HWA CHONG INSTITUTION
JC2 Preliminary Examinations
Higher 1

CANDIDATE NAME		CT GROUP	15S
CENTRE NUMBER		INDEX NUMBER	

PHYSICS   **8866/02**

Paper 2 Structured Question   **13 September 2016**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

INSTRUCTIONS TO CANDIDATES

Write your **Centre number**, **index number, name** and **CT class** clearly on all 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, paperclips, highlighters, glue or correction fluid.

Section A

Answer **all** questions.

Section B

Answer any **two** questions.

Circle the questions attempted in the table on the cover page.

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

INFORMATION FOR CANDIDATES

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

You are reminded of the need for good English and clear presentation in your answers.

For Examiner's Use		
1		6
2		8
3		5
4		5
5		5
6		11
7		20
8		20
9		20
Deductions		
Total		80

This document consists of **24** printed pages.

Data

speed of light in vacuum,

$c = 3.00 \times 10^8$ 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, $\quad s = ut + \dfrac{1}{2}at^2$ s

$$v^2 = u^2 + 2as$$

work done on/by a gas, $\quad W = p\Delta V$

hydrostatic pressure, $\quad p = \rho g h$

resistors in series, $\quad R = R_1 + R_2 + ...$

resistors in parallel, $\quad 1/R = 1/R_1 + 1/R_2 + ...$

Section A

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

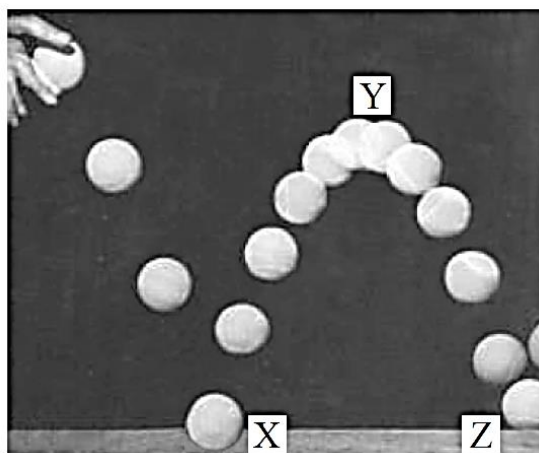**1** The photograph below shows a sequence of images of a bouncing tennis ball.

Fig. 1.1

A student plots the following graph below and claims that it shows the vertical motion of the ball in the photograph.
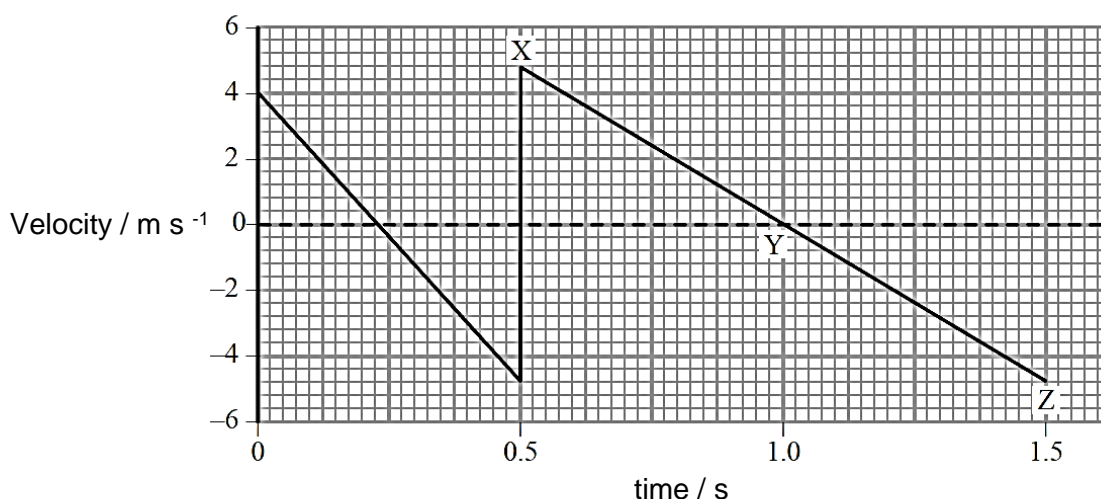

Fig. 1.2

(a) Without carrying out any calculations, describe how the following can be found or deduced from the graph.

(i) The vertical distance travelled by the ball between 0.5 s and 1.0 s.

.... [1]

(ii) The acceleration at Y.

.... [1]

(iii) Velocity is a vector.

.... [1]

(iv) Estimate from the graph, a value for the uncertainty of the initial velocity of the ball.

Δu = ………………………. m s^{-1} [1]

(b) The graph contains several errors in its representations of the motion of the ball. State and explain one of these errors.

………………………………………………………………….......……………………..................

………………………………………………………………………….......………………………………

………………………………………………………………………….......………………………………

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

2   A ball is dropped onto a horizontal plate as shown in Fig. 2.1.

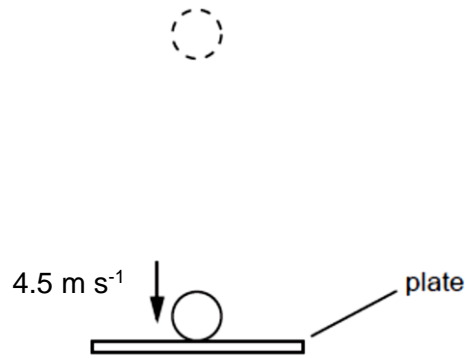**Fig. 2.1**

(a)   Just before impact with the plate, the ball of mass 35 g has a speed of 4.5 m s⁻¹. It bounces
from the plate so that its speed immediately after losing contact with the plate is 3.5 m s⁻¹.
The ball is in contact with the plate for 0.14 s.

Calculate, for the time that the ball is in contact with the plate,

(i)   the average net force acting on the ball

magnitude of force = ... N

direction of force = ... [3]

(ii)   the loss in kinetic energy of the ball.

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

(b) State and explain whether linear momentum is conserved during the bounce.

....

....

....

....

……… [3]

3 **(a)** A heating coil is to be made of wire of diameter 3.5 ×10⁻⁴ m. The heater is to dissipate 980 W when connected to a 230 V d.c. supply. The material of the wire has resistivity 1.3 ×10⁻⁶ Ω m at the working temperature of the heater.

Calculate the length of wire needed to make the heating coil.

length = ... m   [3]

(b) Three identical electrical heaters each provide power *P* when connected separately to a supply S which has zero internal resistance. On the diagram below, complete the circuit by drawing **two** switches so that the power provided by the heaters may be **either** *P* **or** 2*P* **or** 3*P*.

supply S
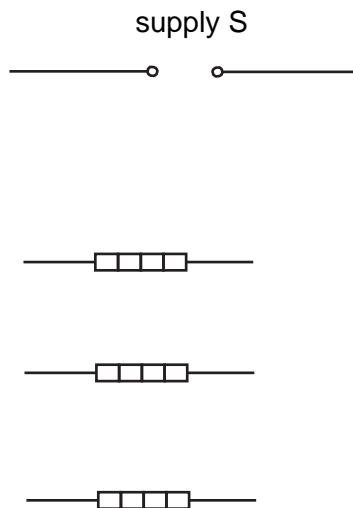
[2]

4   Light of different frequencies is shone on to a metal surface in a photocell connected as shown in Fig. 4.1.
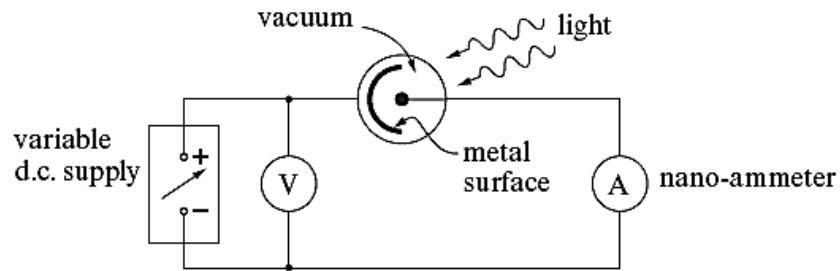

Fig. 4.1

Fig. 4.2 is a graph showing the maximum kinetic energies $E_{k\,max}$ of electrons emitted from the metallic surface by light of different frequencies.
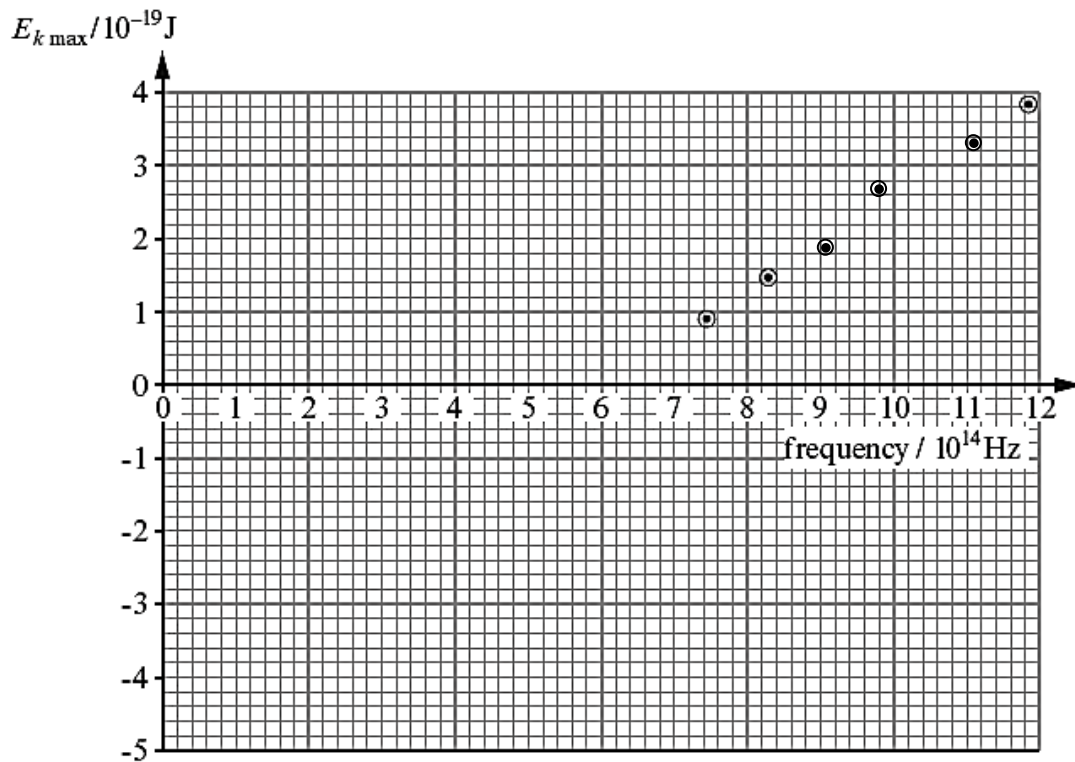

Fig. 4.2

(a)   Determine from Fig. 4.2, a value for the Planck constant,

Planck constant = ...J s   [2]

(b) The metal with the exposed surface in the photocell is known to be one of these five metals whose work functions are listed in the table in Fig. 4.3

| metal	barium	magnesium	aluminum	magnesium	platinum
ϕ / eV	2.5	3.7	4.1	5.0	6.4

Fig. 4.3

Use this table to determine which of these metals is illuminated by the light, giving your reasoning.

Metal = ... [2]

(c) The experiment is repeated now with another metal of a lower work function. Sketch on Fig. 4.2 a new line representing the results for this experiment. Label this graph as **N**. [1]

5   Fig. 5.1 represents three of the visible lines in the emission spectrum of hydrogen, together with the wavelengths of these lines.

434   486   656   λ/nm
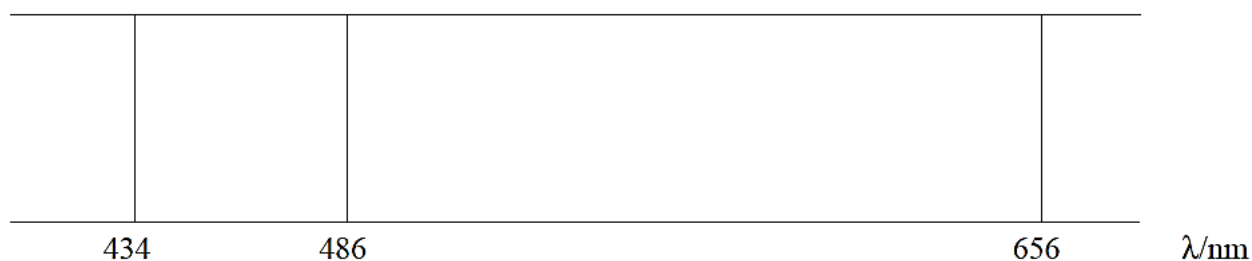
Fig. 5.1

(a)   Show that the photon energy for the 486 nm line is about 4 x 10^{-19} J.

[1]

(b)   Fig. 5.2 represents some of the allowed energy levels within the hydrogen atom. The energy for each is given in the diagram.

energy/10^{-19}J

———————————————————— 0.00

———————————————————— −0.61
———————————————————— −0.88
———————————————————— −1.36

———————————————————— −2.42

———————————————————— −5.45
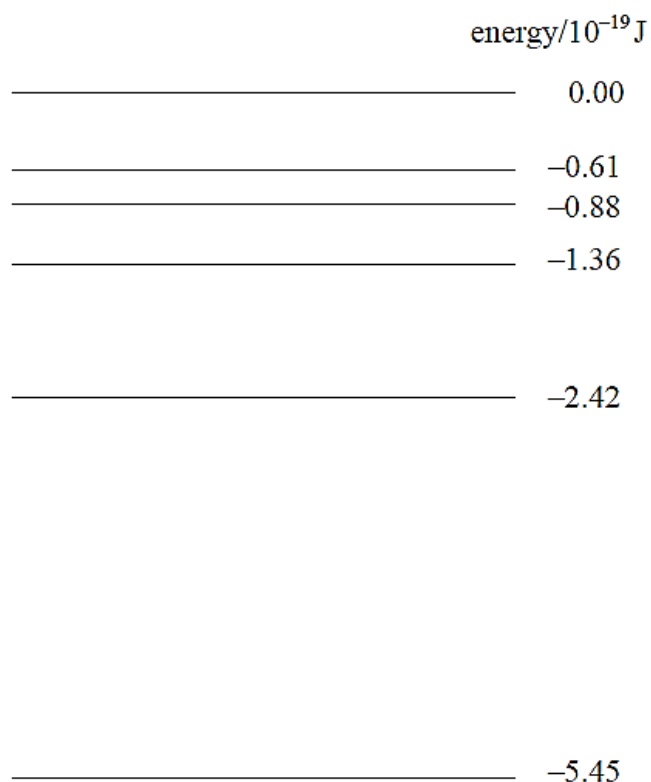
Fig. 5.2

(i) Without any calculations, describe how the energy levels shown in **Fig. 5.2** can be used to explain the emission spectrum of the hydrogen.

-- [3]

(ii) Draw an arrow on **Fig. 5.2** to show which transition within the hydrogen atom leads [1] to the 486 nm spectral line shown in **Fig. 5.1.**

6 In the USA, cars account for about half the oil consumed, half the urban pollution and a quarter of emission of greenhouse gases. Vehicle usage is set to continue its growth globally. With improved technology over the past decade, electric vehicle is touted to be a greener alternative to conventional cars powered by fossil fuels.

The following tables gives the specifications of variants of the same model of car, Ford Focus, one oil-powered (named 'Classic') and one electric-powered (named 'Electric'),

Specifications for Two Variants of Ford Focus:

Electric [1] :

Capacity of lithium-ion battery	23 kWh
Average distance per full charge	122 km
Average cost of 1 kWh of electricity in 2014	$0.1044

Table 6.1(a)

Classic[1]:

Distance per litre of petrol	29.1 km
Average cost of 1 litre of petrol in 2014	$0.9221
Energy released in combustion of 1 litre of petrol	9.7 kWh

Table 6.1(b)

Sources:

1. US Energy Information Administration, Ford Motor, Wikipedia.

2. Tan, Wijaya and Khoo. (2010). Life cycle analysis of fuels and electricity generation in Singapore.

(a) One of the key advantages of electric vehicles over conventional oil-powered vehicles is energy efficiency, this can be measured by comparing the *average energy expenditure per kilometer* for each variant.

Using the data quoted in Table. 6.1(a) and 6.1(b),

(i) show that for the Electric variant, the energy stored in the lithium-ion battery when [1] fully charged is 8.28×10^7 J.

(ii) Hence, calculate the *average energy expenditure per kilometer travelled* for the Electric variant.

Electric variant: .... kJ km^{-1} [2]

(iii) Calculate the *average energy expenditure per kilometer travelled* for the Classic variant.

Classic variant: .... kJ km^{-1} [2]

(b) Besides comparing the energy efficiencies, other aspects of consideration are the cost of usage. Based on a 20,000 km annual mileage, calculate the amount of savings a driver can save by driving the Electric model over the Classic one.

Annual savings = $ .... [2]

(c) One of the key challenges facing electric car manufacturers is how to reduce the long charging time for the vehicular battery pack. A particular electric car has a charging power rating of 40 kW. However, the charging power will decay as the battery gets charged up. It takes about 5 hours for the battery pack to be fully charged from empty state. Fig. 6.2 shows how the charging power vary with time.
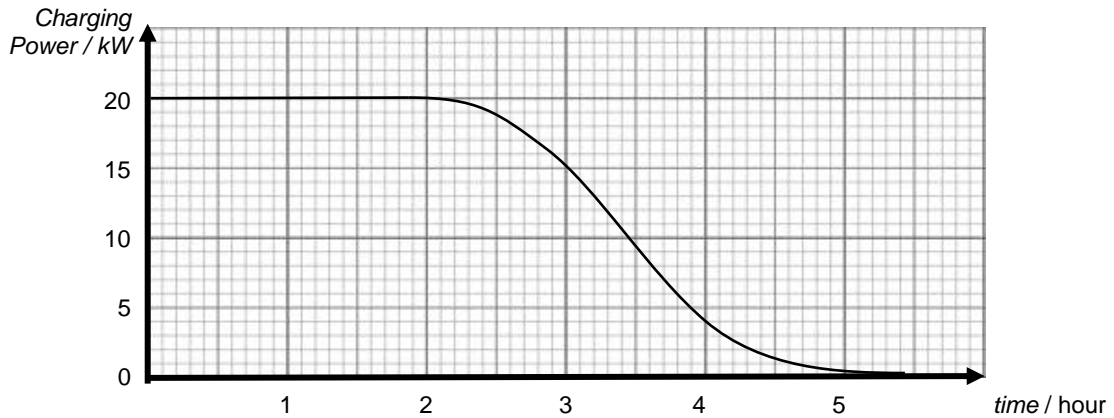

Fig. 6.2

(i) Estimate the amount of energy that the battery can store at full capacity.

capacity = ……..………. kWh   [3]

(ii) Another manufacturer is able to come up with a better charging technology that allows the decay in charging power to be delayed. Assuming that the maximum charging power of this charger is still 20 kW and that the battery capacity remains a constant, sketch on Fig. 6.2 its corresponding charging curve and label it **A**.   [1]

Section B

Answer **two** questions from this Section in the spaces provided.

7 **(a)** A crane consists of a freely pivoting beam of mass 200 kg. The centre-of-mass of the beam is 4.0 m from the pivoting joint. The cable at one end of the beam, 12.0 m from the joint, is used to lower a concrete block of mass 5.0×10^3 kg into the sea. There is a counterweight of mass 3.0×10^4 kg at the other end of the beam and its centre is 1.0 m from the joint. The top of the crane is 3.0 m above the joint and there is a support line connecting it to the part of the beam where the cable is attached.
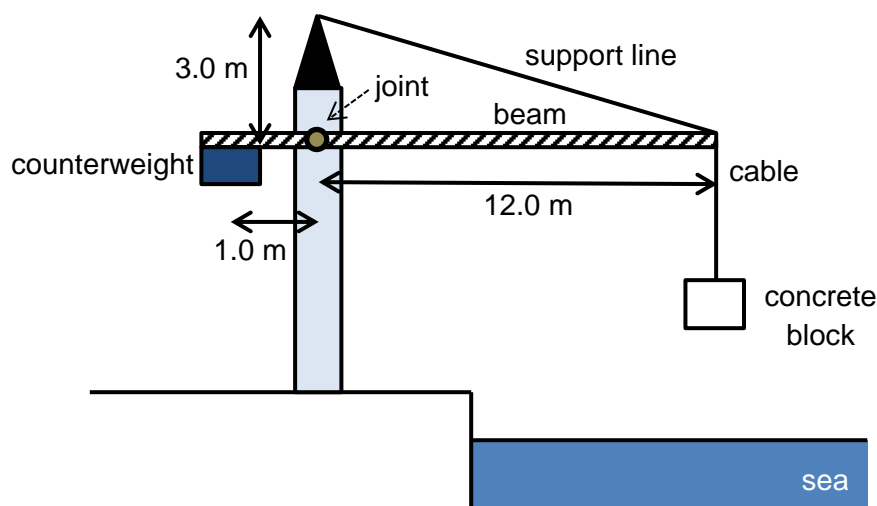

Fig. 7.1

(i) State the requirements for a body to be in static equilibrium.

………………………………………………………………………………………….............

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

(ii) Calculate the tension in the support line as the block is lowered towards the sea at a constant speed.

tension = ………………….. N   [3]

(b) The concrete block is moving downwards at 1.0 m s^{-1}. When the block is 12.5 m above sea level, the cable snaps.

Show that the concrete block hits the sea with a speed of 15.7 m s^{-1}, stating clearly any assumptions you make.

Assumption: ……………………………………………………………………………………… [3]

(c) As the concrete block falls through the water, it encounters a drag force F_d equal to $k\,A\,v^2$, where v is the velocity of the block, A is the area facing downwards and k is a constant. The block decelerates to a terminal velocity of 2.7 m s^{-1} in 0.55 s. Assume negligible upthrust.

The concrete block is a cube of density ρ.

(i) Label on Fig 7.2, the forces acting on block before terminal velocity is reached. [2]

Fig. 7.2

(ii) At the instance the concrete block is falling with velocity v, show that the acceleration of the block a is given by

$$a = g - \frac{kv^2}{\rho A^{\frac{1}{2}}}$$

[3]

(iii) Hence, derive an expression for the terminal velocity v_T of the concrete block.

[2]

(iv) Sketch labelled graphs, starting from the time the concrete block hits the water, to show the variation with time of

1. the block's acceleration a

a / m s^{-2}

t / s

[2]

2. the block's velocity v

v / m s^{-1}

t / s

[3]

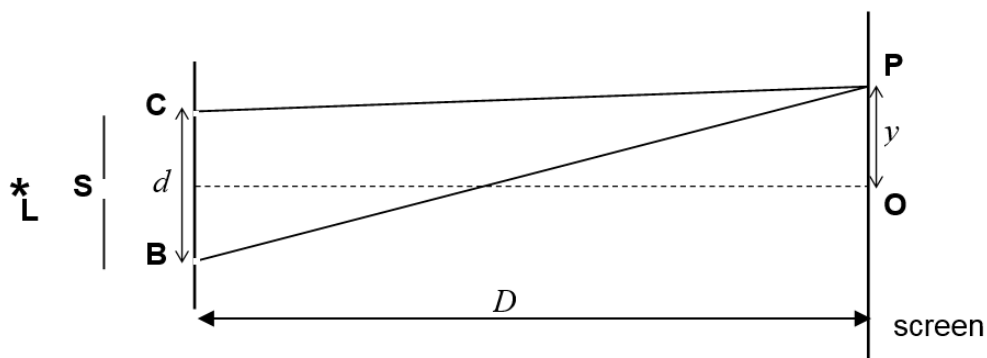8   A Young's double slit experiment is shown in Fig. 8.1.

Fig. 8.1 *(not drawn to scale)*

L is a monochromatic light source emitting radiation of wavelength λ and **S** is a single slit. The separation between the double slits **B** and **C** is d, the distance from the double slits to the screen is D and y is the distance of the *2nd bright fringe* from the central maximum at **O**.

(a) **(i)**   Explain the purpose of the single slit **S** placed before the double slit.

   …………………………………………………………………………………………..

   …………………………………………………………………………………………..

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

   (ii)   **1.** State, in terms of number of wavelengths, λ, the path difference between the two rays from **B** and **C** arriving at **P**.

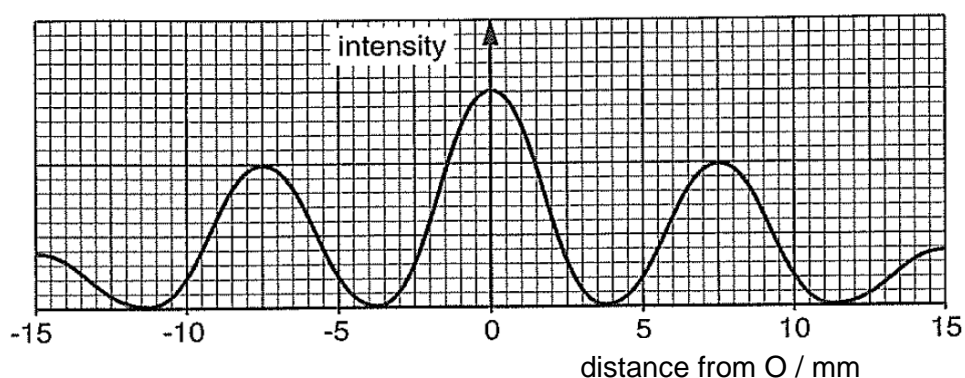   Path difference = ………………………… [1]

   2. State the phase difference between the two rays arriving at **P**.

   Phase difference = …………………… rad   [1]

   (iii)   Express y in terms of λ, d and D.

   [1]

(iv) The separation between the two slits is 0.45 mm. The interference pattern, formed on a screen 6.15 m away from the slits, is shown in Fig. 8.2.

Fig. 8.2

Use Fig. 8.2 to determine the wavelength of the light from the light source.

Wavelength = ……………………………… m   [2]

(v) Suggest the colour of the light being used.

Colour : …………………………………   [1]

(vi) State how the intensity at **O** changes when slit **B** is covered.

....

....   [1]

(b) Describe the changes to the original fringe pattern on the screen if each of the following changes is made separately to the setup in Fig. 8.1.

1. the light emerging from **B** is reduced in intensity as compared to **C**.

……………………………………………………………………………..................

……………………………………………………………………………...................

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

2. the single slit **S** is shifted vertically upwards such that it is closer to slit **C**.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………   [2]

3.   the screen is rotated through 45° as shown in Fig. 8.3

Fig. 8.3

....

....

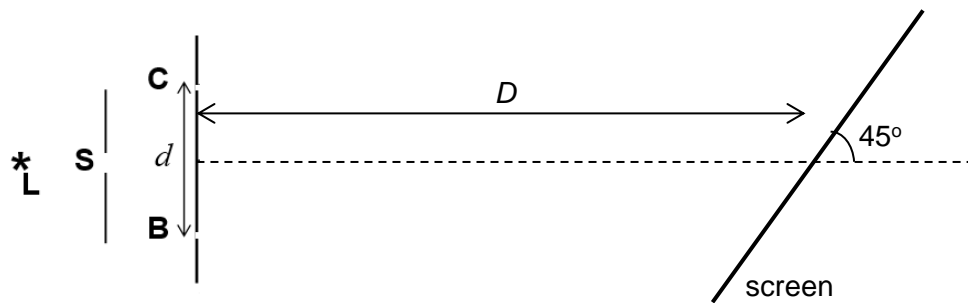... [2]

(c)   Water waves are setup in a ripple tank by dipping a ruler into the water at a frequency *f*.
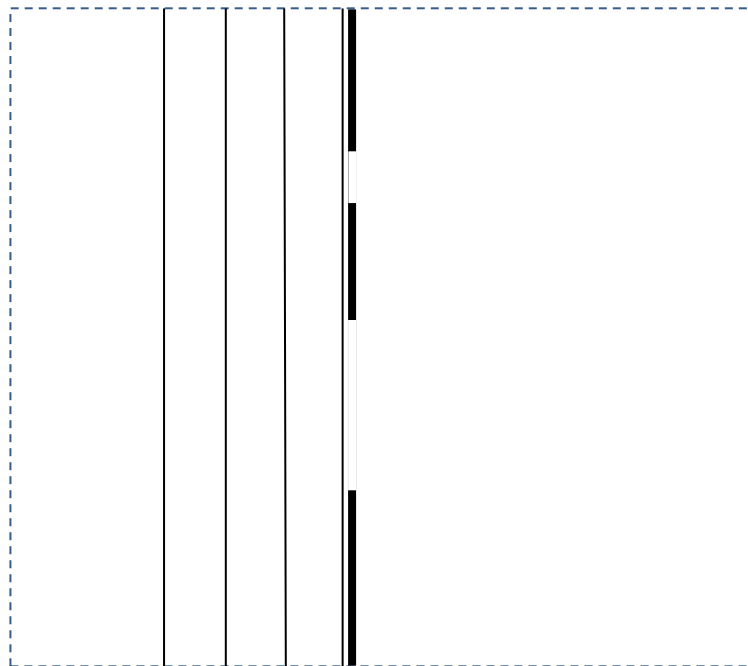A plastic sheet with two holes in it is inserted into the water surface.

Fig. 8.4

(i)   Complete Fig. 8.4 above to show the wavefronts after the water wave passes   [3]
through the plastic sheet. Draw **three** wavefronts for the water wave after passing
through each hole.

(ii)   Mark on Fig. 8.4 a point **C** where constructive interference occurs and a point **D**   [2]
where destructive interference occurs.

9 **(a)** **(i)** Define *magnetic flux density*. [2]

………………………………………………………………………………………………..

………………………………………………………………………………………………..

………………………………………………………………………………………………..

(ii) Hence, derive the S.I. base units for magnetic flux density.

S.I. base units: .... [2]

(b) Fig 9.1 shows the plan view of an electric DC motor. A rectangular coil WXYZ is pivoted so that it is free to rotate about the vertical axis. A current I flows through the coil. The magnetic field produced by the motor's magnet is radial and at the position where W is located, the magnitude of the magnetic flux density is B.
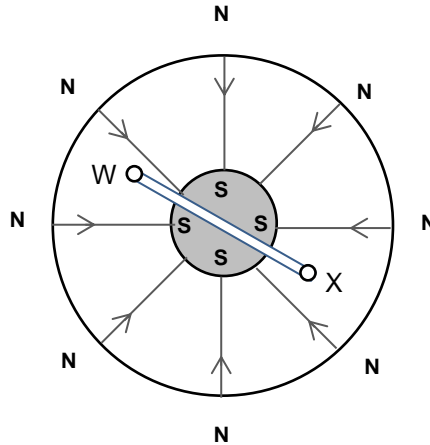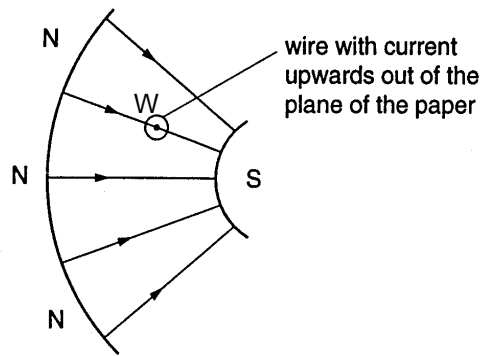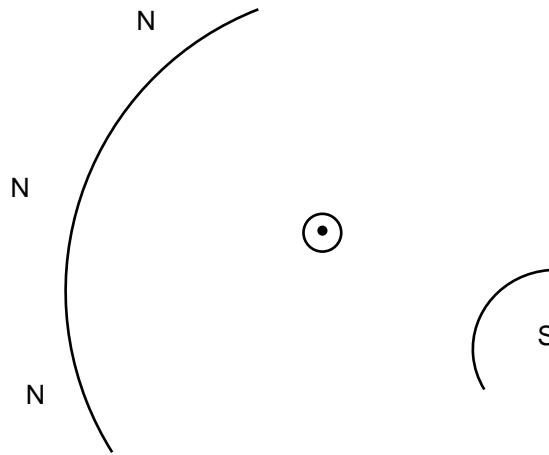

Fig 9.1 Plan view of DC motor

(b) (i) Fig 9.2a shows the magnetic field in the region where W is placed.

On Fig 9.2b, sketch the shape of the combined magnetic field of the current in the wire ZW and the motor's magnet.

Fig 9.2a

[3]

Fig 9.2b

(ii) On Fig 9.2a, label the magnetic force acting on W. [1]

(c) The radial magnetic field is now replaced with a uniform magnetic field as shown in Fig 9.3. The lengths of the rectangular coil WX and XY are *P* and *Q* respectively.
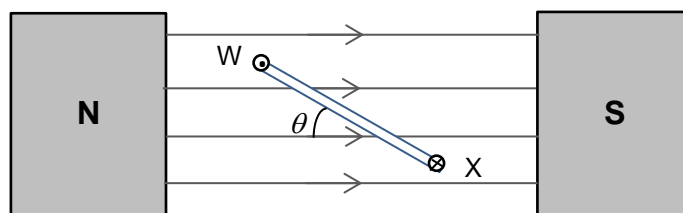
Fig 9.3 Plan view of DC motor

(i) On Fig 9.3, label the force acting on W and X. [1]

(ii) Explain what is meant by

1. the moment of a force

....

.... [1]

2. the torque of a couple

....

....

.... [2]

(iii) Express the torque on the frame WXYZ in terms of *B, P, Q* and θ.

[2]

(iv) Sketch on Fig 9.4 the variation with θ of the torque on the frame WXYZ as it completes one revolution.

Fig 9.4 [2]

(v) By comparing the motion of the motor, suggest an advantage of the design of the DC motor in **(b)** over this design.

....

....

.... [2]

(d) In practice, the rectangle coil WXYZ is made up of many turns of wire rather than just one coil. Suggest an advantage and a disadvantage of having more turns.

Advantage: ....

....

Disadvantage: ....

.... [2]

End of Paper