Name:		Centre/Index Number:		Class:	

DUNMAN HIGH SCHOOL
Preliminary Examination
Year 6

H2 PHYSICS

9749/03

Paper 3 Longer Structured Questions

26 September 2025

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.

Section B

Answer any **one** question.

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	6
2	8
3	6
4	8
5	12
6	11
7	9
Section B (circle attempted)	
8 / 9	20
s.f.	-1
Total	80

This document consists of **26** printed pages and **2** blank pages

Data

speed of light in free space,	c =	3.00×10^{8} m s^{-1}
permeability of free space,	μ_o =	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o =	8.85×10^{-12} F m^{-1}
elementary charge,	e =	1.60×10^{-19} C
the Planck constant,	h =	6.63×10^{-34} J s
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
molar gas constant,	R =	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A =	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k =	1.38×10^{-23} J K^{-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	=	$u^2 + 2as$
work done on/by a gas,	W	=	$p\Delta V$
hydrostatic pressure,	p	=	ρgh
gravitational potential,	ϕ	=	$-Gm/r$
temperature,	T/K	=	T/°C + 273.15
pressure of an ideal gas,	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule,	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.,	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.,	v	=	$v_0 \cos \omega t$
		=	$\pm\omega\sqrt{x_o^2 - x^2}$
electric current,	I	=	$Anvq$
resistors in series,	R	=	$R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential,	V	=	$\frac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage,	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire,	B	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil,	B	=	$\frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid,	B	=	$\mu_0 nI$
radioactive decay,	x	=	$x_0 \exp(-\lambda t)$
decay constant,	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

Section A

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

1 **(a)** Define gravitational field strength at a point.

…………………………………………………………………………………………………

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

(b) From Newton's Law of gravitation and the definition of gravitational field strength, show that the gravitational field strength due to a point mass is given by

$$g = \frac{GM}{r^2}$$

where G is the gravitational constant, M is the mass of the point mass, and r is the distance from the point mass.

[2]

(c) By reference to the lines of gravitational force near to the surface of the Earth, explain why the gravitational field strength g close to the Earth's surface is approximately constant.

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…………………………………………………………………………………………………

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

[Total: 6]

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

………………………………………………………………………………………………

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

(b) A ball of mass 65 g hits a wall with a velocity of 5.2 m s^{-1} perpendicular to the wall. The ball rebounds perpendicularly from the wall with a speed of 3.7 m s^{-1}. The contact time of the ball with the wall is 7.5 ms.

Calculate, for the ball hitting the wall,

(i) the change in momentum,

change in momentum = ………………………………… N s [2]

(ii) the magnitude of the average force.

average force = ………………………………… N [1]

(c) **(i)** For the collision in **(b)** between the ball and the wall, state how the following apply:

1. Newton's third law,

………………………………………………………………………………………

……………………………………………………………………………………… [2]

2. the law of conservation of momentum.

………………………………………………………………………………………

……………………………………………………………………………………… [1]

(ii) State, with a reason, whether the collision is elastic or inelastic.

……………………………………………………………………………………

…………………………………………………………………………………… [1]

[Total: 8]

3 **(a)** State what is meant by the *moment of a force*.

……………………………………………………………………………………

…………………………………………………………………………………… [1]

(b) A traffic light hangs from a uniform metal pole AB, freely pivoted at point A, as shown in Fig. 3.1. The pole is 7.5 m long and has a mass of 8.0 kg. The mass of the traffic light is 12.0 kg.

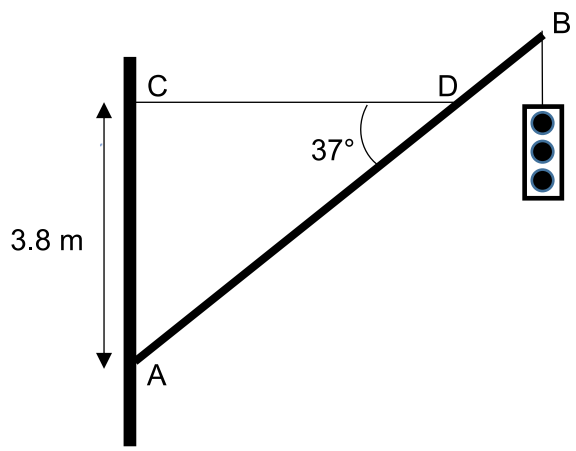

Fig. 3.1

(i) Determine the tension in the horizontal cable CD. Assume the mass of cable CD is negligible.

tension = ………………………………… N [2]

(ii) Determine the force exerted on the metal pole at pivot A.

force = …………………………………. N

direction: ………………………………………………………… [3]

[Total: 6]

4 **(a)** In a space, such as a swimming pool enclosure, water at 30 °C and water vapour, also at 30 °C coexist.

(i) State what is meant by *internal energy* of a system.

....

.... [1]

(ii) With reference to your answer in **(a)(i)**, compare the internal energy per unit mass of water and water vapour at the same temperature.

....

....

....

.... [2]

(b) A helium balloon containing 15000 m^3 of helium at a temperature of 288 K was launched from sea level until it reaches an altitude of 32.0 km. Data concerning atmospheric conditions are given in table 4.1.

Table 4.1

	sea level altitude = 0	equilibrium altitude = 32.0 km
pressure of helium	101 kPa	0.890 kPa
temperature	288 K	228 K
density of air	1.23 kg m^{-3}	0.0134 kg m^{-3}

Assuming that the helium gas behaves as an ideal gas, calculate

(i) the volume of helium at an altitude of 32.0 km,

volume of helium = ... m^3 [2]

(ii) the average translational kinetic energy of one helium atom in the balloon when it is at an altitude of 32.0 km,

average kinetic energy = …………………………………. J [1]

(iii) the change in internal energy of the balloon.

change in internal energy = ………………………………….. J [2]

[Total: 8]

5 **(a)** Low-pressure vapour in a lamp emits monochromatic light that is not coherent.

(i) State what is meant by *coherent* light.

....

.... [1]

(ii) Explain, by reference to the mechanism by which the vapour produces light, why the emitted light is not coherent.

....

....

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....

....

.... [3]

(b) Coherent light of wavelength 590 nm is incident normally on a double slit, as shown in Fig. 5.1.

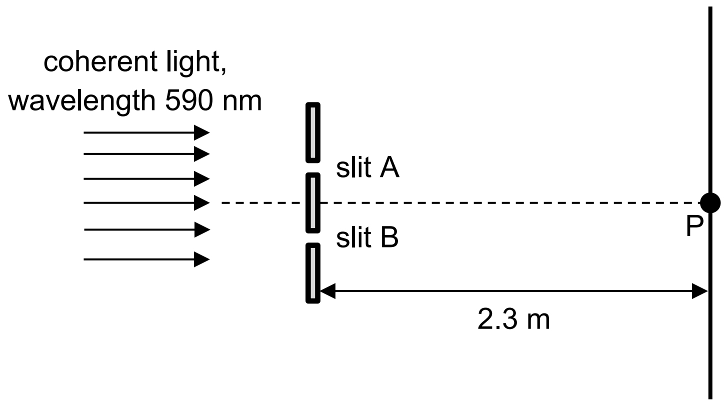

Fig. 5.1

The separation of the slits A and B in the double slit arrangement is 1.2 mm.

Interference fringes are observed on a screen placed parallel to the plane of the double slit and 2.3 m from it.

Assume that, for the fringes near point P on the screen, the light reaching the screen from slit A alone has intensity I and that from slit B alone has intensity $\frac{1}{3}I$.

(i) Apart from coherence, state two other conditions required for two-source interference fringes to be observed.

1. ……………………………………………………………………………………

……………………………………………………………………………………

2. ……………………………………………………………………………………

…………………………………………………………………………………… [2]

(ii) Determine the separation of the bright fringes.

separation = …………………………………. m [2]

(iii) Point P on the screen is equidistant from the two slits A and B.

Determine the intensity, in terms of I, of a dark fringe near P.

intensity = …………………………………. I [4]

[Total: 12]

6 **(a)** A small coil C has 64 turns and cross-sectional area 0.71 cm^2. The coil is placed inside a solenoid as shown in Fig. 6.1.

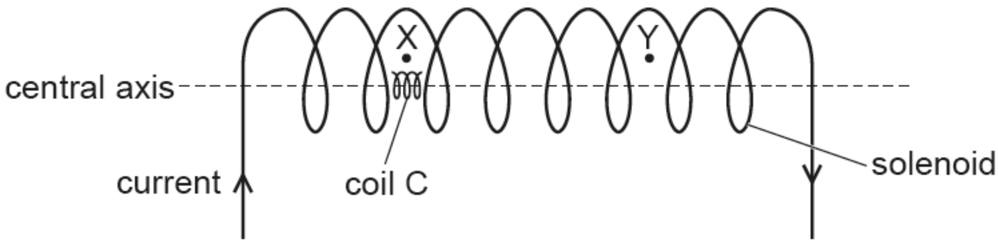

Fig. 6.1

The centre of coil C is on the central axis of the solenoid.

(i) There is a constant current in the solenoid.

Coil C is moved through the solenoid from position X to position Y.

On Fig. 6.2, sketch a line to show the variation of the magnetic flux linkage in coil C with position as it moves from X to Y.

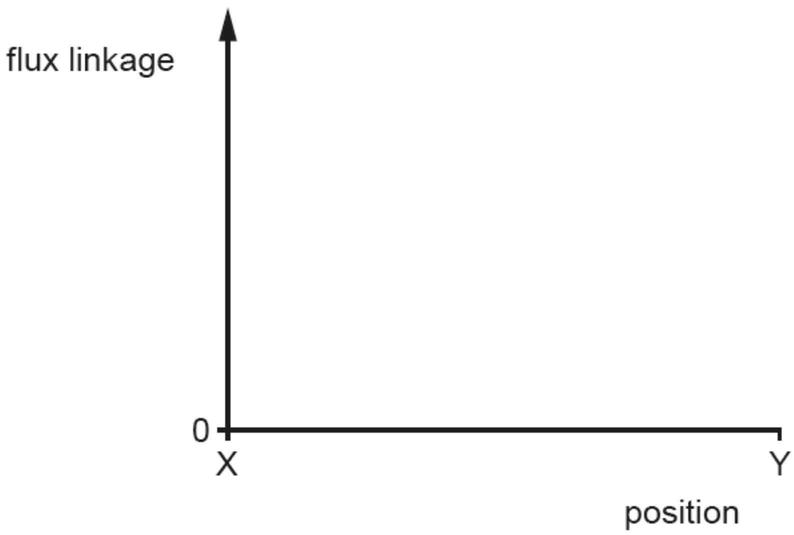

Fig. 6.2 [1]

(ii) Explain the shape of your line in **(a)(i)**.

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

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

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

(iii) Coil C is now held stationary at X. The current in the solenoid varies so that the magnetic flux density B at X varies from time 0 to time 4*t* as shown in Fig. 6.3.

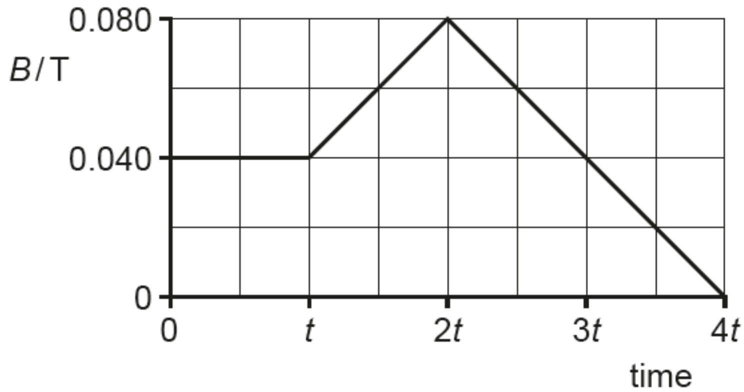

Fig. 6.3

Calculate the maximum magnetic flux linkage in coil C.

maximum flux linkage = ………………………………… Wb [2]

(iv) On Fig. 6.4, sketch a line to show the induced electromotive force (e.m.f.) *E* in coil C from time 0 to time 4*t*.

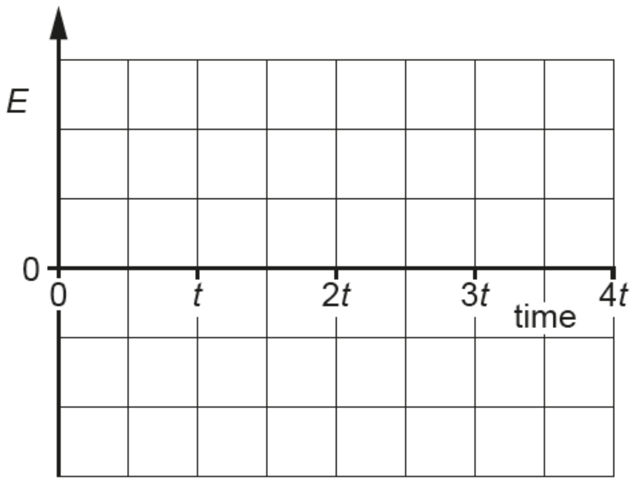

Fig. 6.4 [3]

(b) A metal spring rests on a smooth table. The turns of the spring are equally spaced. The ends of the spring are connected to a d.c. power supply, as shown in Fig. 6.5.

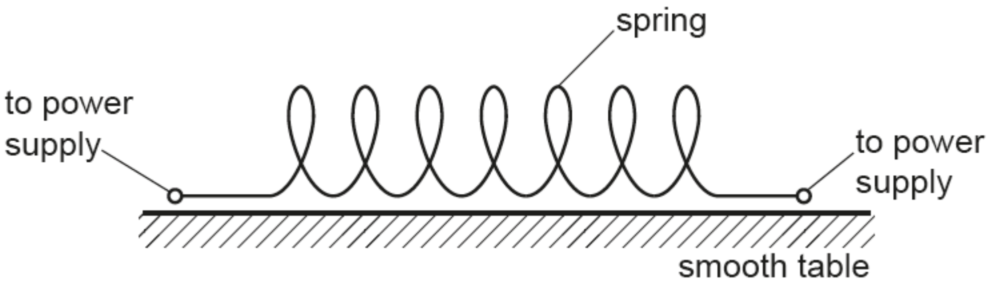

Fig. 6.5

The spring is connected to the d.c. power supply using flexible leads. The spring is not under tension.

With reference to magnetic fields, describe and explain the change in the distance between the turns of the spring when the power supply is first switched on.

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

[Total: 11]

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7 **(a)** State what is meant by the *frequency of an alternating current*.

....

....

.... [1]

(b) An alternating current I in a resistor of resistance 680 Ω varies with time t according to

$$I = 3.5\sin(40\pi t)$$

where I is in A and t is in s.

(i) Show that the period of the alternating current is 50 ms.

[1]

(ii) On Fig. 7.1, sketch the variation of I with t between t = 0 and t = 100 ms.

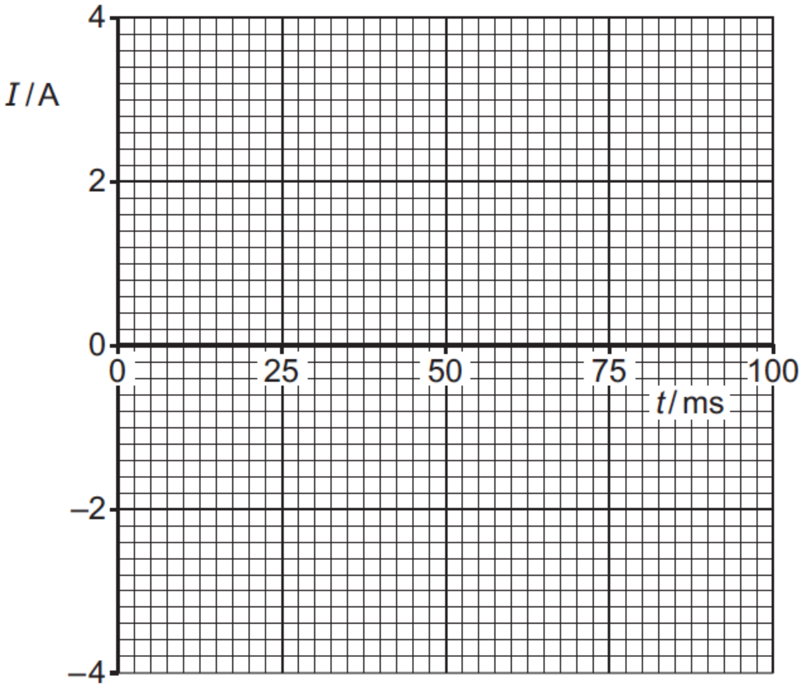


Fig. 7.1

[3]

(iii) Determine the root-mean-square (r.m.s.) current in the resistor.

r.m.s current = ………………………………… A [1]

(c) Use data from **(b)**, including your answer in **(b)(iii)**, show by calculation that the mean power in the 680 Ω resistor is half of the peak power.

[3]

[Total: 9]

Section B

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

8 **(a)** The Earth may be assumed to be a uniform sphere of radius of 6370 km and mass of 5.98×10^{24} kg. An object of mass 1.00 kg is placed on the Equator.

Calculate

(i) the centripetal acceleration of the object,

centripetal acceleration = ………………………………… m s^{-2} [2]

(ii) the gravitational force exerted on the object by the Earth.

gravitational force = ………………………………… N [2]

(b) The object in **(a)** is suspended from a spring balance fixed to the ceiling of a laboratory, as shown in Fig. 8.1. There are two forces acting on the object, namely the gravitational force $\boldsymbol{F_G}$ by the Earth and the support force $\boldsymbol{F_s}$ by the spring.

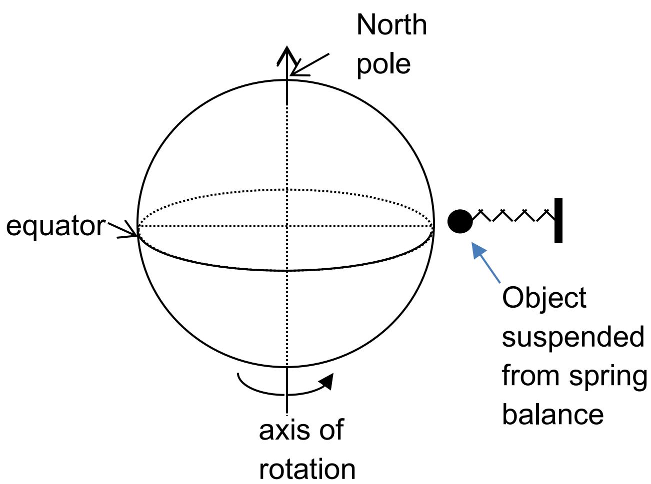


Fig. 8.1

(i) Draw a labelled force diagram to show the forces on the object.

[2]

(ii) Using your answers to **(a)(i)** and **(a)(ii)**, calculate the magnitude of $\boldsymbol{F_s}$.

$\boldsymbol{F_s}$ = …………………………………. N [2]

(iii) A student, situated at the Equator, releases a ball from rest in a vacuum and measures its acceleration towards the Earth's surface. He then states that this acceleration is 'the acceleration due to gravity'.

Comment on his statement.

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

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

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

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

(c) An elastic rope is attached to a man on one end and to a bridge on the other end. The man has a mass of 80.0 kg while the rope has a natural length of 25.0 m and an elastic constant of 120 N m^{-1}. The man steps off the bridge and falls vertically downwards from rest. Assume that air resistance acting on the man is negligible.

(i) Explain why the person has maximum speed when the tension in the elastic rope is equal to his weight.

....

....

....

....

....

.... [2]

(ii) Determine the maximum speed of the man after he steps off the bridge.

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

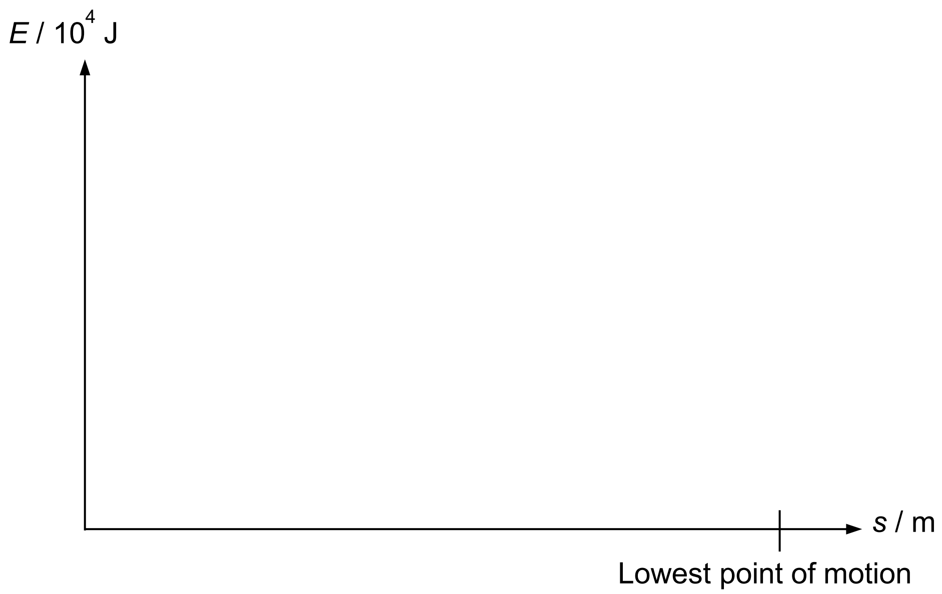
(iii) Calculate the extension of the elastic rope when the man is at the lowest point of his motion.

extension = ... m [2]

(iv) Sketch on Fig. 8.2 three well-labelled graphs for the variation with downward displacement s of

1. the gravitational potential energy of the man, (Label as **G**)
2. the elastic potential energy stored in the rope and (Label as **E**)
3. the kinetic energy of the man. (Label as **K**)

Assume that gravitational potential energy of the man is zero at the lowest point of the man's motion. Take s = 0 m as the start point of motion.



[3]

Fig. 8.2

[Total: 20]

9 A battery of electromotive force (e.m.f.) *E* and internal resistance *r* is connected in series to a variable resistor *R* which has resistance between 0 Ω and 10 Ω, as shown in Fig. 9.1. The ammeter and the voltmeter are both ideal.

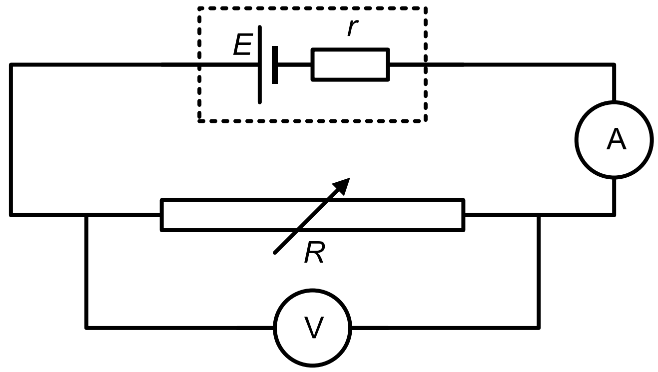


Fig. 9.1

Fig. 9.2 shows the variation of potential difference (p.d.) *V* across the variable resistor with the current *I* flowing through it.

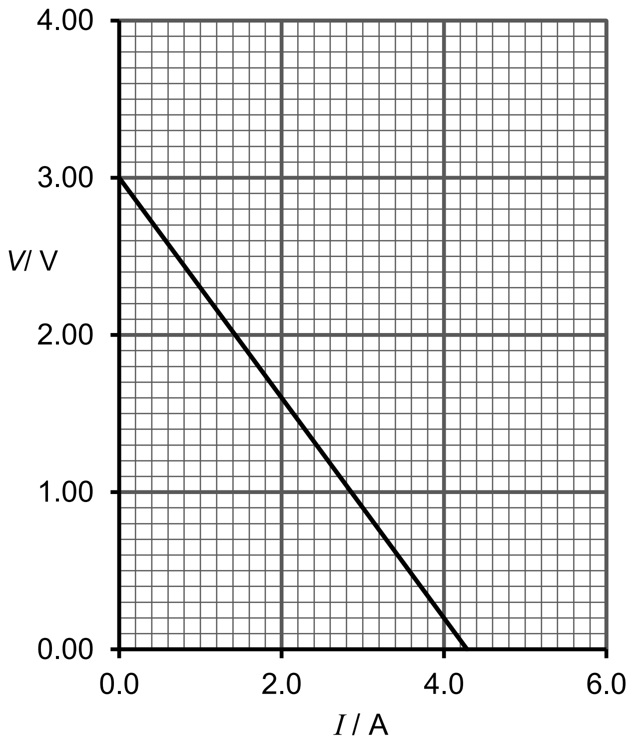


Fig. 9.2

(a) State how the graph in Fig. 9.2 can be obtained using the electrical circuit in Fig. 9.1.

....

.... [1]

(b) Comment on the following statements:

(i) "In Fig. 9.2, since the p.d. V across the variable resistor is not proportional to the current I flowing through it, the variable resistor does not obey Ohm's law."

…………………………………………………………………………………………

…………………………………………………………………………………………

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

(ii) "The battery supplies electrons to the circuit to produce current."

…………………………………………………………………………………………

…………………………………………………………………………………………

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

(c) Using Fig. 9.2,

(i) deduce the e.m.f. E of the battery,

E = ………………………………… V [1]

(ii) determine the internal resistance r of the battery.

r = ………………………………… Ω [2]

(d) **(i)** Using your answers to **(c)**, deduce the p.d. *V* across the variable resistor when the power delivered to it is maximum.

V = ………………………………….. V [1]

(ii) Calculate the maximum power delivered to the variable resistor.

maximum power delivered = ………………………………….. W [2]

(iii) On Fig. 9.3, sketch the variation of power *P* delivered to the variable resistor when the p.d. *V* across it is varied.

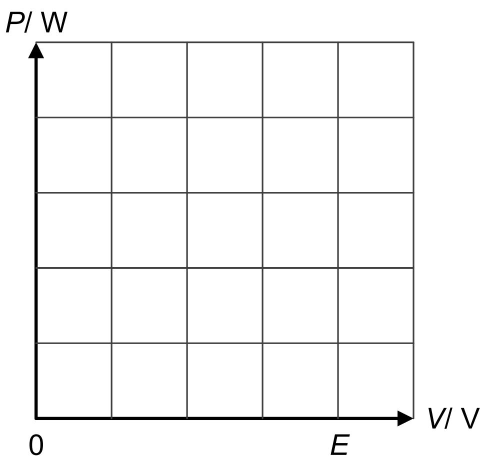


Fig. 9.3

[2]

(e) **(i)** Determine or deduce the efficiency of the circuit when the power delivered is maximum.

efficiency = ………………………………… % [1]

(ii) Determine or deduce the value of *R* to achieve maximum efficiency.

R = ………………………………… Ω [1]

(iii) A student designs a sound system that is analogous to the electrical circuit in Fig. 9.1. The e.m.f. source and the variable resistor represent the amplifier and the loudspeaker, respectively.

Explain whether a high-efficiency or high-power transfer is more desirable in this sound system.

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………………… [2]

(f) To calculate the e.m.f. E' of an unknown cell, a 2.00 V driver cell of negligible internal resistance is connected to a 4.00 Ω resistor and a metre-wire PQ of resistance 6.00 Ω, as shown in Fig. 9.4.

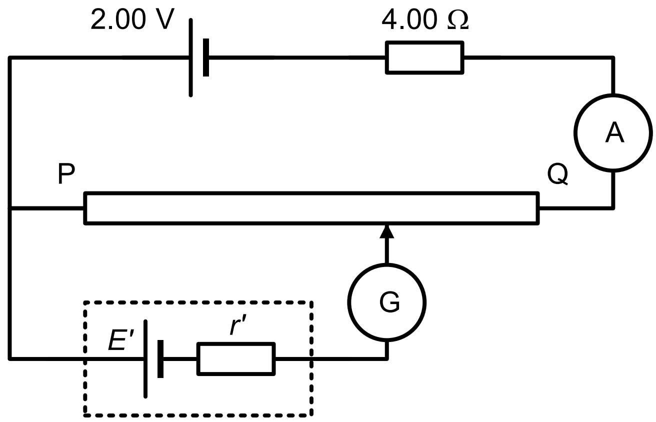


Fig. 9.4

(i) If the balance point is 0.600 m from P, determine the e.m.f. E' of the unknown cell.

E' = ... V [2]

(ii) By drawing an additional electrical component on Fig. 9.4, show how the circuit can be modified to determine the internal resistance r' of the unknown cell. [1]

(iii) If the 2.00 V driver cell is rated at 2000 mAh (milli-ampere hour), calculate the maximum duration that it can be used to power a device which draws 0.080 A of current.

maximum duration = …………………………………. h [2]

[Total: 20]

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