SEA SECONDARY EDUCATION AUTHORITY (WA)

TERTIARY ENTRANCE EXAMINATION, 1987 — QUESTION/ANSWER BOOKLET

PHYSICS

Please place one of your student identification labels in this box

STUDENT NUMBER — In figures

In words

TIME ALLOWED FOR THIS PAPER

Reading time before commencing: Ten minutes
Working time for paper: Three hours

INSTRUCTIONS TO CANDIDATES

This paper consists of TWO (2) sections.

In SECTION A, answer ALL thirty questions, and **write your answers in the spaces provided beneath each question.** This section carries 48% of the total marks for the paper. Each of these questions is of equal value.

In SECTION B, answer any FOUR (4) of the Five (5) questions, and write your answers in the Standard Answer Book provided. Each of these questions is of equal value and this section is worth 52%. Graph paper is provided in the centre of the Standard Answer Book and should be used for questions requiring graphical work.

In both sections, note that all answers should be given numerically where possible, and that numerical answers should be evaluated and not left in fractional or radical form.

Slide rules, a calculator satisfying the conditions set by the Secondary Education Authority and approved mathematical tables may be used to evaluate numerical answers.

Despite an incorrect final result, credit may be obtained for method and working, provided these are clearly and legibly set out.

At the commencement of this examination, attach one of your STUDENT IDENTIFICATION labels to the front cover of this Question/Answer Booklet and one STUDENT IDENTIFICATION label to the Standard Answer Booklet. Write your student number in the spaces provided in each Booklet.

INSTRUCTIONS TO CANDIDATES CONTINUED ON PAGE 2

SEE PAGE 2

STRUCTIONS TO CANDIDATES (Cont'd)

the end of the examination, attach this Question/Answer Booklet to the BACK of the Standard swer Booklet with the paper binder provided. Section B, pages 17, 18, 19, 20, 21, 22, 23 and 24 ich are perforated, may be removed by students at the end of the examination.

REFER TO PAGE 25 FOR PHYSICAL CONSTANTS

)TE: Page 25 is perforated and may be removed for easier use during the examination.

ATERIAL REQUIRED/RECOMMENDED FOR THIS PAPER

BE PROVIDED BY THE SUPERVISOR

s Question/Answer Booklet comprising 25 pages (Section A — 30 questions, tion B — 5 questions)
ndard Answer Book (Graph paper provided in the centre)
per Binder

BE PROVIDED BY THE CANDIDATE

ndard Items

ıs, pencils, eraser, ruler

ecial Items

od & Storer Mathematical & Statistical Tables, Source Book of Chemical Data, OR the mbined Book of Mathematical & Statistical Tables and Chemical Data, a calculator satisfying conditions set by the Secondary Education Authority, a slide rule, compass, protractor and set ıare.

)TE: Personal copies of Tables/Chemical Data should not contain any handwritten or typewritten notes, symbols, signs, formulae or any other marks (including underlining and highlighting), except the name and address of the candidate, and may be inspected during the examination.

PORTANT NOTE TO CANDIDATES

other items may be taken into the examination room.

s your responsibility to ensure that you do not have any unauthorised notes or other items of a n-personal nature in the examination room. Please check carefully and if you have any uthorised material with you hand it to the supervisor BEFORE reading any further.

SEE PAGE 3

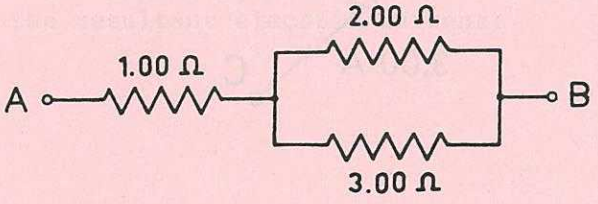
SECTION A

MARKS ALLOTTED : 48

Attempt ALL THIRTY (30) questions in this section. All questions are worth equal marks. Answers are to be written in the spaces provided for each question below or next to the question.

Evaluate answers numerically where possible. Credit will be given for working, if shown. Numerical constants are listed on page 25.

1. Determine the equivalent resistance of the network shown; that is the resistance between points A and B.

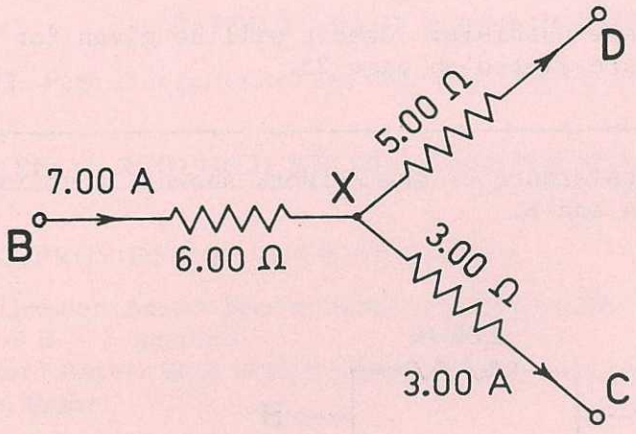


2. If a 2.00 MΩ resistor is connected for 61.5 s to a power supply delivering 1.00 kV, calculate the heat developed.

SEE PAGE 4

In the figure shown what is the potential difference across

(a) BX?
(b) XC?
(c) XD?



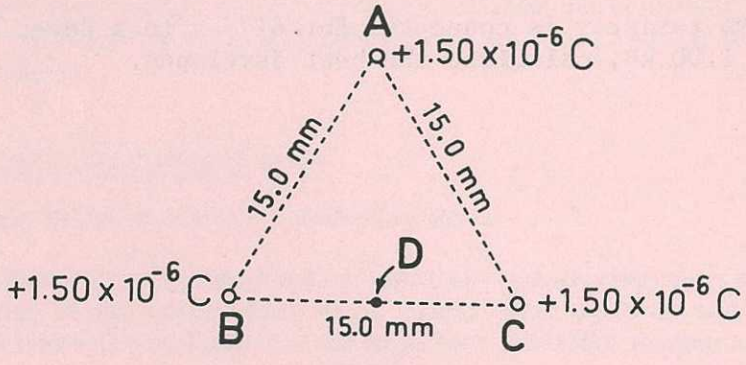
(a) .....

(b) .....

(c) .....

Determine the electric field at point D due to the charges shown. D is the mid-point of BC.

AB = BC = CA = 15.0 mm

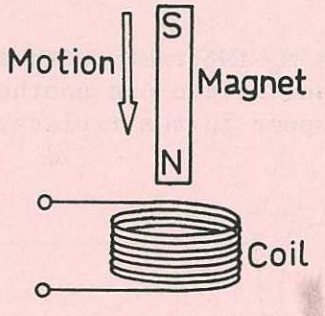


SEE PAGE 5

5. What is the force between two parallel wires 1.80 m long separated by 50.0 mm and each carrying 10.0 A of current in the same direction? Is the force attractive or repulsive?

6. If 30.0 C of negative charge pass in one direction and 2.00 C of positive charge pass in the opposite direction in 4.00 seconds, what is the magnitude of the resultant electric current?

7. A bar magnet passed through a coil as shown induces an emf in the coil. List 3 ways by which such an emf could be increased.



(a) .....

(b) .....

(c) .....

SEE PAGE 6

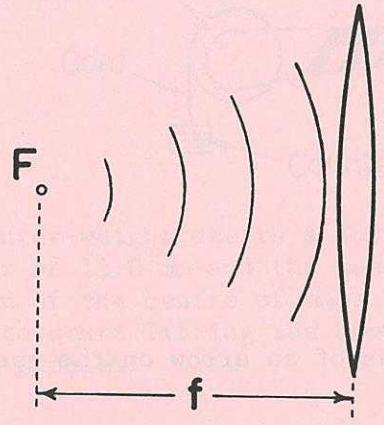
The radiation from a sample of the radioactive isotope ${}^{3}_{1}H$ decreases to one quarter in a period of 25 years. What would be the intensity of radiation after a further period of 50 years?

A nucleus ${}^{A}_{Z}X$ absorbs a neutron and some time later emits an α particle. Write nuclear equations to show these two processes indicating the change in mass number (A) and atomic number (Z).

When an electron of mass m_e interacts with a positron (positive electron of the same mass) they annihilate one another (their mass disappears), and two γ ray photons appear in their place. What is the total energy of the two γ rays?

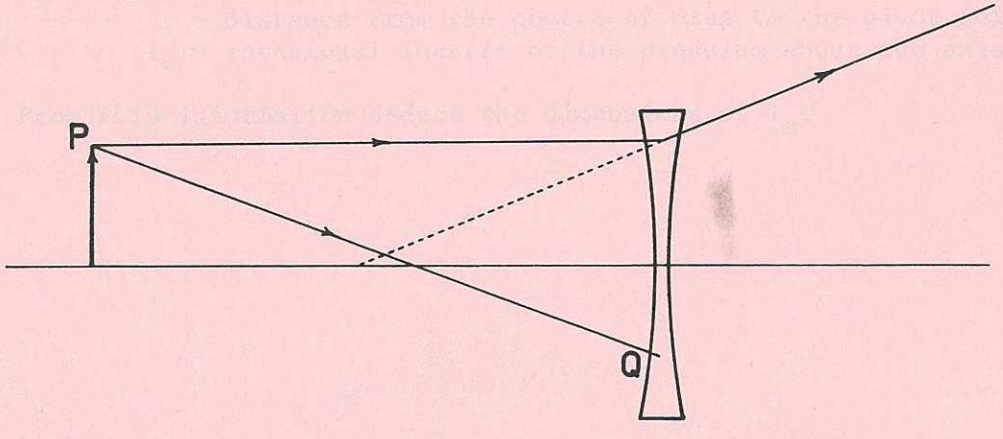
SEE PAGE 7

11. Complete the missing wavefronts in the situation shown to illustrate what happens beyond the lens when a point source of light is placed at the focal point (F) of a convex lens.

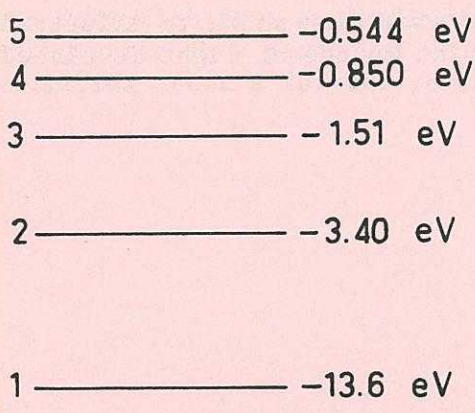


12. List two conditions necessary for the formation of standing waves.

13. Show the position of the image and complete the path of the ray PQ in the diagram.



SEE PAGE 8



Five energy levels of hydrogen are shown in the diagram. Photons of wavelength 486.2 nm are found to be absorbed by hydrogen.

Show this absorption process by means of an arrow on the energy level diagram.

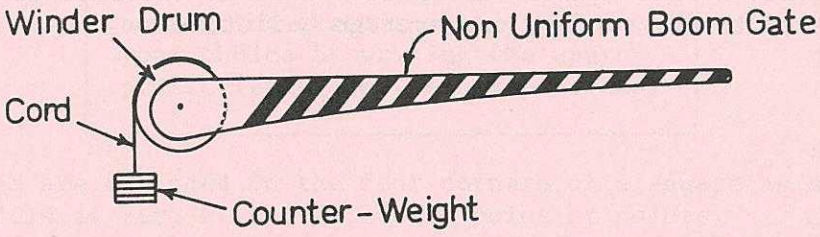
A frog sets off from P swimming at 0.050 m s^{-1} through the water directly towards the opposite parallel bank of a stream. It lands at Q on the other side, some way down stream. The frog swims a total distance of 5.0 m from P to Q in 25 s.

(a) Draw a vector diagram of this situation showing -
(i) the velocity of the frog through the water,
(ii) the velocity of the water along the bottom of the stream and
(iii) the velocity of the frog over the bottom of the stream.

(b) Find the speed of the flow of the stream.

SEE PAGE 9

16. A model railway set has a 105 mm long boom gate which is arranged as follows:



The counter-weight exerts a force of 1.80 N. If the winder drum has a diameter of 15.0 mm and the mass of the boom is 0.0450 kg determine the location of the centre of mass of the boom if the counter weight is just enough to start lifting the boom. Ignore the mass of the winder drum in this problem.

17. A rigid pendulum, such as the familiar pendulum in a grandfather clock, has a period of oscillation given by the expression:

$$T = 2\pi \sqrt{\frac{I_o}{mgr}}$$

where T = period of oscillation
m = mass of the pendulum
g = acceleration due to gravity
r = distance from the centre of mass to the pivot point
I_o = rotational inertia of the pendulum about the axis.

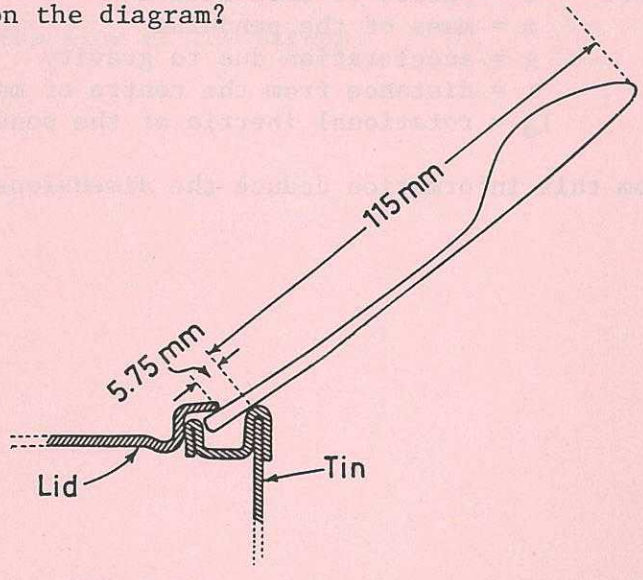
From this information deduce the dimensions of I_o.

SEE PAGE 10

Hailstones of average mass 6.50×10^{-4} kg fall vertically onto a horizontal roof with an average velocity of $10.0\ m\ s^{-1}$. Assume the hailstones do not bounce on impact. What is the average impulse delivered to the roof by one average hailstone?

The acceleration due to gravity on the surface of the planet Jupiter is $25.9\ m\ s^{-2}$ and the radius of Jupiter is 6.99×10^{7} m. What is the mass of Jupiter?

A person is able to remove the lid of a coffee tin by placing the handle of a teaspoon under the lip of the lid and pushing down on the end of the spoon. A force of 20.0 N is applied downwards and perpendicular to the end of the teaspoon. What is the resulting force on the lid if the dimensions are as shown on the diagram?

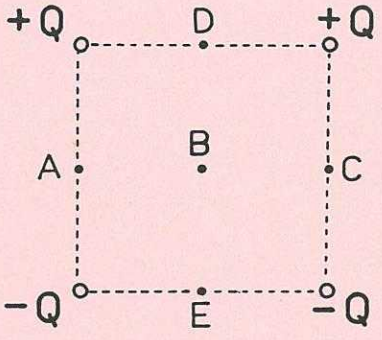


SEE PAGE 11

For the next ten questions, choose which of the alternatives best answer the questions and indicate your choice by writing the appropriate letter in the box provided.

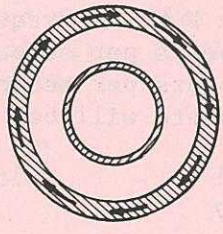
21. Four charges are arranged on the four corners of a square as shown. The electric field is zero at the following point or points.

A. B
B. D and E
C. A and C
D. None of the above.



22. Two different wire loops are concentric and lie in the same plane. The current in the outer loop is clockwise and increasing with time. The induced current in the inner loop is

A. zero
B. clockwise in direction
C. anticlockwise in direction
D. dependant on the ratio of the loop radii for direction.



23. Of the following combinations of units the one that is NOT EQUAL to the watt is the

A. joule second^{-1}
B. ampere volt
C. ampere^2 ohm
D. ohm^2 volt^{-1}
E. weber ampere second^{-1}.

SEE PAGE 12

The discovery of the photoelectric effect demonstrated that

A. light consists of photons of a definite energy $E = h\nu$.

B. electrons in atoms occupy distinct energy levels.

C. atoms only absorb light of certain wavelengths giving rise to line absorption spectra.

D. red light (wavelength about 700 nm) is not able to eject electrons from metals.

Tuning fork X has a frequency of 512 Hz. When tuning fork Y is sounded with X, 3 beats per second are heard. When tuning fork Z is sounded with X, 7 beats per second are heard. When Y is sounded with Z the number of beats will be

A. 0
B. 3 or 7
C. 4
D. 4 or 10
E. dependant on how loudly the forks are sounded.

SEE PAGE 13

26. A ray of light in water is incident on an interface between the water and a glass plate. If $n_{glass} = 1.4$ and $n_{water} = 1.3$ then the angle of incidence θ for which total internal reflection occurs is given by

A. $\sin \theta = 1.4/1.3$

B. $\sin \theta = 1.3/1.4$

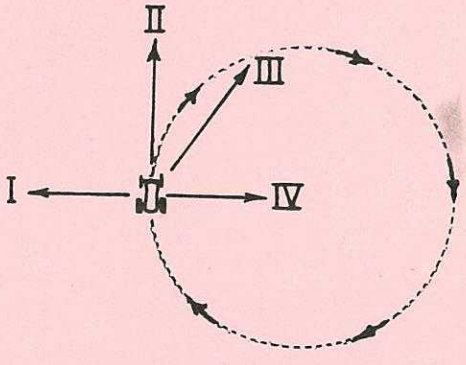
C. $\theta = 42°$

D. $\sin \theta = (1.4 - 1.3)/1.3$

E. none of these as total internal reflection doesn't occur.

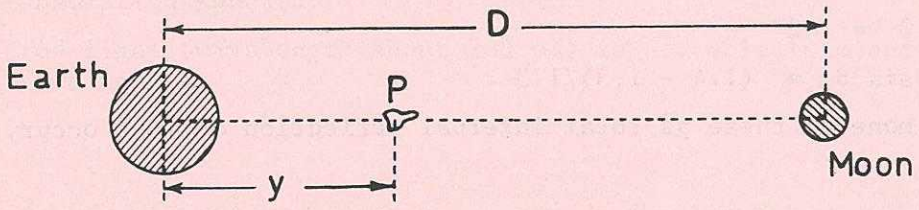
27. A model racing car is moving clockwise around a circular track at constant speed. At the instant shown the velocity, acceleration and force vectors will be along the directions given by

	velocity in direction of	acceleration in direction of	force in direction of
A.	II	II	IV
B.	II	II	I
C.	II	III	IV
D.	II	IV	IV
E.	III	III	I



SEE PAGE 14

The following question refers to the journey of Apollo 11 to the moon. Assume that Apollo 11 has a mass of M_A and is on a straight line joining the centres of the Earth and Moon whose masses are M_E and M_M respectively. R_E is the radius of the Earth and R_M is the radius of the Moon.



At some point P, a distance y from the centre of the Earth the resultant gravitational field on the spacecraft is zero. At this point the correct equation is

A. $\dfrac{GM_E}{y^2} = \dfrac{GM_M}{(D-y)^2}$

B. $\dfrac{G M_M M_A}{R_M^2} = \dfrac{G M_E M_E}{R_E^2}$

C. $\dfrac{GM_A}{y^2} = \dfrac{GM_A}{(D-y)^2}$

D. $\dfrac{G M_M M_A}{R_M} = \dfrac{G M_E M_A}{R_E}$

E. $y = \dfrac{D}{2}$

SEE PAGE 15

29. A satellite is in orbit around the Earth. The centripetal force is supplied by

A. the motion of the body.
B. the reaction of the centrifugal force.
C. the acceleration of the satellite.
D. the gravitational force between the Earth and the satellite.
E. the thrust motors of the satellite.

30. A ball of mass 1.00 kg is dropped onto a horizontal surface and rebounds vertically upwards. If the speed immediately before impact is 3.00 m s^{-1} and immediately after impact is 2.00 m s^{-1} then the magnitude of the change in momentum is

A. 1.00 kg m s^{-1}
B. 5.00 kg m s^{-1}
C. 6.00 kg m s^{-1}
D. 1.50 kg m s^{-1}
E. 2.50 kg m s^{-1}

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SECTION B

MARKS ALLOTTED : 52

Attempt FOUR questions from this section. Answers are to be written in the Standard Answer Booklet provided. Credit will only be obtained for method and reasoning if these are clearly shown. Answers should be evaluated numerically. Numerical constants which may be required are listed on page 25 and/or within the question itself.

[7 Marks]

1. (a) A proton moves in a circular path of radius 50.0 mm in a region of uniform magnetic field of strength 1.50 T.

(i) What is the speed of the proton if it maintains a circular orbit in the field?

(ii) What is the frequency of rotation?

(iii) Through what potential difference must this proton be accelerated to have this speed?

[6 Marks]

(b) (i) A convex lens of focal length f forms a real image of an object whose height is n times that of the object. Show that the object is a distance

$$f\left(\frac{n+1}{n}\right)$$

from the lens.

(ii) A convex lens forms an image a distance 2f from the lens. What is the magnification of the image?

SEE PAGE 18

arks]

(a) (i) Explain the terms <u>mass defect</u> and <u>binding energy</u> of a nucleus.

(ii) Show how you would calculate the binding energy per nucleon for $^{32}_{15}P$ (do not attempt the actual calculation, you are not given sufficient data).

(iii) The isotope $^{32}_{15}P$ of phosphorus is radioactive and decays according to the equation

$$^{32}_{15}P \rightarrow {}^{32}_{16}S + \beta$$

The masses of the particles involved are -

$^{32}_{15}P$ = 31.98403 atomic mass units

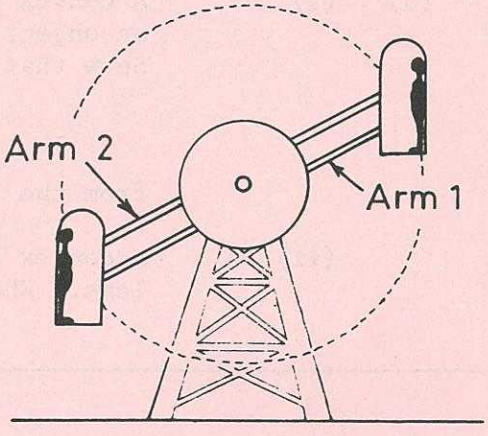
$^{32}_{16}S$ = 31.98224 atomic mass units

β = 0.00055 atomic mass units

Determine the energy liberated in the above β decay reaction.

ks]

b) A side-show amusement machine consists of two cages at the ends of rotating arms. The cages pivot during the motion, so the person having the ride always remains in the vertical standing position. Each arm is 20.0 m long and rotates once every 9.50 s in a vertical circle as shown. The radius of the motion is 20.0 m. The cages just clear the ground. If a person having a ride has a mass of 45.0 kg calculate



(i) the speed of the person,

(ii) the resultant force the cage floor exerts on the person's feet at the top position,

(iii) the resultant force the cage floor exerts on the person's feet at the bottom position,

(iv) the period of rotation necessary to satisfy the proprietor's claim that people who have a ride will experience weightlessness.

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[6 Marks]

3. (a) Sodium has a work function of 2.30 eV.

(i) What is the wavelength of light which will just eject an electron from a sodium surface?

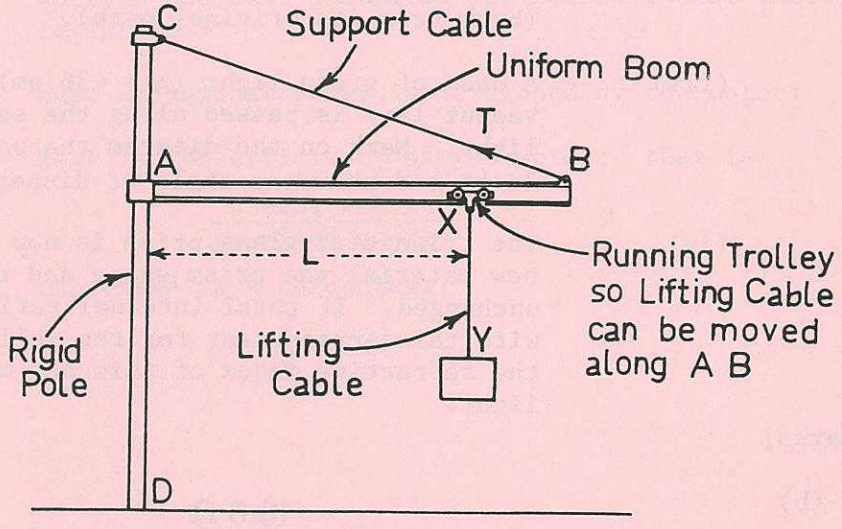
If light of wavelength 121.6 nm is incident on a sodium photo-cathode what is

(ii) the maximum energy in eV of the emitted photoelectrons?

(iii) the maximum speed of the emitted photoelectrons?

[7 Marks]

3. (b) A small truck loading crane consists of a very strong rigid vertical pole CD, a horizontal uniform boom AB, a support cable BC and a lifting cable XY which is on a runner. This can move along AB.



The boom and cable system is set up so heavy loads can be lifted from the ground and then swung around and placed onto the truck tray.

Angle ABC is 25.0° and AB is perpendicular to the rigid pole. The boom AB has a mass of 55.0 kg and is 1.20 m long.

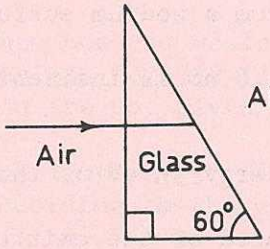
(i) State the general conditions necessary for a body to be in both translational and rotational equilibrium.

(ii) Taking moments about point A determine the tension T in the support cable when X is at a distance of 1.05 m from A and a mass of 745 kg is being supported by the lifting cable.

(iii) Show how the tension T varies as the running trolley supporting this load is moved towards point A. Express your answer as an equation relating T and L.

SEE PAGE 20

(a) A triangular glass prism is set upon a table as shown. A beam of yellow light (λ = 589 nm) from a sodium vapour lamp passes perpendicularly into one face of the prism and is refracted as it passes out the other side.



DATA: n_{589} = 1.520

n_{436} = 1.533

(i) Redraw the diagram into your answer booklet and show the ray's path as it leaves the prism into the air beyond the prism.

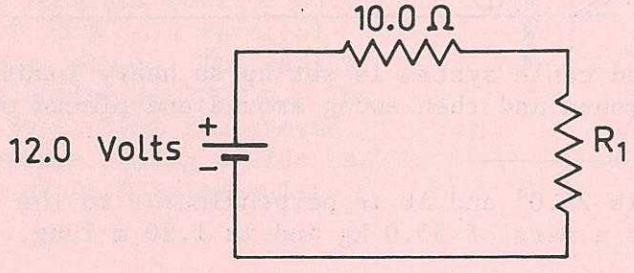
(ii) Calculate the angle through which the ray is deviated (bent from its original path).

(iii) A beam of green light (λ = 436 nm) from a mercury vapour lamp is passed along the same path as the yellow light. Mark on the diagram the path of this green light and show the angle of dispersion for these colours.

(iv) The triangular glass prism is now replaced by one of a new material the prism shape and ray direction being unchanged. If total internal reflection just occurs with this arrangement for the yellow light, what is the refractive index of this new material for yellow light?

rks]

(b)



(i) What is the power dissipated by resistor R_1? Express the answer in terms of R_1.

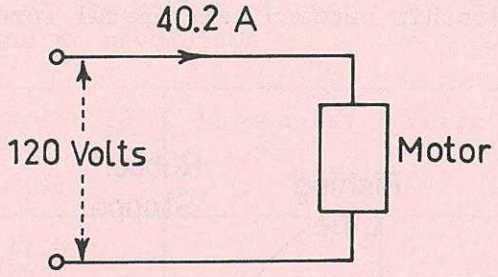
(ii) Let R_1 = 2.00, 4.00, 6.00 ..... 16.00 ohms. Determine for each value the power dissipated by resistor R_1.

(iii) Plot power dissipated by R_1 (y axis) versus resistance R_1 (x axis) and find the value of R_1 for the greatest power dissipated by resistor R_1.

SEE PAGE 21

[6 Marks]

5. (a)



A direct current motor has an internal resistance of 0.125 Ω. It draws 40.2 A at full load from a 1.20×10^2 V supply.

(i) What is the total power supplied to the motor?

(ii) What is the heat generated per second in the internal resistance?

(iii) What mechanical power is developed by the motor?

(iv) What is the efficiency of the motor; that is

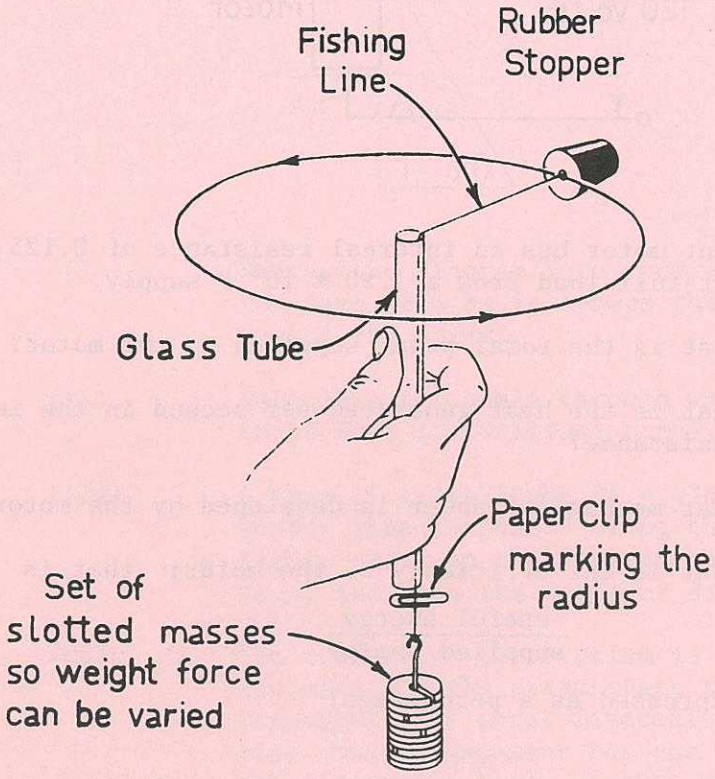
$$\frac{\text{useful energy}}{\text{supplied energy}}$$

expressed as a percentage?

SEE PAGE 22

arks]

(b) A group of students used the following piece of apparatus to find the relationship between centripetal force and velocity.



The rubber stopper is whirled around in a horizontal plane while the glass tube is held vertically. For this particular investigation the same rubber stopper is used throughout and the position of the paper clip marking the radius is not altered.

To determine the period of revolution the students decided to time 10 revolutions. They thought there were some advantages in doing this.

A weight force of 0.50 N was used initially.

They set up their data tables as follows and their results for 6 trials are shown. DO NOT REDRAW THIS TABLE INTO YOUR ANSWER BOOKLETS.

.../cont'd.

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5. (b) (Cont'd)

Mass of the rubber stopper = 52.3 g
Radius of revolution = 0.70 m

Trial	Force (N)	Time for 10 revolutions (s)	Period (s)	Velocity ($m\ s^{-1}$)	Velocity^2 (m^2s^{-2})
1	0.50	17.0			
2	1.50	9.8			
3	2.50	7.6			
4	3.50	6.5			
5	4.50	5.9			
6	5.50	5.3			

HINT: This question should be answered using the graph section (centre pages) of your answer booklet.

(i) REDRAW the following table and record the values of force and velocity squared in the appropriate place.

Trial	1	2	3	4	5	6
Force (N)						
Velocity^2 (m^2s^{-2})						

(ii) Plot force (on the vertical axis) against velocity squared (on the horizontal axis).

(iii) What does this graph suggest about the relationship between force and velocity?

(iv) Why was the time for 10 revolutions taken rather than the time for just one revolution?

(v) In analysing their data to establish the relationship between force and velocity, the group first plotted force against velocity, rather than velocity squared as you were asked to do in part (ii) above. What shape graph would they have found for their data?

(vi) Find the slope of the graph plotted in part (ii) above. What does this slope represent?

END OF PAPER

SEE PAGE 25 FOR THE PHYSICAL CONSTANTS

SEE PAGE 25