H2 PHYSICS

Exam papers with worked solutions

(Selected from Top JC)

SET E

PAPER 2

Compiled by

THE PHYSICS CAFE

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number and on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough workings.
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 AND FORMULAE

Data

speed of light in free space,	c	$= 3.00 \times 10^{8}$ m s^{-1}
permeability of free space,	μ_o	$= 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o	$= 8.85 \times 10^{-12}$ F m^{-1}
		$\approx (1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e	$= 1.60 \times 10^{-19}$ C
the Planck constant,	h	$= 6.63 \times 10^{-34}$ J s
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
molar gas constant,	R	$= 8.31$ J K^{-1} mol^{-1}
the Avogadro constant,	N_A	$= 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant,	k	$= 1.38 \times 10^{-23}$ J K^{-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	$= ut + ½at^2$
	v^2	$= u^2 + 2as$
work done on/by a gas,	W	$= p\Delta V$
Average kinetic energy of a molecule of an ideal gas	U	$= \frac{3}{2}kT$
hydrostatic pressure,	p	$= \rho gh$
gravitational potential,	Φ	$= -\frac{GM}{r}$
displacement of particle in s.h.m.	x	$= x_o \sin \omega t$
velocity of particle in s.h.m.	v	$= v_o \cos \omega t$
		$= \pm\omega\sqrt{\left(x_o^{\ 2} - x^2\right)}$
resistors in series,	R	$= R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	$= 1/R_1 + 1/R_2 + \ldots$
electric potential	V	$= Q/4\pi\varepsilon_o r$
alternating current/voltage,	x	$= x_o \sin \omega t$
transmission coefficient	T	$\propto \exp(-2kd)$
	where $k =$	$\sqrt{\frac{8\pi^2 m(U-E)}{h^2}}$
radioactive decay,	x	$= x_o \exp(-\lambda t)$
decay constant,	λ	$= \frac{0.693}{t_{½}}$

For Examiners Use

1 **(a)** The *kilogram* and the *metre* are base units. Name two other base units.

………………………………………………………………………………………[1]

(b) The capacitance of a conductor C is the amount of charge Q required to cause a unit change in its potential difference (p.d.), V.
Potential difference is defined as the electrical energy per unit charge converted to non-electrical energy.

The formula is $C = Q / V$

(c) **(i)** Express the unit for capacitance in base units.

Base units = ………………………………..[2]

(ii) A student conducted an experiment to find the capacitance of a conductor. He recorded the following values:

Current passing through the conductor = 1.0 μA ± 10%
Time taken during the charging process = (0.4 ± 0.1) s
Potential difference across the conductor = (2.0 ± 0.2) V

Calculate, with its actual uncertainty, the value of the capacitance of the conductor.

Capacitance = ……………….. ± ………………… [3]

For Examiners Use

2 A ski jumper lands 96 m from his take off point as shown in Figure 2.1 below. The slope is at an angle of 45° and the jumper is in the air for 4.3 s.

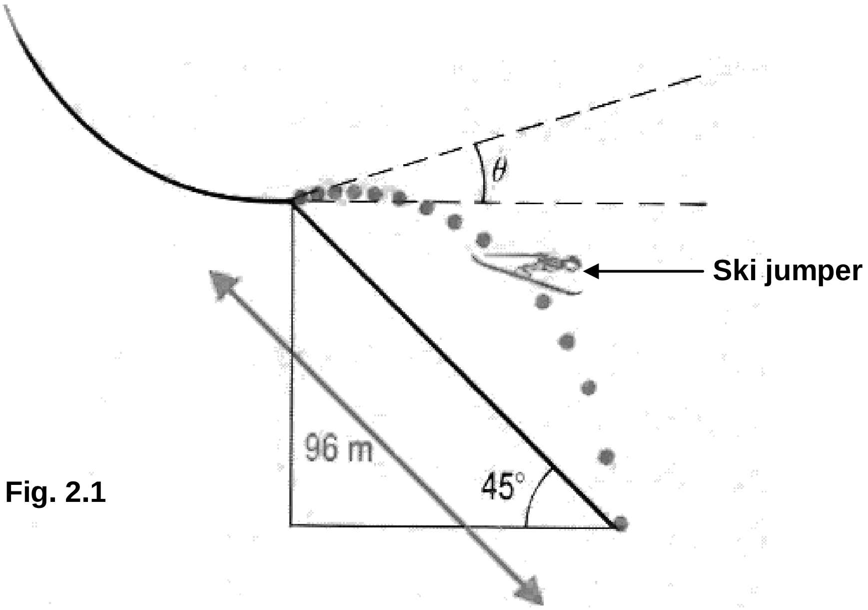


Fig. 2.1

Assuming that air resistance is negligible, find

(a) the horizontal distance traveled

Distance = ……………………… m [1]

(b) the horizontal component of the velocity at take off

Velocity = ………………… m s^{-1} [1]

(c) the vertical distance from take off to landing

Distance = …………………… m [1]

(d) the vertical component of the take off velocity

Velocity = ………………… m s^{-1} [2]

For Examiners Use

(e) the angle of take off, θ

θ = …………………………..° [1]

(f) the speed of take off.

Speed = ………………………. m s^{-1} [2]

(g) State the effect on the maximum horizontal distance travelled by the ski jumper if air resistance is not negligible.

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

3 A student did the following experiments. The density of water is 1.0×10^3 kg m^{-3}.

(a) He finds that a rock whose mass is 100 g has an apparent mass of 82 g when submerged in water. Find the density of the rock.

Density = ……………………………. kg m^{-3} [3]

(b) He puts an ice-cube of mass 120 g in a glass of water. The ice-cube floats. Determine

(i) the upthrust on the ice-cube,

For Examiners Use

Upthrust = …………………………… N [1]

(ii) the volume of the water displaced by the ice-cube.

V = …………………………… m^3 [1]

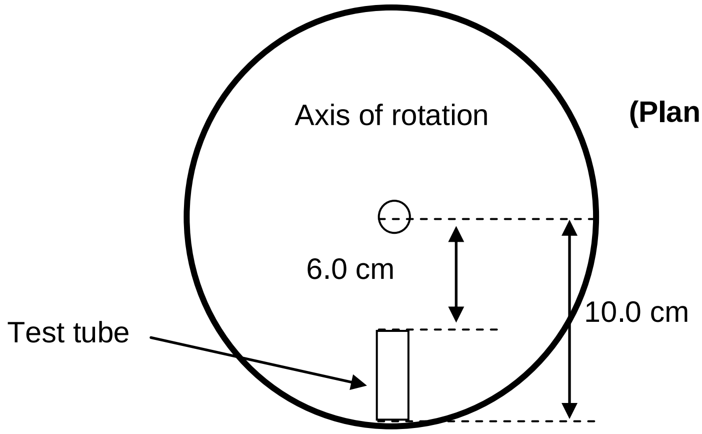
(c) He observes that in **(b)**, when the ice-cube floating in a jug of water melts, there is no change in the level of the water. Explain.

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………[2]

4 **(a)** A centrifuge rotor, in Fig. 4.1 (not drawn to scale), rotates at 3 000 r.p.m. (revolutions per minute). The top of a test tube (perpendicular to the rotation axis) is 6.0 cm, and the bottom of the tube is 10.0 cm, from the axis of rotation. A test tube of blood is secured in the centrifuge. It can be assumed that the test tube of blood undergoes uniform circular motion.



(Plan view of centrifuge)

Fig. 4.1

Blood cells and plasma are separated and found at the bottom and top of the tube respectively after one minute in the centrifuge.

(i) Show that the frequency of the rotation is 50 Hz.

Frequency = ………………………… Hz [1]

(ii) Calculate the acceleration at the bottom of the tube.

Acceleration = ………………………… m s^{-2} [2]

For Examiners Use

(iii) Use the appropriate Newton's Laws of motion to explain why the heavier blood cells will be found at the bottom of the tube.

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………….. [2]

(b) The centripetal acceleration, *a*, of a body undergoing a uniform circular motion of radius *r* can be expressed as either (1) $a = \frac{v^2}{r}$ or (2) $a = r\omega^2$, where *v* and ω are linear and angular speeds of the body respectively.

For a uniform circular motion of constant period, student A thinks that *a* decreases with *r* according to equation (1), while student B argues that *a* increases with *r* according to equation (2).

Explain which student's argument is correct.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………[2]

5 **(a)** Explain the meaning of *coherence* in relation to the superposition of the two waves.

……………………………………………………………………………………[1]

(b) The apparatus illustrated in Fig. 5.1 (not drawn to scale) is used to demonstrate two-source interference using light.

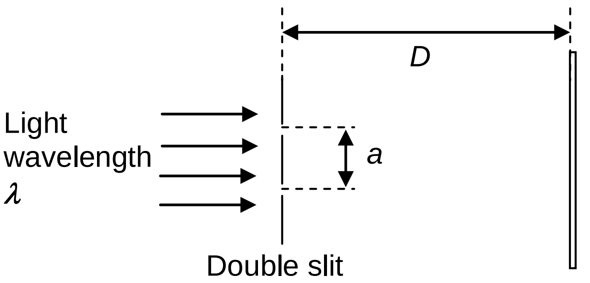


Fig. 5.1

The separation of the two slits in the double slit arrangement is *a* and the interference fringes are viewed on a screen at a distance *D* from the double slit. When light of wavelength λ is incident on the double slit, the separation of the bright fringes on the screen is *x*.

(i) Write down an expression relating λ, *a*, *D* and *x*. [1]

(ii) Light of wavelength 500 nm is used in an experiment. The distance between the double slit and the screen is 1.0 m.
It is observed on screen that the first to the last of the 12 bright fringes span a distance of 3.0 cm. Calculate the separation of the two slits.

For Examiners Use

Slit separation = ………………………… mm [2]

(iii) Describe the effect, if any, on the separation and on the maximum brightness of the fringes in **(ii)** when the following changes are made. [3]

1. Red light is used instead with half the original amplitude of the light used in **(ii)**, while keeping *a* and *D* constant.

……………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

2. The width of each slit is increased, while keeping *a*, λ and *D* constant.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

6 **(a)** A radioactive source has an initial number of *N* undecayed atoms and it's half-life is *T*. Sketch on the axis in Fig. 6.1 below a graph which shows qualitatively how the number of undecayed atoms varies with time. Indicate on your sketch for at least 2 half-lives. [2]

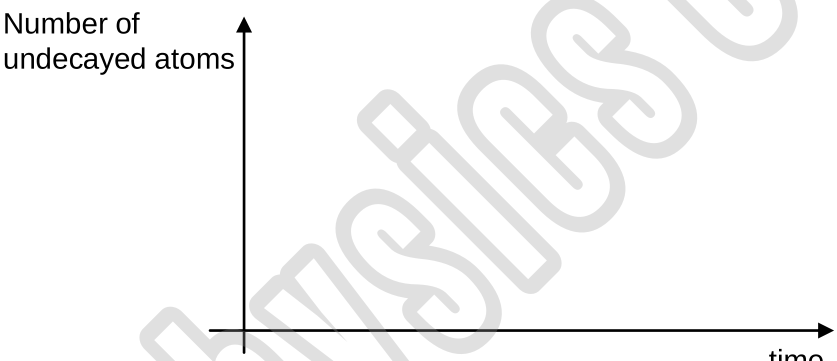


Fig. 6.1

(b) For a particular radioactive source, the decay constant is 1.8×10^{-6} s^{-1}, and N = 3.7×10^{21}.

For Examiners Use

(i) Calculate the half-life of the source.

Half-life = ……………………….. s [1]

(ii) Calculate the number of undecayed atoms after 30 days.

Number = ………………………….. [2]

(iii) Calculate the activity of the source after 30 days.

Activity = ……………………… s^{-1}. [2]

7 If a conducting liquid flows through a magnetic field, the conditions exist for an e.m.f. to be set up across the liquid. The principle is used in electromagnet flow meters to measure the rate of flow of liquid along a pipe. A diagram of this type of flowmeter is given in Fig. 7.1. As the liquid flows through the tube it cuts through the magnetic field set up by the field winding coils, causing an e.m.f. E_1 to be induced. The e.m.f. is sensed by two electrodes *X* and *Y* which are opposite each other and in contact with the liquid at right angle to the axis of the magnetic field.

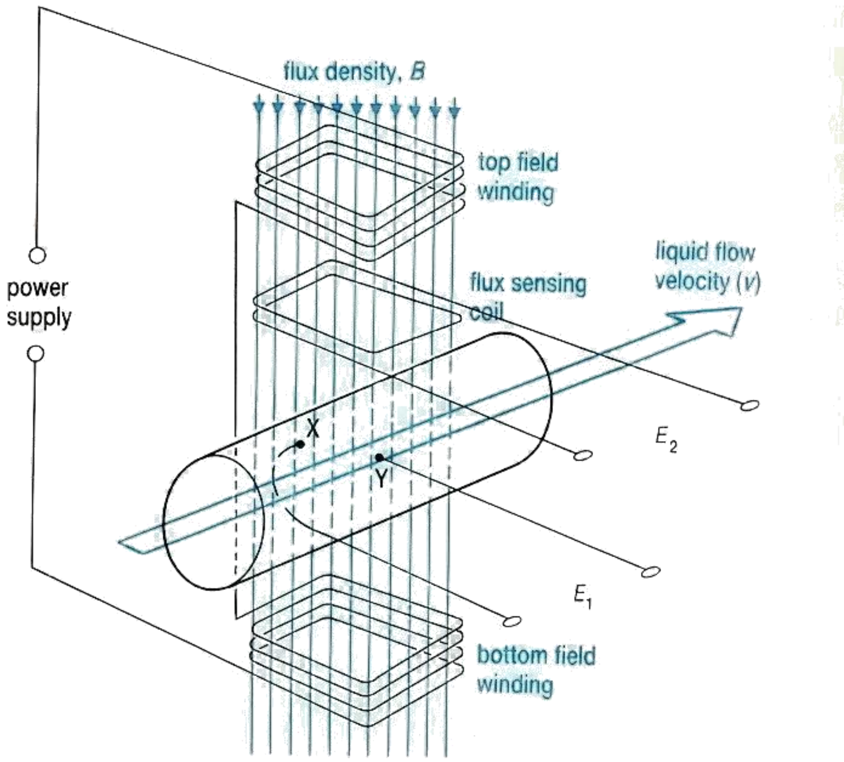


Fig. 7.1

In addition, there is a flux sensing coil which gives an output E_2 proportional to the magnetic flux density.

For Examiners Use

(a) Explain why the pipe, in the vicinity of the electrodes, have to be non-conducting.

…………………………………………………………………………………………….

…………………………………………………………………………………………[1]

(b) **(i)** Show that $E_1 = kvB$ where *k* is a constant. [2]

(ii) Show that the velocity $v = k'\frac{E_1}{E_2}$ where *k'* is another constant. [2]

(c) Show that for a liquid travelling along a pipe of internal diameter 65 mm with a velocity of 0.73 m s^{-1}, when B = 0.35 T, the value of E_1 is 16.6 mV. [2]

(d) Only a small conductivity is necessary for the liquid used in such a flowmeter. One of the following liquids is unsuitable. Make a reasoned guess which of these liquids is not suitable.

1. Sewage
2. Water
3. Hydrocarbon
4. Fruit Juice

Answer = …………………………………… [1]

(e) What advantage is there in using platinum electrodes?

…………………………………………………………………………………………

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

(f) Why does E_2 become zero if the power supply is d.c.?

………………………………………………………………………………………..

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

For Examiners Use

(g) **(i)** How does using a.c. overcome the problem?

..……………………………………………………………………………….. .

..…………………………………………………………………………..…[1]

(ii) What complication occurs if an a.c. is used?

..………………………………………………………………………………. .

…………………………………………………………………………………[1]

(h) **(i)** What liquid speed would you expect a flowmeter to read on a 450 mm bore pipe if liquid passes through the pipe at a rate of 200 m^3 h^{-1} (cubic metres per hour).

Speed = ………………………… m s^{-1} [2]

(ii) State an assumption you are making.

…………………………………………………………………………………[1]

(i) In practice, there is a limit on the usable length of cable from electrodes to the measuring instrument. Explain why the usable length depends on the liquid being used.

……………………………………………………………………………………………

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

(j) Electromagnetic flow meters are used to measure the blood flow rate in patients undergoing heart or arterial surgery. Suggest a possible advantage of using such a flow meter.

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

End of Paper