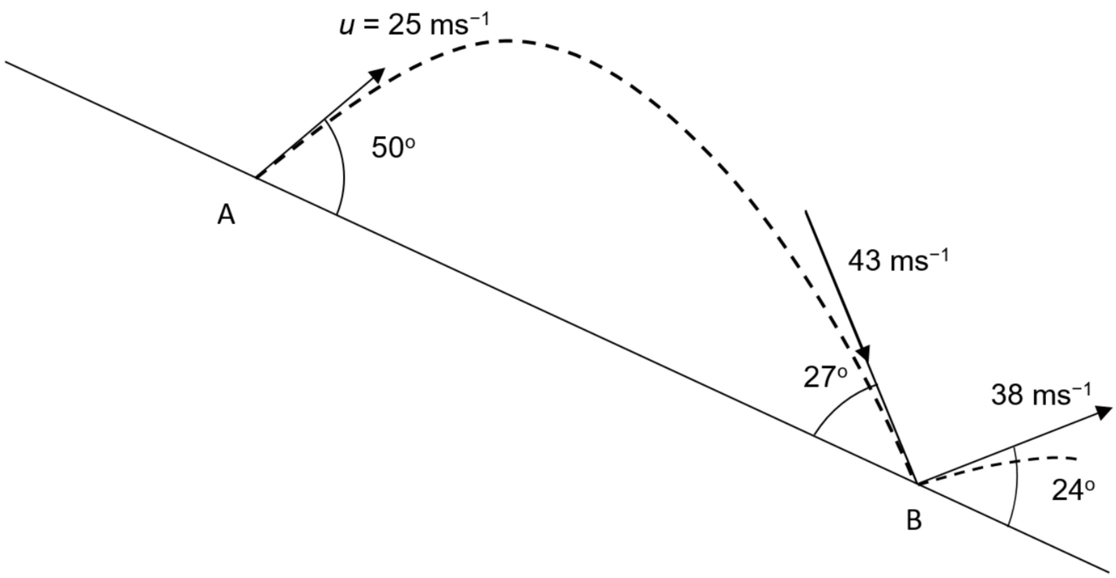



**Fig. 2.2**

Calculate the change in velocity of the ball at B due to the impact.

change in velocity = ……………………. m s$^{-1}$ [3]

**(iii)** Calculate the average resultant force of the ball at B, given the duration of impact is 0.050 s.

average resultant force = ……………………………… N [1]

[Total: 9]

**3** Fig 3.1 shows a man pushing a wheelbarrow with a total weight of 100 N. At the instant shown, the wheelbarrow is stationary. The dimensions of the wheelbarrow, the contact force $R$ exerted by the ground on the wheelbarrow, and the combined weight $W$ of the wheelbarrow and the load it carries are shown in Fig. 3.2. The force $H$ exerted by the person on the wheelbarrow is not given in the diagram.

$W$
$R$
0.50 m
0.90 m

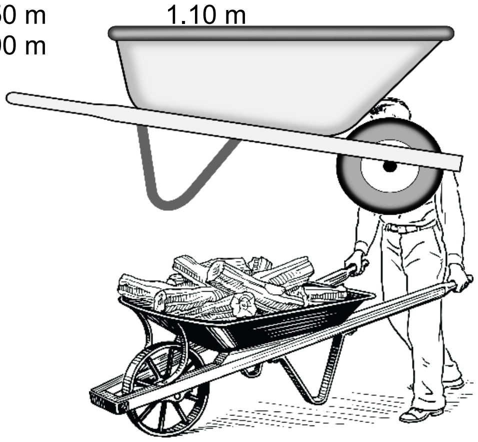



**Fig. 3.1** **Fig. 3.2**

**(a)** Given that the force $R$ exerted by the ground on the wheelbarrow acts 73° above the horizontal, determine the magnitude of $R$.

$R$ = ………………………………….. N [2]

**(b)** Hence, determine the magnitude and direction of $H$.

magnitude of $H$ = ……………………………………….. N

direction of $H$ = …………………………………………….. [3]

[Total: 5]

**4** **(a)** A force $F$ is acting on a body of mass $m$ that causes it to move with a velocity $v$. Given that the body started from rest, show that the kinetic energy $E_k$ of the body is given by

$$E_k = \frac{1}{2}mv^2$$

[3]

**(b)** Fig. 4.1 below shows a semi-circular path which has a radius of 2.0 m centred at **O.** A point object of mass 3.0 kg is released from rest at **P**. The path exerts a constant frictional force on the object and it reaches point **Q** where it comes to rest momentarily. The angular displacement between **P** and **Q** with respect to **O** is 145°.

**P**
**Q**
**O**
145°

**Fig. 4.1**

**(i)** Calculate the frictional force exerted by the track on the object.

frictional force =..........................................N [2]

**(ii)** Calculate the kinetic energy of the object at the lowest point on the track.

kinetic energy =..........................................J [2]

[Total: 7]

**5** **(a)** A light helical spring is suspended vertically from a fixed point, as shown in Fig. 5.1.

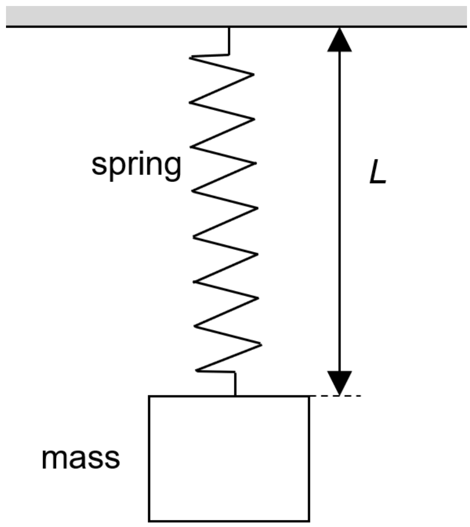



**Fig. 5.1**

Different masses are suspended from the spring. The weight W of the mass and the length L of the spring are recorded. The variation with weight W of the length L is shown in Fig. 5.2.

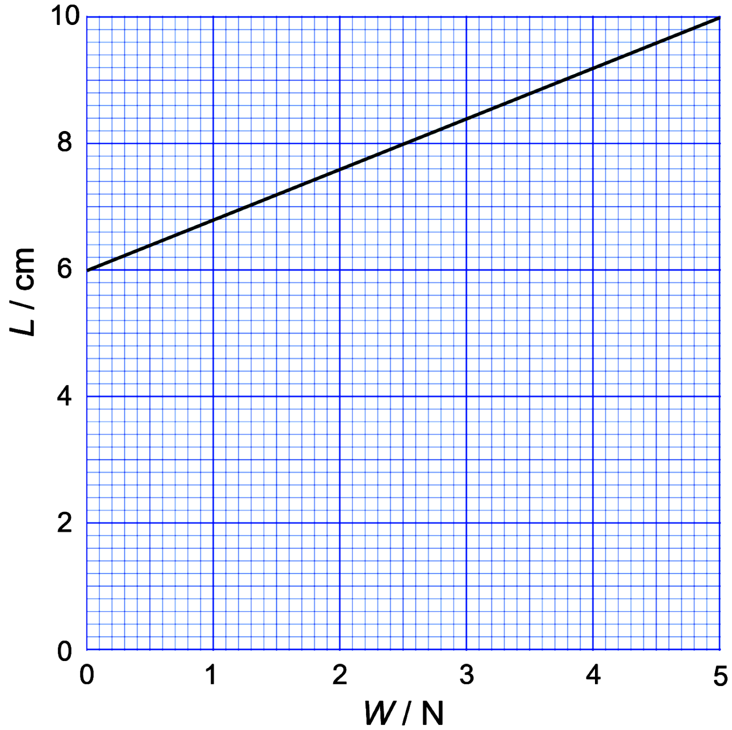



**Fig. 5.2**

**(i)** On Fig. 5.2, show clearly the area of the graph that represents energy stored in the spring when the weight on the spring is increased from zero to 5.0 N. [1]

**(ii)** For a spring undergoing an elastic change, the force per unit extension of the spring is known as constant *k*.

Show that the energy *E* stored in the spring for an extension x of the spring is given by the expression

$$E = ½ k x^2$$

[2]

**(b)** A mass of weight 4.0 N is suspended from the spring in **(a)**.

When the mass is stationary, it is then pulled downwards a distance of 0.80 cm and held stationary.

**(i)** Determine the total length of the spring.

length = ……………. cm [1]

**(ii)** For the increase in extension of 0.80 cm, determine the magnitude of the change in

**1.** the gravitational potential energy of the mass,

change in gravitational potential energy = ……………..…. J [1]

**2.** The elastic potential energy of the spring.

change in the elastic potential energy = ……………..…. J [2]

**(iii)** Use your answer in **(ii)** to calculate the work done to cause the additional extension of 0.80 cm.

work done = …………….. J [1]

[Total: 8]

**6** Fig. 6.1 shows the current-voltage ($I$-$V$) characteristics of two resistors R and X.

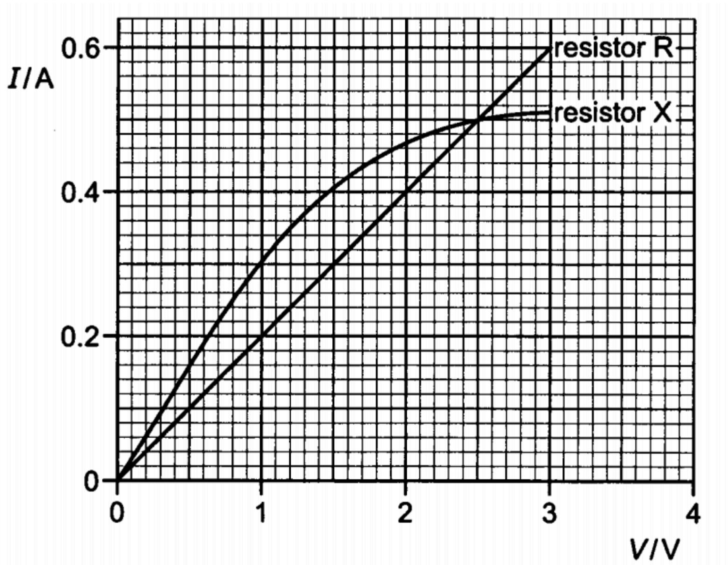



**Fig. 6.1**

The two resistors are connected in series with a cell of negligible internal resistance as shown in Fig. 6.2. The *e.m.f.* of the cell is 2.5 V.

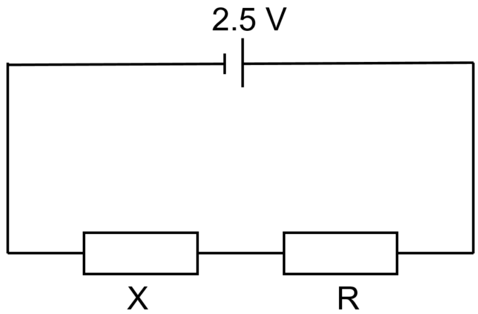



**Fig. 6.2**

**(a)** What is meant by the term *e.m.f.* of a cell?

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

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

**(b)** Describe and explain how the resistance of resistor X varies with increasing potential difference with reference to the motion of the electrons.

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

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

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

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

**(c)** **(i)** Using Fig. 6.1, determine the current passing through resistor X.

current = ………………………. A [3]

**(ii)** State the resistance of X and R.

resistance of X = …………………….. Ω

resistance of R = ……………………..Ω [2]

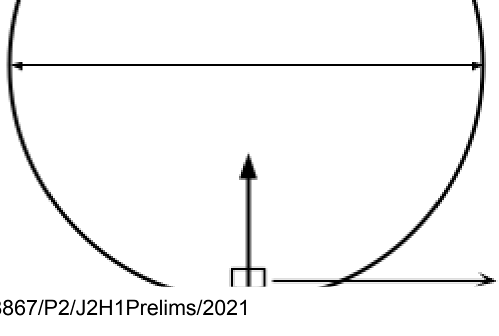
**(d)** Sketch the resistance-temperature characteristics of a thermistor in the space provided below.

[2]

[Total: 12]

**7** A roller coaster carriage of mass *m* enters a circular loop-the-loop at point A with speed $v_A$, reaches the top of the loop at B with speed $v_B$ and exits the loop with the same speed $v_A$ as shown in Fig. 7.1.

The radius of the loop is *R*. The magnitudes of the normal contact forces acting on the carriage at A and B are $N_A$ and $N_B$ respectively.



A
$v_A$
$v_B$
B
$2R$
$N_A$
$N_B$

**Fig. 7.1**

The track is smooth and there is no other resistive force present.

**(a)** **(i)** Express the loss in kinetic energy of the carriage as it moves from A to B, in terms of *m*, *g* and *R*.

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

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

**(ii)** Using your answer in **(i)**, show that

$$N_A - N_B = 6mg$$

[3]

**(b)** A rider may feel that he is heavier or lighter during a roller coaster ride depending on the normal contact force *N* from the seat that is acting on him. A quantity known as the *g*-force compares *N* with his weight as follows:

$$g\text{-force } = \frac{N}{\text{weight}}.$$

A *g*-force of 2.0 means that the rider feels twice as heavy as his normal weight.

As the carriage moves through the loop, the *g*-force varies with the angle $\theta$ with the vertical as shown in Fig. 7.2, according to the relation

$$g\text{-force } = \frac{v_A^{\ 2}}{gR} + 3\cos\theta - 2$$

A
$v_A$
$\theta$
$N_A$
$N$
$R$
$v$

**Fig. 7.2**

**(i)** In order for the carriage to just reach the top of the loop ($\theta$ = 180°), the $g$-force at A ($\theta$ = 0°) would have to be 6.0, as shown in Fig. 7.3. The contact force at the top of the loop is then zero, and the rider would feel 'weightless'.

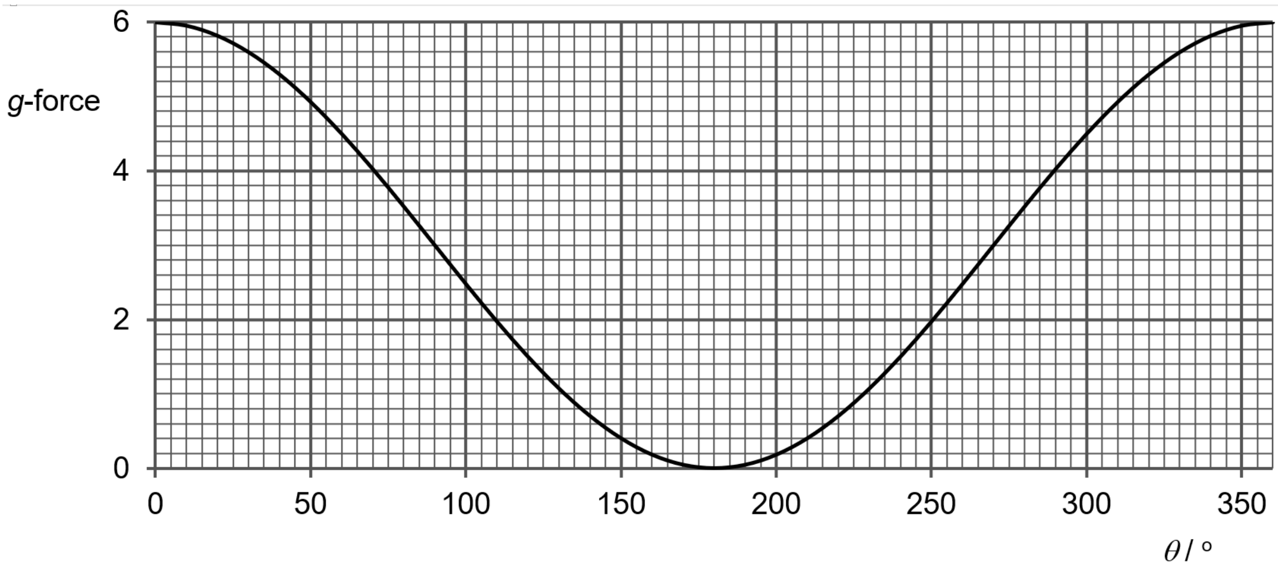



**Fig. 7.3**

**1.** Use information from Fig. 7.3 or otherwise to complete Fig. 7.4.
$a_c$ refers to the centripetal acceleration.

[2]

| $\theta$ / ° | $\dfrac{a_c}{g}$ |
|---|---|
| 0 | ………………………… |
| 90 | ………………………… |
| 180 | 1.0 |

**Fig. 7.4**

**2.** Show that the speed of the carriage at A is equal to $\sqrt{5gR}$ .

[1]

**(ii)** If the carriage enters the loop with a speed slower than $\sqrt{5gR}$ such that the *g*-force at A is 5.0, the carriage would lose contact with the track before it reaches the top of the loop.

Use Fig. 7.3 to deduce a value for $\theta$ at which the carriage first loses contact with the track.

$\theta$ = ………………………. ° [1]

**(c)** A major disadvantage of circular loop-the-loop is that the circular track generates intense *g*-force, which makes it very uncomfortable if not dangerous for riders. A modern loop-the-loop is carefully designed with non-constant radius to overcome such limitations.

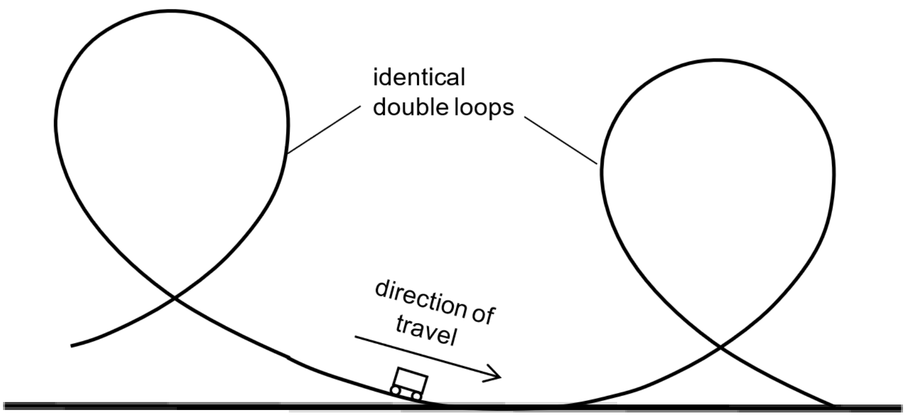



**Fig. 7.5**

**(i)** Fig. 7.5 shows two identical loop-the-loops one after another at the Carolina Cyclone roller coaster located at Carowinds in North Carolina.

State and explain one advantage of the non-circular loop in Fig. 7.5 over the circular loop in **(a)** and **(b)**.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

**(ii)** Explain why the second loop in Fig. 7.5 is lower in height than the first loop.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

[Total: 10]

## Section B

Answer **one** question from this section.

**8 (a)** Fig. 8.1 shows a mass initially travelling at right angles to the Earth's uniform gravitational field.

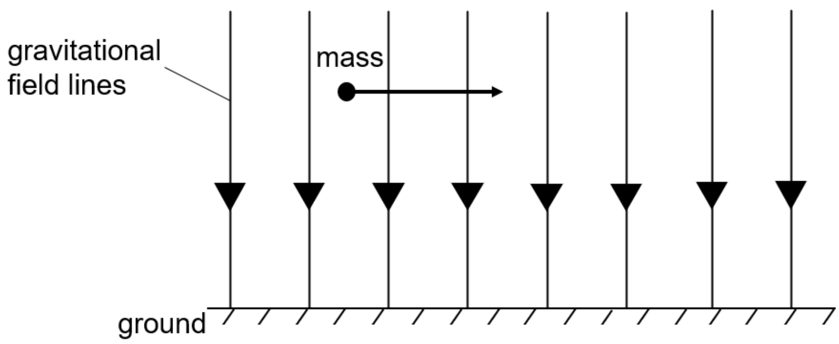



**Fig. 8.1**

**(i)** State the direction of the gravitational force experienced by the mass.

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

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

**(ii)** Describe the subsequent motion of the mass.

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

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

**(b)** Fig. 8.2 shows an electron initially travelling parallel to a uniform electric field.

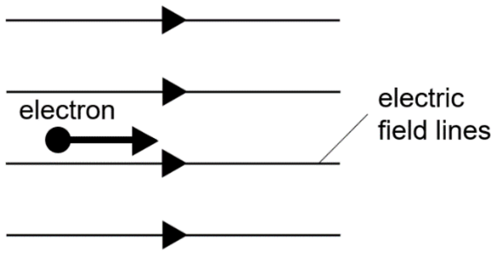



**Fig. 8.2**

**(i)** State the direction of the electric force experience by the electron.

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

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

**(ii)** Describe the subsequent motion of the electron.

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

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

**(c)** Fig. 8.3 shows a long molecule placed in a uniform electric field.

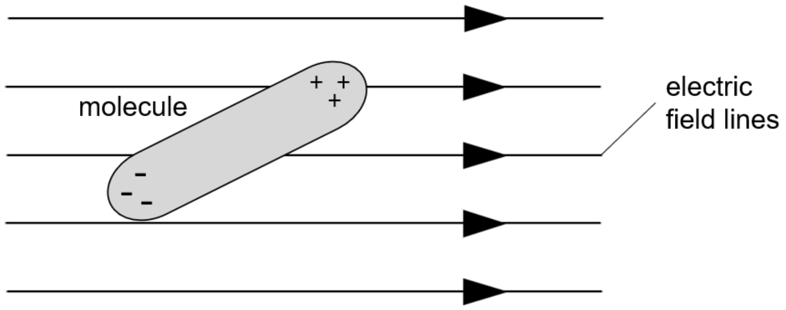



**Fig. 8.3**

The ends of the molecules have equal but opposite charges. Describe the initial motion of the molecules in the electric field.

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

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

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

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

**(d)** **(i)** Define magnetic flux density.

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

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

**(ii)** Sketch on Fig. 8.4 the magnetic flux pattern around a long straight wire carrying a current upwards towards the paper.

[2]

**(iii)** Use your diagram from Fig. 8.4 to deduce and sketch, on Fig. 8.5, the magnetic flux pattern around two long straight wires carrying equal currents upwards through the paper.

[2]

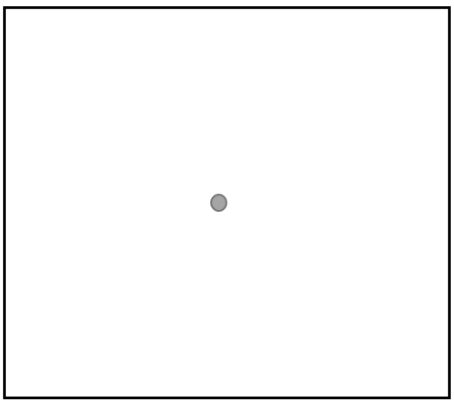


**Fig. 8.4**

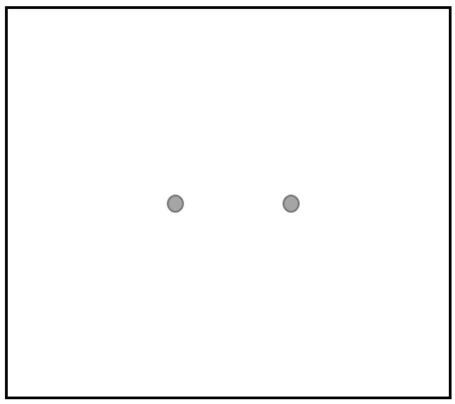


**Fig. 8.5**

**(e)** A large horseshoe magnet produces a uniform magnetic field of flux density B between its poles. Outside the region of the poles, the flux density is zero. The magnet is placed on a top-pan balance and the wire XY is situated between its poles, as shown in Fig. 8.6.

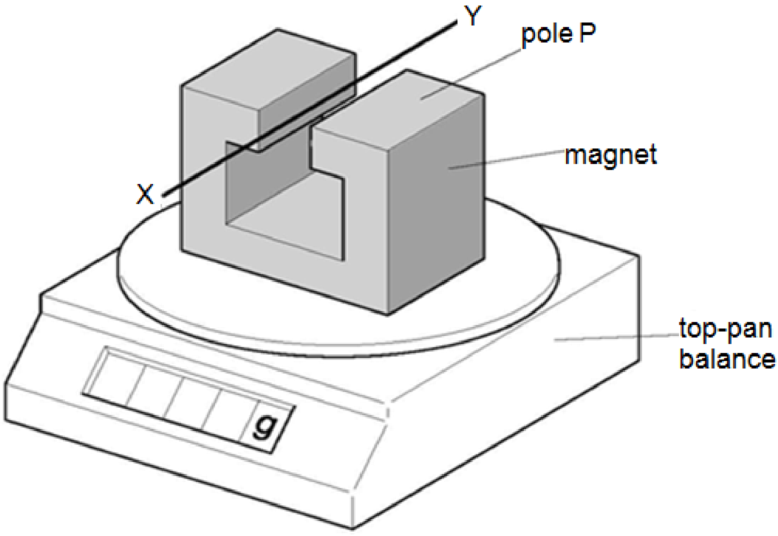



**Fig. 8.6**

The wire XY is horizontal and normal to the magnetic field. The length of wire between the poles is 4.4 cm. A direct current of magnitude 2.6 A is passed through the wire in the direction from X to Y. The reading on the top-pan balance increases by 2.3 g.

**(i)** State and explain the polarity of the pole P of the magnet.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

**(ii)** Calculate the magnetic flux density between the poles.

magnetic flux density = ……………….. T [2]

**(f)** Fig. 8.7 shows an electron travelling at right angles to a uniform magnetic field.

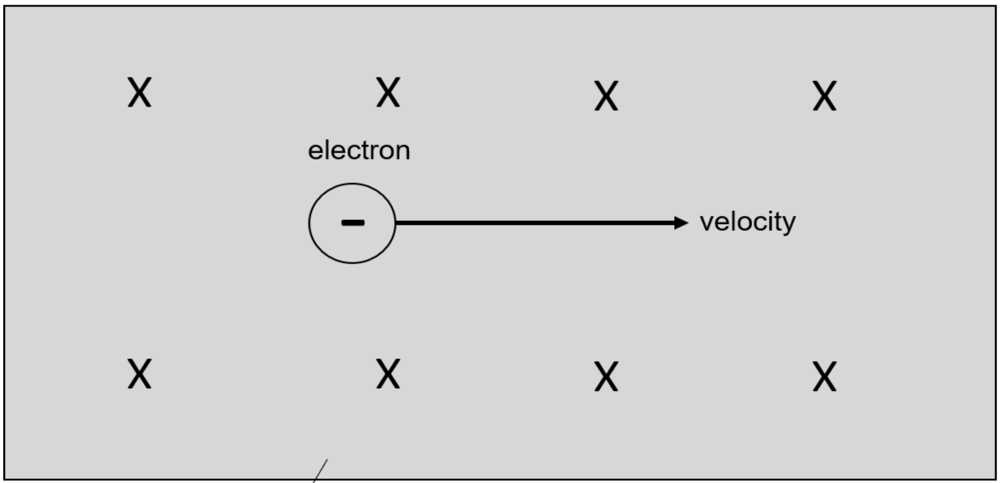



**Fig. 8.7**

The magnetic field is into the plane of the paper.

**(i)** On Fig. 8.7, indicate with an arrow the direction of the force experienced by the electron. [1]

**(ii)** Explain why the force experienced by the electron due to the magnetic field does not change the speed of the electron.

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

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

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

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

[Total: 20]

**9** **(a)** A coil of 1500 turns of insulated wire is tightly wound on a non-magnetic tube to make a solenoid of mean radius 22 mm, as shown in Fig. 9.1. The wire itself has radius 0.86 mm and is made of a material of resistivity $1.7 \times 10^{-8}$ Ω m. The coil is connected to a supply of e.m.f. 12 V and negligible internal resistance.

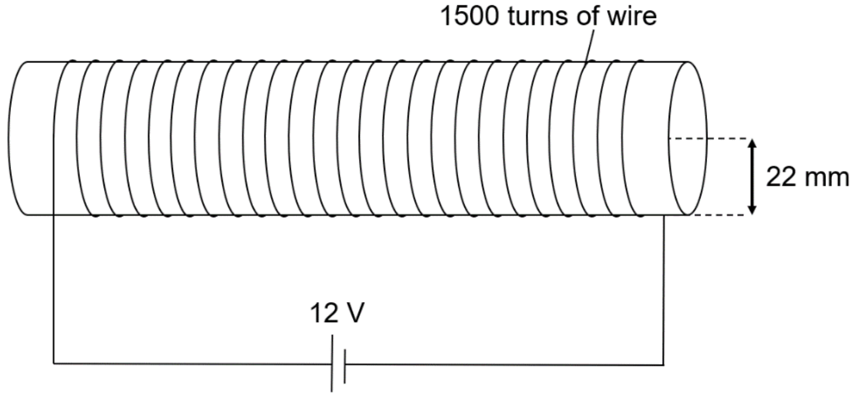



**Fig. 9.1**

Calculate

**(i)** the total length of wire in the coil,

length = …………………… m [2]

**(ii)** the total resistance of the coil,

resistance = …………………… Ω [3]

**(iii)** the current in the coil.

current = …………………… A [2]

**(b)** On Fig. 9.1, draw the pattern of the magnetic field within and around the solenoid. Use arrows to show the direction of the field inside the solenoid. [3]

**(c)** The magnetic flux density in the solenoid is measured using a current balance. The current balance is a U-shaped piece of stiff wire ABCDEF pivoted at BE, as shown in Fig. 9.2.

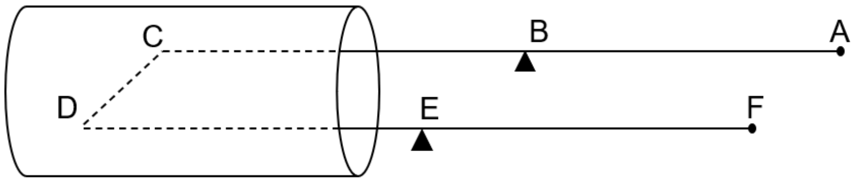



**Fig. 9.2**

When in used, there is a turning force on the stiff wire caused by a current in CD.

**(i)** Explain why the current in CD causes a turning effect.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

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

**(ii)** Explain why currents in CB and DE do not contribute to the turning force.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

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

**(iii)** CD has length 25 mm, CB and DE each have length 106 mm.

The stiff wire is first balanced when there is no current in it. A current of 4.9 A is then passed through CD and, in order to rebalance the stiff wire, a force of $5.7 \times 10^{-4}$ N is applied at a distance 77 mm from the pivot, as shown in the side view of the balance, Fig. 9.3.

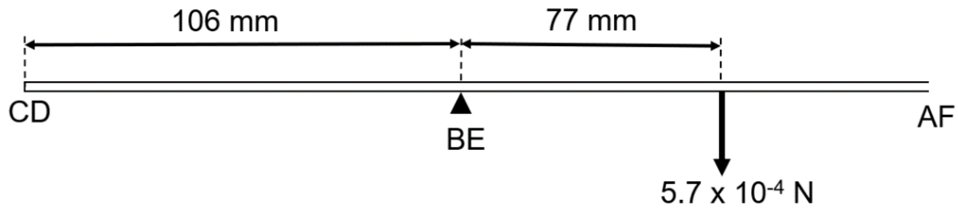



**Fig. 9.3**

**1.** State the direction of the current in the segment CD.

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

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

**2.** Calculate the magnetic flux density in the solenoid.
Give the full name of the unit for magnetic flux density.

magnetic flux density = ……………………………… T

name of unit for magnetic flux density = …………………………….. [5]

[Total: 20]

**END OF PAPER**