H

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 1

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| CANDIDATE NAME | |

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| CLASS | | TUTOR'S NAME | |

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| CENTRE NUMBER | S | | | | | INDEX NUMBER | | | | | |

# PHYSICS 8867/02

Paper 2 Structured Questions **10 September 2024**

**2 hours**

Candidates answer on the Question Paper.

No Additional Materials are required.

**READ THESE INSTRUCTIONS FIRST**

Write your name, class and tutor's name in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use a HB pencil for any diagrams, graphs.
Do not use staples, paper clips, glue or correction fluid.

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

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

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

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** | **/ 9** |
| **2** | **/10** |
| **3** | **/10** |
| **4** | **/17** |
| **5** | **/14** |
| **Section B** | |
| **6** | **/20** |
| **7** | **/20** |
| **Total** | **/80** |

This document consists of **23** 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 | $R$ | = | $R_1 + R_2 + \ldots$ |
| resistors in parallel | $1/R$ | = | $1/R_1 + 1/R_2 + \ldots$ |

## Section A

Answer **all** questions.

**1** **(a)** State what is meant by the term *accuracy.*

Accuracy refers to how closely a measured value agrees with the “true” value.

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

**(b)** A trampoline consists of a central section supported by springy material.

At $t$ = 0, a girl starts to fall vertically onto a trampoline as shown in Fig 1.1.

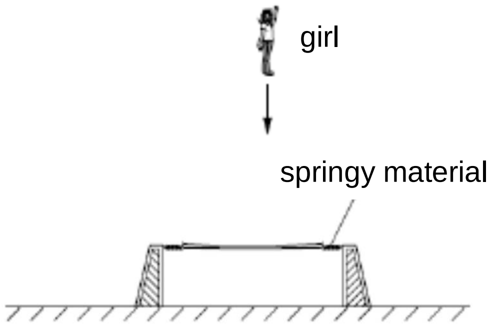


**Fig 1.1**

The girl hits the trampoline and rebounds vertically. The variation with time $t$ of the velocity $v$ of the girl is shown in Fig 1.2.

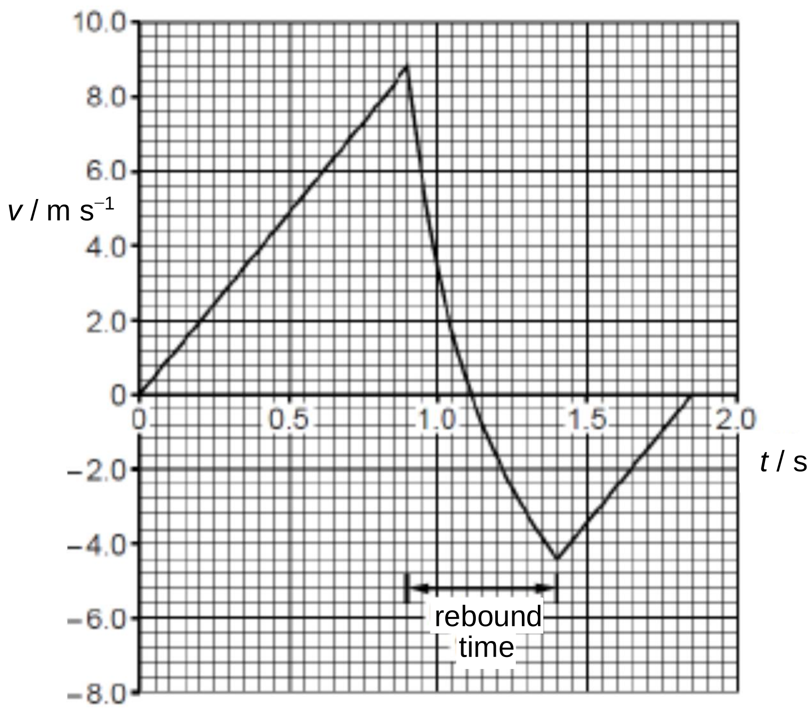


**Fig. 1.2**

**(i)** For the motion between $t = 0$ to $t = 0.90$ s,

**1.** Calculate the acceleration.

$$\text{Grad} = \frac{8.8 - 0}{0.90 - 0} \text{ [M1]}$$
$$= 9.78 \text{ m s}^{-2} \text{ [A1]}$$

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

**2.** The values obtained from both axes have an absolute uncertainty of half of the smallest division.

Determine the absolute uncertainty of the value in **(b)(i)(1)**.

$\Delta v = 0.2$ m s$^{-1}$ (half smallest division expressed to 1 sf)
$\Delta t = 0.03$ s
Uncertainty in change of velocity = $2 \times \Delta v = 0.4$ m s$^{-1}$
Uncertainty in time = $2 \times \Delta t = 0.06$ s

$$\Delta\text{grad} = \left(\frac{0.4}{8.8} + \frac{0.06}{0.90}\right) \times 9.78 \text{ [M1][}\Delta t \text{ to 1 sf]}$$

$= 1$ m s$^{-2}$ [A1][ans to 1 sf]

absolute uncertainty = .......................................... m s$^{-2}$ [2]

**3.** Using your answers in parts **(a)** and **(b)(i)(2)**, comment on the accuracy of of the value in **(b)(i)(1)**.

The acceleration of free fall is 9.81 m s$^{-2}$. This is within the calculated value of (10 ± 1) m s$^{-2}$. Hence it is accurate. [A1]

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

**(c)** Using Fig 1.2, estimate the maximum compression of the trampoline.

Area under graph from t= 0.90 s to t = 1.13 s

Maximum compression = ½ × 8.8 × (1.13 – 0.90) = 1.01 m [A1]

maximum compression = .......................................... m [2]

**(d)** Without further calculation, describe and explain the motion of the girl from $t = 1.40$ s to $t = 1.85$ s.

The grad from t = 1.40 s is same as that from t= 0 to t= 0.90 s. She rebound and rises up with a constant deceleration of acceleration 9.8 m s$^{-2}$. [A1]

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

[Total: 9]

**2** **(a)** Fig. 2.1 shows a tennis ball at rest on a horizontal ground.

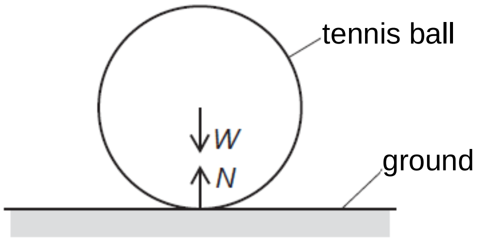


**Fig. 2.1**

The weight of the tennis ball is *W* and the normal contact force on the tennis ball is *N*.

A student made the following statement in Fig. 2.2.

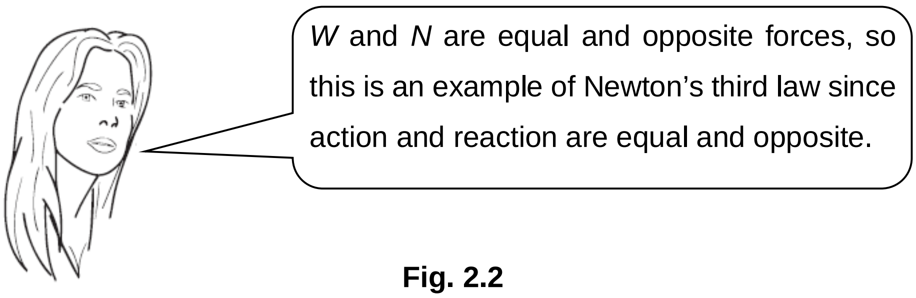


**Fig. 2.2**

Explain whether the student's statement is correct.

Incorrect, as the forces are acting on the same body OR the forces are not of the same type

(so not N3L) [B1] ..................................................[1]

**(b)** Fig. 2.3 shows the tennis ball before and after bouncing on the ground. The mass of the tennis ball is 0.062 kg. The tennis ball hits the ground at a speed of 14 m $s^{-1}$.

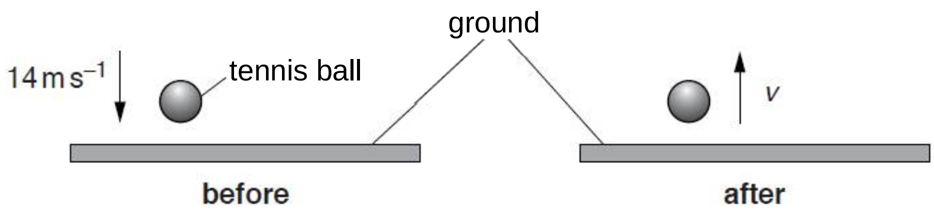


**Fig. 2.3**

The resultant force acting on the tennis ball during collision with the ground is $F$.
Fig. 2.4 shows how force $F$ varies with time $t$ during the collision.

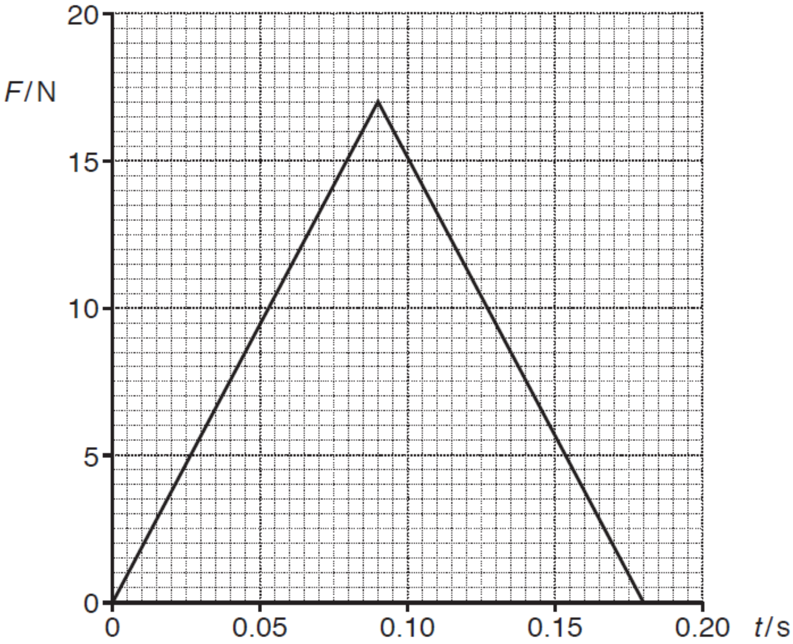


**Fig. 2.4**

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

Rate of change of momentum is directly proportional to the resultant force acting on the body and the momentum change takes place in the direction of the resultant force [B1]

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

**(ii)** Calculate the momentum of the tennis ball just before it hits the ground. Give a unit with your answer.

$p = mu$

$= (0.062)(14)$

$= 0.868$ N s OR kg m $s^{-1}$ [B1] answer [B1] unit

momentum = 0.868 unit = N s, kg $ms^{-1}$ [2]

**(iii)** Determine the speed $v$ of the tennis ball with which it leaves the ground.

$\Delta p =$ area under F-t graph $= \frac{1}{2}(0.18)(17) = 1.53$ Ns [M1]

Taking upwards as +ve,

$\Delta p = m(v - u)$

$1.53 = 0.062\left[v - (-14)\right]$ [M1]

$v = 10.7$ m $s^{-1}$ [A1]

$v$ = 10.7 m $s^{-1}$ [3]

**(iv)** Using your answer in **(iii)**, explain whether the collision is elastic.

Speeds of ball before and after collision are different, KE not conserved so collision is not elastic [B1]

[1]

**(v)** During collision with the ground, a normal contact force acts on the tennis ball.

State and explain whether the magnitude of this normal contact force is greater than, less than, or equal to the normal contact force in **(a)** when the ball is at rest.

As there is a rate of change of momentum / resultant force upwards [M1]

so normal contact force > weight (= normal contact force in Fig. 2.1) [A1]

[2]

[Total: 10]

**3** Fig. 3.1 shows an experiment to investigate the extension of two identical springs connected end to end. A student initially measures the length *L* of the two-spring combination without a load attached.

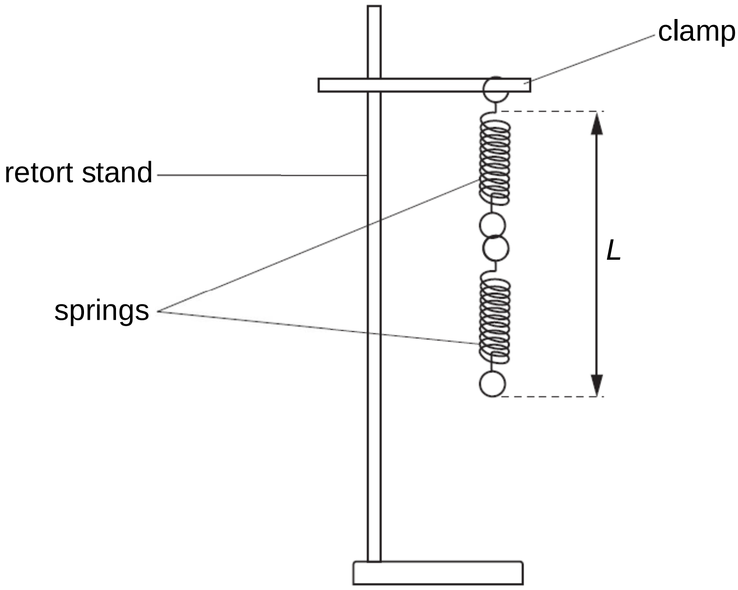


**Fig. 3.1**

The student adds mass *m* to the lower spring and measures the new length *L* of the two-spring combination.

The student determines the weight *F* of the mass added to the spring.

The student's results are shown in Fig. 3.2.

| ***m* / g** | ***F* / N** | ***L* / cm** | ***e* / cm** |
|---|---|---|---|
| 0 | 0 | 12.0 | 0 |
| 50 | 0.49 | 13.0 | 1.0 |
| 100 | 0.98 | 13.8 | 1.8 |
| 150 | 1.47 | 14.8 | 2.8 |
| 200 | 1.96 | 15.6 | 3.6 |
| 250 | 2.45 | 16.6 | 4.6 |

**Fig. 3.2**

**(a)** Complete the missing values for the extension *e* of the spring combination in the table shown in Fig. 3.2.

[1]

**(b)** On Fig. 3.3, plot the remaining points on the graph and draw the straight line of best fit.

[2]

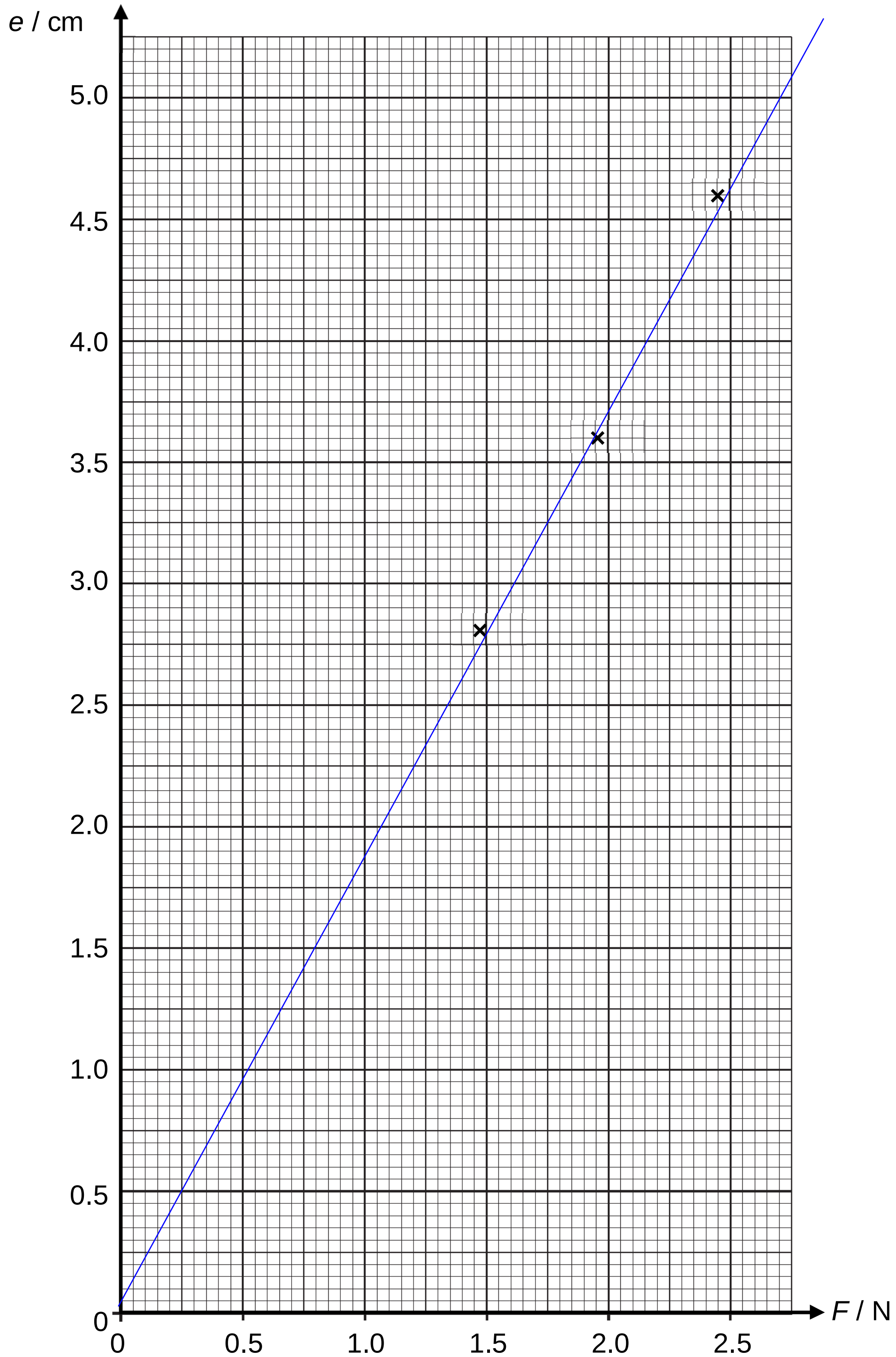


**Fig. 3.3**

**(c)** Determine the gradient of the straight line of best fit.

$$\text{gradient} = \frac{5.05 - 0}{2.75 - 0} = 1.84$$

$$\text{gradient} = \frac{0.0505 - 0}{2.75 - 0} = 0.0184$$

[B1] for gradient between 1.80 to 1.94 OR 0.0180 to 0.0194

gradient = 1.84 OR 0.0184 [1]

**(d)** Use your answer in **(c)** to determine the experimental value for the spring constant *k* of the two-spring combination. Include an appropriate unit.

$k = \dfrac{1}{\text{gradient}}$ [C1]

$= \dfrac{1}{1.84}$

$= 0.543\ \text{N cm}^{-1}$ [A1] with correct unit

$k = \dfrac{1}{\text{gradient}}$ [C1]

$= \dfrac{1}{0.0184}$

$= 54.3\ \text{N m}^{-1}$ [A1] with correct unit

*k* = .......................................... unit = ..................... [2]

**(e)** State and explain whether your graph shows that the spring combination obeys Hooke's law.

To obey Hooke's law, extension is directly proportional to the load (provided elastic limit is not exceeded) [B1]

Since graph is a straight line passing through origin so Hooke's law is obeyed OR since graph is not a straight line passing through origin, so Hooke's law is not obeyed [B1]

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

**(f)** The student repeats the experiment with a third identical spring added to the bottom of the two springs.

State and explain how the elastic potential energy stored in each spring in this three-spring combination would be different from that in each spring in the two-spring combination.

Same load / force acts throughout the springs (in series) [B1]

(for the same force) extension is still the same in each spring OR each spring still extends by the same amount, so elastic PE is the same (by $EPE = \frac{1}{2}Fx$) [B1]

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

[Total: 10]

**4** **(a)** Distinguish between electrical resistance and resistivity.

resistance: Resistance is the ratio of the potential difference across a conductor to the current passing through it. [B1]
Resistance is dependent on the dimension of the conductor eg length and cross section area. [B1]

resistivity : Resistivity is a measure of how strongly a material opposes electric current. [B1]
Resistance is independent n of the materials' dimensions. [B1] [4]

**(b)** Fig 4.1 shows the variation of potential difference *V* with current *I* of a filament lamp.

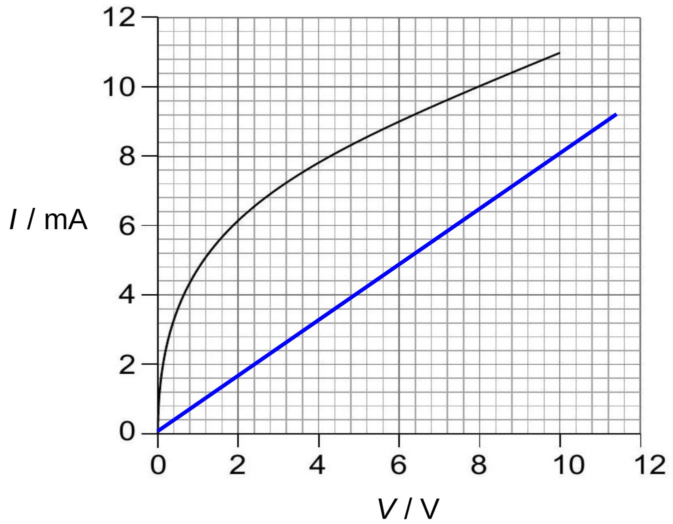


**Fig 4.1**

**(i)** Explain in terms of charged particles, why the *I*-*V* characteristics for a filament lamp has this shape.

As power increase ($P = VI$), electrons have more kinetic energy and make more random collision (or increase frequency of collision) with lattice ions. [B1]

Upon collision electrons lose some energy to the lattice ions and cause increase in lattice vibration, hence temperature increase. [B1]

This result is greater resistance to current flow. [B1]

Hence the shape of graph shows greater resistance at greater power. [B1]

[4]

**(ii)** Using Fig 4.1, complete Table 4.2.

| *I* / mA | *V*/V | *R* = *V*/*I* /Ω |
|---|---|---|
| 6.0 | 2.0 | 333 |
| 7.9 | 4.0 | 506 |
| 9.0 | 6.0 | 667 |
| 10.0 | 8.0 | 800 |

**Table 4.2**

At least three points show different resistance [1]

**(ii)** Use Table 4.2 to show that resistance of filament lamp is not constant.

[1]

**(c)** The filament lamp is connected in a circuit with a cell of e.m.f. 12 V and internal resistance $r$, and a resistor P of resistance 1.25 kΩ as shown in Fig. 4.3. The current in the cell is 6.0 mA.

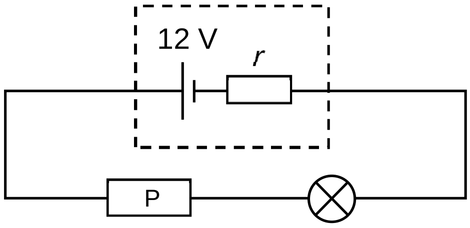


**Fig. 4.3**

**(i)** On Fig 4.1 draw a line to show the $I$-$V$ characteristics for P. [1]

**(ii)** Hence determine the value of $r$.

For a current of 6.0 mA,

$\varepsilon = I\,(R_F + R_P + r)$ [M1]

$12 = V_F + V_P + 6.0 \times 10^{-3}\, r = 2.0 + 6.0 \times 10^{-3}(1.25 \times 10^{-3}) + 6.0 \times 10^{-3}\, r$

$r = 400\ \Omega$ [A1]

$r$ = ........................................... Ω [2]

**(d)** The temperature dependence of a resistance is given by the formula

$$\frac{R}{R_0} = 1 + \alpha(T - T_0)$$

where $R$ is the resistance at temperature $T$ and $R_0$ is the resistance at temperature $T_0$. $\alpha$ is the temperature coefficient of resistance.

Table 4.4 shows the resistance – temperature dependence.

| $R / R_0$ | $(T - T_0)$ / K |
|---|---|
| 1.43 | 100 |
| 1.87 | 200 |
| 2.34 | 300 |
| 2.85 | 400 |
| 3.36 | 500 |
| 3.88 | 600 |

**Table 4.4**

The corresponding values of ($R$ / $R_0$) and ($T$ – $T_0$) for the data in Table 4.4 are plotted on the graph of Fig. 4.5.

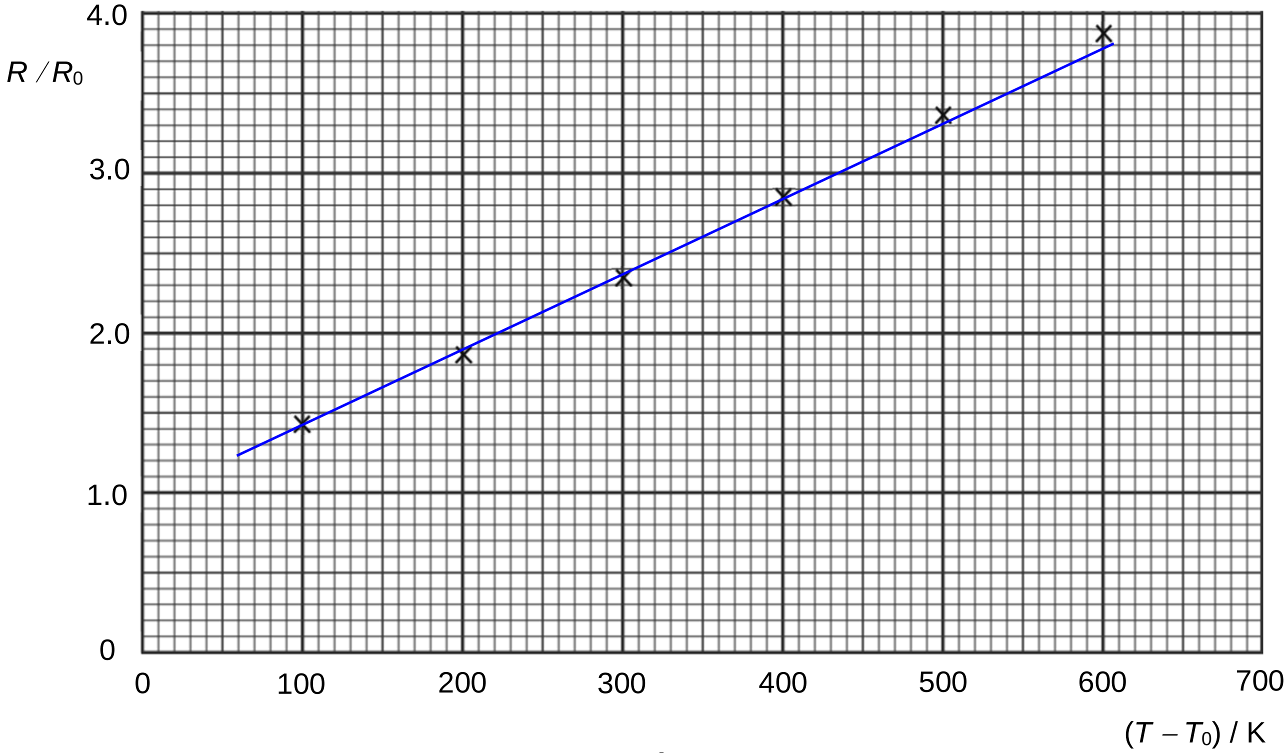


**Fig. 4.5**

**(i)** On Fig 4.5, draw the best-fit line for all the plotted points. [1]

**(ii)** Hence, using Fig. 4.5, determine $\alpha$.

[ [A1]: grad; [A1]: mag of $\alpha$; [A1]: unit of $\alpha$]

Grad = $\alpha$

Grad = 0.0050

Unit of $\alpha$ is $K^{-1}$

$\alpha$ = .......................................... [3]

[Total: 17]

**5** **(a)** Slow-moving neutrons react with the nuclei of sodium-23 to form the isotope sodium-24. The reaction is represented by the equation shown.

$$^{23}_{11}\text{Na} + ^{1}_{0}\text{n} \rightarrow ^{24}_{11}\text{Na} + \gamma$$

Sodium-23 is stable.

Data for the masses of the particles are given in Fig. 5.1.

| | | mass/u |
|---|---|---|
| proton | $^{1}_{1}\text{p}$ | 1.00814 |
| neutron | $^{1}_{0}\text{n}$ | 1.00898 |
| sodium-23 | $^{23}_{11}\text{Na}$ | 22.99706 |
| sodium-24 | $^{24}_{11}\text{Na}$ | 23.99857 |

**Fig. 5.1**

**(i)** State what is meant by the *binding energy* of a nucleus and how it is related to its mass defect.

Amount of work needed to take all its constituent nucleons apart so that they are separated an infinite distance from one another. [B1]

The energy equivalence of the mass defect which is the product of the mass defect and the square of the speed of light is the binding energy. [B1]

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

**(ii)** Use data from Fig. 5.1 to determine, to three decimal places, the binding energy per nucleon, in MeV, of sodium-23.

Mass defect = (11 × 1.00814) + (12×1.00898) – 22.99706 = 0.20024 u [C1]

Total binding energy =0.20024 × 1.66x10$^{-27}$ x(3x10$^{8}$)$^{2}$ = 186.9741 MeV [C1]

Binding energy per nucleon = $\frac{186.9741}{23}$ = 8.129 MeV

binding energy per nucleon = .......................................... MeV [3]

**(iii)** Show that the energy equivalent of 1.00 u of mass is 934 MeV.

$E = mc^2$

$E = 1.66 \times 10^{-27} \times (3 \times 10^8)^2 = 1.494 \times 10^{-10}$ J C1

$= \dfrac{1.494 \times 10^{-10}}{1.6 \times 10^{-13}}$ M1

$= 934$Mev

[2]

**(iv)** For the absorption of a neutron by a sodium-23 nucleus, calculate the energy released in MeV.

Mass difference $= 22.99706 + 1.00898 - 23.99857$ [M1]

$= 7.47 \times 10^{-3}$ u

Energy released $= (7.47 \times 10^{-3}$ u)(934 MeV/u)

$= 6.98$ MeV [A1]

energy released = .......................................... MeV [2]

**(b)** The radioactive isotope Polonium-218 has a half-life of 3.0 minutes. A pure sample initially contains $6.0 \times 10^{15}$ Polonium-218 nuclei.

Show that the number of polonium nuclei remaining after 7.0 minutes is $1.2 \times 10^{15}$.

$N = N_o(\frac{1}{2})^t$ M1

N = $= (\frac{1}{2})^{7/3} \times 6.0 \times 10^{15}$ C1

$= 1.2 \times 10^{15}$ A0

[2]

**(c)** In an experiment, a detector is held a fixed distance from a sample of a radioactive material and the data provided is used to plot a graph of count-rate against time, shown in Fig. 5.2.

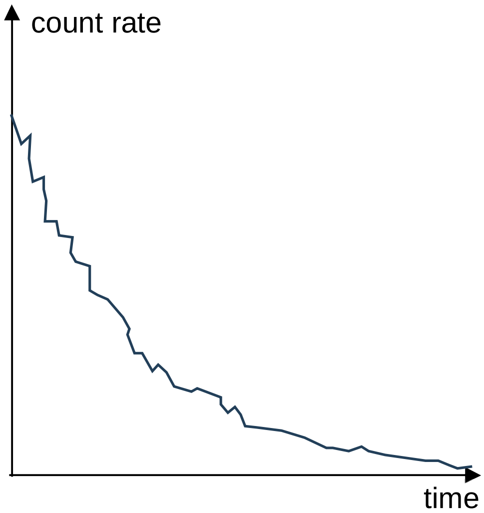


**Fig. 5.2**

**(i)** Explain why the data points on the graph do not lie on a smooth curve

random nature of emission

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

**(ii)** Suggest two reasons why the count-rate recorded is not the same as the activity of the sample.

**1** detector not surrounding source of radiation

.................................................................................................................................................

**2** background radiation

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

[Total: 14]

## Section B

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

**6** **(a)** Earth has a mass of $5.97 \times 10^{24}$ kg and a radius of 6370 km, and it rotates about its axis once every day. Singapore lies very close to the equator of the Earth on its surface.

**(i)** Using Newton's Law of Gravitation, calculate the gravitational force exerted by the Earth on a man of mass 80.0 kg in Singapore.

$$F = \frac{GM_E M_m}{R^2} = \frac{6.67 \times 10^{-11} \times 5.97 \times 10^{24} \times 80.0}{(6.37 \times 10^6)^2} \quad \text{[M1]}$$

$$= 785 \text{ N} \quad \text{[A1]}$$

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

**(ii)** Show that the linear speed of the man due to Earth's rotation is 463 m $s^{-1}$.

period = 1 day = 86400 s [B1]

$$v = \frac{2\pi R}{T} = \frac{2\pi \times 6.37 \times 10^6}{86400} \quad \text{[B1]} \quad = 463 \text{ m s}^{-1}$$

[2]

**(iii)** Calculate the magnitude of the centripetal force on the man due to the Earth's rotation.

$$a = \frac{v^2}{R} = \frac{463^2}{6.37 \times 10^6} \quad \text{[M1]} \quad = 3.37\times10^{-2} \text{ m s}^{-2}$$

$$F = m\,a = 80 \times 3.37\times10^{-2} = 2.70 \text{ N [A1]}$$

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

**(iv)** Hence calculate the force a weighing scale registers when the man stands on it.

$\Sigma F = m\,a$ → $W - R = 2.70$ [M1]

→ Force by weighing scale $R = 785 - 2.70 = 782$ N [A1]

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

**(v)** Explain why the man will not experience the magnitude of force in **(iii)** when he is in Melbourne which is very much further from the equator.

Radius of the circular path in Melbourne is smaller. [B1]

Period is the same, so linear speed and centripetal acceleration is smaller.

Thus centripetal force is smaller. [B1]

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

**(b)** In an imagined universe, Earth has an identical twin Areth with which it forms a double planet system. They are separated by a distance of $9.80 \times 10^7$ m, and they orbit about the centre of mass of the system.

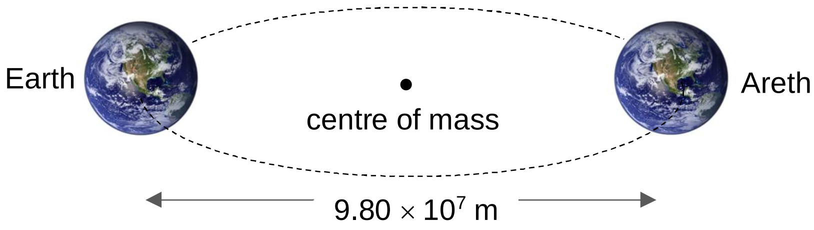


**Fig. 6.2**

**(i)** Show that the magnitude of the force that Earth and Areth exert on each other is $2.48 \times 10^{23}$ N.

$$F = \frac{GM_E M_A}{d^2} = \frac{6.67\times10^{-11}\times(5.97\times10^{24})^2}{(9.80\times10^7)^2} \qquad \text{[B1]}$$

$$= 2.48\times10^{23}\text{ N}$$

[1]

**(ii)** Determine the orbital period of the double planet system in days.

$$r = \frac{9.80\times10^7}{2} \qquad \text{[B1]}$$

$$F = M_A r\,\omega^2 \quad \rightarrow \quad 2.48\times10^{23} = 5.97\times10^{24} \times \frac{9.80\times10^7}{2} \times \omega^2 \qquad \text{[B1]}$$

$$\omega = 2.91\times10^{-5}\text{ rad s}^{-1}$$

$$T = \frac{2\pi}{\omega} = \frac{2\pi}{2.91\times10^{-5}} \qquad \text{[M1]}$$

$$= 2.16\times10^5\text{ s} = 2.50\text{ days} \qquad \text{[A1]}$$

period = ........................................ days [4]

**(c)** P is a point on the equator of Earth that lies on the line joining the centres of Earth and Areth, as shown in Fig. 6.3.

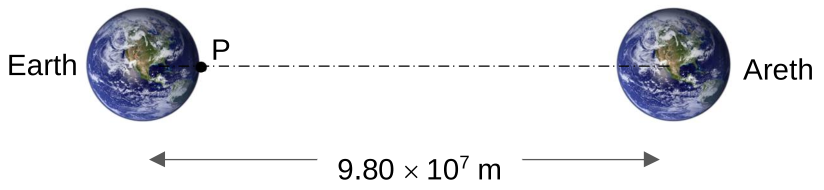


**Fig. 6.3**

**(i)** Calculate the gravitational force on the man in **(a)** when he is at P.

Distance from Areth to P = $9.80\times10^7 - 6.37\times10^6 = 9.16\times10^7$ m [B1]

Gravitational force of Areth on man = $\dfrac{GM_AM_m}{d^2} = \dfrac{6.67\times10^{-11}\times5.97\times10^{24}\times80.0}{(9.16\times10^7)^2}$ [B1]

= 3.79 N

Resultant gravitational force = 785 – 3.79 = 781 N [A1]

force = .......................................... N [3]

**(ii)** When the man in **(a)(i)** steps on a weighing scale, the reading produced is greater than the value determined in **(c)(i)**. Suggest a reason for this.

The man is also orbiting about the double planet's centre of mass, thus it has an acceleration (and resultant force) towards it. [B1]

Thus the force the weighing scale exerts on the man (towards the centre of orbit) must be greater than the gravitational force (towards centre of Earth). [B1] [2]

[Total: 20]

**7 (a)** Apart from being different types of forces, state a difference between electric force and magnetic force.

Electric forces are (created by and) act on, both moving and stationary charges; while magnetic forces are (created by and) act on only moving charges. [1]

**(b)** Two oppositely charged parallel metal plates P and Q are placed in a vacuum. The electric field is uniform in the region between the plates, which exerts a constant force on charged particles within it.

A uniform magnetic field also exists in the region between the plates. The direction of the magnetic field is into the page as illustrated in Fig. 7.1.

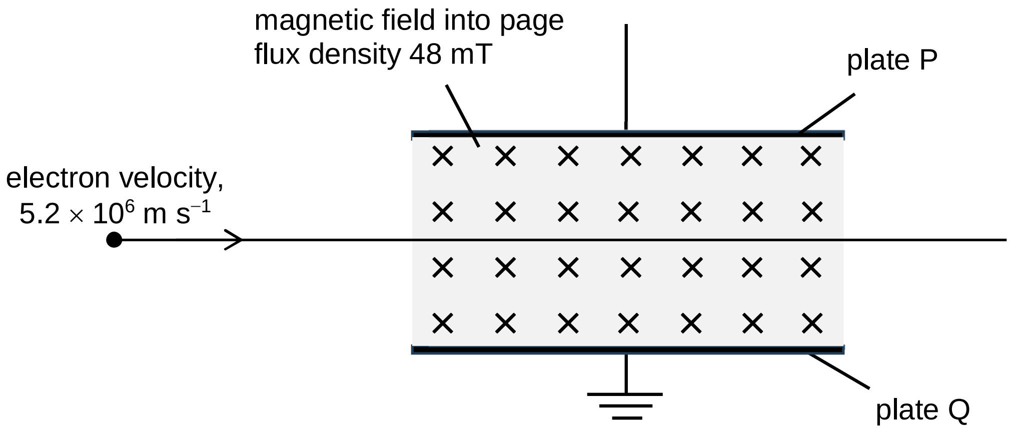


**Fig. 7.1**

An electron enters the region between the plates at right angles to both the electric field and the magnetic field. The electron travels through the field.

The magnetic flux density is 48 mT. The velocity of the electron is $5.2 \times 10^6$ m s$^{-1}$.

The magnetic force and electric force acts on the electron in opposite directions.

**(i)** State and explain the polarity, positive or negative, of plate P.

By Flemings left hand rule, the magnetic force on the electron acts downwards. [M1]
Hence the electric force on the electron should act upwards, and plate P will be positive with respect to plate Q. [A1]

[2]

**(ii)** Calculate the magnitude of the magnetic force $F_M$ acting on the electron.

$F_M = Bqv$

$= (48 \times 10^{-3})(1.6 \times 10^{-19})(5.2 \times 10^{6})$ M1

$= 4.0 \times 10^{-13}$ N A1

$F_M$ = .................................... N [2]

**(iii)** The electron passes through the field undeflected when the magnitudes of the magnetic and electric forces are the same.

With reference to the forces acting on the electron as it passes through the plates, state and explain how the path will change if the electric field strength across the metal plates is decreased slightly.

When the potential decreases, the electric field strength and hence the electric force on the electron decreases. ($F = qE$)[B1]
Upon entering the field, the downwards magnetic force is larger than the upward electric force and hence there is a net downward force. The electron is deflected downwards. [A1]
As the electron path curves downwards, the subsequent net force is the resultant of the upward electric force and the magnetic force tangential to the motion of the electron. The path curves further downwards. [B1]

[3]

**(c)** Two flat coils, P and Q each of diameter 29 cm are fixed so that their planes are parallel and are separated by a constant distance equal to the radius of each coil, with the direction of the current as shown in Fig. 7.2.

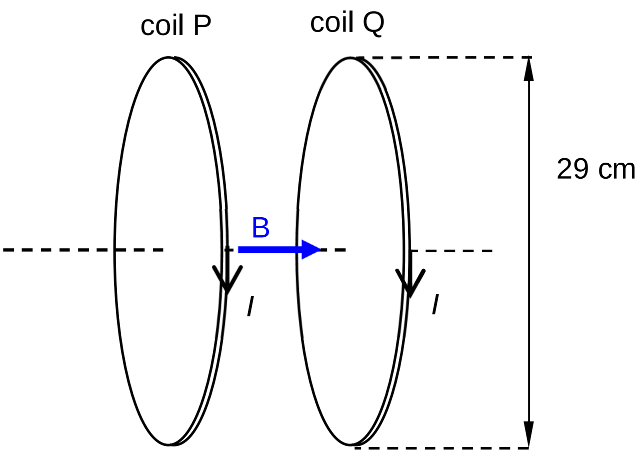


**Fig. 7.2**

The current $I$ in both coils is 1.3 A.

The magnetic flux density B in the region between the two coils is uniform and given by the expression

$$B = 0.72\,\mu_0 \frac{NI}{r}$$

where $N$ is the number of turns on each of the flat coil of radius $r$. The permeability of free space is $\mu_0 = 4\pi \times 10^{-7}$ H m$^{-1}$.

**(i)** By considering the flux pattern around the current carrying coils, explain how a uniform field is set up between the coils.

When there is a current in the coil, by right hand grip rule, there is field set up around each loop such that within the loop the magnetic field passes from left to right. [B1]

The fields from each of the loops superpose to set up a close to uniform field between them.

[2]

**(ii)** Draw an arrow to show the direction of the magnetic flux density between the coils. Label this arrow B. [1]

**(iii)** Each coil has 160 turns. Show that the magnetic flux density $B$ is approximately 1.3 mT.

$$B = 0.72\,\mu_0 \frac{NI}{r} = (0.72)(4\pi\times10^{-7})\frac{(130)(1.3)}{(2.9\times10^{-2}/2)}$$

$$= 1.298\times10^{-3}$$

$$= 1.3 \text{ mA}$$

[1]

**(iv)** The space between the coil in **(c)** is a vacuum.

An electron of velocity $5.2 \times 10^{6}$ m s$^{-1}$ travels at right angles into the uniform magnetic field produced by the two coils.

Calculate the radius of its orbit in the magnetic field.

Magnetic force provides centripetal force [B1]

$$\sum F = ma_c$$

$$F_M = Bqv = \frac{mv^2}{r}$$

$$(1.3\times10^{-3})(1.6\times10^{-19})(5.2\times10^{6}) = \frac{(9.11\times10^{-31})(5.2\times10^{6})^2}{r} \quad \text{M1}$$

$$r = 2.2775\times10^{-2}$$

$$= 2.28 \text{ cm} \quad \text{A1}$$

radius = .......................................... m [3]

**(d)** The magnetic field in **(c)** is rotated. The initial direction of the electron is now at an angle to the direction of the uniform magnetic field, as shown in Fig. 7.3.

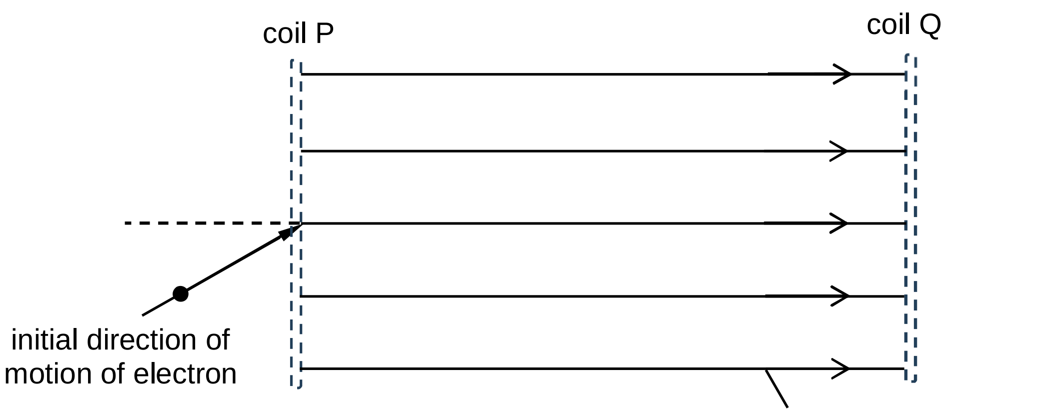


**Fig. 7.3**

**(i)** State the path of the election in the magnetic field.

The electron moves in a helical path. [1]

**(ii)** By considering the components of the velocity parallel to the magnetic field and at right angles to the magnetic field, explain the motion of the electron as stated in your answer in **(d)(i).**

The horizontal component of velocity is parallel to the direction of the B field, hence remains unchanged. [B1]

By Flemings left hand rule, a magnetic force acts on the electron perpendicular to the B field and its perpendicular component of velocity.[B1]

This provides the centripetal force causes the electron to chart out a circular path in the plane perpendicular to the B field.[B1]

The motion of the electron is the vector sum of the horizontal and perpendicular components of velocity, hence a helical path. [B1] [4]

[Total: 20]

**End of Paper**