H2 PHYSICS

Exam papers with worked solutions

(Selected from Top JC)

SET C

PAPER 3

Compiled by

THE PHYSICS CAFE

READ THESE INSTRUCTIONS FIRST

Candidates answer on the Question Paper.

No Additional Material are required.

Write your name, class index number and class at the top of this page and on all the work you hand in.

Write in dark blue or black pen on both sides of the paper.

You may use a soft pencil for any diagrams, graphs or rough working.

Do not use staples, paper clips, highlighters, glue or correction fluid or correction tape.

Section A
Answer **all** questions.

Section B
Answer any **Two** questions.

You are advised to spend about one hour on each section.

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 of part of question.

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}
			$(1/(36\pi)) \times 10^{-9}$ 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,	$p = \rho gh$
gravitational potential,	$\phi = -Gm/r$
displacement of particle in s.h.m.,	$x = x_o \sin \omega t$
velocity of particle in s.h.m.,	$v = v_o \cos \omega t$
	$= \pm \omega \sqrt{x_o^2 - x^2}$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$
electrical potential,	$V = Q/(4\pi\varepsilon_o r)$
alternating current /voltage,	$x = x_o \sin \omega t$
transmission coefficient,	$T = \exp(-2kd)$
	where $k = \sqrt{\frac{8\pi^2 m(U-E)}{h^2}}$
radioactive decay,	$x = x_o \exp(-\lambda t)$
decay constant,	$\lambda = \frac{0.693}{t_{½}}$

Section A
Answer **All** questions in this Section.

1 The moon orbits about the Earth in a circular orbit of radius 3.82×10^{8} m with a period of 2.36×10^{6} s. The mass of the Moon is 7.35×10^{22} kg.

(a) Deduce the angular velocity of the Moon. [2]

(b) Calculate the acceleration of the Moon. [2]

(c) Explain why the acceleration in (b) does not increase the speed of the moon. [2]

(d) Calculate the gravitational force which the Earth exerts on the Moon. [1]

(e) Explain why the moon does not move towards Earth and clash onto Earth despite the gravitational force in (d). [3]

2 A rectangular coil is rotating about an axis between two magnets with uniform angular velocity ω due to action of external applied force. The uniform magnetic field B between the two magnets is 0.8 T. The coil is rotating at 50 revolutions per second. The number of turns N of the coil is 30. The cross sectional area A of the coil is 2.5 m^2. A current is found going through the resistor of resistance R of 40 Ω. Fig. 2.1 shows the instant when the plane of the coil is in a horizontal position.

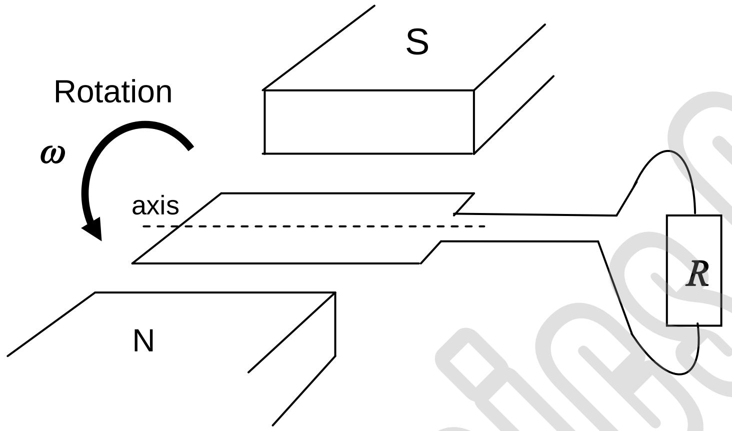


Fig. 2.1

(a) Explain how the current flowing through the resistor R is formed. [2]

(b) In Fig. 2.1, draw arrows in the circuit to indicate the direction of flow of current. Explain how you arrive at the answer. [2]

(c) Draw a well labeled graph to show the variation with time of the current through the resistor, with all workings clearly shown. Take Fig. 2.1 as the initial condition (t = 0 s). [4]

(d) Calculate the mean power passing through the resistor R. [2]

3 **(a)** A potentiometer is used to measure the electromotive force (e.m.f.) of a solar cell, as shown in Fig. 3.1. The potentiometer wire is 1.000 m long and has a resistance of 10.0 Ω. The 6.0 V battery has negligible internal resistance.

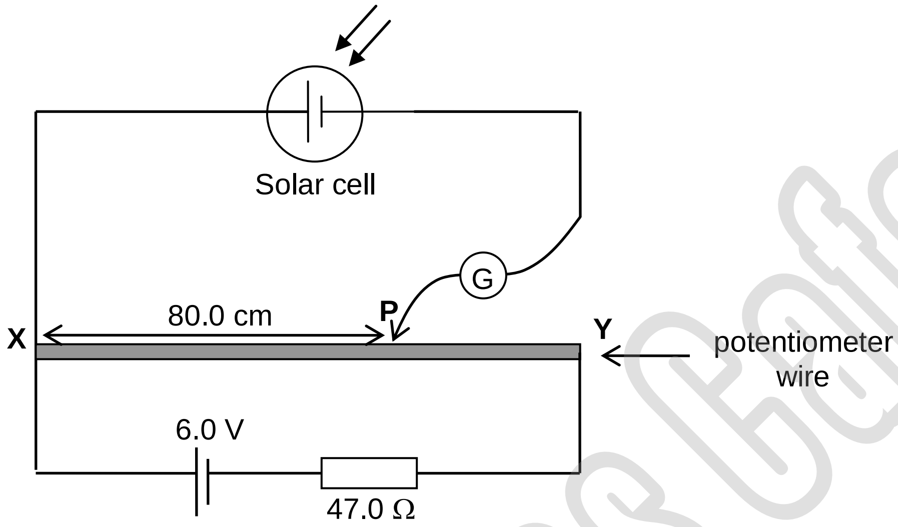


Fig. 3.1

(i) Define electromotive force (e.m.f.). [1]

(ii) If the galvanometer shows null deflection at point **P**, 80.0 cm from **X**, calculate the e.m.f. of the solar cell. [2]

(iii) Explain why the internal resistance of the solar cell does not have to be taken into account in your calculation for part **(a)(ii)**. [1]

(b) The graph in Fig. 3.2 shows the relationship between current and potential difference of a semi-conductor.

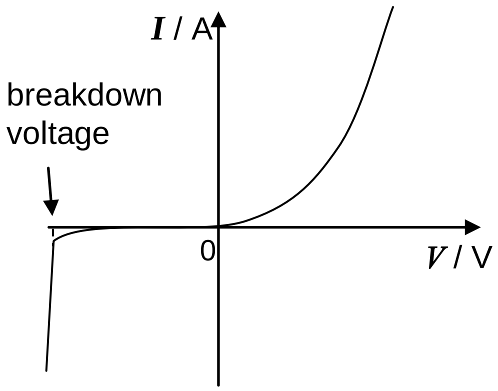


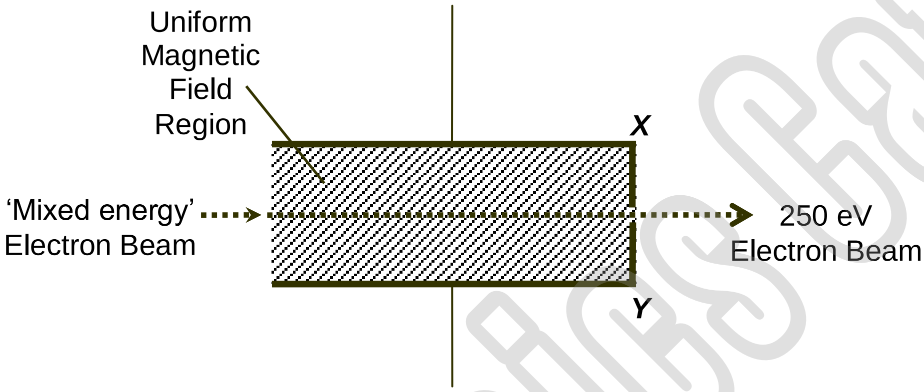
Fig 3.2

(i) With reference to the graph in Fig. 3.2, explain what is meant by *forward bias* and *reversed bias*. Label the regions in the graph in Fig. 3.2 which show forward bias and reversed bias characteristic respectively. [2]

(ii) With reference the graph in Fig. 3.2, explain what is meant by *breakdown voltage*. [1]

(iii) By means of drawing the p-n junction of a semi-conductor together with a cell, explain how *breakdown voltage* occurs. [3]

4 In a particle collision experiment, electrons with a kinetic energy of 250 eV are required. In order to obtain an electron beam with this specific kinetic energy, accelerated electrons are passed through a velocity selector as shown below with plate ***Y*** at a potential +600 V at plate ***X*** at a potential -600 V. The two plates are 2 cm apart.



(a) Define

(i) Electric field strength, and [1]

(ii) Magnetic flux density [1]

(b) Calculate the electric field strength E between the two plates. [2]

(c) Calculate the magnetic flux density $\boldsymbol{B}$. [3]

(d) Determine the direction of the magnetic field with explanation on how you arrive at the answer. [1]

(e) Describe and explain the path of the electron beams if the electrons have kinetic energies greater than 250 eV. [2]

Section B
Answer **TWO** questions in this Section.

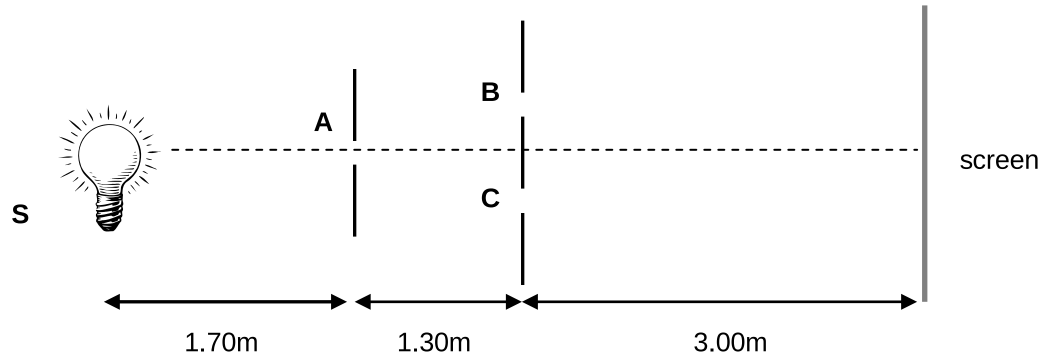
5 (a) State the conditions for establishing a well-defined *stationary wave* using two separate sources. [3]

(b) In a room, sound waves typically bounce off walls with negligible loss of intensity. A subwoofer speaker placed at the centre of a circular room emits continuous sound waves of frequency 60 Hz. A person walking from the centre of the room towards the wall experiences a series of loud and soft sounds.

(i) With the aid of a diagram, explain the variation of loudness of the sound. State any simplifying assumptions you have made. [You may ignore the effects of the ceiling and the floor surfaces.] [4]

(ii) If the speed of sound is 300 m s^{-1}, calculate the frequency of the fluctuation in loudness that a man walking across the room at 1 m s^{-1} from the subwoofer would hear. [3]

(c) The figure below shows a double slit setup used to measure the wavelength of light from a monochromatic neon lamp **S**.



(i) Explain why it is necessary to have Slit **A**. [1]

(ii) The distance of the 5^{th} bright fringe from the central bright fringe is found to be 9.50 mm. Given that the two slits **B** and **C** are 1.00 mm apart, calculate the wavelength of the source. [2]

(iii) State with reason the changes to the fringe pattern with regards to intensity, contrast and fringe separation when each of the following changes is made separately to the setup.

1. Monochromatic light of longer wavelength is used. [2]

2. A thin glass plate is used to cover slit **C**. [2]

3. The intensity of light from one of the two slits is reduced. [3]

6 (a) Figure 6.1 shows the variation with time t of the velocity v of two runners during the first 5 seconds of a 100 m sprint (t = 0 s corresponds to when the gun was shot).

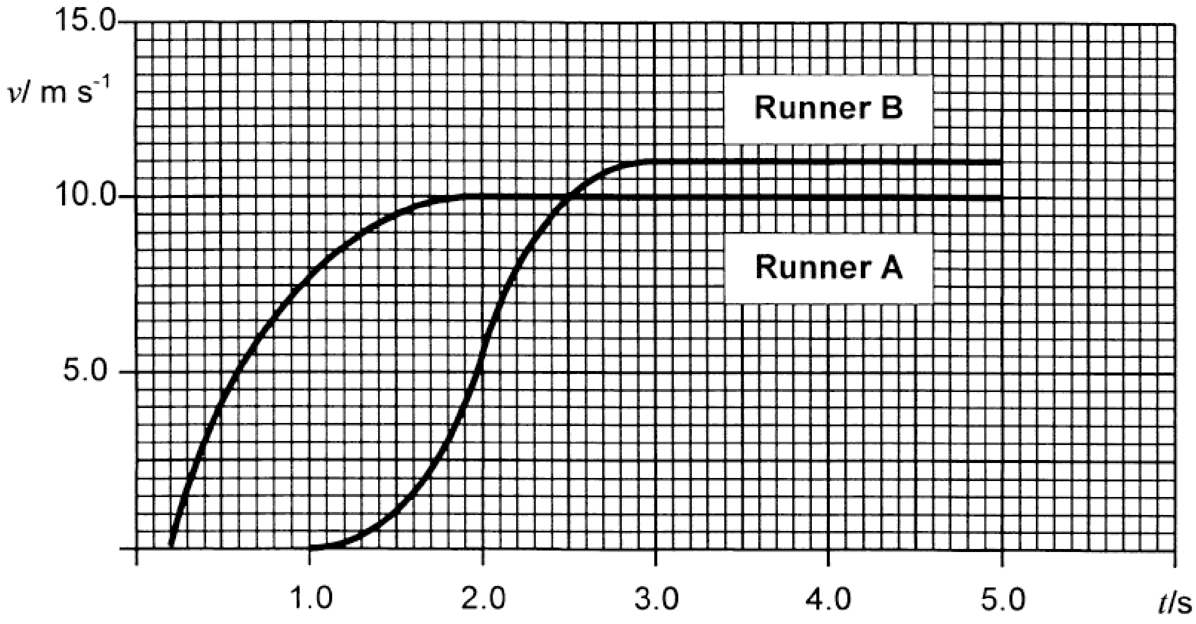


Figure 6.1

(i) State how acceleration can be determined from the velocity-time graph. [1]

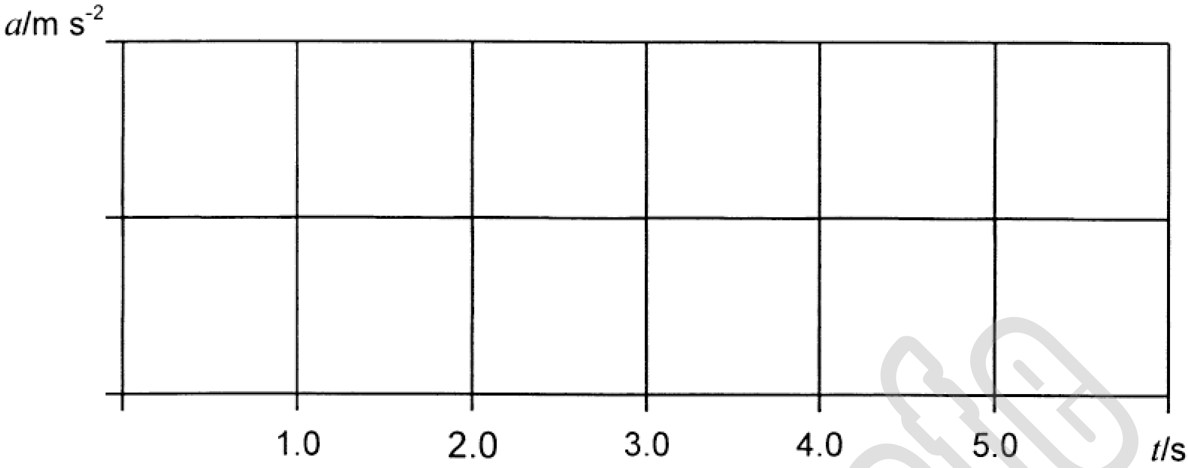


Figure 6.2

(ii) In Figure 6.2, sketch the acceleration-time graph of Runner B. [2]

(iii) State the time when the distance between the two runners was the largest. [1]

(iv) State and explain which runner is ahead at t = 5.0 s. [2]

(b) Figure 6.3 shows a skateboarder descending a ramp.

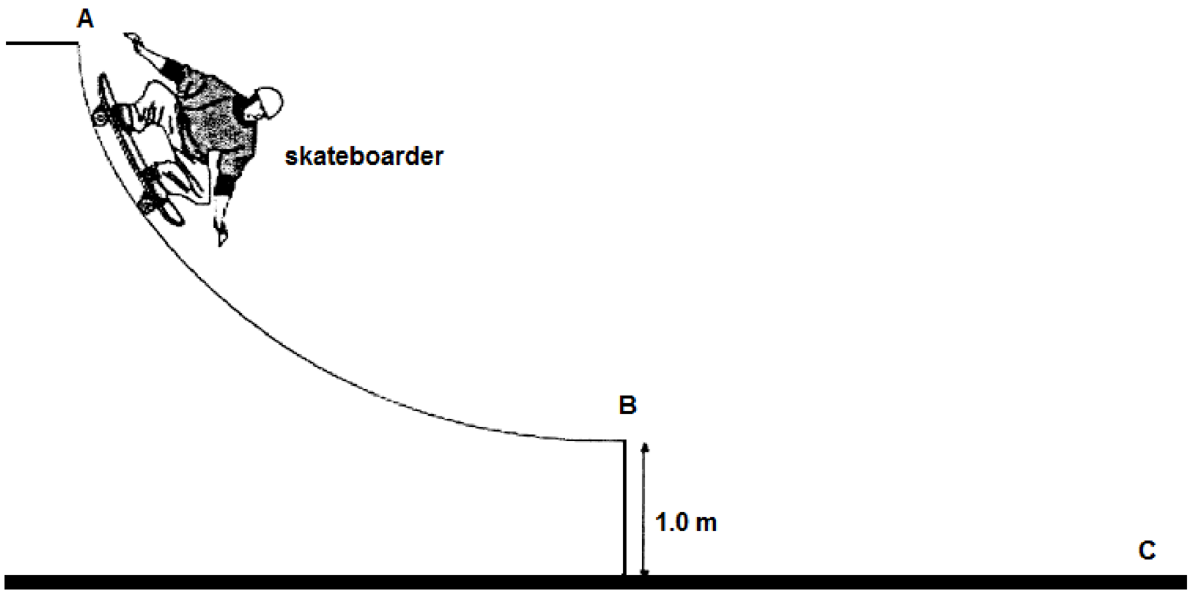


Figure 6.3

The skateboarder starts from rest at the top of the ramp at **A** and leaves the ramp at **B** horizontally with a velocity v.

(i) In going from **A** to **B** the skateboarder's centre of gravity descends a vertical height of 1.5 m. Calculate the horizontal velocity, v, stating an assumption that you make. [2]

(ii) Explain why the acceleration decreases as the skateboarder moves from **A** to **B**. [2]

(iii) After leaving the ramp at **B** the skateboarder lands on the ground at **C** 0.45 s later. Calculate for the skateboarder

1. the horizontal distance travelled between **B** and **C**, [1]

2. the vertical component of the velocity immediately before impact at **C**, [1]

3. the resultant velocity immediately before impact at **C**. [1]

(c) (i) State Archimedes' Principle. [1]

An evening party is in progress in a small swimming pool of a private residence. All the invited guests are gathered together and placed comfortably into a large rubber dinghy. They are having an interesting argument about Archimedes' Principle. Joshua thinks that if all the guests leave the dinghy and float in the pool, the water level will rise. However, Cherie says that it will fall.

(ii) Who is right, or are they both wrong? Explain your answer. [3]

(iii) Is the answer different if the guests are replaced with bricks? Explain your answer. [3]

7 a) (i) Explain the wave-particle duality of matter and the significance of the de Broglie relation. [2]

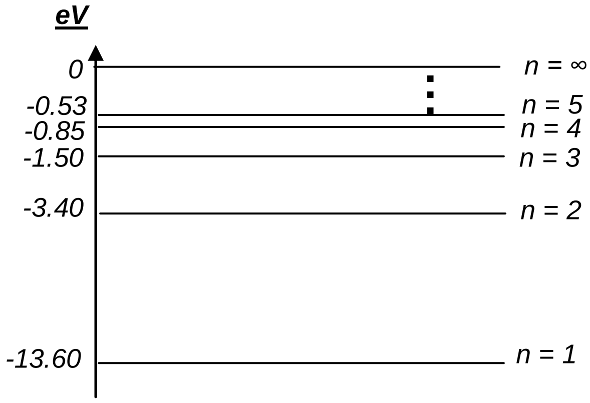
(ii) What is the de Broglie wavelength of a neon atom moving at its r.m.s. speed if the temperature is 30 °C? (Molar mass of neon is 20 g) [4]

b) In a photoelectric experiment, a source of ultra-violet light of wavelength 2.55×10^{-7} m is incident on the electron emitting metal.

(i) Calculate the energy of the ultra-violet light photons in eV. [1]

(ii) A current reading is observed from the ammeter in the circuit. The electric field strength across the plates is increased until the ammeter reading drops to zero. The final electric field strength at this point is 7.5 V m^{-1}. What is the work function of the metal, given that the plates are 50 cm apart? [3]

c) The diagram below shows the possible energy levels of the electron in a hydrogen atom.



(i) Explain the significance of an electron with energy level of 0 eV [1]

(ii) Explain why an atom with the energy levels shown above can produce emission spectral lines [3]

(iii) Describe the appearance of an emission spectrum [1]

(iv) What are the respective maximum wavelengths of photons that electrons at energy levels n =1, n = 2 and n =3 need to absorb to be ionised?

Given that photons in the visible light region have an energy range of between 2.84×10^{-19} to 5.68×10^{-19} J, deduce which of the above three transitions will absorb photons from the visible range. [4]

(v) "The first excitation energy of the cool hydrogen atom is 10.2 eV". If this excitation is caused by electrons, find the minimum speed the electrons need to have. [1]