INNOVA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION 2
in preparation for General Certificate of Education Advanced Level
Higher 1

CANDIDATE NAME

CLASS

INDEX NUMBER

PHYSICS 8866/02

Paper 2 Structured Questions **15 Sep 2011**

Candidates answer on the Question Paper **2 hours**

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number 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.

For Section A
Answer **all** questions.

For Section B
Answer any **two** questions.

At the end of the examination, fasten all your work securely together.
The number of marks is given in the brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section A	
1	8
2	9
3	8
4	6
5	9
Section B	
6	20
7	20
8	20
Total	80

This document consists of **19** printed pages.

Data

speed of light in free space,	c	$= 3.00 \times 10^{8}$ m s^{-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
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	$= \rho gh$
resistors in series,	R	$= R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	$= 1/R_1 + 1/R_2 + \ldots$

Section A

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

For Examiner's Use

1 (a) Complete Fig. 1.1 to show each quantity and its base units.

Quantity	Base Unit
speed	$m\ s^{-1}$
density	$kg\ m^{-3}$
power	$kg\ m^2\ s^{-3}$
voltage	$kg\ m^2\ s^{-3}\ A^{-1}$

[3]

Fig. 1.1

(b) Two parallel strings S_1 and S_2 are attached to a disc of diameter 12 cm, as shown in Fig. 1.2.

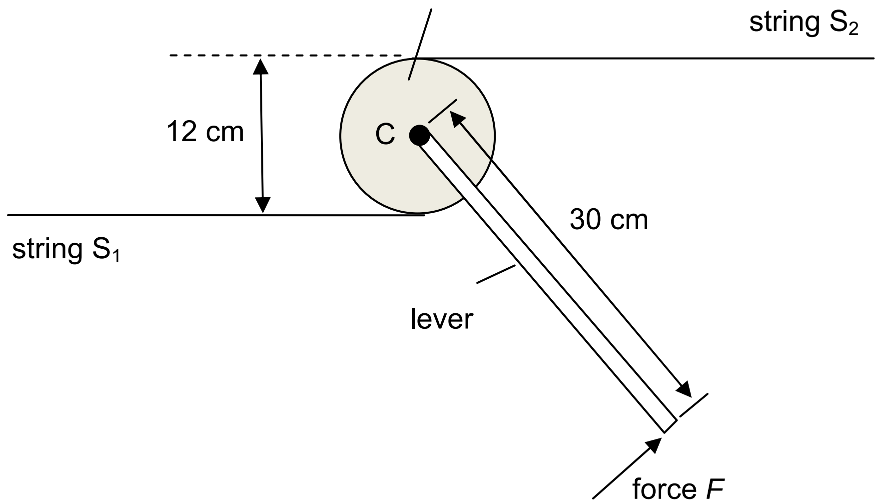


Fig. 1.2

The disc is free to rotate about an axis normal to its plane. The axis passes through the centre C of the disc.

A lever of length 30 cm is attached to the disc. When a force *F* is applied at right angles to the lever at its end, equal forces are produced in S_1 and S_2. The disc remains in equilibrium.

(i) On Fig. 1.2, show the direction of the force in each string that acts on the disc. [1]

Force is leftward for string S_1 and rightward for string S_2. (B1)

For Examiner's Use

(ii) For a force *F* of magnitude 150 N, determine

1. the moment of force *F* about the centre of the disc,

Moment = F x d = 150 x 0.30 = 45 N m (C1)

moment = ... N m [1]

2. the torque of the couple produced by the forces in the strings,

By Principle of Moments,
torque of couple produced by strings = Clockwise moment caused by F
= 45 N m (C1)

torque = ... N m [1]

3. the force in S_1.

Torque of couple in strings = S_1 x 0.06 = 45 (C1)
Hence S_1 = 45 / 0.06 = 750 N (A1)

force = ... N [2]

For Examiner's Use

2 A steady stream of water strikes a wall horizontally without rebounding, and, as a result, exerts a force on the vertical wall.

(a) With reference to Newton's Laws of motion,

(i) state and explain why the momentum of the water changes as it strikes the wall,

The momentum of the water changes because the **velocity of the water changes** when the water was brought to rest by the wall. [B1] This is because when the water strikes the wall, **it exerts a force on the wall and by Newton's third law, the wall exerts an equal but opposite force on the water**. [B1] By Newton's second law, the **force experienced by the water means that the water undergoes a rate of change of momentum**. Thus the momentum of the water changes. [B1]

..........[3]

(ii) explain why the water exerts a constant force on the wall.

The water exerts a constant force because the **water flows at a constant rate. [B1]**

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

(b) Water arrives at the wall at a rate of 18 kg s^{-1}. It strikes the wall horizontally, at a speed of 7.2 m s^{-1} without rebounding. Calculate

(i) the change in momentum of the water in one second,

change in momentum in one second = $m\Delta v$ [C1]

= 18(0 – 7.2) = - 130 kg m s^{-1} [A1]

change in momentum = ... kg m s^{-1} [2]

(ii) the force exerted by the water on the wall.

Force by the water on the wall = - force on water by wall = 130 kg m s^{-2} [A1]

force = ... kg m s^{-2} [1]

(c) State and explain the effect on the magnitude of the force if the water rebounds after striking the wall.

The magnitude is **greater** [A1] because there is a **bigger rate of change of momentum** of the water when the water rebounds. [M1]

....

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

For Examiner's Use

3 (a) What do you understand by progressive wave?

....

....[1]

(b) A radar transmitter produces pulses of microwaves each with a mean power *P* = 2.0 MW which are emitted uniformly in all directions. A small spherical target of effective area *S* is placed at a distance of 50 km from the transmitter. The target reflects *k* of the energy incident on it uniformly in all directions as shown in Fig 3.1.

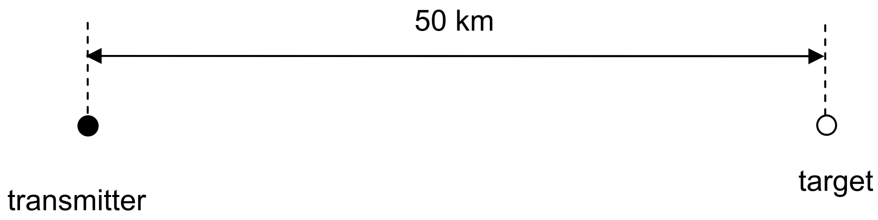


Fig. 3.1

(i) Calculate the mean intensity of the emitted pulse at a range of 50 km.

$2 \times 10^6 / (4 \times \pi \times 50^2 \times 10^6) = 6.4 \times 10^{-5}$ W m^{-2}

intensity = ... W m^{-2} [2]

(ii) Given that $S = 1.0$ m^2. Calculate the power received by a target.

$6.4 \times 10^{-5} \times 1 = 6.4 \times 10^{-5}$ W

power = ... W m^{-2} [2]

(iii) Assuming that the fraction of energy reflected is k = 0.50, calculate the mean intensity of the reflected pulse when received back at the transmitter.

$I = P / (4\pi r^2)$
$= \{0.50 \times 6.4 \times 10^{-5}\} / \{4\pi \times 50^2 \times 10^6\}$
$= 1.0 \times 10^{-15}$ W m^{-2}

intensity = ... W m^{-2} [3]

For Examiner's Use

4 A household electric lamp is rated as 240 V, 60 W. The filament of the lamp is made from tungsten and is a wire of constant radius 6.0 x 10^{-6} m. The resistivity of tungsten at the normal operating temperature of the lamp is 7.9 x 10^{-7} Ω m.

(a) State Ohm's law.

Ohm's law states that for an ohmic conductor, the ratio of its potential difference to its current is constant, at constant temperature. [C1]

(b) For the lamp at its normal operating temperature,

(i) calculate the current in the lamp,

Current = P / V
= (60) / (240)
= 0.25 A [A1]

current = ... A [1]

(ii) show that the resistance of the filament is 960 Ω.

Resistance, R = V / I
= (240) / (0.25) [C1]
= 960 Ω

current = ... A [1]

(c) Calculate the length of the filament.

Using, R = ρ l / A
l = R A / ρ
= (960) (π) (6.0 x 10^{-6} m)^2 / (7.9 x 10^{-7} Ω m) [M1]
= 0.137 m [A1]

length = ... m [2]

(d) Comment on your answer to **(c)**.

The length of the filament must be coiled to fit into the light bulb. [A1]

5 The thermistor is connected into the circuit of Fig. 5.1 in order to monitor temperature changes in a room. The battery of e.m.f. 1.50 V has negligible internal resistance and the voltmeter has infinite resistance. The value of *R* is given to be 4800 Ω.

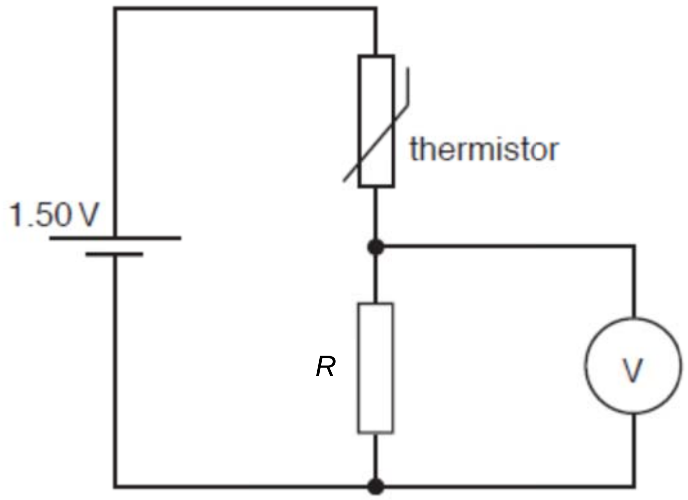


Fig. 5.1

Fig. 5.2 shows the variation with temperature, measured in degrees Celsius, of the resistance of the thermistor in the range 12 °C to 24 °C.

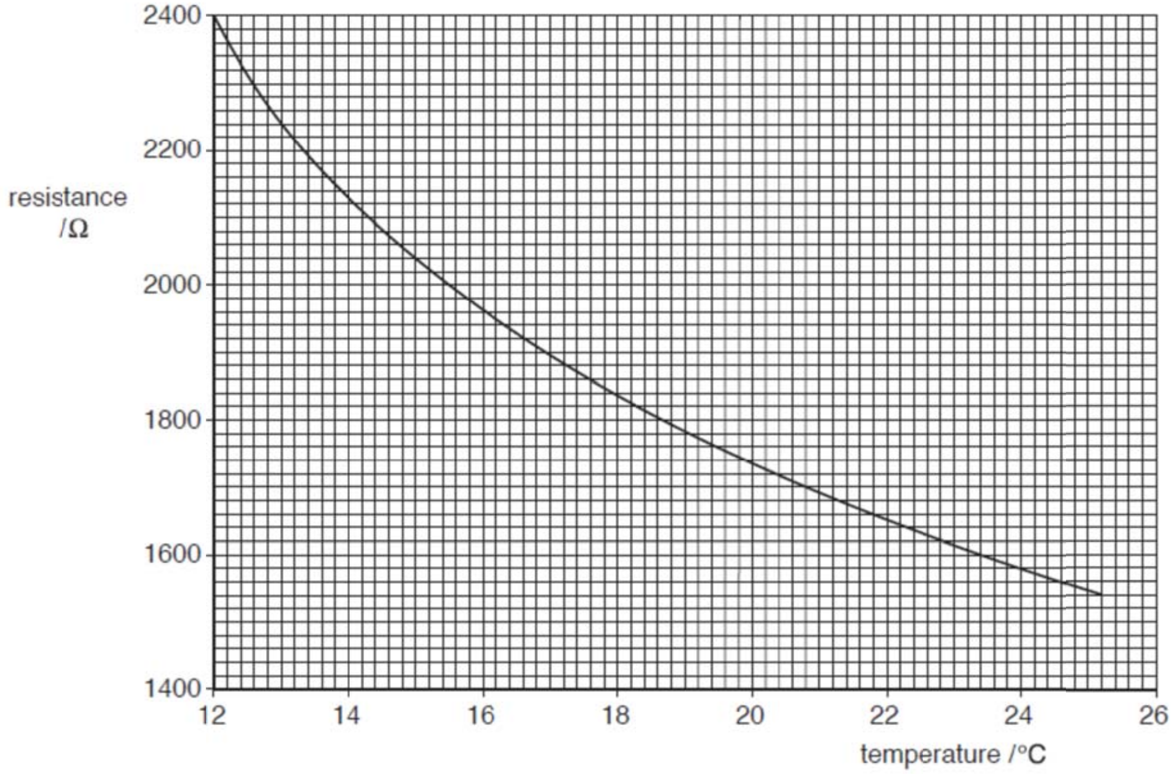


Fig. 5.2

For Examiner's Use

(a) State the resistance of R at 12 °C.

2400 Ω (A1)

resistance = ... Ω [1]

(b) Deduce the reading on the voltmeter at 12 °C.

Using V = [R / R_{total}] x emf
= 4800 x 1.5 / (2400 + 4800) (C1)
= 1.0 V (A1)

reading = ... V [2]

(c) The circuit is now placed in a room at an unknown temperature *T*. The voltmeter reading is 1.13 V. Find *T*.

Using V = [R / R_{total}] x emf
1.13 = 4800 x 1.5 / (R + 4800) (C1)
R = 1570 Ω (A1)

temperature = ... °C [3]

(d) The voltmeter is later found to be non-ideal with a resistance of 8.0 kΩ. Find the value of the voltmeter when it is set up in Fig. 5.1 at a temperature of 12 °C.

Combined resistance of R and voltmeter = $(1/8000 + 1/4800)^{-1}$ = 3000 Ω (C1)
V = 3000 / (3000 + 2400) x 1.5 = 0.83 V (A1)

value = ... [2]

(e) Suggest one way to ensure the reading in **(d)** is as close to the true reading as possible.

Add in a resistor of very high resistance in series with the voltmeter. (B1)

....[1]

Section B

For Examiner's Use

Answer **two** of the questions in this section.

6 A car starts from rest and travels upwards along a straight road inclined at an angle of 5.0° to the horizontal, as illustrated in Fig. 6.1.

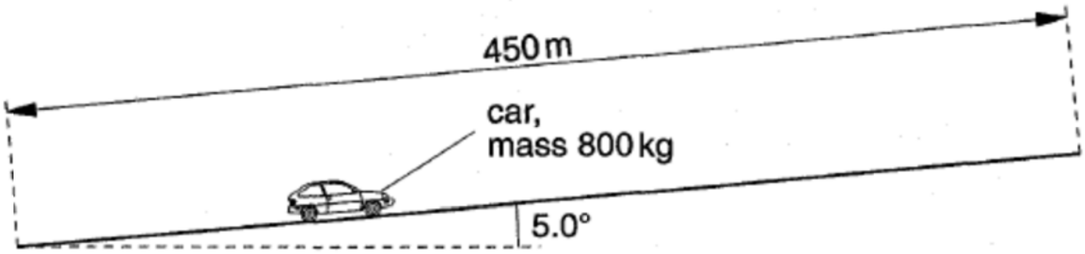


Fig. 6.1

The length of the road is 450 m and the car has mass 800 kg. The speed of the car increases at a constant rate and is 28 m s^{-1} at the top of the slope.

(a) Determine, for this car traveling up the slope,

(i) its acceleration,

Using $v^2 = u^2 + 2as$,
$28^2 = 0^2 + 2\ a\ (450)$, [M1]
$a = 0.871$ m s^{-2}. [A1]

acceleration = ... m s^{-2} [2]

(ii) the time taken to travel the length of the slope,

Using $v = u + a\ t$,
$28 = 0 + (0.871)\ t$,
$t = 32.1$ s [A1]

time = ... s [1]

(iii) the gain in kinetic energy,

Gain in KE = $\frac{1}{2} m \Delta v^2$.
$= \frac{1}{2} m \Delta v^2$.
$= \frac{1}{2} (800) (28^2 - 0^2)$ [M1]
$= 3.14 \times 10^5$ J [A1]

gain in kinetic energy = ... J [2]

(iv) the gain in gravitational potential energy.

Gain in GPE = $mg\ \Delta h$
$= (800) (9.81) (450 \sin 5^o)$ [M1]
$= 3.08 \times 10^5$ J [A1]

gain in GPE = ... J [2]

For Examiner's Use

(b) Use your answers in **(a)** to determine the useful output power of the car.

Useful power output = useful gain in energy / total time taken
= (3.14×10^5 J + 3.08×10^5 J) / (32.1) [M1]
= 19.4 kW [A1]

power = ... W [2]

(c) Suggest one reason why the actual power output of the car engine is greater than that calculated in **(b)**.

Extra work done is required to overcome frictional forces. [A1]

(d) At the top of the slope, the driver loses control of his car, and veers off the cliff in the diagram shown in Fig. 6.2. There is a stationary car, some distance away at the foot of the cliff.

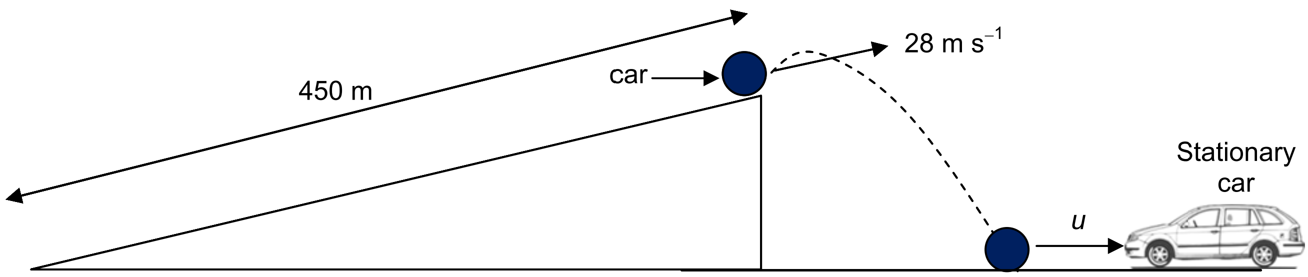


Fig. 6.2

(i) Deduce the height of the cliff.

Height = 450 m (sin 5.0°) = 39.2 m [A1]

height = ... m [1]

(ii) Show that the instantaneous vertical component of speed of the car when it veers off the cliff is 2.4 m s^{-1}.

Vertical component = 28 sin 5° [C1]
= 2.4 m s^{-1}.

[1]

(iii) Calculate the time of flight of the car just before it crashes into the ground.

Using $s = u\,t + ½\,a\,t^2$,
$(-39.2 \text{ m}) = 2.4\,t + ½\,(-9.81)\,t^2$,
$0 = ½\,(9.81)\,t^2 - 2.4\,t - 39.2$ [M1]
t = 3.08 s [A1]

time = ... s [2]

For Examiner's Use

(iv) Find the distance from the foot of the cliff where the car will land.

Horizontal distance = (28 cos 5°) (3.08 s) [M1]
= 86.0 m [A1]

distance = ... m [2]

(v) The car landed at a distance from the foot of the cliff. In the process, the car has lost 90% of its mechanical energy after its collision with the ground. It continues to move forward with a speed *u*.

1. Find *u*.

10% of total energy at top of cliff = total energy at the bottom of cliff
0.10 x [1/2 (800) $(28)^2$ + (800)(9.81)(39.2)] = ½ (800) $(u)^2$. [M1]
u = 12.5 m s^{-1}. [A1]

u = ... m s^{-1} [2]

2. The mass of stationary car is 1200 kg. Assume that the road between the cars is frictionless, find the resultant speed of the 2 cars if the collision between them is perfectly inelastic.

Using conservation of momentum,
$m_1 u_1 + m_2 u_2 = (m_1 + m_2) v$
(800) (12.46) = (800 + 1200) (v) [M1]
v = 4.98 m s^{-1}. [A1]

speed = ... m s^{-1} [2]

7 **(a)** **(i)** Define magnetic flux density in terms of the force on a current carrying conductor.

is the **magnetic force** acting on a **straight** wire **per unit length** **per unit current** flowing through it, when the wire is placed **perpendicular** to the **magnetic field**.

....

....[2]

(ii) Fig. 7.1 shows a rectangular coil ABCD with sides 3*L* and 2*L* carrying a current *I* is next to a long straight wire XY carrying a current 4*I*

For Examiner's Use

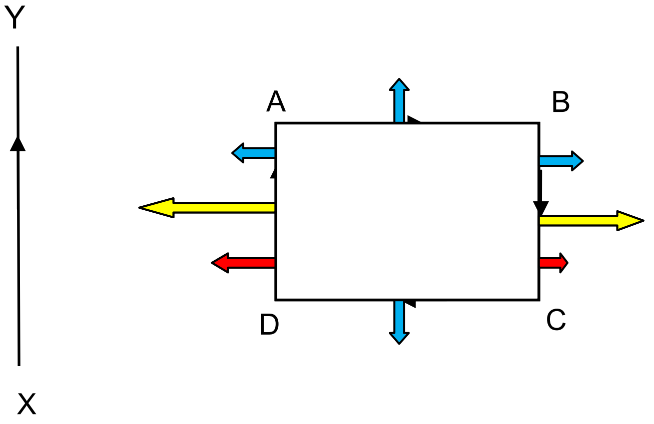


Fig. 7.1

1. Indicate clearly on the diagram, the direction of the forces acting on the current in section AB, BC, CD and DA. [2]

2. Hence, explain the resultant force acting on the coil ABCD.

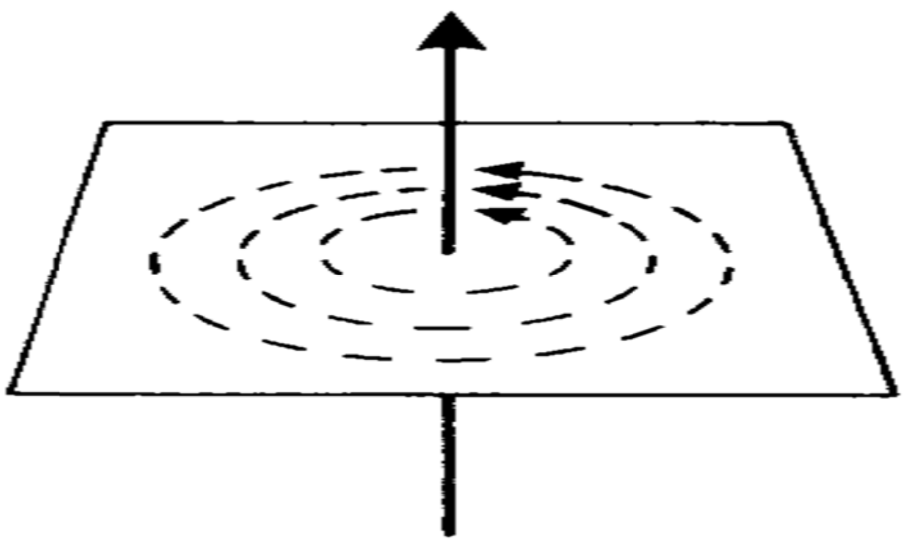
Since $F_1 = F_2$, ∴ coil ABCD move towards the wire XY

....

....[2]

(b) Sketch the form of the magnetic field due to

(i) a long, straight current-carrying wire. [2]



(ii) two long straight conductors with current in the same direction, [2

For Examiner's Use

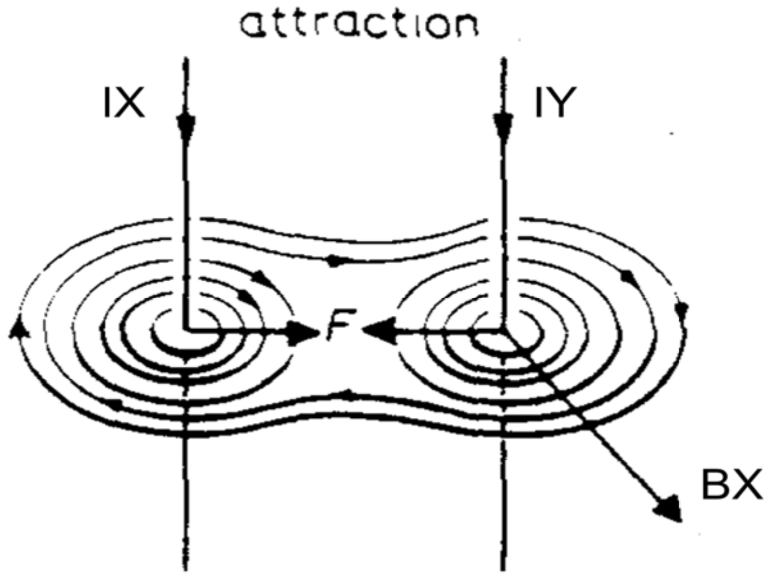
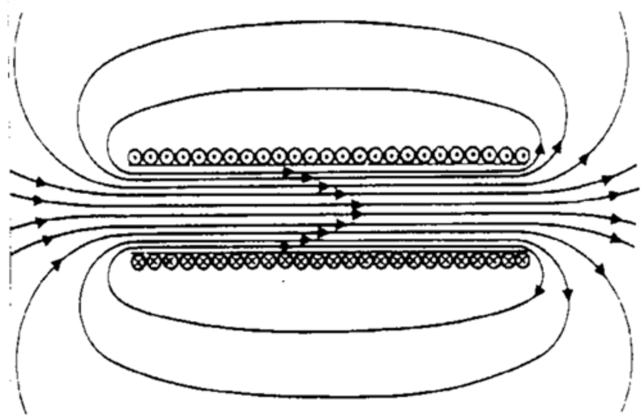


Figure (i): Forces between currents in same directions

(iii) a long helical coil. [2



For Examiner's Use

(c) Fig. 7.2 shows a square coil with sides of 8.0 cm and consisting of 50 turns of wire wound on an insulating frame is freely pivoted about a horizontal axis XY. The coil is in a magnetic field of flux density *B*.

When no current flows in the coil, the plane of the coil Is vertical. When a current of 5.7 A flows in the coil, a rider of 3.6 g placed at distance *d* = 0.12 m from the pivot is required to restore equilibrium.

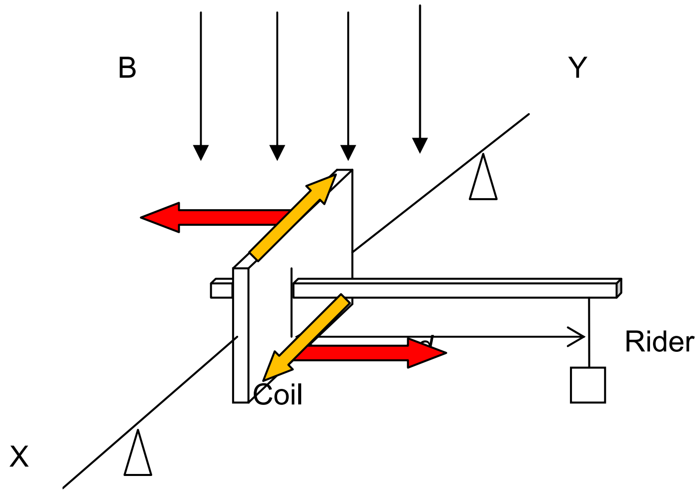


Fig. 7.2

(i) Mark the direction of the current in the coil, and the direction of the magnetic forces on the sides of the coil. [2]

(ii) Calculate the magnetic flux density of the coil. [3]

Taking moment about the pivot

$F_B \times 8 \times 10^{-2} = (3.6 \times 10^{-3} \times 9.81) \times 0.12$

$(50 \times B \times 5.7 \times 8 \times 10^{-2}) \times 8 \times 10^{-2} = (3.6 \times 10^{-3} \times 9.81) \times 0.12$

$B = 2.3 \times 10^{-3}$ T

(iii) If the current in the coil is from a battery of constant e.m.f. and negligible internal resistance, discuss the effect on the value of *d* if the coil is replaced by another square coil of sides 4 cm with 100 turns of the same wire.

For Examiner's Use

Let d_2 be the new value of the distance of rider from the pivot

$(N_1BI_1L_1) \times L_1 = W \times d_1$
$(N_2BI_2L_2) \times L_2 = W \times d_2$

Current $I = \frac{V}{R} = \frac{VA}{\rho L} = \frac{k}{L}$ where $k = \frac{VA}{\rho}$ is a constant

$$\therefore \frac{d_2}{d_1} = \frac{N_2(N_1 4L_1)L_2L_2}{N_1(N_2 4L_2)L_1L_1} = \frac{(4)}{(8)} = 0.5$$
$$d_2 = 0.5d_1 = 0.06 \text{ m}$$

NB: the total length of wire for the two cases are the same, 50 x 4 x 8 = 100 x 4 x 4 = 1600 cm

....

....

....

....[3]

For Examiner's Use

8 In an experiment to investigate photoelectric effect, a line emission spectrum from hydrogen discharge tube is used.

(a) Explain how a line emission spectrum leads to an understanding of the existence of discrete electron energy levels in atoms.

A line emission spectrum shows a discrete number of bright lines in a dark background.
Each line corresponds to a specific photon energy. [B1]

The photon is emitted when electron makes a transition from a higher energy level to a lower energy level. The energy of the photon corresponds to the energy change between the two energy level. [B1]

Since the photon energy is of a specific value, it implies that the energy change is also of specific amount. [B1]

The discrete energy changes implies that the energy levels are discrete.
....[3]

(b) Some of the lines of emission spectrum of atomic hydrogen are shown in Fig. 8.1

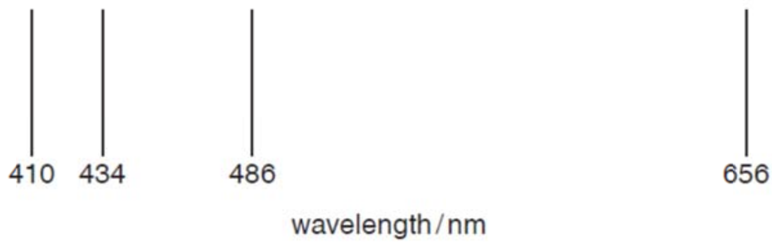


Fig. 8.1

The photon energies associated with some of these lines are shown in Fig. 8.2

wavelength / nm	Photon energy / 10^{-19} J
410	4.85
434	4.58
486	....
656	3.03

Fig. 8.2

(i) Complete Fig. 8.2 by calculating the photon energy for a wavelength of 486 nm. [2]

$E = hc/\lambda = (6.63 \times 10^{-34})(3.0 \times 10^{8})/(486 \times 10^{-9})$
$= 4.09 \times 10^{-19}$ J [C1]

Complete the table with a value of 4.09. [A1]

For Examiner's Use

(ii) Energy levels of a single electron in a hydrogen atom are shown in Fig. 8.3.

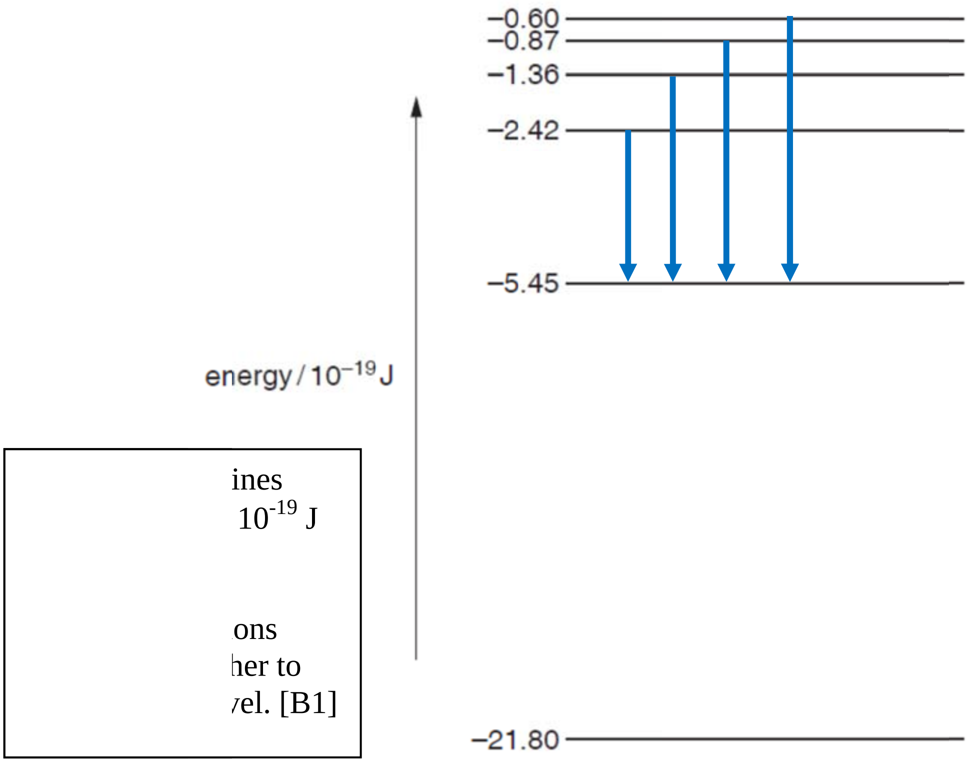


Fig. 8.3 (not to scale)

Use data from **(i)** to show, on Fig. 8.3, the transitions associated with each of the four spectral lines shown in Fig. 8.1. Show each transition with an arrow.[2]

(c) Fig. 8.4 shows a photocell.

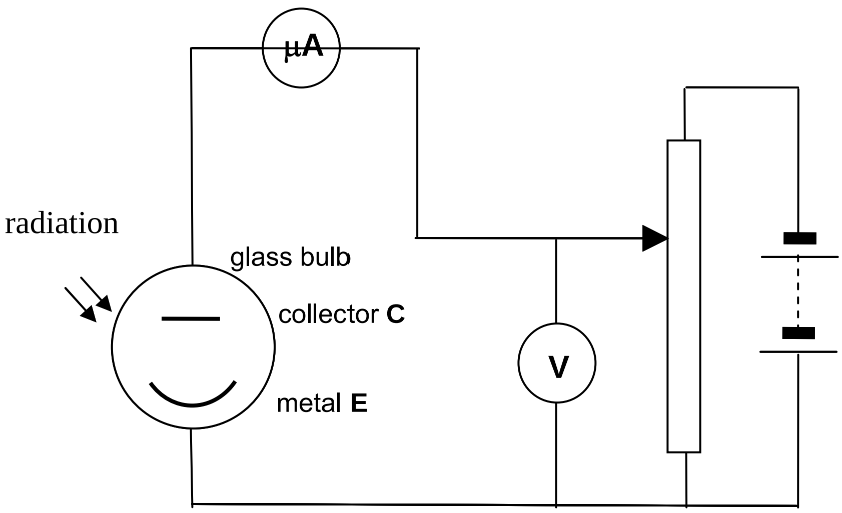


Fig. 8.4

When the metal surface is exposed to electromagnetic radiation, photoelectrons are ejected. The collector collects the photoelectrons and the sensitive ammeter indicates the presence of a tiny current.

For Examiner's Use

(i) The light of a wavelength of 434 nm from the hydrogen discharge tube was selected to shine on the photocell. The ammeter shows a current of 1.2×10^{-7} A. Calculate

1. the charge reaching the detector in 5.0 s,

Charge reaching the detector = $I \times t = (1.2 \times 10^{-7})(5.0)$
$= 6.0 \times 10^{-7}$ C [A1]

charge = ... C [1]

2. the number of photoelectrons reaching the collector in 5.0 s.

Q = Nq
$N = (6.0 \times 10^{-7})/(1.6 \times 10^{-19}) = 3.8 \times 10^{12}$ [A1]

number of electrons = ... [1]

(ii) The work function energy of the metal is 2.2 eV. Calculate

1. the maximum kinetic energy of an ejected photoelectron,

Energy of photon = $\Phi + KE_{max}$ [C1]
$KE_{max} = hc/\lambda - \Phi$
$= (6.63 \times 10^{-34})(3.0 \times 10^{8})/(434 \times 10^{-9}) - 2.2(1.6 \times 10^{-19})$
$= 1.06 \times 10^{-19}$ J [A1]

energy = ... J [2]

2. the potential to stop the most energetic electrons from reaching the collector.

$eV_s = KE_{max}$
$V_s = 0.66$ V [A1]

potential = ... V [1]

(iii) The intensity of the incident radiation is doubled but the wavelength is kept constant. State and explain the effect this has on each of the following

1. the maximum kinetic energy of each photoelectron,

The maximum kinetic energy of each photoelectron is affected by the energy of each photon and the work function energy. Since the wavelength is kept constant, the energy of each photon remains constant. The work function energy remains the same since the metal is unchanged. [M1] Therefore the maximum kinetic energy of each photoelectron remains unchanged. [A1]

....[2]

For Examiner's Use

2. the current in the photocell.

The current in the photocell is doubled. [A1] This is because when the light intensity is doubled, there are twice the number of photons incident on the metal per unit time. This resulted in twice the number of electrons emitted per unit time. Since current is proportional to the rate of emission of electrons, current is doubled.[M1]

....[2]

(d) Moving electrons have a wave-like property.

(i) Calculate the speed *v* of an electron having a de Broglie wavelength equal to the wavelength of the light in **(c)**.

From De Broglie equation,
$\lambda = h/p = h/mv$ [C1]

$v = (6.63 \times 10^{-34})/(9.11 \times 10^{-31})(434 \times 10^{-9})$
$= 1680 \text{ m s}^{-1}$ [A1]

speed = ... m s^{-1} [2]

(ii) The electrons are directed into a thin film of graphite. Explain if the wave-nature of the electrons moving with the speed in **(d)(i)** is observable.

The associated wavelength of the electron (434×10^{-9}) is about 1000 times bigger than the atomic spacing of the order of 10^{-10} m. [M1] Thus the diffraction pattern is not observable. [A1]

....

....

....

....

....[2]

END OF PAPER