DOONSIDE TECHNOLOGY HIGH SCHOOL

2001
Higher School Certificate
Trial Examination

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Board approved calculators may be used
- Write using black or blue pen
- Draw diagrams using pencil
- A Data Sheet, Formulae Sheets and Periodic Table are provided at the back of this paper
- Write your student number and/or name at the top of every page

Section I - Pages 3 – 21
Total marks (75)
This section has two parts, Part A and Part B

Part A
Total marks (15)
Attempt questions 1-15
Allow about 30 minutes for this part

Part B
Total marks (60)
Attempt questions 16-33
Allow about 1 hour 45 minutes for this part

Section II - Pages 23 – 30
Total marks (25)
Attempt all question from Questions 34- 37
Allow about 45 minutes for this section

This paper MUST NOT be removed from the examination room

Section I

Total marks (75)

Part A

Total marks (15)
Attempt questions 1 – 15
Allow about 30 minutes for this part

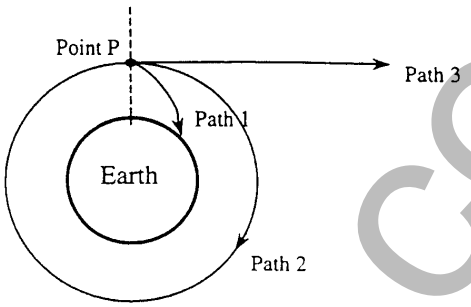
Select the alternative A, B, C or D that best answers the question and indicate your choice with a cross (X) in the appropriate space on the grid below.

	A	B	C	D
1			X	
2		X		
3	X			
4				X
5		X		
6	X			
7				X
8	X			
9		X		
10				X
11	X			
12		X		
13				X
14			X	
15		X		

14

1. A mass is projected horizontally from a point P above the Earth's surface. Three possible pathways are shown for this projectile.

NOT TO SCALE



If the projectile follows path 2, instead of the other paths, we can conclude that:

(A) Point P must have been above the equator
(B) The friction due to the atmosphere was too high for it to follow path 1
(C) The horizontal velocity of the projectile was too low for it to follow path 3
(D) The projectile experienced no gravitational pull towards the Earth because point P is too far above the Earth's surface.

2. Name the scientist that first put forward the idea that projectile motion was the resultant of two component motions at right angles to each other.

(A) Einstein
(B) Galileo
(C) Kepler
(D) Newton

3. Rocket ship Alpha has a mass of 14 500 kg as measured on Earth. Rocket ship Alpha then travels out across space and positions itself near a wormhole where its weight is measured as 7.28×10^7 N. What is the acceleration due to gravity near the wormhole?

(A) 5.02×10^3 m s^{-2}
(B) 1.06×10^{12} m s^{-2}
(C) 1.99×10^{-4} m s^{-2}
(D) 2.00×10^{-2} m s^{-2}

$F = ma$

$\frac{7.28 \times 10^7}{14500} = a$

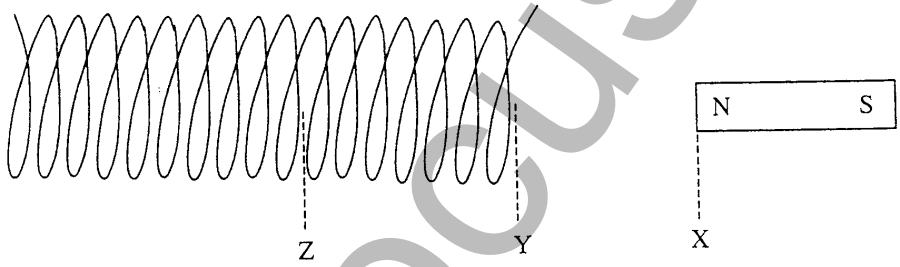
4. Kepler's Law of Periods $T^2 = kr^3$ shows the relationship between the period and the orbital radius of a planet that revolves around a star. The value k, a constant, can be changed by varying:

(A) the period of the planet
(B) the orbital radius of the planet
(C) the mass of the planet
(D) the mass of the star

5. The Russian space station which was orbiting Earth for many years eventually crashed into the Earth. This occurred because of:

(A) a reduction in its orbital velocity due to friction from the magnetosphere
(B) a reduction in its orbital velocity due to friction from the atmosphere
(C) an increase in its orbital velocity due to a stronger gravitational force
(D) a reduction in its orbital velocity causing the gravitational force to increase

6. Two experiments are performed with a coil and a magnet.

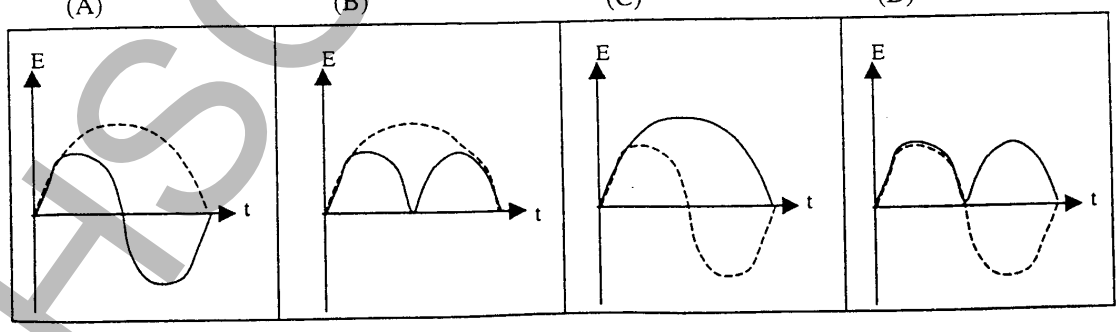


Experiment 1: Magnet moved from X to Y, then back to X
Experiment 2: Magnet moved from X through Y to Z
(The magnet was stationary at the beginning and at the end of each experiment)

Which of the following graphs of induced emf in the coil vs time best illustrates the experimental results?

Experiment 1 ——— Experiment 2 -------

(A) (B) (C) (D)



7. Eddy currents occur in circuits as a result of Lenz's Law. Sometimes these eddy currents are a nuisance and cause loss of efficiency. At other times devices have been designed which specifically make use of eddy currents. Which of the following devices works on the principle of eddy current production?

(A) a transformer
(B) a resistor
(C) an electric motor
(D) a braking device in a roller coaster

8. A heavy load is being lifted using an electric motor to raise a cable attached to the load. The useful energy transformations involved in this procedure are:

(A) electrical energy → kinetic energy → gravitational potential energy
(B) electrical energy → heat energy → gravitational potential energy
(C) electrical energy → magnetic energy → kinetic energy
(D) electrical energy → gravitational potential energy → kinetic energy

9. Two long parallel conductors carry equal currents in opposite directions. The force between them is 3F.

The current in one of the conductors is doubled, but the current in the other is reduced to a third of its original value. The distance between the conductors is halved.

The new force between the conductors is closest to:

$F = k\frac{I_1 I_2}{d} \times 1 \times \frac{4}{3}$

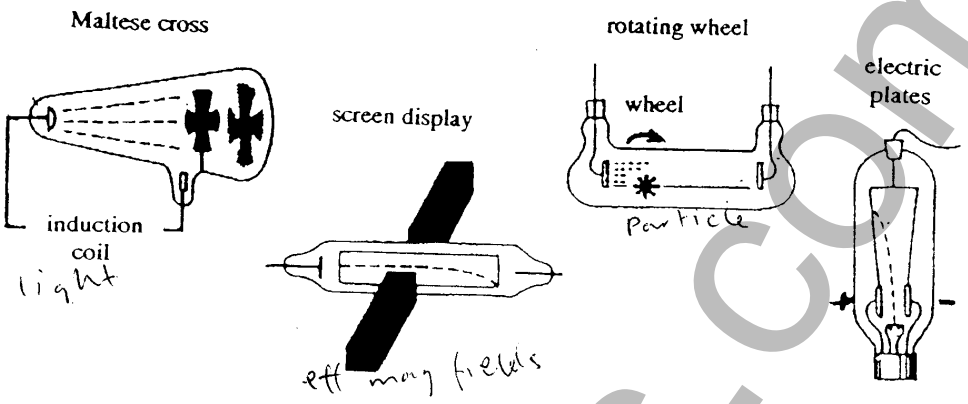
(A) 2F
(B) 4F
(C) 8F
(D) 16F

10. A set of Christmas tree lights requires 36 V A.C. to operate. They are connected through a transformer to the household 240 V A.C. supply.

If there are 320 turns in the primary coil of the transformer, the number of turns in the secondary coil is:

(A) 16
(B) 27
(C) 36
(D) 48

11. This question refers to the following diagram which shows how some of the properties of cathode rays are demonstrated using assorted discharge tubes connected to an induction coil.



Those properties of cathode rays which can be deduced from these demonstrations are:

(A) Cathode rays: travel in straight lines
are negatively charged
have energy and momentum

(B) Cathode rays: are electromagnetic
can be easily deflected from travelling in straight lines
do not penetrate solids

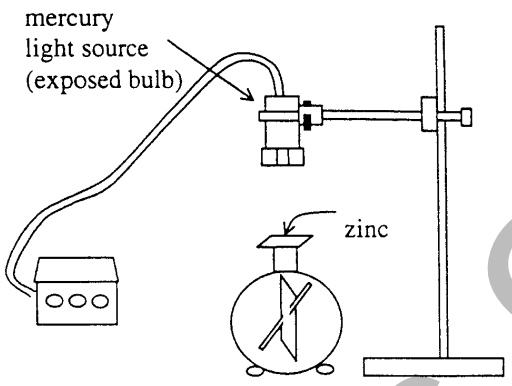
(C) Cathode rays: are fast moving electrons
cause fluorescence on impact with solids
require high voltage electric fields in which to be observed

(D) Cathode rays: have energy but no mass
remain undeflected travelling in the Earth's gravitational field
are more affected by magnetic and electric fields

12. Hertz's experiments with radio waves provided convincing evidence that:

(A) light rays travel at 3×10^8 m s^{-1}
(B) radio waves are electromagnetic waves
(C) light is a form of electromagnetic radiation
(D) there are many frequencies of radio waves

13. When a negatively charged electroscope surmounted by a piece of zinc is illuminated with ultraviolet light, the electroscope is observed to discharge rather rapidly.



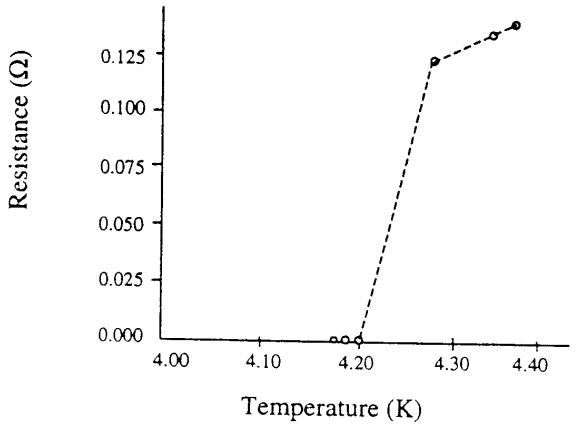
The observation is explained by:

(A) a chemical reaction occurred between the zinc and the radiation
(B) the radiation caused the air surrounding the electroscope to become positively ionised
(C) ultraviolet radiation is positively charged
(D) the radiation caused the zinc to lose negative charges

14. In semiconductors, the energy gap between the valence band and the conduction band is:

(A) equal to the energy of electrons that occupy the valence band
(B) very small because they are poor conductors at low temperatures
(C) very small so some electrons can be excited to the conduction band at normal temperatures
(D) equal to the energy of electrons that occupy the conduction band

15. The graph below shows the electrical resistance of the metal mercury plotted against temperature.



From the graph we can conclude that

(A) mercury is a superconductor of electricity above 4.20 degrees Kelvin
(B) mercury is a superconductor of electricity below 4.20 degrees Kelvin
(C) the conductivity of mercury drops to zero below 4.20 degrees Kelvin
(D) the electrical resistance of mercury can only be extrapolated from the graph below 4.20 degrees Kelvin.

Section I

Part B

Total marks (60)
Attempt questions 16 – 26
Allow about 1 hour 45 minutes for this part

Answer the questions in the spaces provided

Question 16 (5 marks) **Marks**

(a) Explain the difference between a satellite that has a geostationary orbit and one that has a low earth orbit. **2**

Geostationary obit is much further out and has a period of 24 hours (1)

Compare ?? Explain ??

(b) What is ONE advantage of a geostationary satellite over a low earth orbiting satellite? **1**

It can remain above the same place on earth (1)

(c) Give an example of an application where scientists would choose to use a low earth orbiting satellite over a geostationary satellite. Explain why they would choose the low earth orbiting satellite for this particular application. **1** (1)

Weather reporting. The low earth satellite can sweep over the earth nuggerous times a day to provide constant weather informatio

(d) State ONE safety precaution that should be taken when a satellite eventually crashes back to Earth? **1**

Ensure that the satellite, if it hasn't burnt up, will land in the ocean. (1)

Question 17 (4 marks)

Marks

Describe an investigation which you carried out in class which demonstrates the changes in the motion of a satellite as it gets closer to its parent body. In your answer, describe what occurs to the satellite's motion and describe how this result can be tested or validated using real satellites.

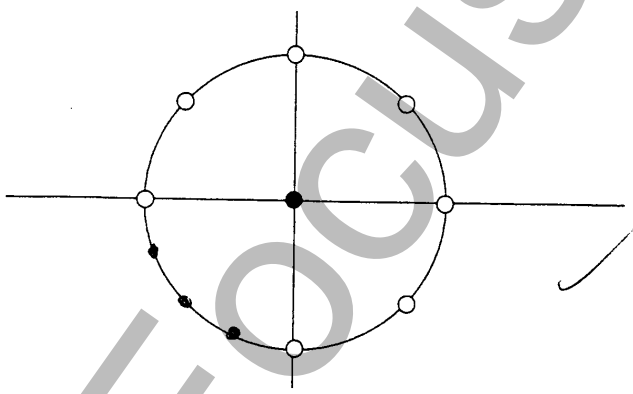
4

we swung a weight on end of string above heads at different lengths of string. ~~those~~ Shorter string produced faster speed of weight. This happen with satellites, closer orbits produce faster speeds on satellite. This can be tested by calculating speeds of satellites at different distances above earth.

4

Question 18 (4 marks)

A satellite's position is being monitored once every 2 hours. A copy of the plot of its position relative to Earth is shown below.



1

(a) What is the minimum length of time indicated by the plot?

1

2 hours.

(b) It was decided to increase the monitoring of the satellite to once every hour. Indicate on the diagram what position you would expect the next three images of the satellite to appear in, if no change was made to the satellite's control system.

1

(c) Discuss TWO important design elements required in a spacecraft if it is to allow safe re-entry to the atmosphere for the astronauts on board.

2

Porous ceramic and other heat absorbing materials to keep craft from burning up

Appropriate devices to calculate angle of descent (6.8° ± 1°)

2

Question 19 (5 marks) **Marks**

(a) What are the van Allen radiation belts? **2**

Belts ~~around~~ perpendicular to equator where trapped particles (from sun) exist. Affect the magnetic fields on earth. (1)

(b) Why are they so important to life on Earth? **1**

Absorb a lot of radiated particles from the sun. (1)

(c) Explain how changes in sun spot activity can produce changes in the van Allen Belts. **1**

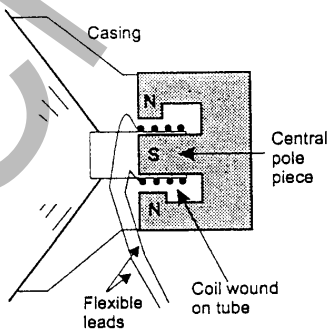
When sunspots flare an increased amount of particles reach the radiation belts (1)

(d) Why do these changes in the van Allen belts cause communication problems between Earth and its satellites? **1** (½)

They cause interference of the radio waves used for communication between earth & satellites. How?

Question 20 (2 marks)

A schematic diagram of a moving coil loudspeaker follows.



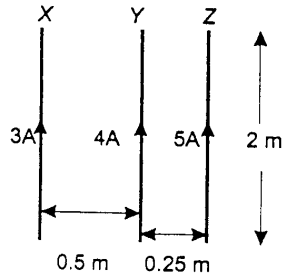
(2)

Briefly explain how it is used to produce sound. **2**

Varing voltages produce vibrations in the speaker creating sound. The core moves from attraction & repulsion from central pole.

Question 21 (3 marks)

Three long parallel current-carrying wires, *X*, *Y* and *Z* are shown in the diagram. They all lie in the same plane.



(Diagram not to scale)

(a) Calculate the force on *Y* due to *X*. 1

(b) Calculate the force on *Y* due to *Z*. 1

(c) What is the resultant force on *Y*? 1

a) $F = 2.0 \times 10^{-7} \times \frac{3 \times 4}{0.5} \times 2 = 9.6 \times 10^{-6}$ N ✓ (1)

b) $F = 2.0 \times 10^{-7} \times \frac{4 \times 5}{0.25} \times 2 = 32 \times 10^{-6}$ N (or 3.2×10^{-5}) (1)

c) Y is attracted more towards Z (1)

(1/2)

Question 22 (4 marks)

A stone is projected horizontally out to sea from the edge of a cliff 200 m high. Given that the stone is thrown with an initial speed of 20 m.s^{-1}, find:

(a) the time the stone takes to hit the water 1

(b) the distance from the cliff base at which the stone hits the water (assuming the cliff face is vertical) 1

(c) the velocity at this instant (size and direction). 2

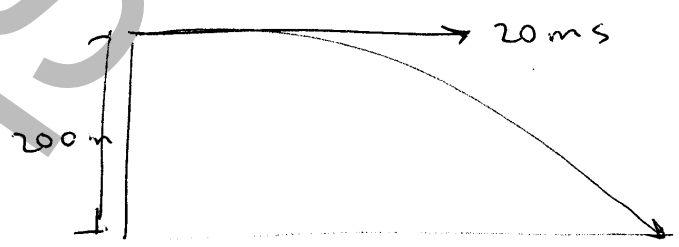
$s = ut + \frac{1}{2}at^2$ $\Delta y = v_y t + \frac{1}{2} a_y t^2$

a) $-200 = 20 \sin 0 \times t - 4.9t^2$ $t = 6.4$ seconds (1)

b) $\Delta x = v_x t = 20 \cos 0 \times 6.4 = 128$ m (1)

c) $\sqrt{(62.72)^2 + 20^2} = 65.8$ m s

$\tan \alpha = -72^\circ 19'$ (ie $72^\circ 19'$ below horizontal) (1)



20 ✓

$V = u + at$

$v = 9.6t$

$v = -62.72$

Question 23 (2 marks)

A rectangular coil, 4 cm x 2 cm, of 500 turns is placed in a magnetic field of intensity 0.6 T. A current of 0.05 A flows in the coil.

(a) What is the relationship between the coil and the field when the torque is a maximum? **1**

(b) What is the maximum torque on the coil? **1**

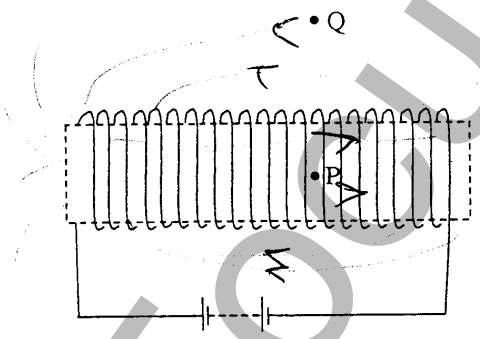
a) subtends an angle of 0° ($\cos 0 = 1$) from mag field (1)

b) $\tau = nBIA\cos\theta = 500 \times 0.6 \times 0.05 \times 0.008 \times 1$

$= 0.012$ Nm (1)

Question 24 (2 marks)

A coil is wound on a cardboard cylinder.



The ends of the wire are connected to a battery, producing a magnetic field in and around the coil.

Compare the size and direction of the field at points P and Q **2**

Strong magnetic field direction ~~→~~ is experienced at P. weaker field direction ← experienced at Q. (2)

Question 25 (3 marks)

Marks

A square coil is moved out of a magnetic field as shown, inducing an emf between the ends of the coil.

Diagram 1 (time = 0)

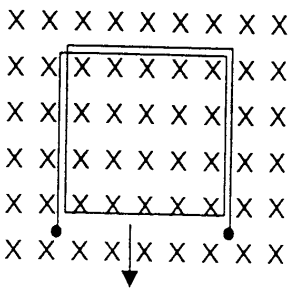
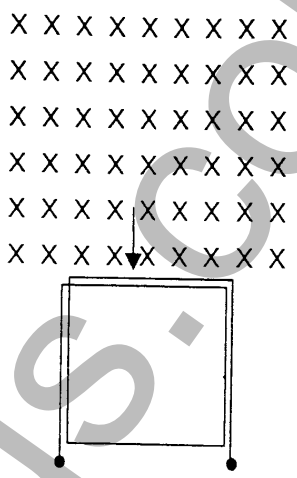


Diagram 2 (time = t)



Describe THREE ways in which this experiment could be modified so that a larger emf was induced between the ends of the coil. **3**

move the coil faster
Increase strength of magnetic field.
Increase number of turns in coil

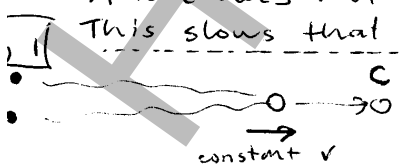
3

Question 26 (4 marks)

Two events that are simultaneous for one observer will not necessarily be simultaneous for a second observer in another inertial frame of reference. This is called the *relativity of simultaneity*. Explain, with an example, how this lack of simultaneity occurs. **4**

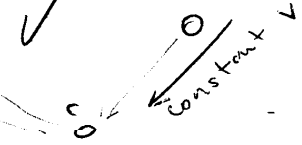
4

Suppose the two dots in each example were beams of light. In eg 1, both beams appear simultaneous to observer moving away as shown with constant velocity. Eg 2 however, the observer is in another inertial frame of reference, travelling as shown. In this example time from A to C does not equal time B to C, whereas it did in Eg 1. This shows that events simultaneous in one frame of reference may not be in another.



Eg 2

A

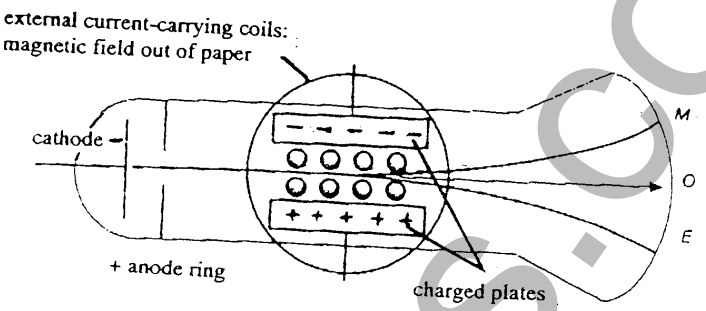


Question 27 (5 marks)

Marks

(a) Towards the end of the 19th century, the English physicist JJ Thomson was able to add to the knowledge of cathode rays by his investigations into their charge to mass ratio. **3**

A simplified diagram of Thomson's experimental cathode ray tube is shown below.



Thomson's observations included the following:

- when a cathode ray beam is subjected to an electric field only, it is deflected such that the position marked E at the end of the tube glows
- when a cathode ray beam is subjected to a magnetic field only, it is deflected such that the position marked M glows
- when a cathode ray beam is subjected to both electric and magnetic fields, the beam is not deflected and the position at the end of the tube marked O glows

(i) Use your understanding of the nature of cathode rays to explain these observations.

(2)

Cathode rays are negatively charged particles (electrons) and therefore attracted to positive plate, curve down. Using the right hand rule, shows (current flowing right to left as negative charge) the force of magnetic field on charge forces cathode curve up. When both are in effect they cancel each other out.

(ii) Use your understanding of the behaviour of cathode rays in electric and magnetic force fields to outline how Thomson measured the value $\frac{q}{m}$, where q is the charge of the particle, of mass m moving with a speed v in a magnetic field B and electric field E, and travelling in a circular path of radius r.

(4)

Thomson knew $\frac{q}{m}$ ratio of hydrogen. He measured this value to be 1800 that of H for cathode rays. Th could mean charge 1800 times stronger or 1800 x lighter mass. It was later found to be 1800 times lighter and to be an electron.

Marks

(b) A television picture tube is a modern day application of cathode rays moving in an evacuated glass container.

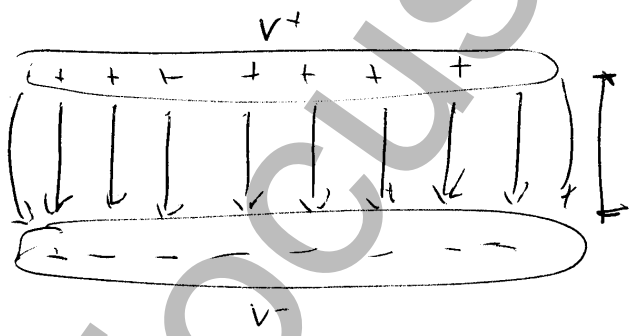
Explain how deflection of the cathode rays is achieved differently in a television picture tube compared with a cathode ray oscilloscope (C.R.O.) **2**

Deflection of both tube & CRO is a constant deflection on x-axis, with "sawtooth" voltage. In the CRO the y-axis deflection is created by varying voltage whereas on a picture tube this is another sawtooth voltage to 'paint' out the entire screen than just a curve.

Question 28 (3 marks)

(a) Draw a labelled diagram to show the electric field between two parallel plates which have a potential difference applied between them. **2**

$E = \frac{V}{d}$



(b) If the potential difference between the plates is 2 kV, and the distance between them is 1.5 cm, find the magnitude of the electric field between them. **1**

$E = \frac{V}{d} = \frac{2000}{0.015} = 133,333.\dot{3}$ V m

Question 29. **Marks**

(i) Define the term "superconductivity". **2**

(2)

When a metals electrical resistance falls to zero as it approaches 0°k.

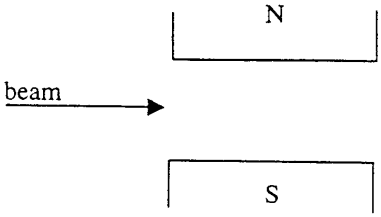
(ii) Name ONE new technology that uses a superconductors exclusion of magnetic fields to function and briefly explain how this technology works. **2**

Maglev trains (magnetic levitation) The repulsion of magnetic fields by the superconductor forces the train to lift above the tracks, hence there is much less friction. ✓

(2)

Question 30 (2 marks) **Marks**

A beam of cathode rays moving at 1×10^3 m s^{-1} passes at right angles through a magnetic field of intensity 0.5 T as shown:



Find the magnitude and direction of the force on each cathode ray particle. **2**

Direction is out of the page

Magnitude = $qvB\sin\theta = 1.602 \times 10^{-19} \times 1 \times 10^3 \times 0.5$

$= 8.01 \times 10^{-17}$ N

2

Question 31 (2 marks)

How much energy does a photon of ultraviolet light of wavelength 1.6×10^{-7} m have? **2**

$E = hf \quad c = f\lambda \therefore E = \frac{hc}{\lambda} = \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{1.6 \times 10^{-7}}$

$E = 1.24 \times 10^{-18}$ J

2

Question 32 (3 marks)

You are placed inside a room without windows on a large ocean liner. The liner can be considered, for the purpose of this question, to be isolated from outside influences. Suggest how you could determine (if indeed it is possible) whether the ship is:

(a) undergoing a linear acceleration **1**

(b) moving with constant (or zero) linear velocity. **2**

Explain your answers.

1

a) If you had a glass of water (or pendulum type
you will be able to detect acceleration as water wi
not be horizontal on surface but angling (same w
b) Constant velocity means there is no acceleration
thus the water surface will be level as
a pendulum would not be slanting.

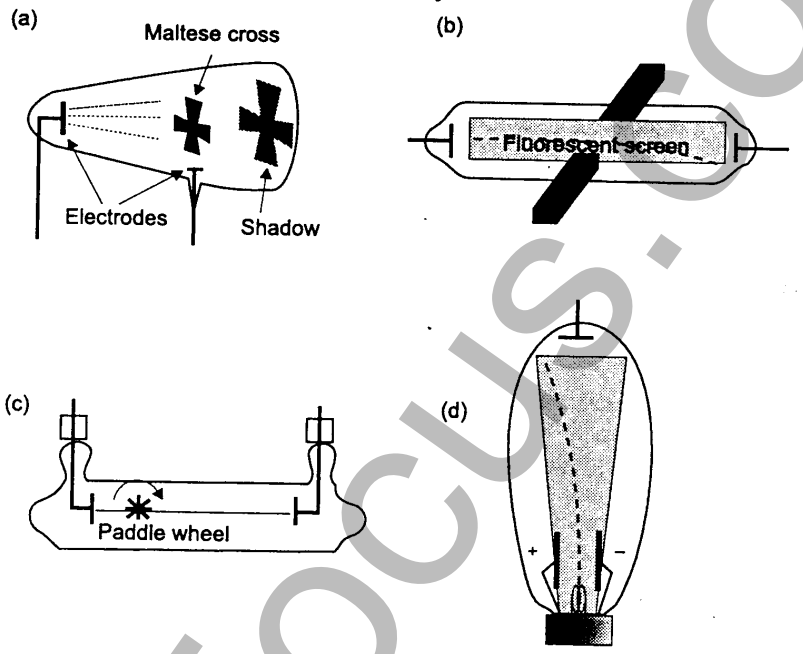
pendulum

1

Question 33

Marks

The following diagrams illustrate some scientific apparatus commonly used to demonstrate various properties of cathode rays.



Take any TWO of these and clearly state what property each one is demonstrating and how this can be deduced from the observations. 4

a) Diagram a) shows that cathode rays travel in straight lines as they form a shadow on back of tube ✓ (1)

b) Diagram c) shows that the cathode rays are particle-like and have energy and mass as they can push paddle wheel up slight incline. (2)

Question 34 **Marks**

(a) The reflecting telescope is used in most observatories throughout the world in preference to the refracting type. List TWO differences between reflecting and refracting telescopes. (Use diagrams if you wish) **2**

The reflecting telescope in most cases can be made smaller than refracting one. Refracting telescopes make use of lenses whereas reflecting make use of mirrors

(2)

(b) The Hubble Space Telescope provides a much better view of the Universe than that provided by "Earth-bound" telescopes. Give reasons why this would be so. **2**

The telescope doesnt suffer from distortion from our atmosphere that earth telescopes do, and it does not receive interference from van allen radiation belts

(2)

(c) A hypothetical rocket ship is moving away from the Earth through space at a speed of c/2. What effect would this have on length and time in the view of **2**

(i) those on Earth

(ii) The crew on the ship

$l = l_0\sqrt{1-\frac{v^2}{c^2}}$ $t = \frac{t_0}{\sqrt{1-\frac{v^2}{c^2}}}$

i) observed length $\doteq \sqrt{0.75} \times l_0$ (less than actual)

observed time $\doteq \frac{t_0}{\sqrt{0.75}}$ * (greater length time)

The spaceship will appear shorter and time appear longer to observer on ground.

ii) The crew wont see view length or time on ship any difference to its actual length

(2)

Question 35

Newton once wrote:

> *I began to think of gravity extending to the orbit of the moon and ... from Kepler's rule (Third Law) ... I deduced that the force which keeps the planets in their orbits must be reciprocally as the square of the distances from the centres about which they revolve: and thereby compared the force requisite to keep the moon in her orbit with the force of gravity at the surface of the Earth and found them to fit pretty nearly.*

(a) What Law is Newton referring to in this quote? 1

(b) Given that the moon is 60 Earth-radii from the Earth's centre and the acceleration due to gravity at the Earth's surface is 9.8 $m.s^{-2}$, calculate the acceleration of the moon towards the Earth. 2

(c) "The Earth's atmosphere is a churning sea of gases that is impenetrable tomuch of the electromagnetic spectrum."

Discuss this statement by referring to the difficulties this presents for observation of astronomical phenomena, and the advances humans have made in overcoming these difficulties. 5

(a) For all objects orbiting around the same body (1)

$\frac{r^3}{t^2} = \frac{GM}{4\pi^2}$ where r = distance seperation, t = period, M = mass of body being orbited

(b) $g = \frac{GM}{r^2} = \frac{6.67 \times 10^{-11} \times 6.0 \times 10^{24}}{(60 \times 6.83 \times 10^6)^2}$ (2)

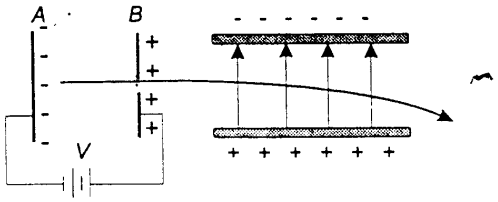
$= 2.38 \times 10^{-3}\ m\,s^{-1}$ ✓

(c) with the exception of visible light, radio waves and to a limited extend infrared waves the atmosphere absorbs all other electromagnetic wavelengths. To overcome this, telescopes to detect the other wavelengths have been made upon mountains (such as 4km high mt in Hawaii, which lies above 40% of earths atmosphere) and on space vehicles that are sent outside of the earths atmosphere. ✓ (4)

Marks

Question 36.

An electron (charge $q = -1.6 \times 10^{-19}$ C and mass $m = 9.1 \times 10^{-31}$ kg) is accelerated in an electron gun from rest at A to a speed v at B.



Electron Gun

The potential difference between the plates in the electron gun is 1000 V. The electrons pass through a hole at B and enter a uniform electric field of intensity 10 000 $N.C^{-1}$ between two parallel plates. The plates are 2 cm long.

(a) What is the velocity of the electron at B? **2**

(b) What is the vertical acceleration of the electron in the electric field? **3**

(a) $v^2 = u^2 + 2as$ $F = 1.6 \times 10^{-15}$ $F = ma$ $10000 = \frac{1000}{0.1}$

$v^2 = 0 + 2 a \times 0.1$ $a = 1.758 \times 10^{15}$

$v^2 = 3.5 \times 10^{14}$ (2)

$v = 1.875 \times 10^7$ m/s ✓ (no idea about this one)

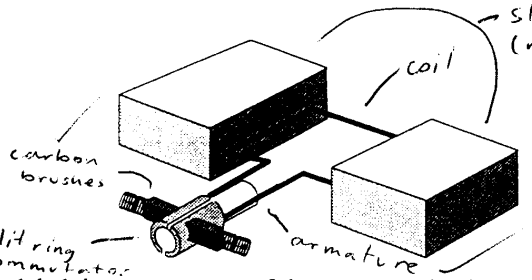
(b) $v = u + at$ $t = 1.07 \times 10^{-8}$

$1.875 \times 10^7 = a = -1.78 \times 10^{15}$ m/s² Bloody good guess then!!

(2)

Question 37 (5 marks)

A schematic diagram of a simple DC electric motor is shown.



(a) Clearly label the components of the motor on the diagram. 2

(b) Describe the function of each component. 2

(c) Name one way that this simple motor could be improved in its design, and state how this would improve the motor. 1

b) carbon brushes; provide current to coil and allow it to be switched. split ring commutator: allows the voltage to be reversed every half turn to keep moto in motion. coil: forms armature and turns due to forc acting on current carrying wires in magnetic field stator: produced the magnetic field of the motor.

c) Increasing number of turns in coil. This would produce more force due to increase turns and would make the motor turn faster and/or with more torque. (stronger)