Name:		Centre/Index Number:		Class:	

DUNMAN HIGH SCHOOL
Preliminary Examination
Year 6

H1 PHYSICS

8867/02

Paper 2 Structured Questions

12 September 2024
2 hours

Candidates answer on the Question Paper

READ THESE INSTRUCTIONS FIRST

Write your class, index number and name at the top of this page
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A

Answer **all** questions in the spaces provided on the question paper.

Section B

Answer any **one** question in the spaces provided

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

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

For Examiner's Use	
Section A	
1	10
2	8
3	19
4	12
5	11
Section B (circle attempted)	
6 / 7	20
s.f.	-1
Total	80

This document consists of **20** 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** the questions in the spaces provided.

1 Student X attempts to determine the acceleration of free fall *g* experimentally by determining the time taken *t* for a small metal ball to free fall through a vertical distance *s* from rest in vacuum. The data obtained by the student are as follows.

$t = (860 \pm 10)$ ms
$s = (359 \pm 1)$ cm

(a) Define *acceleration*.

……

…… [1]

(b) **(i)** Calculate the magnitude of the *g* obtained by the student.

g = …… m s^{-1} [2]

(ii) Express *g* with its associated uncertainty.

g = …… ± …… m s^{-1} [3]

(iii) Another student Y uses the same method as student X to determine *g* but in the presence of significant air resistance.

State and explain how student Y's calculated value of *g* calculated will differ from the value of *g* obtained by student X.

……

…… [2]

(c) The accuracy of the experiment to determine *g* can be further improved by collecting several pairs of values of *s* and *t*. Fig. 1.1 shows the variation with time *t* of distance $\sqrt{s}$.

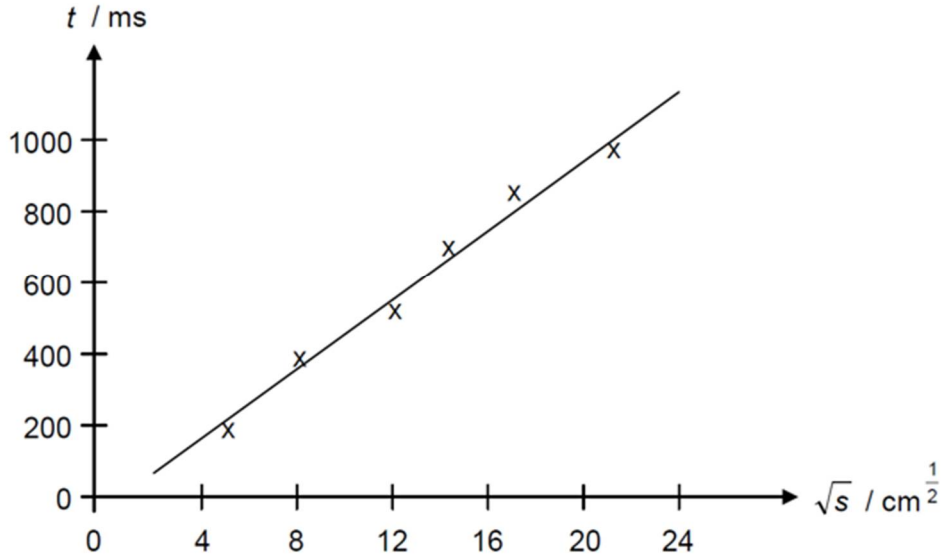


Fig. 1.1

(i) Suggest why drawing a best fit line reduces random errors.

……

…… [1]

(ii) Explain what feature of Fig. 1.1 suggests the presence of systematic errors.

……

…… [1]

[Total: 10]

2 **(a)** State the conditions necessary for equilibrium of a body acted upon by a number of forces.

……

…… [2]

(b) A non-uniform beam of mass 5.0 kg and length 5.0 m is supported by a cable and hinged to a wall as shown in Fig. 2.1.

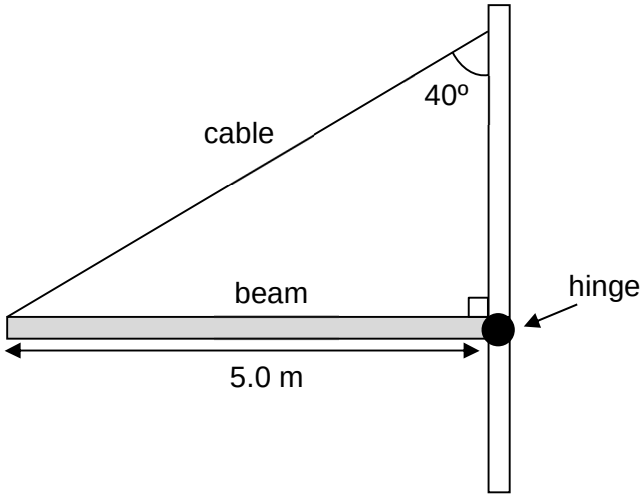


Fig. 2.1

(i) Explain what is meant by the *centre of gravity* of an object.

……

…… [1]

(ii) Given that the tension in the cable is 120 N, determine the distance of the centre of gravity of the beam from the hinge.

distance = …… m [2]

(iii) Determine the magnitude and direction of the force acting by the hinge on the beam.

force = …… m

direction of force = …… [3]

[Total: 8]

3 The planets in the solar system are said to move in circular orbits around the Sun. The masses m of the various planets, distances r of planets from the Sun, and their velocities v, are given in Table 3.1.

planet	m / 10^{24} **kg**	r / 10^{8} **km**	v / 10^{4} **m s^{-1}**
Mercury	0.330	0.579	4.74
Venus	4.87	1.082	3.50
Earth	5.97	1.496	2.98
Mars	0.642	2.279	2.41
Jupiter	1898	7.786	1.31
Saturn	568.5	14.33	0.97
Uranus	86.8	28.72	0.68
Neptune	102	44.95	0.54

Table 3.1

(a) Explain how an object undergoing uniform circular motion can be accelerating even though it travels at constant speed.

……

……

……

…… [3]

(b) Using the data in Table 3.1, the graph of v against $\frac{1}{\sqrt{r}}$ is plotted as shown in Fig. 3.1.

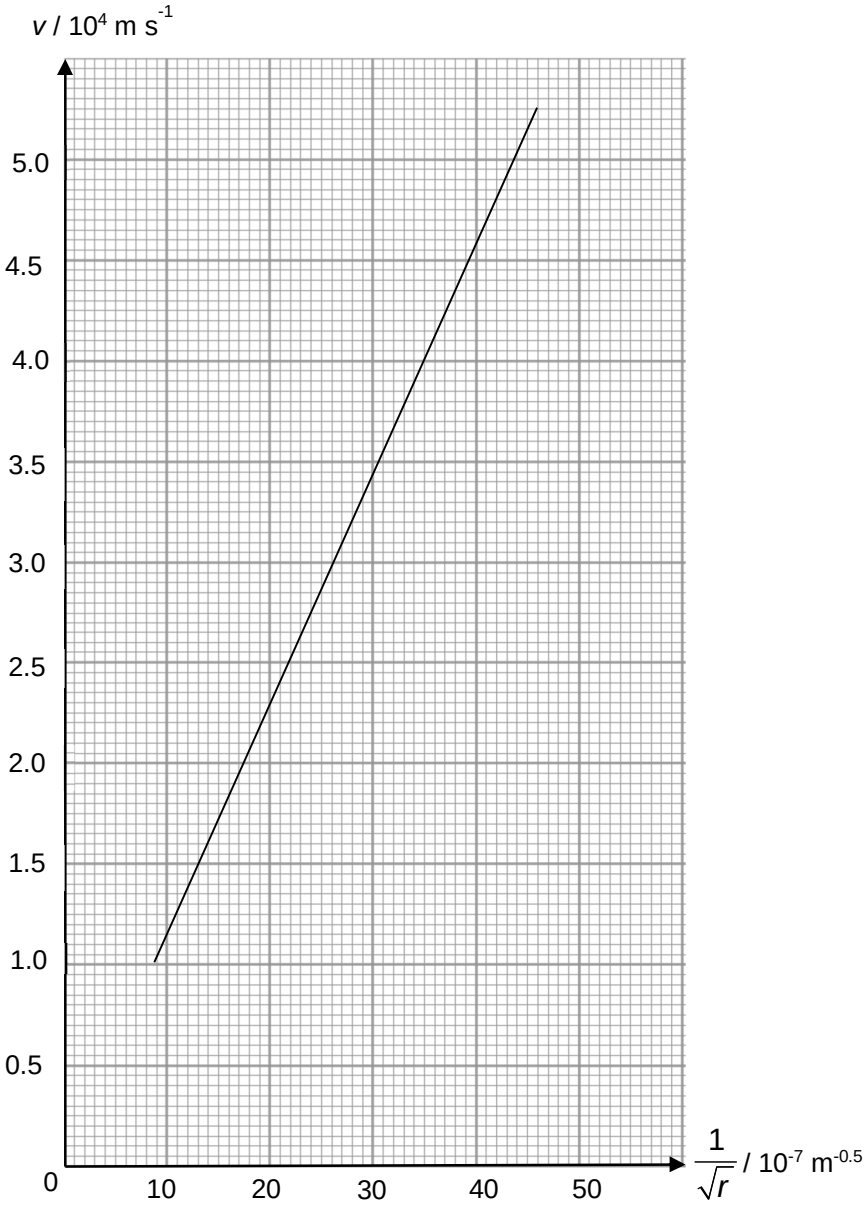


Fig. 3.1

(i) Show that the velocity of a planet that is travelling in a circular orbit around the Sun is given by

$$v = \sqrt{\frac{GM}{r}}$$

Where G is the universal gravitation constant, M is the mass of the Sun, and r is the distance of the planet from the Sun.

[2]

(ii) Using the graph in Fig. 3.1, estimate the mass of the Sun.

mass of Sun = …….. kg [3]

(iii) Hence, determine the magnitude of the gravitational force exerted by the Sun on Mars.

gravitational force = …….. N [2]

(iv) Suggest a reason why the mass of the Sun calculated in **b(ii)** is an estimate.

……

…… [1]

(c) As the planets orbit around the Sun, they experience an acceleration *a* towards the centre of the Sun.

planet	m / 10^{24} kg	r / 10^{8} km	v / 10^{4} m s^{-1}	a / 10^{-4} m s^{-2}
Mercury	0.330	0.579	4.74	388
Venus	4.87	1.082	3.50	
Earth	5.97	1.496	2.98	58.0
Mars	0.642	2.279	2.41	

Table 3.2

(i) Using your knowledge of orbital motion, complete Table 3.2 for the values of *a* for Venus and Mars. [2]

(ii) With reference to Table 3.2, calculate the angular velocity of Venus.

angular velocity = …… rad s^{-1} [2]

(d) Table 3.3 shows the radii and masses of each of the three satellites A, B and C that move around the Earth in a circular orbit.

satellite	orbital radii / km
A	7071
B	26570
C	42230

Table 3.3

With reference to Tables 3.2 and 3.3, state and explain which satellite(s) is/are likely to be geostationary. Support your answer with appropriate calculations.

……

…… [4]

[Total: 19]

4 **(a)** **(i)** Explain what is meant by a *field of force*.

……..

…….. [1]

(ii) On Fig. 4.1, sketch magnetic field lines due to a current-carrying solenoid.

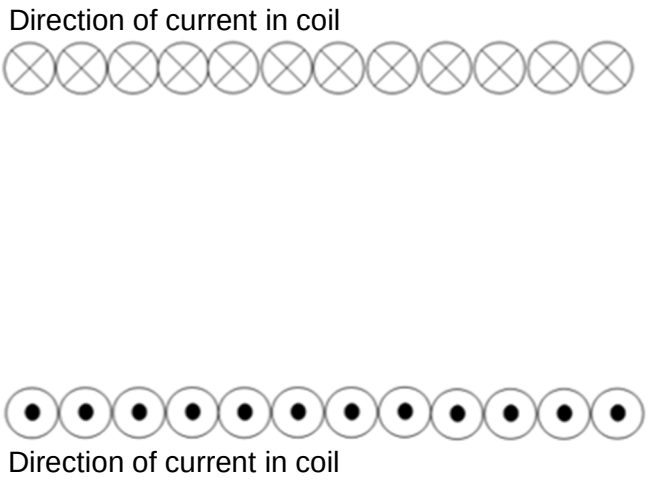


Fig. 4.1 [2]

(b) A proton, travelling in a vacuum at a speed of 4.5×10^6 m s^{-1}, enters a region of uniform magnetic field of flux density 0.12 T. The path of the proton in the field is a circular arc as shown in Fig. 4.2.

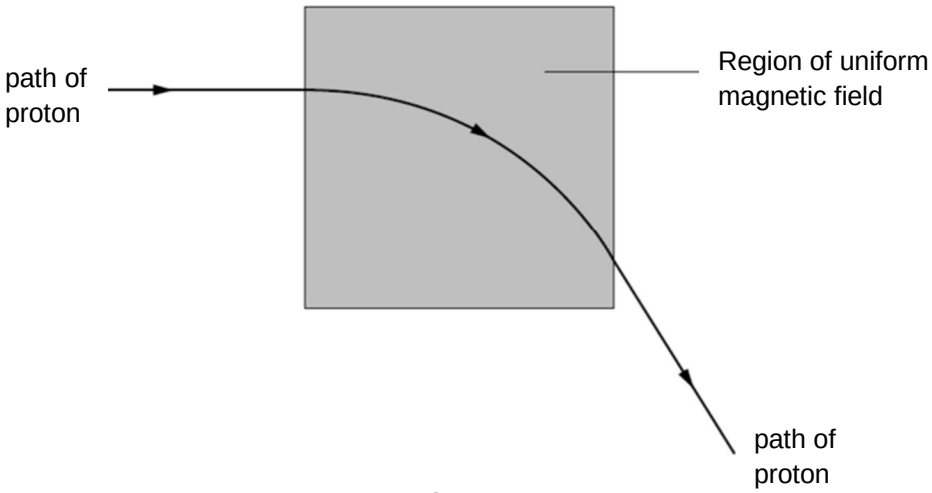


Fig. 4.2

(i) State the direction of the magnetic field.

……. [1]

(ii) Calculate the radius of the path of the proton in the magnetic field.

radius = …… m [2]

(c) A uniform electric field is now applied in the same region as the uniform magnetic field such that the protons will pass through the region undeflected.

(i) On Fig. 4.2, draw an arrow to represent the direction of the electric field produced in the region. [1]

(ii) With reference to Newton's laws, explain your answer in **(c)(i)**.

……..

……..

……..

……..

…….. [3]

(iii) Determine the electric field strength produced in the region.

electric field strength = …… N C^{-1} [2]

[Total: 12]

5 Bismuth – 214 ($^{214}_{83}$Bi) has an unusual decay pattern. Sometimes it decays by α emission into Thallium (Tl) and sometimes by β emission into Polonium (Po).

(a) **(i)** Write down two nuclear equations to represent the two decays of $^{214}_{83}$Bi.

1. ……

2. …… [2]

(ii) The rest masses of the three particles involved in the α decay of $^{214}_{83}$Bi are given below.

particle	rest mass / *u*
Bi (Bismuth)	213.9987
Tl (Thallium)	209.9901
He (Helium)	4.0015

Calculate the energy released in this decay.

energy released = …… J [3]

(iii) The two decay patterns of $^{214}_{83}$Bi each give rise to gamma ray photons. Suggest why each of these photons has different energy.

……

……

…… [1]

(b) A sample of $^{214}_{83}$Bi has mass of 2.0 μg at time $t = 0$.

(i) Show that the sample contains approximately 5.6×10^{15} atoms.

[1]

(ii) Calculate the number of radioactive nuclei that remains after 2.7 half-lives.

number of radioactive nuclei = …… [2]

(iii) Explain how ionising radiation such as those emitted by $^{214}_{83}$Bi can cause damage to living cells.

……

……

……

…… [2]

[Total: 11]

Section B

Answer **any ONE** question in the spaces provided.

6 An engineer wants to drive a steel pile of mass of 2.0×10^3 kg vertically into a soft riverbed. To do this, the engineer raises a hammer of mass 1.0×10^3 kg through a height of 5.0 m using a crane and releases it, so that the hammer falls freely onto the top of the steel pile as shown in Fig. 6.1. Upon collision, the hammer sticks to the steel pile.

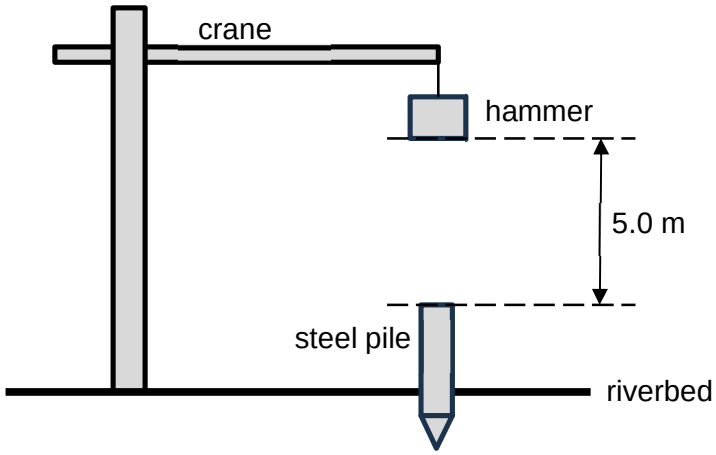


Fig. 6.1

(a) **(i)** Describe the energy changes that take place when the steel pile is driven into the riverbed.

……

……

……

……

……

…… [3]

(ii) Calculate the initial gravitational potential energy of the hammer.

gravitational potential energy = …… J [2]

(iii) Calculate the speed of the hammer just before it strikes the pile.

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

(b) **(i)** State the *principle of conservation of momentum.*

.....

..... [2]

(ii) Fig. 6.2 shows the variation with time of the force exerted by the hammer on the pile.

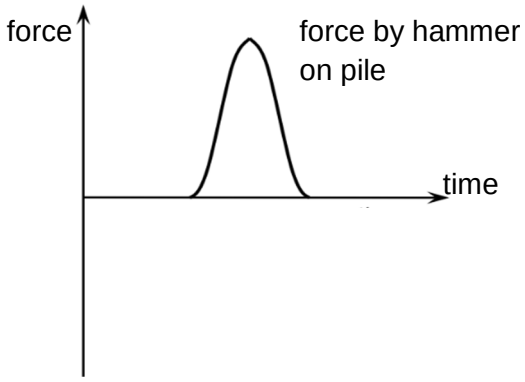


Fig. 6.2

On Fig. 6.2, add a graph to represent the force that the pile exerts on the hammer. Explain how your graph is consistent with the principle of conservation of momentum.

.....

.....

.....

.....

.....

..... [4]

(iii) Calculate the velocity of the hammer and the pile after the collision

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

(iv) Using your answers in **(a)(iii)** and **(b)(iii)**, explain whether the collision is elastic or inelastic.

.....

..... [2]

(c) **(i)** Given that the hammer-pile system is driven 8.1 mm into the riverbed.

Calculate the force that the riverbed exerts on the hammer-pile system.

force = ... N [2]

(ii) State an assumption for your answer in **(c)(i)**.

.....

..... [1]

[Total: 20 marks]

7 Two identical filament lamps, each of resistance 15 Ω and a thermistor of resistance R_T are connected to a power supply with internal resistance r as shown in Fig. 7.1.

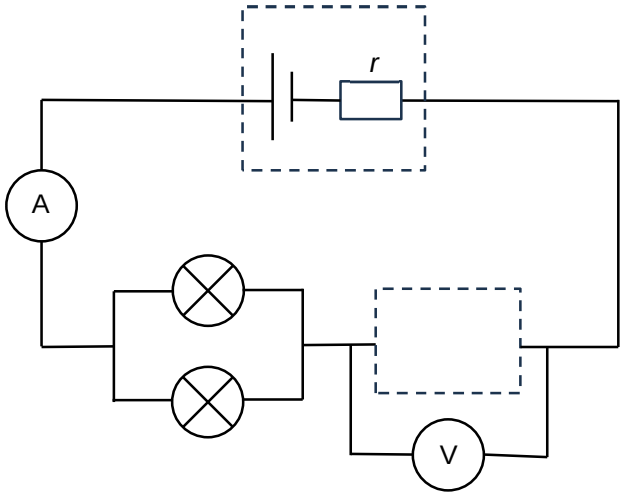


Fig. 7.1

(a) Complete Fig. 7.1, by drawing the symbol for the thermistor. [1]

(b) **(i)** Explain what is meant by an *electric current*.

……

…… [1]

(ii) Distinguish between *electromotive force* (e.m.f.) and *potential difference*.

……

…… [1]

(c) **(i)** The thermistor in Fig. 7.1 is being heated. Explain how this affects the brightness of the filament lamps.

……

……

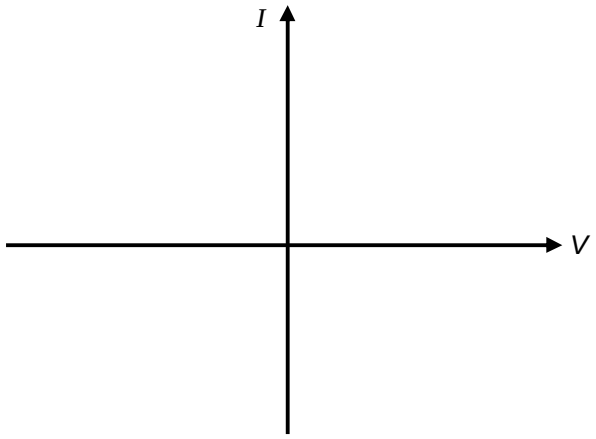
……

……

……

…… [3]

(ii) On Fig. 7.2, sketch the *I*-*V* characteristics of a filament lamp.



[1]

Fig. 7.2

(iii) Explain the shape of the graph for your answer in **(c)(ii)**.

……

……

……

……

…… [3]

(d) At a particular temperature T_1, the readings in the voltmeter and ammeter are 6.53 V and 725 mA respectively. At another temperature T_2, the readings in the voltmeter and ammeter are 7.37 V and 614 mA respectively.

(i) Determine the resistance of the thermistor at temperature T_1.

resistance of thermistor = …… Ω [2]

(ii) Determine the e.m.f. of the cell and its internal resistance *r*.

e.m.f. = …… V

r = …… Ω [4]

(iii) Determine the power dissipated in the filament lamp at temperature T_2.

power dissipated = …… W [2]

(e) The filament in the lamp has a resistivity 7.9×10^{-7} Ω m and diameter 6.0×10^{-5} m.

Calculate the length of the filament in the lamp.

length = …… m [2]

[Total: 20]