NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 1

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

Formulae

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

....

....[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.

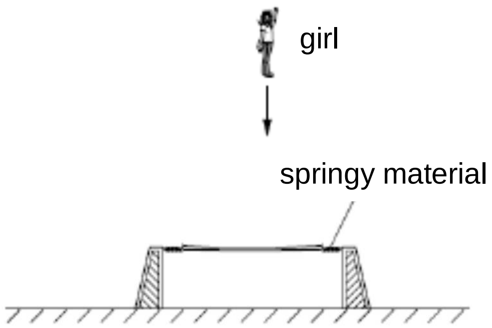

Fig 1.1

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.

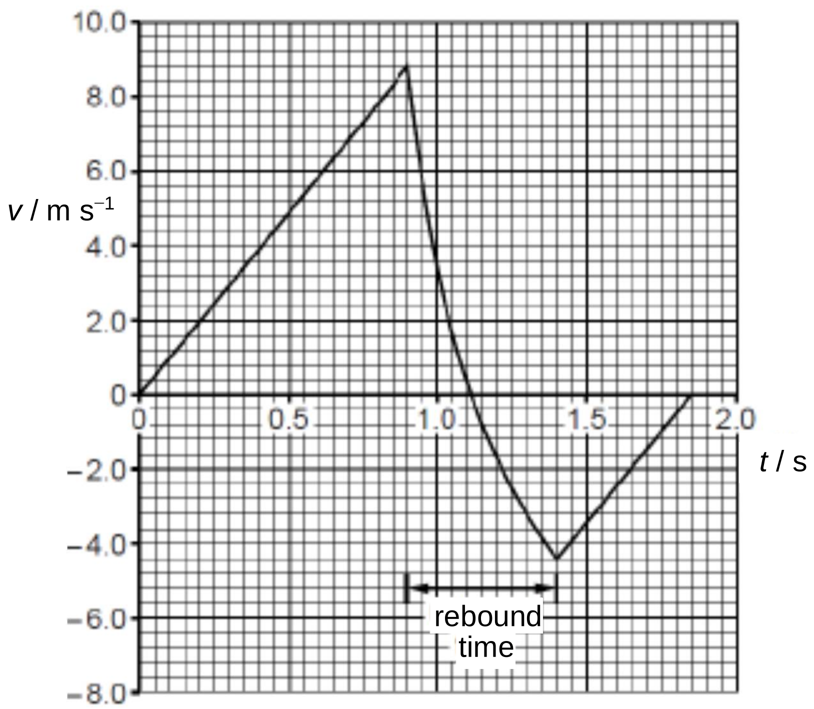

Fig. 1.2

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

1. Calculate the acceleration.

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)**.

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)**.

....

.... [1]

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

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.

....

....[1]

[Total: 9]

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

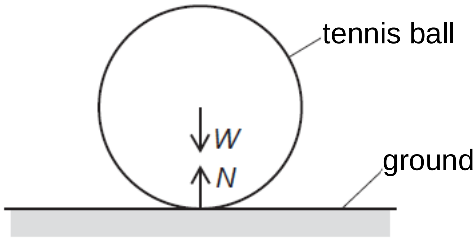

Fig. 2.1

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.

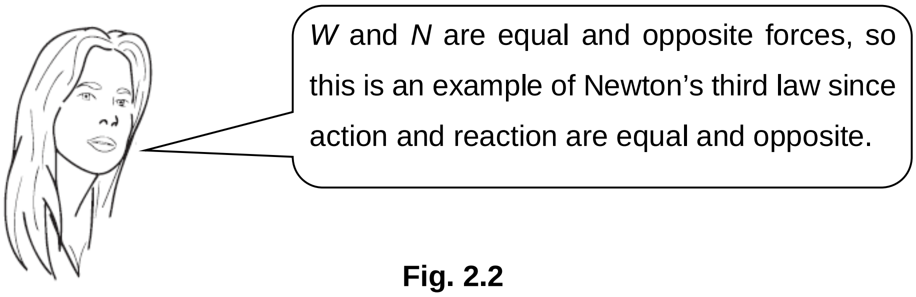

Fig. 2.2

Explain whether the student's statement is correct.

....

....[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}.

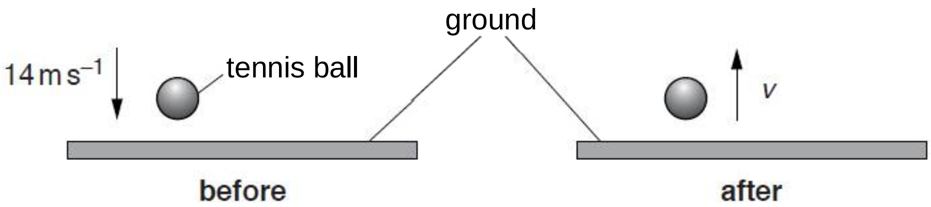

Fig. 2.3

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.

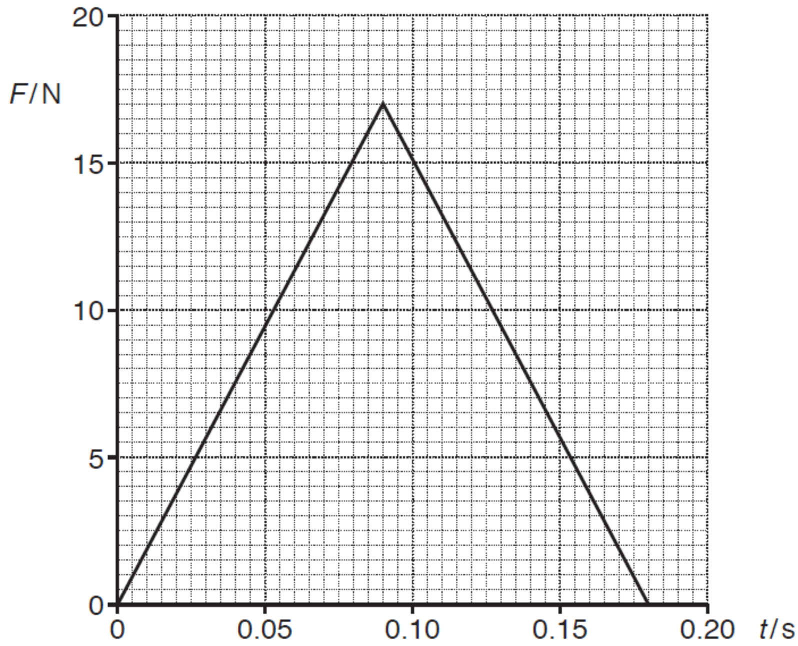

Fig. 2.4

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

....

....

....[1]

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

momentum = ... unit = ... [2]

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

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

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

....

....

....[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.

....

....

....[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.

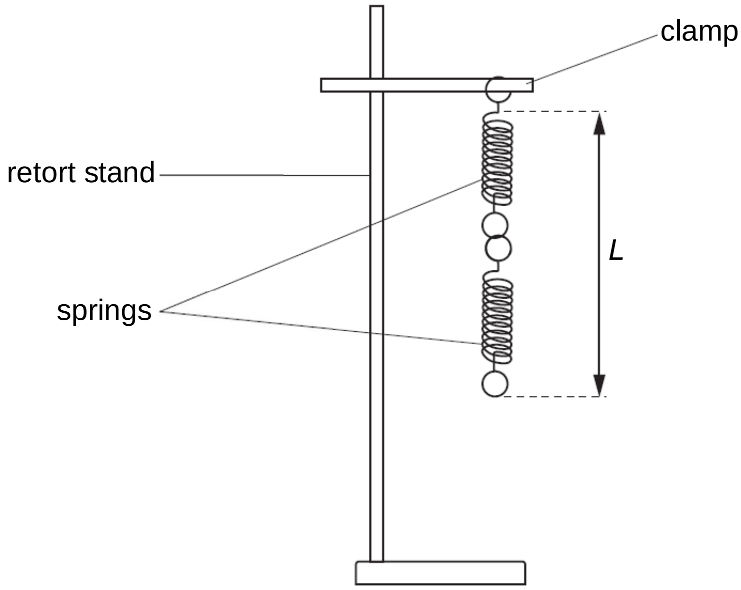

Fig. 3.1

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	
50	0.49	13.0	
100	0.98	13.8	
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]

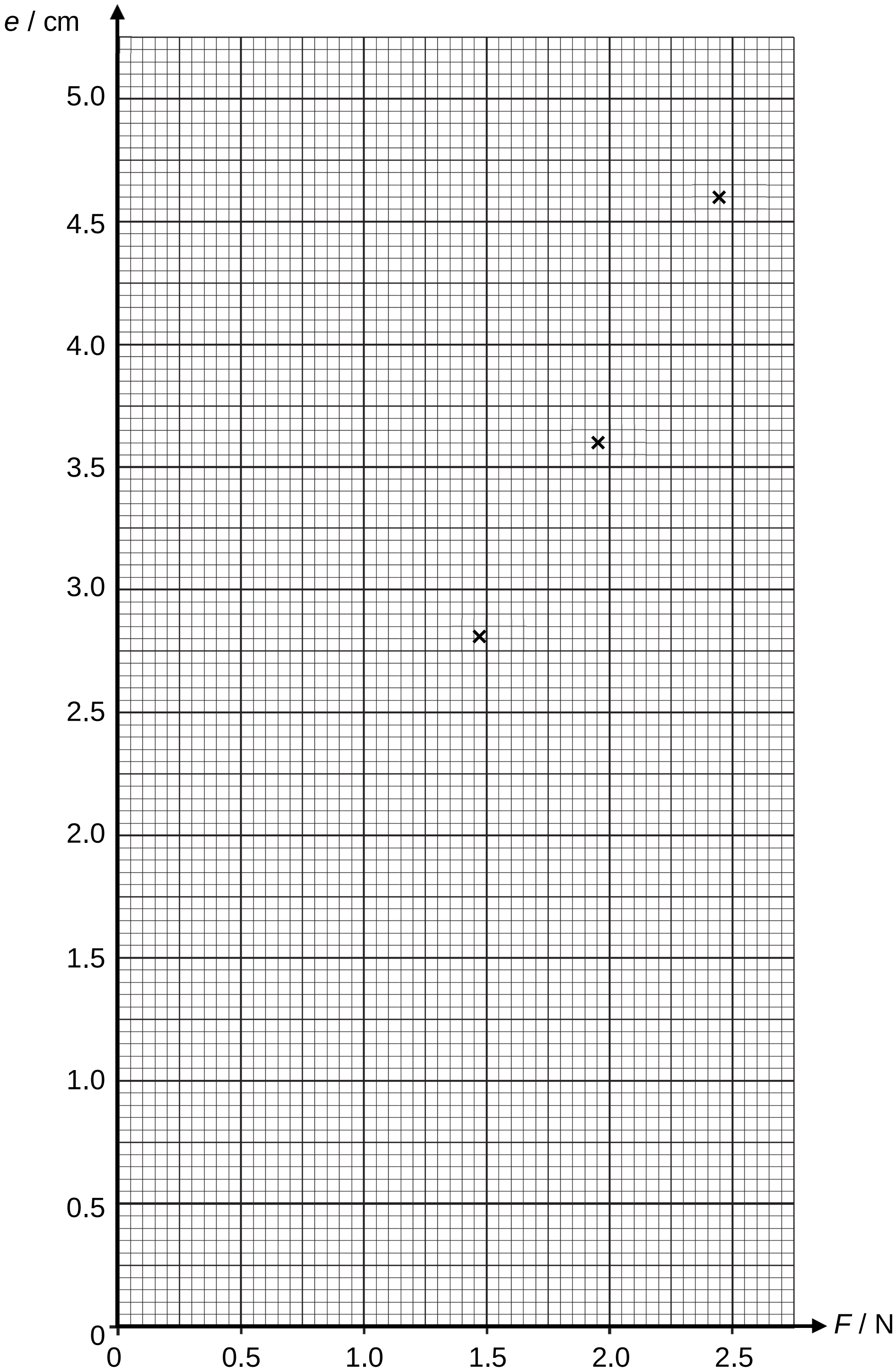

Fig. 3.3

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

gradient = ... [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 = ... unit = ... [2]

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

....

....

....

....[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.

....

....

....

....[2]

[Total: 10]

4 (a) Distinguish between electrical resistance and resistivity.

resistance: ....

....

resistivity : ....

....[4]

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

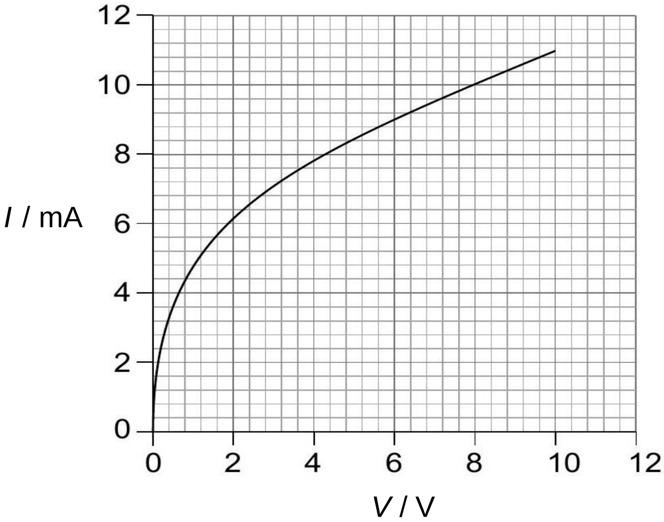

Fig 4.1

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

....

....

....

....

....

....[4]

(ii) Using Fig 4.1, complete Table 4.2.

I / mA	*V*/V
6.0	2.0
	4.0
9.0	6.0
10.0	

Table 4.2

[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.

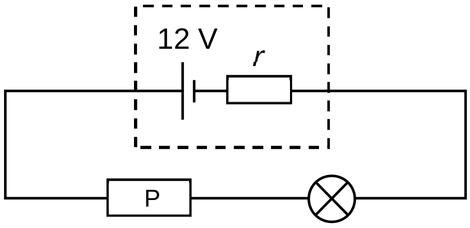

Fig. 4.3

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

(ii) Hence determine the value of r.

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. α 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.

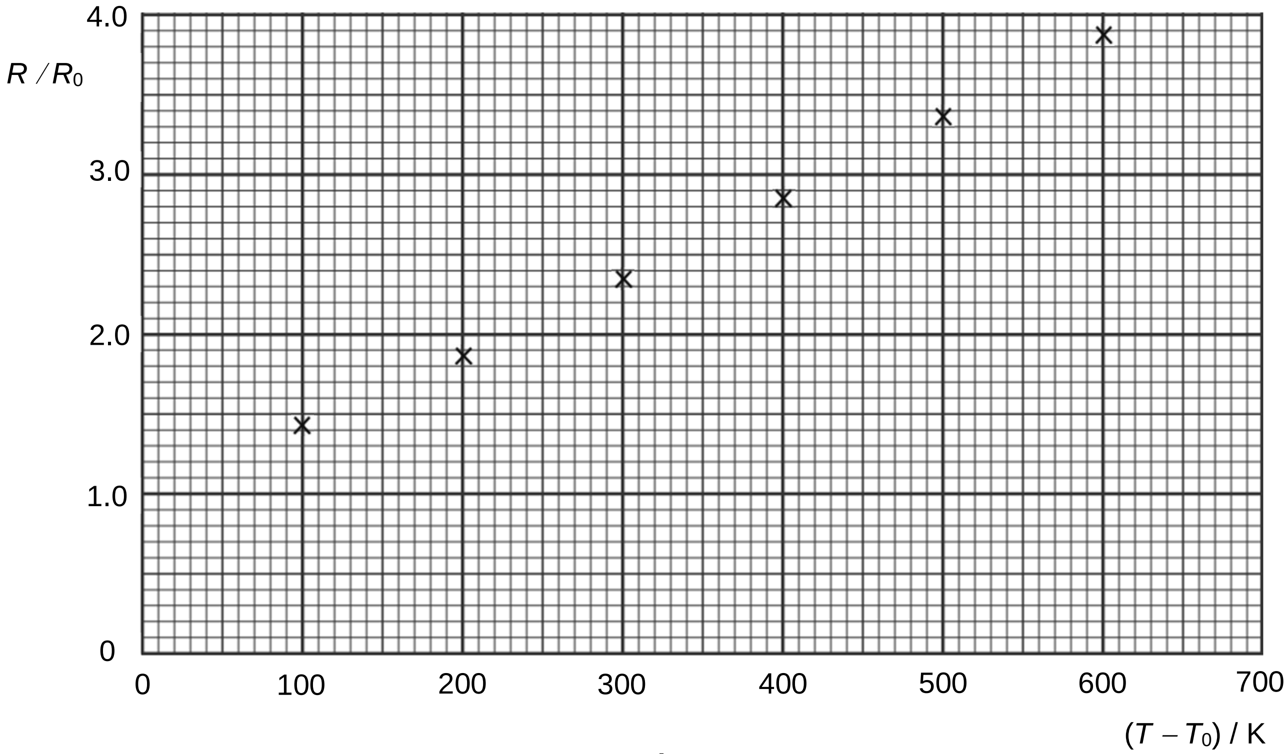

Fig. 4.5

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

(ii) Hence, using Fig. 4.5, determine α.

α = ... [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.

....

....

....

....[2]

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

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

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

[2]

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

energy released = ... MeV [2]

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

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

[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.

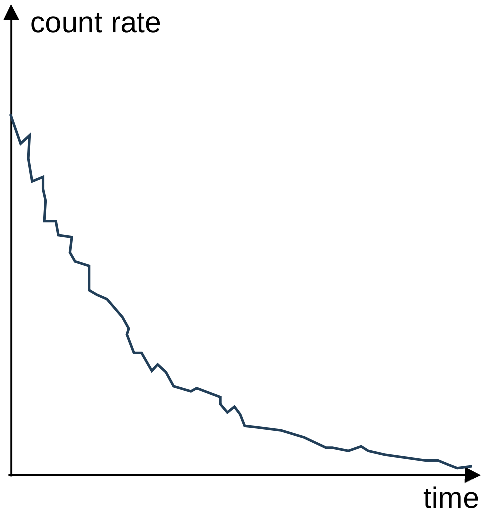

Fig. 5.2

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

....

....[1]

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

1 ....

....

2 ....

....[2]

[Total: 14]

Section B

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

6 **(a)** Earth has a mass of 5.97×10^{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.

force = ... N [2]

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

[2]

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

force = ... N [2]

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

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.

....

....

....

....[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 9.80×10^7 m, and they orbit about the centre of mass of the system.

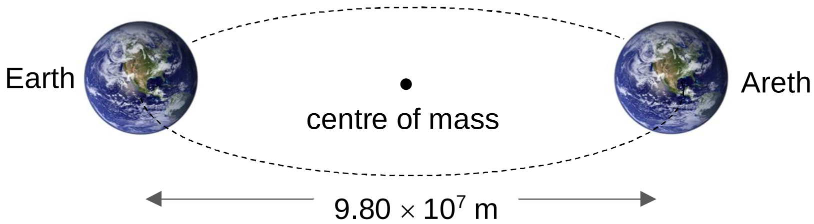

Fig. 6.2

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

[1]

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

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.

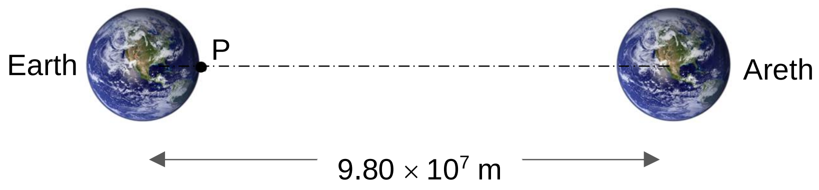

Fig. 6.3

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

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.

....

....

....

....[2]

[Total: 20]

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

....

....[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.

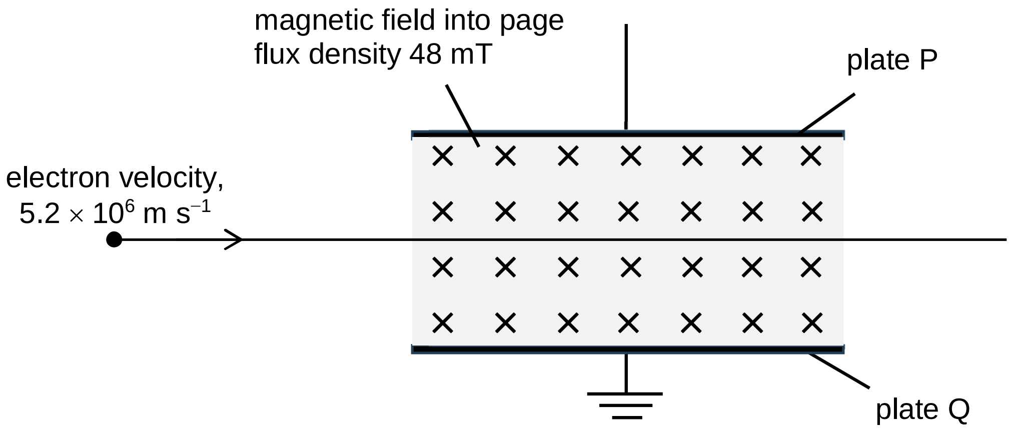

Fig. 7.1

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 5.2×10^6 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.

....

....

....[2]

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

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.

....

....

....

....

....[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.

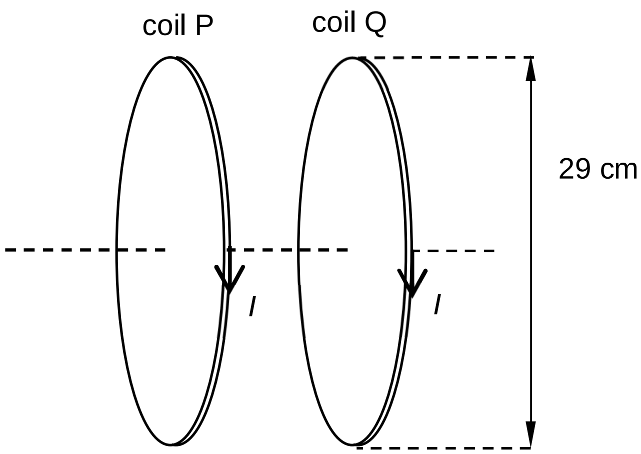

Fig. 7.2

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.

....

....

....

....[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.

[1]

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

An electron of velocity 5.2×10^6 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.

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.

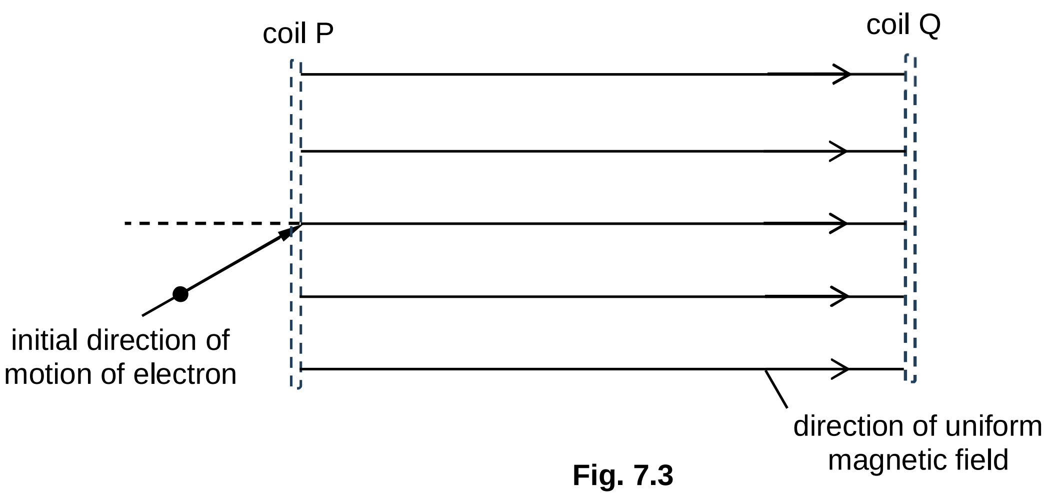

Fig. 7.3

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

....[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).**

....

....

....

....

....

....[4]

[Total: 20]

End of Paper