

H2 PHYSICS

Exam papers with worked solutions

(Selected from Top JC)

SET B

PAPER 2

Compiled by

THE PHYSICS CAFE

READ THESE INSTRUCTIONS FIRST

Write your name and tutorial group on all the work you hand in.

Write in dark blue or black pen in the spaces provided on the Question 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

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

FOR EXAMINER'S USE	
1	/ 10
2	/ 10
3	/ 10
4	/ 10
5	/ 20
TOTAL	

This question paper consists of **14** printed pages.

PHYSICS DATA:

speed of light in free space,	c	$= 3.00 \times 10^8 \text{ m s}^{-1}$
permeability of free space,	μ_0	$= 4\pi \times 10^{-7} \text{ H m}^{-1}$
permittivity of free space,	ϵ_0	$= 8.85 \times 10^{-12} \text{ F m}^{-1}$ $\approx (1/(36\pi)) \times 10^{-9} \text{ F m}^{-1}$
elementary charge,	e	$= 1.60 \times 10^{-19} \text{ C}$
the Planck constant,	h	$= 6.63 \times 10^{-34} \text{ J s}$
unified atomic mass constant,	u	$= 1.66 \times 10^{-27} \text{ kg}$
rest mass of electron,	m_e	$= 9.11 \times 10^{-31} \text{ kg}$
rest mass of proton,	m_p	$= 1.67 \times 10^{-27} \text{ kg}$
molar gas constant,	R	$= 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
the Avogadro constant,	N_A	$= 6.02 \times 10^{23} \text{ mol}^{-1}$
the Boltzmann constant,	k	$= 1.38 \times 10^{-23} \text{ mol}^{-1}$
gravitational constant,	G	$= 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
acceleration of free fall,	g	$= 9.81 \text{ m s}^{-2}$

PHYSICS FORMULAE:

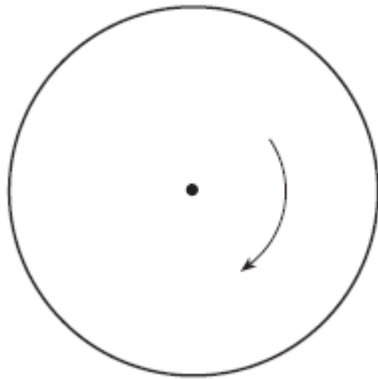
uniformly accelerated motion,	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
work done on / by a gas,	$W = p \Delta V$
Hydrostatic pressure	$P = \rho gh$
gravitational potential,	$\phi = -Gm/r$
Displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
Velocity of particle in s.h.m.	$v = v_0 \cos \omega t$
	$= \pm \omega \sqrt{x_0^2 - x^2}$
resistors in series,	$R = R_1 + R_2 + \dots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \dots$
electric potential,	$V = Q / 4 \pi \epsilon_0 r$
alternating current / voltage,	$x = x_0 \sin \omega t$
Transmission coefficient	$T = \exp(-2kd)$

$$\text{where } k = \sqrt{\frac{8 \pi^2 m (U - E)}{h^2}}$$

radioactive decay,	$x = x_0 \exp(-\lambda t)$
decay constant,	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

1. A disc in a DVD player is rotating in a horizontal plane at a rate of 11.0 revolutions per second.

(a) Calculate its angular velocity. [2]



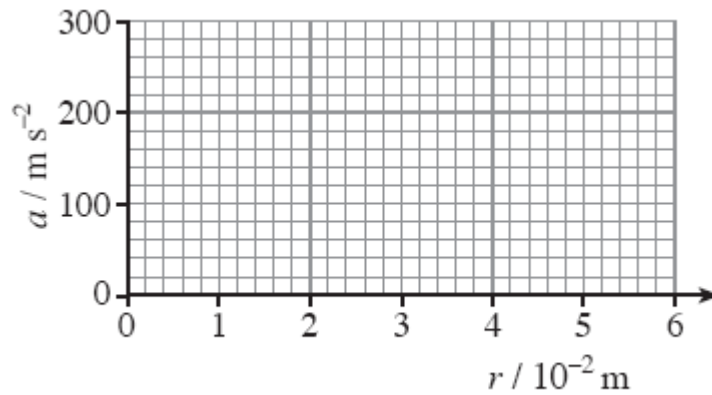
Angular velocity: s^{-1} .

(b) The radius of the disc is 0.060 m. For a point on the edge of the disc,
(i) calculate the speed, [2]

Speed: m s^{-1} .

(ii) and show that the centripetal acceleration is approximately 290 ms^{-2} . [2]

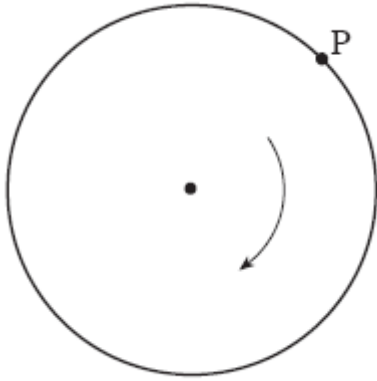
- (c) On the grid provided, sketch a graph of a against r , in which a is the centripetal acceleration of a point a distance r from the centre of the disc. [1]



- (d) A speck of dust of mass 2.0×10^{-12} kg is stuck to the edge of the disc, at point P. [1]
(i) Calculate the centripetal force on the speck.

Centripetal force: N.

- (ii) Show the direction of this force by an arrow, labelled 'A' on the diagram. [1]
(iii) The speck now becomes detached. Show the direction in which it moves immediately afterwards, as an arrow, labelled 'B'. [1]



The Physics Cafe

- 2 Figure 2.1 shows the displacement-time graph for the centre of a loudspeaker cone when it is displaced manually and then allowed to vibrate naturally.

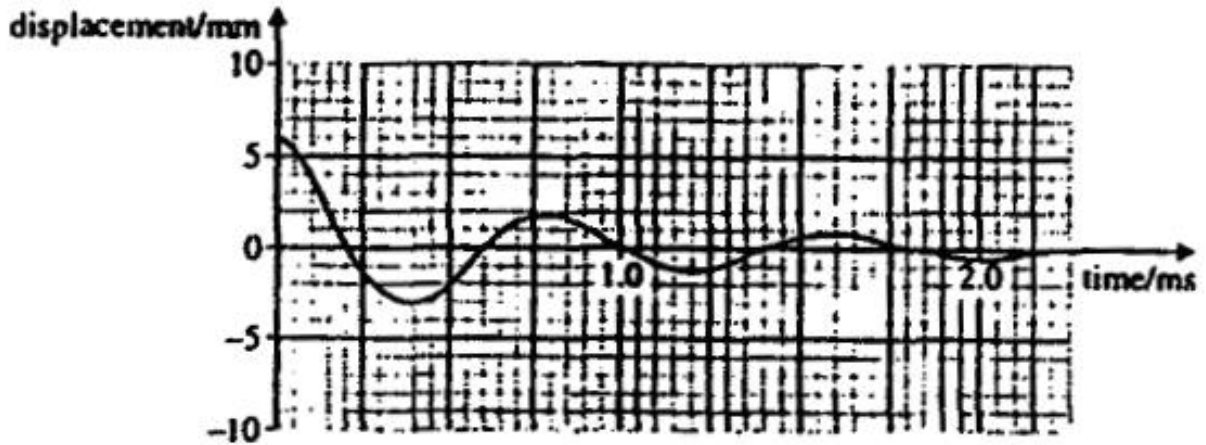


Figure 2.1

- (a) Explain the feature which shows that the oscillations are damped. [2]

.....
.....
.....
.....

- (b) (i) Calculate the natural frequency of oscillation of the cone. [2]

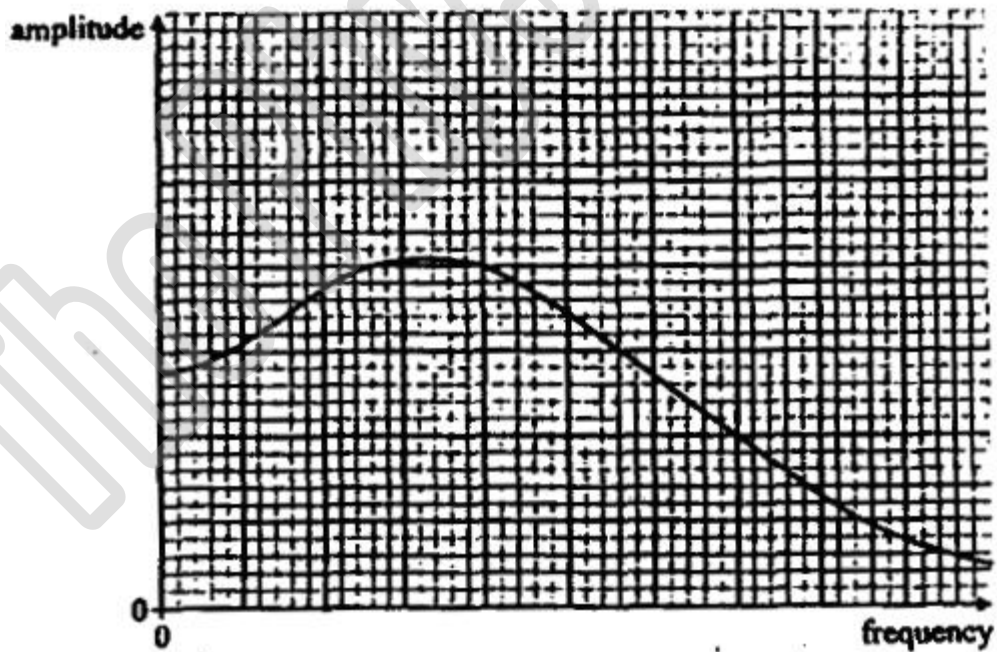
Natural frequency = Hz

- (ii) Calculate the maximum acceleration of the cone during the time interval shown in the figure. [2]

Maximum acceleration = m s⁻²

- (iii) Draw a graph to show how the acceleration of the body changes with time. [2]

- (c) The graph below shows how the amplitude of the cone varies with frequency (the frequency response graph) when a signal generator provides alternating current of different frequencies but similar amplitude to the loudspeaker.



- Sketch and label on the graph above, the effect of:
- (i) Increasing the damping (label this graph, A);
 - (ii) Decreasing the damping (label this graph, B).

[2]

- 3 (a) Define Electric Potential. [2]

.....
.....

- (b) A radioactive nucleus emits a 6.5 MeV alpha particle. The particle then races toward a pair of charged plates that are 3 cm apart, as shown in Figure 4.1.

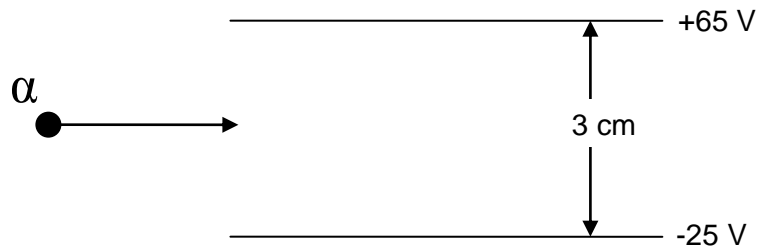


Figure 3.1

- (i) Calculate the speed of the alpha particle. [2]

Speed = m s⁻¹

- (ii) In Figure 3.2, draw the electric field lines and the subsequent path of the alpha particle as it enters the region between the two plates. [2]

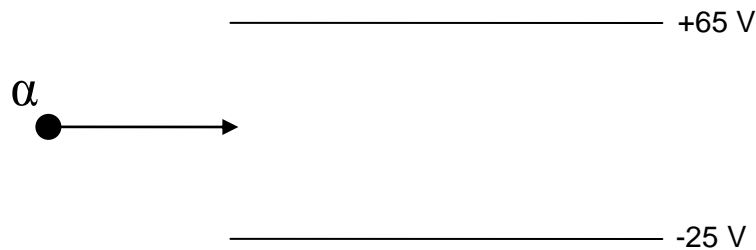


Figure 3.2

- (iii) Calculate the force on the alpha particle. (Hint: The alpha particle has 2 protons and 2 neutrons.) [3]

Force = N

- (iv) Given that the alpha particle travels between the plates for 5 seconds, determine the change in momentum of the alpha particle, caused by the electric field. [1]

Change in momentum = kg m s^{-1}

- 4 Light is incident on a clean metal surface in a vacuum. The maximum kinetic energy KE_{\max} of the electrons ejected from the surface is measured for different values of the frequency f of the incident light.

The measurements are shown plotted below in Figure 4.1.

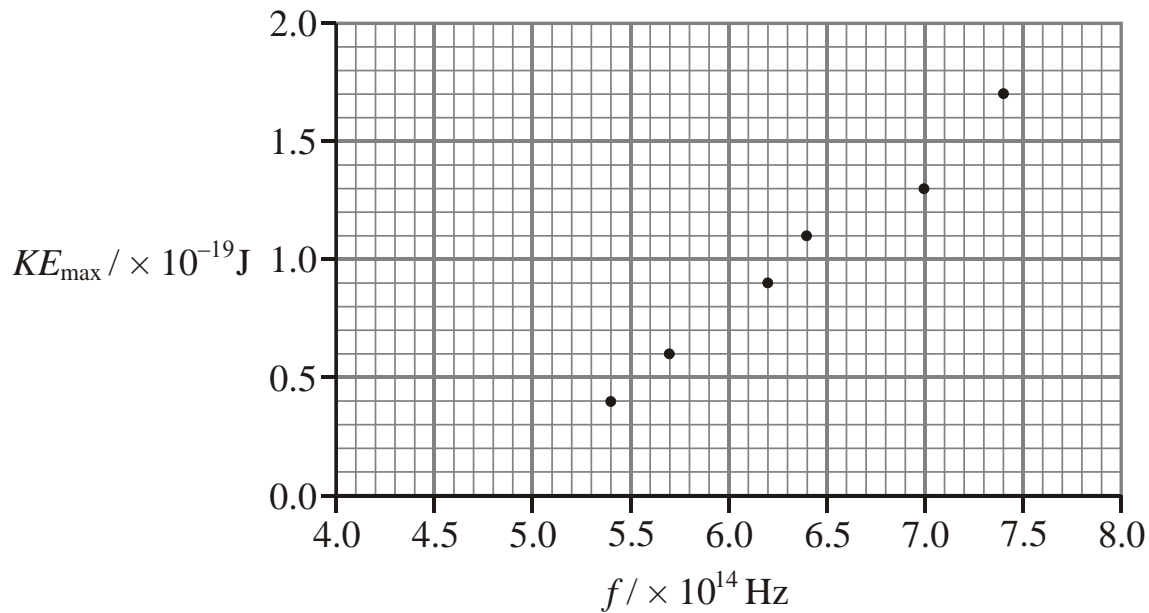


Figure 4.1

- (a) By drawing the line of best fit, use the graph to determine

(i) the Planck constant.

[2]

Planck's constant: J s

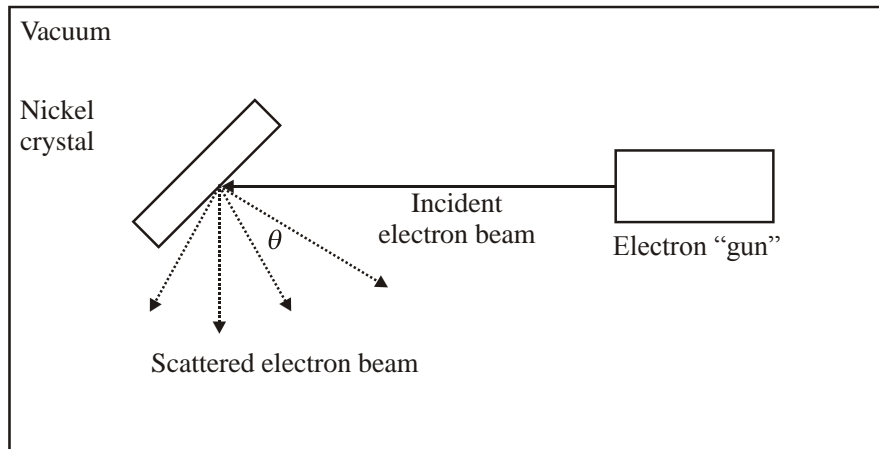
- (ii) the work function of the metal. [2]

Work function of the metal: J

- (b) Explain briefly how Einstein's photoelectric theory accounts for the fact that no electrons are emitted from the surface of this metal if the frequency of the incident light is less than a certain value. [2]

.....
.....
.....
.....
.....
.....
.....

- (c) An experiment is carried out in which a beam of electrons is scattered from a single nickel crystal. A schematic diagram of the apparatus is shown below.

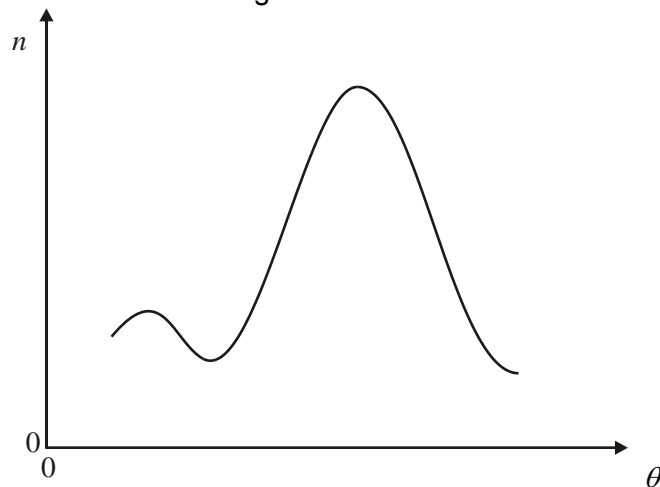


The electrons are accelerated in the electron “gun” by a potential difference of 75 V.

- (i) Determine the wavelength associated with the electrons as predicted by the de Broglie hypothesis. [3]

Wavelength = m.

The number n of electrons scattered per second through an angle θ is measured. The graph below shows the variation with angle θ of n .



- (ii) Suggest how data from the graph can be used to support the de Broglie hypothesis.

[1]

.....

.....

.....

.....

.....

The Physics Cafe

5. If you wish to get the maximum power transfer from, say a battery to an electrical appliance, what sort of resistance should the appliance have?

At first sight a small resistance seems sensible, because then a large current will flow, but unfortunately drawing a large current from a supply lowers its voltage because of the supply's internal resistance.

In the extreme case of zero resistance, a very large current may flow, but all the power transferred heats up the supply !

At the other extreme, a large resistance means little current and so only a small power transfer.

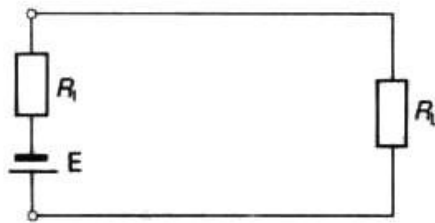


Figure 5.1

Figure 5.1 shows a power supply of e.m.f. E and internal resistance R_1 connected to a load, resistance R_L . It can be shown that the maximum power is transferred when $R_1 = R_L$. It is not always possible to design an electrical device to have the same resistance as the supply, but in the case of a.c. supply, matching can be provided by a transformer.

An example include matching output resistance of an audio amplifier to that of the loudspeakers.

Ignoring the real, but small inefficiencies of a transformer, the effective supply resistance R_1 matches a load resistance of $N^2 R_L$, where N is the ratio of turns on the primary coil to turns on the secondary coil of the transformer. The details are shown in figure 5.2.

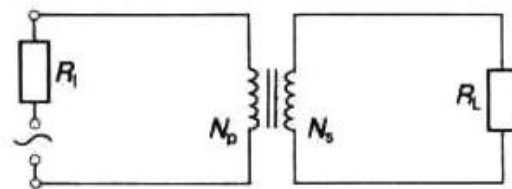


Figure 5.2

- (a) Write down an expression for the current in the circuit of figure 5.1. [1]

- (b) (i) Show that the power delivered to the load is [2]

$$\frac{E^2 R_L}{(R_L + R_I)^2}$$

- (ii) Show that the power supplied by the battery is given by [2]

$$\frac{E^2}{R_L + R_I}$$

- (c) Using the data:

$$E = 12 \text{ V};$$

$$R_I = 3 \Omega$$

$$R_L = 0, 1, 2, 3, 4, 5 \Omega$$

- (i) Complete the table below: [3]

R_L / Ω	0	1	2	3	4	5
P1 = P(supplied) (watts)						
P2 = P(delivered to R_L) (watts)						
P3 = P(delivered to R_I) (watts)						

- (ii) Plot P1, P2 and P3 against R_L in the graph paper below. [3]



- (iii) Determine the maximum power delivered to the load resistor R_L from the graphs that you have plotted. [1]

Maximum power: W.

- (iv) State and explain whether the law of conservation of energy holds for this circuit. [2]

- (d) (i) Assuming that the transformer is 100% efficient, write down expressions for the voltage ratio, V_P/V_S and the current ratio, I_P/I_S in terms of N . (p refers to primary and s to secondary circuits) [2]

- (ii) Use the expressions in (d)(i) to show that the ratio of the supply to load resistances is N^2 . [2]

(e) (i) Suggest a modification to the circuit in figure 5.2 so that the a.c. signal may be rectified into a dc signal using only diode(s). [1]

(ii) State one disadvantage of the rectified d.c. signal you have designed in (e)(i). [1]

.....

THE END