H2 PHYSICS

Exam papers with worked solutions
(Selected from Top JC)

SET A
PAPER 2

Compiled by

THE PHYSICS CAFE

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST
te your name and PDG on the spaces provided above.
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.

Answer **all** questions.

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.

Data

speed of light in free space,	c = 3.00 x 10^{8} m s^{-1}
permeability of free space,	μ_0 = 4π x 10^{-7} H m^{-1}
permittivity of free space,	ε_0 = 8.85 x 10^{-12} F m^{-1}
	(1/(36π)) x 10^{-9} F m^{-1}
elementary charge,	e = 1.60 x 10^{-19} C
the Planck constant,	h = 6.63 x 10^{-34} J s
unified atomic mass constant,	u = 1.66 x 10^{-27} kg
rest mass of electron,	m_e = 9.11 x 10^{-31} kg
rest mass of proton,	m_p = 1.67 x 10^{-27} kg
molar gas constant,	R = 8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A = 6.02 x 10^{23} mol^{-1}
the Boltzmann constant,	k = 1.38 x 10^{-23} J K^{-1}
gravitational constant,	G = 6.67 x 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,	$\phi = -\frac{Gm}{r}$
displacement of particle in s.h.m.,	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.,	$v = v_0 \cos \omega t$
	$v = \pm\omega\sqrt{x_0^2 - x^2}$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential,	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage,	$x = x_0 \sin \omega t$
transmission coefficient,	$T = exp(-2kd)$
	where $k = \sqrt{\frac{8\pi^2 m(U-E)}{h^2}}$
radioactive decay,	$x = x_0 exp(-\lambda t)$
decay constant,	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

1 The jib on a tower crane is rotating with constant angular velocity about a vertical axis through the centre of the tower as shown in Fig. 1.1. A fixed load is suspended by a light cable from the end of the jib.

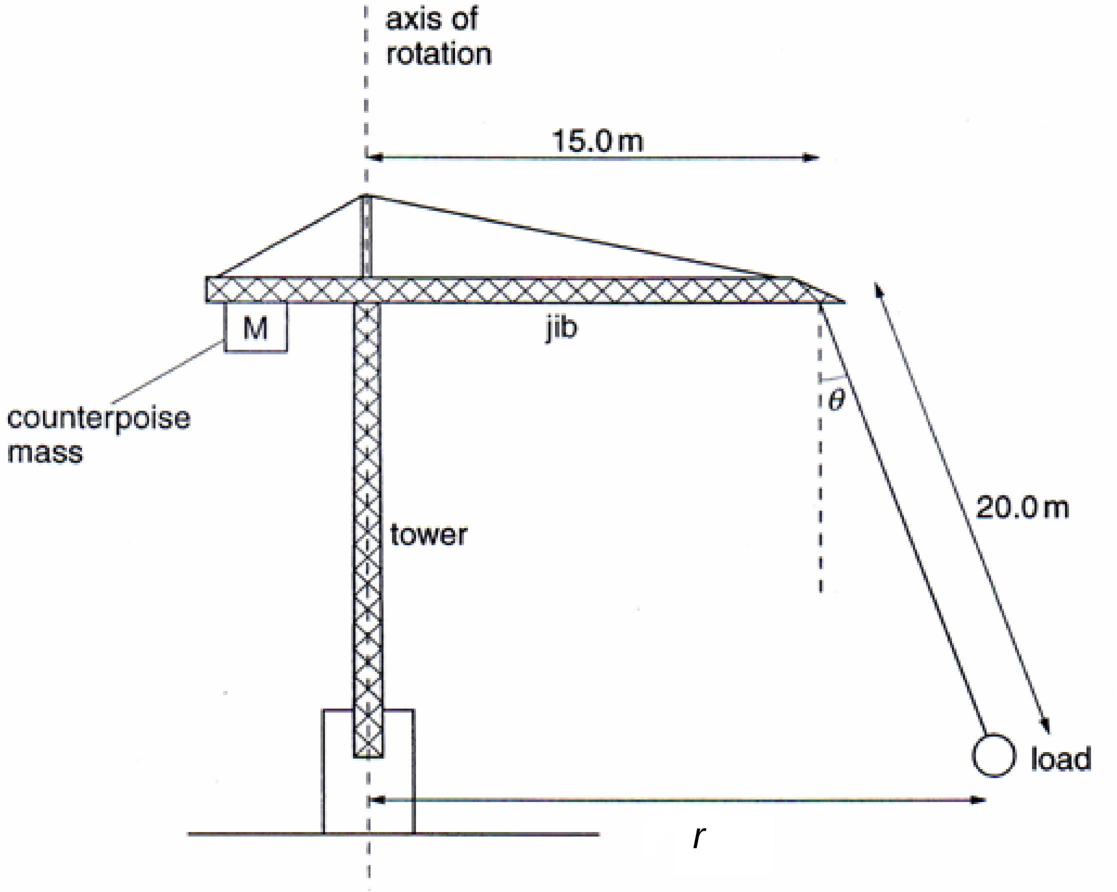

Fig. 1.1

Under these conditions, the load swings away from the axis of rotation so that the cable makes an angle θ with the vertical and the load travels in a horizontal circle of radius r. Forces that the air exerts on the load may be neglected.

(a) State how the vertical equilibrium of the load is maintained.

-- [1]

(b) In order that the crane does not topple, a counterpoise mass M is attached to the jib as shown in Fig. 1.1. Explain why the position of M does not need to be altered as the jib begins to rotate.

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.... [4]

(c) State and explain the work done on the load as the jib is rotating.

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.... [2]

2 Fig. 2.1 shows a basketball player taking a free throw. The ball is thrown with an initial velocity of 8.0 m s^{-1} at an angle of 52.3° to the horizontal. The ball leaves the player's hands at a point which is at a horizontal distance of 4.6 m from the basket and at a height of 1.5 m above the floor. The basket is 3.1 m above the floor.

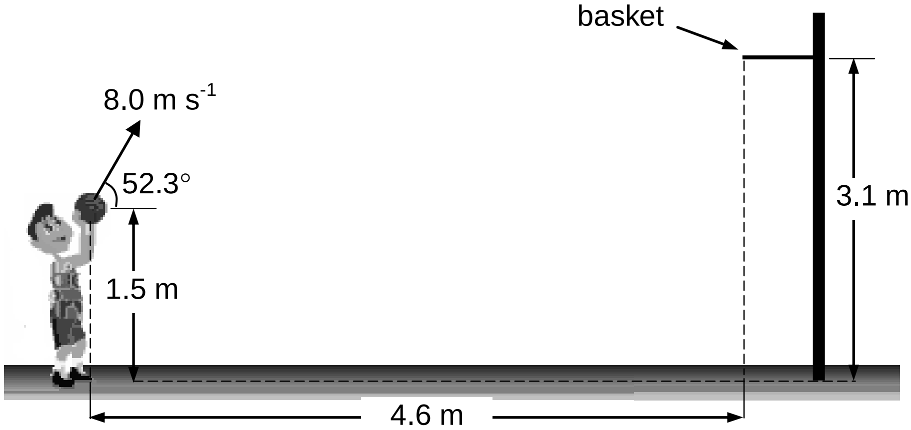

Fig. 2.1

The rules state that the basketball is 0.79 m in circumference and the basket's rim is 0.45 m in diameter.

The ball passes through the basket at the smallest possible angle, θ, without touching the rim as shown in Fig. 2.2.

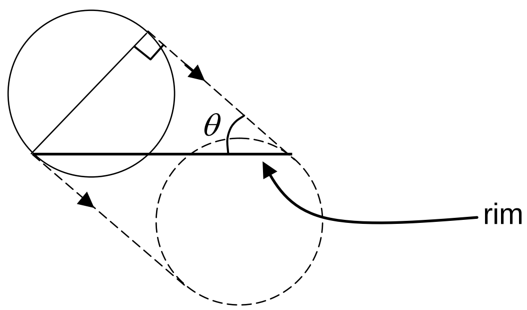

Fig. 2.2

(a) Calculate θ

θ =…………………….. ° [2]

(b) You may assume the velocity of the ball remains constant as it passes through the basket, By reference to Fig. 2.2, calculate

1. the horizontal speed of the ball, and

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

2. the horizontal distance travelled.

horizontal distance =……………………..m [3]

(c) Use your answers to **(b)** to calculate the time the ball passes through the basket.

time =……………………..s [1]

3 **(a)** Define the *tesla*.

-- [1]

(b) A narrow beam of electrons at a speed of 3.2 x 10^7 m s^{-1} travels along a circular path in a uniform magnetic field of flux density, ***B***, as shown in Fig. 3.1.

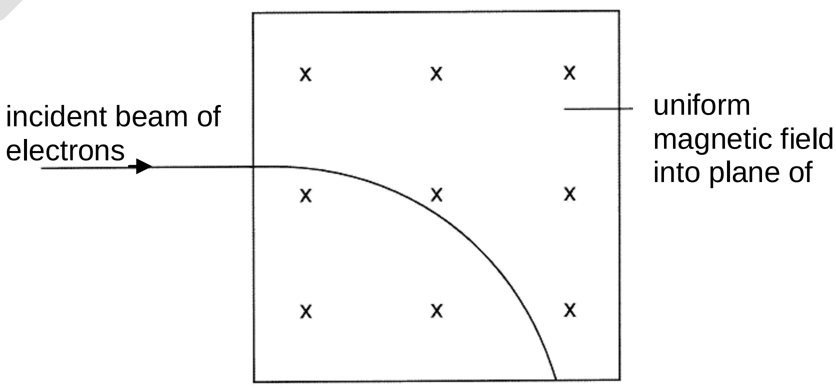

Fig.

4 A network of resistors R is connected between the terminals of a battery of e.m.f. *E* and internal resistance *r*, as shown in Fig. 4.1.

(i) Explain why the path of the beam in the field is circular.

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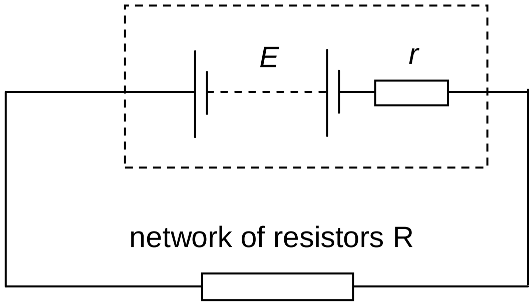
.... [2]



The potential difference across R is *V* and the current in R is *I*.

Fig. 4.1

(ii) When the magnetic flux density is 7.3 mT, the radius of the circular path of the beam in the field is 25 mm. Deduce the charge to mass ratio, e/m, of the electron.

e/m =……………………..C kg^{-1} [3]

(iii) State the effect on the path of the electrons if the magnetic flux density is doubled.

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.... [1]

The variation with potential difference V of the current I is shown in Fig. 4.2.

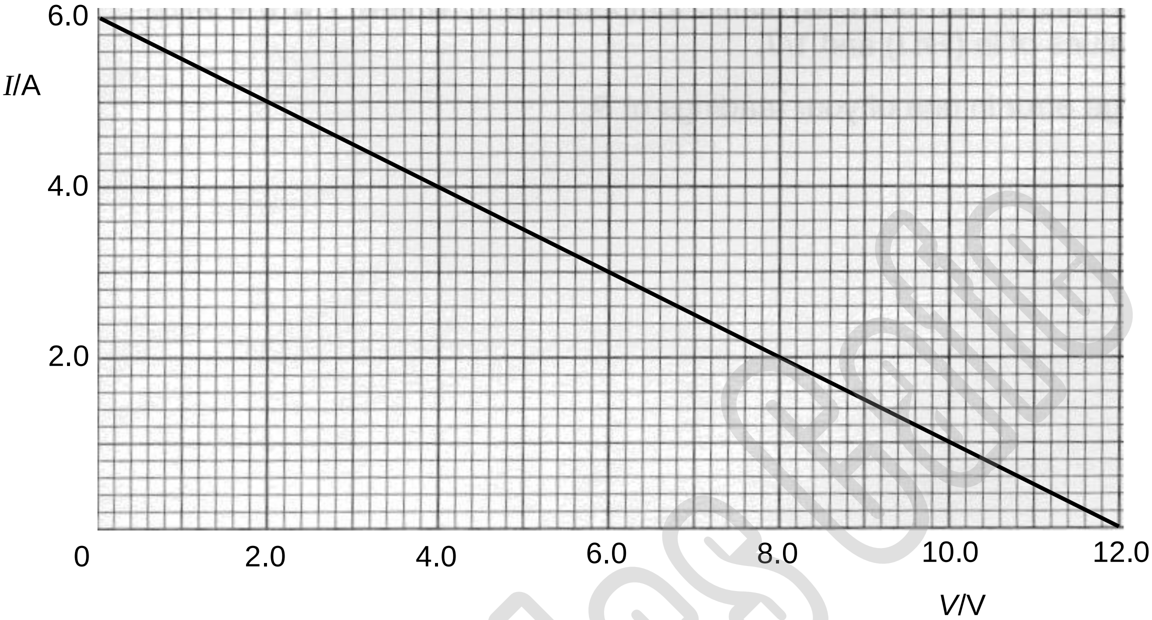

Fig. 4.2

(a) Use Fig. 4.2 to

(i) deduce the e.m.f. E of the battery. Suggest a reason for your answer.

E =……………………..V [2]

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

r =…………………….. Ω [2]

(b) On Fig. 4.2, mark the positions when R comprises three resistors of resistances 2 Ω, 3 Ω and 5 Ω, and the resistors are all connected

(i) in series. Label the position S. [1]

(ii) in parallel. Label the position P. [1]

(c) An ammeter and a voltmeter are used to measure I and V respectively. Suggest how they should be connected to the network of resistors.

ammeter ____________________

voltmeter ....

[1]

5 **(a)** Discuss briefly the three conditions for lasing – *population inversion, metastable state* and *stimulated emission*.

population inversion

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.... [1]

metastable state

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.... [1]

stimulated emission

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[1]

(b) Use the band theory to explain why the conductivity of an intrinsic semiconductor increases after it has been doped with an n-type impurity. You may draw a diagram if you wish.

[4]

6 Sodium-24 has a half-life of 15 hours and decays with the emission of gamma radiation. It is used to trace the flow of blood in humans by injecting it into the blood system.

(a) Suggest two advantages of using gamma radiation to trace the flow of blood in humans.

[2]

(b) A sample of Sodium-24 has an initial activity of 1.2×10^4 Bq when it arrives at a hospital. For effective tracing of the flow of blood in humans using Sodium-24, the minimum activity required is 400 Bq.

(i) Determine the time duration a sample of Sodium-24 can be kept on the shelf at the hospital before it loses its effectiveness.

time duration =……………………..h [1]

(ii) Hence find the mass of Sodium-24 having this minimum activity.

mass =…………………….. kg [3]

(c) Explain why it is critical for the background count rate to be low for the effective tracing of the flow of blood in humans using Sodium-24.

-- [1]

7 This question is about a space shuttle used to take tourists to the 'edge of space' 100 km above the surface of the Earth.

Fig. 7.1 shows the space shuttle carrying three people taken to a height of about 10 km above the Earth's surface on the back of a carrier craft. At this height where the air pressure is only 25% of that at the surface of the Earth, the space shuttle is released from the carrier craft.

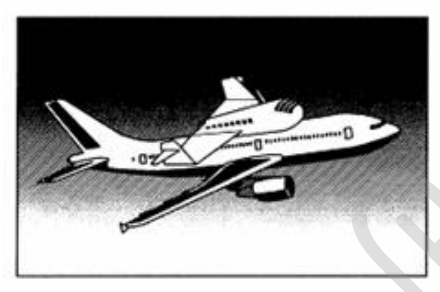

Fig. 7.1

Fig. 7.2 shows the space shuttle starting to ignite its fuel and rising to a height of 100 km above the Earth's surface.

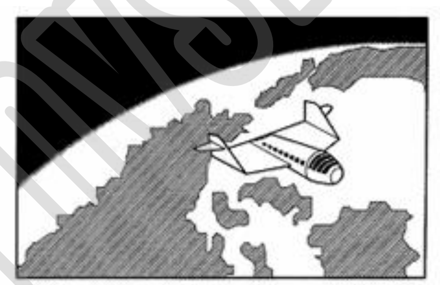

Fig. 7.2

(a) Suggest and explain an advantage of releasing the space shuttle at the height at which air pressure is significantly reduced.

--- [2]

(b) Fig. 7.3 shows the variation with the height *h* near the Earth's surface of the gravitational potential V_g.

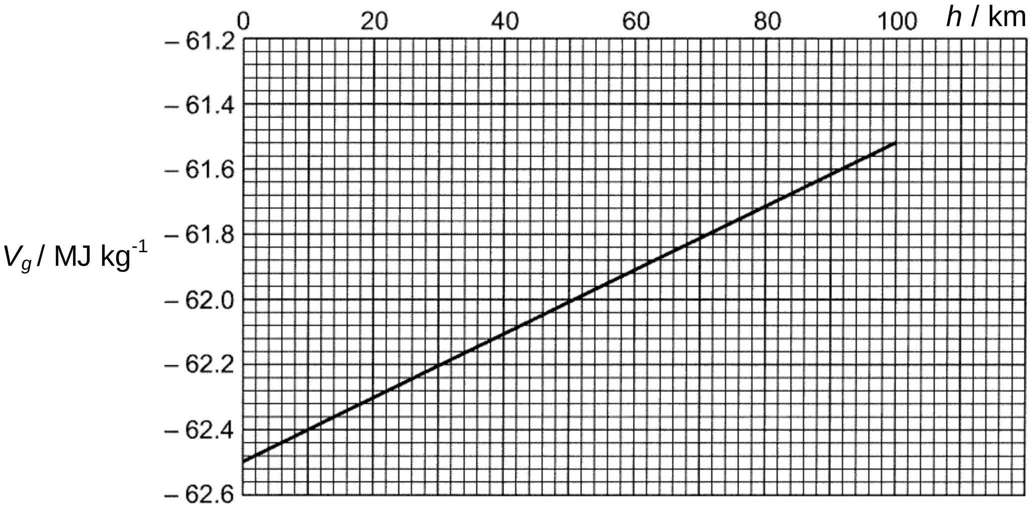

Fig. 7.3

(i) State the feature of the graph that shows that the gravitational field strength is approximately uniform over the range of the flight.

....

.... [1]

(ii) Hence show that the value of gravitational field strength, g, over this height range is 9.7 N kg^{-1}.

[2]

(c) Using values from the graph, or otherwise, show that the energy required by the space shuttle of mass 3800 kg to rise from 10 km to 100 km above the Earth is about 3.3×10^9 J.

[2]

(d) At one instant, the engines of the space shuttle exert a vertical (radial) thrust of 74 kN. Calculate the acceleration on the shuttle at this instant. You may neglect the effect of resistive forces in your calculation.

acceleration =……………………m s^{-2} [2]

(e) **(i)** With the engines turned off, the space shuttle travels vertically (radially) away from the Earth in very thin atmosphere. Explain why the velocity of the space shuttle decreases even though the air resistance is negligible.

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.... [2]

(ii) During this period when the space shuttle travels through a region of low atmospheric pressure without any thrust acting on it, the people in the cabin of the space shuttle float and experience 'weightlessness'. However when the space shuttle descends nearer the Earth's surface, the atmospheric pressure increases and the experience of weightlessness by the people in the cabin disappears. Explain the changing weight experienced by the people in the cabin.

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.... [4]

(f) If at the height of 100 km above the Earth's surface the space shuttle is made to orbit round the Earth instead, calculate the angular speed of the space shuttle, given that the radius of the Earth is 6.4×10^6 m.

angular speed =…………………….rad s^{-1} [3]