GIRRAWEEN HIGH SCHOOL
2013
TRIAL
HIGHER SCHOOL CERTIFICATE
EXAMINATION

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
  Black pen is preferred
- Draw diagrams using pencil
- Board-approved calculators may be used
- A data sheet, formulae sheets and Periodic Table are provided at the back of this paper
- Write your name on the Part A Answer sheet, the Part B Question and Answer Booklet and the Section II Answer Booklet.

Total marks – 100

Section I **Pages 1 - 20**

75 marks

This section has two parts, Part A and Part B

Part A – 20 marks
- Attempt Questions 1–20
- Allow about 35 minutes for this part

Part B – 55 marks
- Attempt Questions **21 - 34**
- Allow about 1 hour and 40 minutes for this part

Section II **Pages 21 - 25**

25 marks
- Attempt **Question 35**
- Allow about 45 minutes for this section

Instructions for answering questions in Section 1

- Complete your answer in either blue or black pen
- Multiple choice

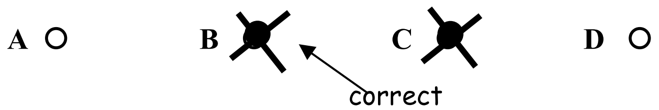
Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

Sample 1: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

A ○ **B** ● **C** ○ **D** ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word ***correct*** and drawing an arrow as follows.



Part A Answer Sheet is on the next page

Write your name and class in the space provided →

Name ……………………………..

Class………………………………

GIRRAWEEN HIGH SCHOOL

PHYSICS

2013

TRIAL HSC EXAMINATION

Part A Answer Sheet

1.	**A** ○	**B** ○	**C** ○	**D** ○
2.	**A** ○	**B** ○	**C** ○	**D** ○
3.	**A** ○	**B** ○	**C** ○	**D** ○
4.	**A** ○	**B** ○	**C** ○	**D** ○
5.	**A** ○	**B** ○	**C** ○	**D** ○
6.	**A** ○	**B** ○	**C** ○	**D** ○
7.	**A** ○	**B** ○	**C** ○	**D** ○
8.	**A** ○	**B** ○	**C** ○	**D** ○
9.	**A** ○	**B** ○	**C** ○	**D** ○
10.	**A** ○	**B** ○	**C** ○	**D** ○
11.	**A** ○	**B** ○	**C** ○	**D** ○
12.	**A** ○	**B** ○	**C** ○	**D** ○
13.	**A** ○	**B** ○	**C** ○	**D** ○
14.	**A** ○	**B** ○	**C** ○	**D** ○
15.	**A** ○	**B** ○	**C** ○	**D** ○
16.	**A** ○	**B** ○	**C** ○	**D** ○
17.	**A** ○	**B** ○	**C** ○	**D** ○
18.	**A** ○	**B** ○	**C** ○	**D** ○
19.	**A** ○	**B** ○	**C** ○	**D** ○
20.	**A** ○	**B** ○	**C** ○	**D** ○

Section I
75 Marks
Part A - 20 Marks
Attempt Questions 1-20
Allow 35 Minutes for this part
Use the multiple-choice answer sheet for questions 1-20

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1 In which case is an astronaut closest to true weightlessness?

(A) Floating around in the cabin of the space shuttle orbiting Earth.

(B) Walking on the surface of the Moon.

(C) Falling back to Earth during re-entry in the space shuttle.

(D) At a point between Earth and its Moon where the forces of gravity from each are equal and opposite.

2 Two satellites, A and B, orbit Earth. A is at a higher altitude than B. Their masses are unknown. Which of the following statements is correct?

(A) A has less gravitational force acting on it than B.

(B) B has less gravitational force acting on it than A.

(C) A has a greater orbital velocity than B.

(D) B has a greater orbital velocity than A.

3 A spaceship is 100 m long when docked at a space station. Some time later, when it passes another stationary spaceship, its length is measured as being 50 m.

What was the speed of the spaceship, relative to the stationary spaceship, when its length was being measured as 50 m?

(A) $0.75\ c^2$

(B) 0.87 c

(C) 0.99 c

(D) Twice as fast

4 Which of the following list of properties was attributed to the aether?

(A) It permeated all of space; was of low density; perfectly transparent; had great elasticity.

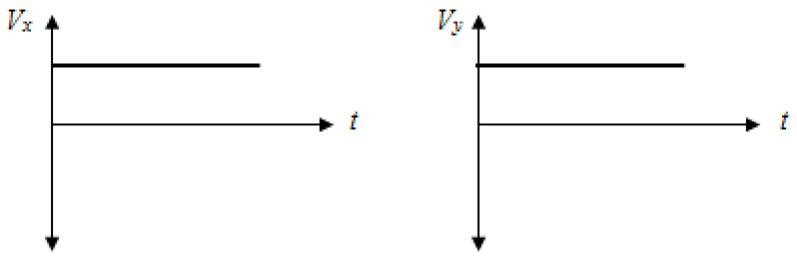
(B) It permeated all of space; was of high density; perfectly transparent; had great elasticity.

(C) It permeated all of space; was of low density; perfectly opaque; had great elasticity.

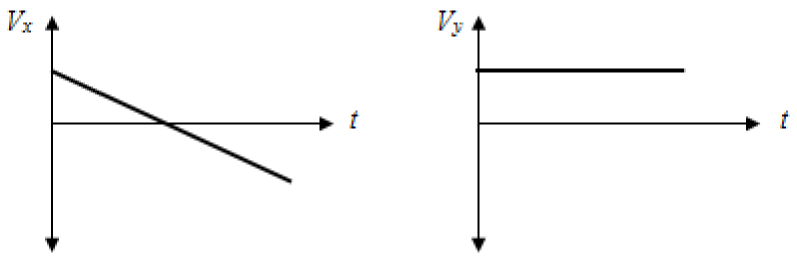
(D) It permeated all of space; was of low density; perfectly transparent; was inelastic.

5 Which pair of velocity time graphs best represents the motion of a projectile in both the x and y directions?

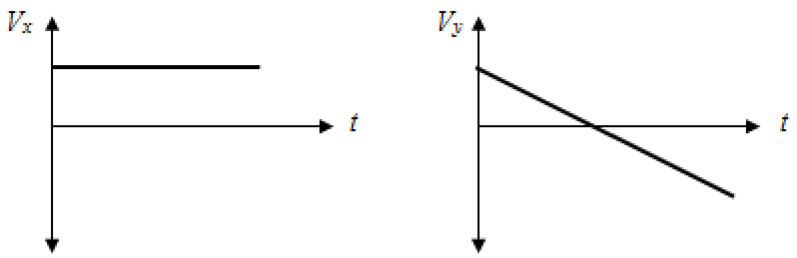
(A)



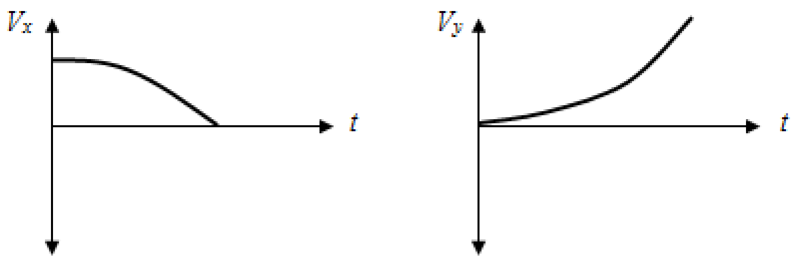
(B)



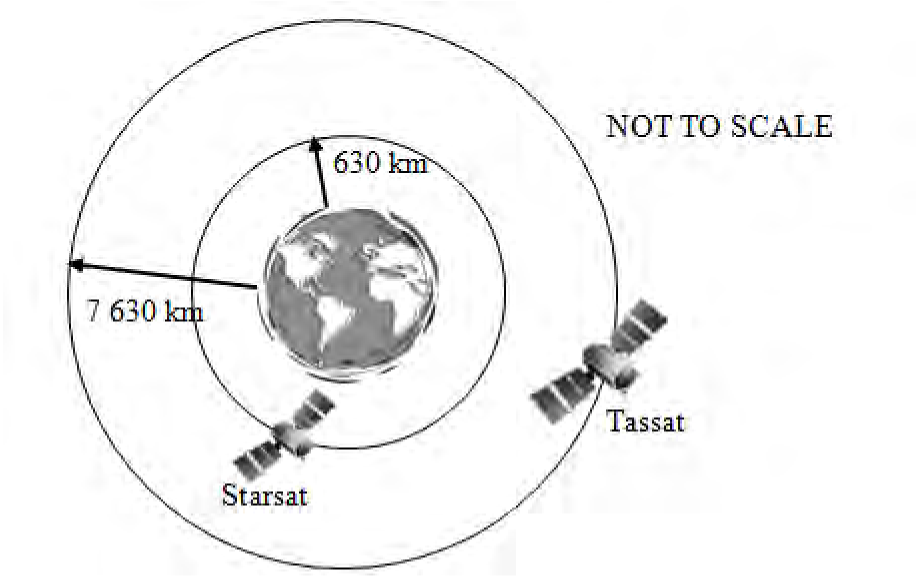
(C)



(D)



6 Starsat is a satellite orbiting with an altitude of 630 km. Tassat is another satellite orbiting with an altitude of 7 630 km. The radius of the Earth is 6370 km.



The period of Tassat is 16452.6 seconds. The period of Starsat is

(A) 523.5 s

(B) 5816.86 s

(C) 6340.4 s

(D) 14457 s

7 In a nuclear reaction, 1.20×10^{17} J of energy is released. The nuclear fuel used had an initial mass of 2.75 kg.

The mass of the remaining fuel is closest to:

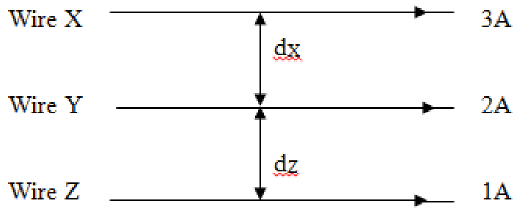
(A) 0.01 kg

(B) 1.33 kg

(C) 1.42kg

(D) 2.75kg

8 Three long parallel wires X, Y and Z are positioned in the same plane and conduct different currents in the same direction as shown. The current in wire X is 3A, in wire Y is 2A and in wire Z is 1A. Wires X and Y are separated by distance dx and wires Y and Z are separated by distance dz.



The relationship between the distances dx and dz if the net force on the wire Y is zero is:

(A) 3 dx = dz

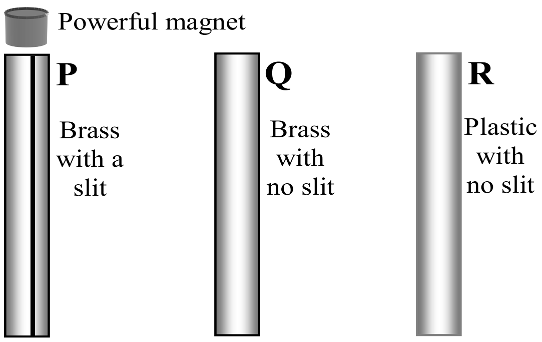
(B) dx = 3 dz

(C) 5dx = 2 dz

(D) dx = dz

9 A strong magnet is dropped in turn through three tubes of identical dimensions. Tubes P and Q are made of brass. P has a single narrow slit from top to bottom. Tube Q has no slit. Tube R is made of plastic and has no slit.

Which statement is true about the time it takes for the magnet to fall through the tubes?



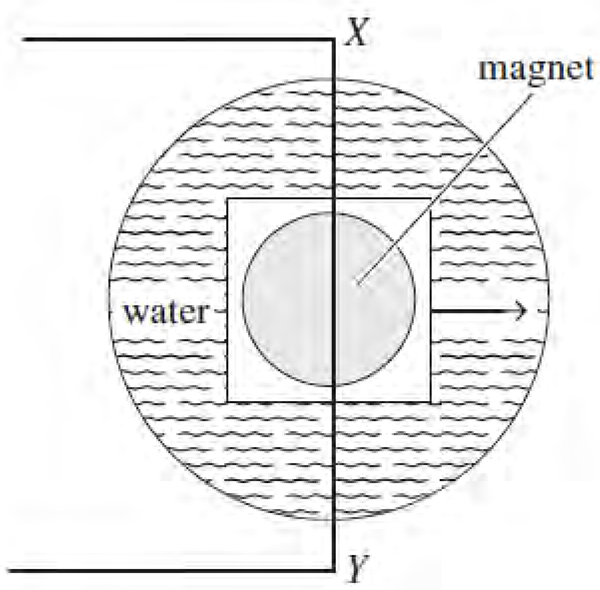
(A) It takes the shortest time to fall through R, and longest to fall through Q.

(B) It takes the shortest time to fall through R, and longest to fall through P.

(C) It takes the shortest time to fall through Q, and longest to fall through R.

(D) It takes the same time to fall through P and R, and longer to fall through Q.

10 A conducting wire was placed over a disc magnet sitting on a piece of foam that was floating in a dish of water as shown below.



When the current was passed through the wire the magnet moved to the right, as shown by the arrow. From this we can conclude that:

(A) the current flowed from X to Y and the N pole of the magnet faced out of the page.

(B) the current flowed from *Y* to *X* and the N pole of the magnet faced out of the page.

(C) the current flowed from *X* to *Y* and the S pole of the magnet faced out of the page.

(D) no current flowed in the wire.

11 How is the magnetic field strength from flux lines perpendicularly threading a loop coil related to the magnetic flux and the area of the loop coil? The magnetic field strength is equal to:

(A) the magnetic flux divided by the area of the loop;

(B) the magnetic flux multiplied by the area of the loop;

(C) the area of the loop divided by the magnetic flux;

(D) the number of flux lines.

12 What is a major impact of the development of transformers on modern societies?

(A) The widescale transmission of AC existing as high voltage electricity only.

(B) The widescale transmission of AC existing as both high and low voltage electricity.

(C) The widescale transmission of electricity with zero power loss.

(D) The widescale transmission of DC existing as low voltage electricity.

13 Electrical power was first transmitted by Edison in 1882 and soon afterwards a competition developed between Edison and Westinghouse to supply electricity to cities.

What is the main reason that Westinghouse was successful?

(A) AC current required fewer substations to be built and so the cost was much lower than the competition.

(B) DC current required fewer substations to be built and so the cost was much lower than the competition.

(C) He developed a safer system of electricity supply.

(D) The Westinghouse company was better known.

14 The wavelength of electromagnetic radiation that has an energy of 0.75 eV is:

(A) 1.654×10^{-9} m

(B) 16.5×10^{-9}m

(C) 1.65×10^{-7} m

(D) 1.65×10^{-6} m

15 J.J. Thomson set up an experiment in which he was able to determine the charge to mass ratio for the electron. He did this by opposing a magnetic field with an electric field so that the forces produced by each acting on a beam of electrons would cancel and the path of the electrons would be not be deflected.

If the strength of the electric field is 50 V/m and that of the magnetic field is 3.2 T, the speed of the electron beam must be:

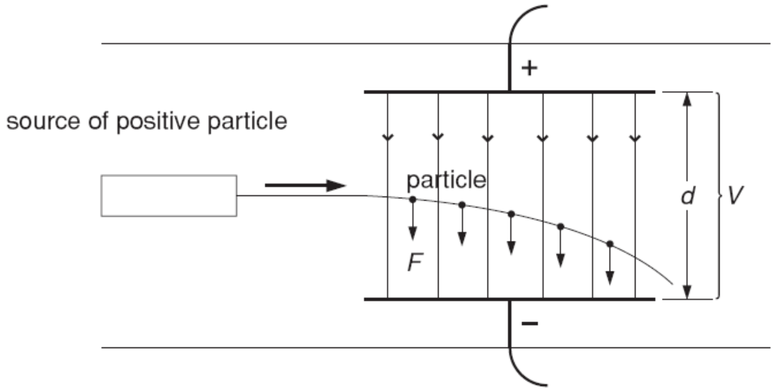
(A) 1.563 m/s

(B) 15.6 m/s

(C) 156.3 m/s

(D) 1563 nm/s

16 A positron is fired at right angles into an electric field as shown in the diagram below.



Path of a positive particle in an electric field between two charged plates.

The electric potential difference between the plates is 250 V and the plate separation distance is 0.186 m. The particle is fired at a height of exactly half of the plate separation distance. If the particle has a charge of $+1.6 \times 10^{-19}$ C, how much work will be done on the particle by the field?

(A) 200×10^{-17} J

(B) 200×10^{-18} J

(C) 2.00×10^{-17} J

(D) 4.00×10^{-17} J

17 Two identically charged particles of different masses are separated by mass spectrometry, a technique for identifying charged particles as a function of their mass by measuring the radius of curvature of their paths in magnetic fields. Which of the following statements is accurate?

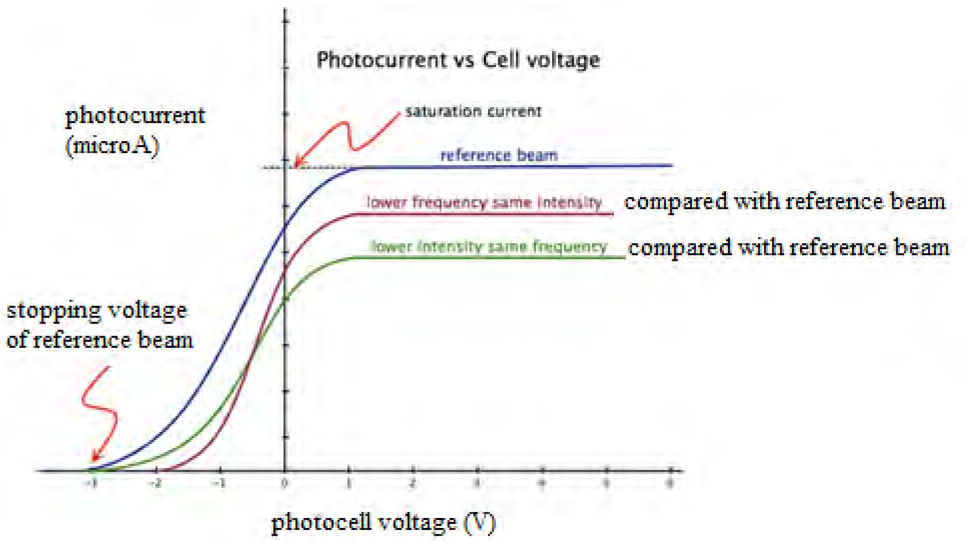
(A) The two particles will have identical radii of curvature.

(B) The heavier particle will have the larger radius of curvature.

(C) The lighter particle will have the larger radius of curvature.

(D) The particles will curve in opposite directions.

18 The graph below shows how photoelectric current relates to both frequency and intensity of incident radiation in a photocell.



The best explanation of the above data is

(A) The stopping voltage is a function of the intensity of the incident light while the photocurrent is a function of the frequency.

(B) The stopping voltage is a function of the frequency of the incident light while the photocurrent is a function of the intensity.

(C) Both the stopping voltage and the photocurrent are functions only of the intensity of the incident light.

(D) Both the stopping voltage and the photocurrent are functions only of the frequency of the incident light.

19 During the 1930's Einstein's response to Nazism in Germany saw him emigrate to the U.S.A. Max Planck, also a German, chose to deal with the same issue by:

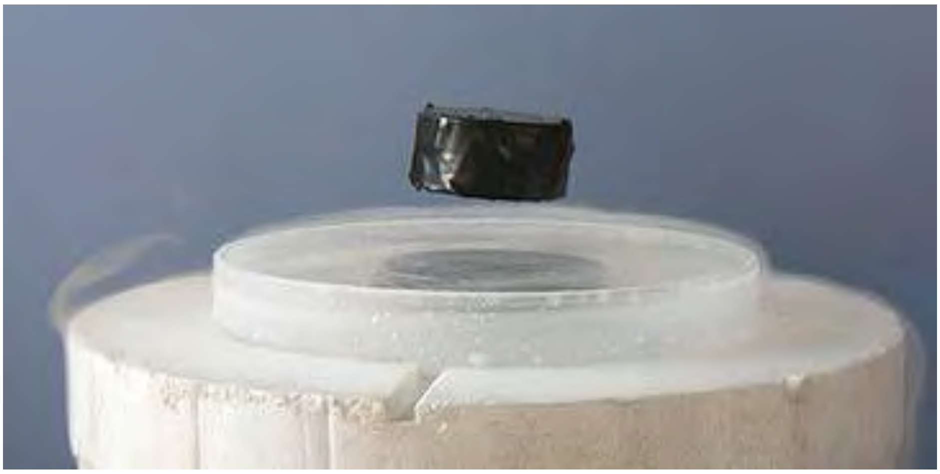
(A) Continuing to work in Germany and joining the Nazi Party, as he felt that science and politics are linked.

(B) Continuing to work in Germany, but not becoming a Nazi - as he felt that science has nothing to do with politics.

(C) By leaving Germany to work for the U.S.A as a scientist.

(D) By leaving Germany to work in a field not related to science.

20 The Meissner effect, where a magnet is suspended over a superconducting disc is shown below.



The most correct explanation of this effect is

(A) The superconductor when cooled produces a levitating force. Placing the magnet above it makes the magnet float.

(B) The magnet is floating on currents of supercooled air.

(C) The magnet's magnet field induces eddy currents in the disc. Since the disc superconducts, the eddy currents do not dissipate. The superconductor expels magnetic fields from its interior, producing an effect which is as if there is another magnet identical to the first one located under the disc with like poles facing each other.

(D) The superconductor's magnetic field induces one eddy current in the magnet. The magnetic field produced by the eddy current opposes that of the field of the magnet and hence the magnet floats.

End of Part A

2013 Trial Higher School Certificate

Name:
Class:
Teacher:

Physics

Section I (Continued)

Part B – 55 Marks

Attempt Questions 21 – 34

Allow about 1 hour and 40 minutes for this part.

Answer the questions in the spaces provided. These spaces provide guidance for the expected length of the response.

Write your name, class and teacher at the top of this page

Show all relevant working in questions involving calculations.

Question 21 (4 Marks)

A 2000 kg satellite is to be placed in a circular orbit 8000 km above the surface of the Earth. Assume the Earth's radius is 6370 km.

(a) Calculate the gravitational potential energy of the satellite before it is launched. **1**

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(b) Explain why the energy required to place the satellite in orbit is much greater than the work required to lift the satellite to the correct height. **3**

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Question 22 (5 Marks)

A United Nations plane travelling horizontally with a velocity of 120 ms^{-1}, at an altitude of 320 m above the ground, drops a food parcel when it is directly above a small village. (Neglect air friction in your calculations.)

(a) Calculate the time for the parcel to reach the ground. **1**

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(b) Calculate how far from the village the parcel will land. **1**

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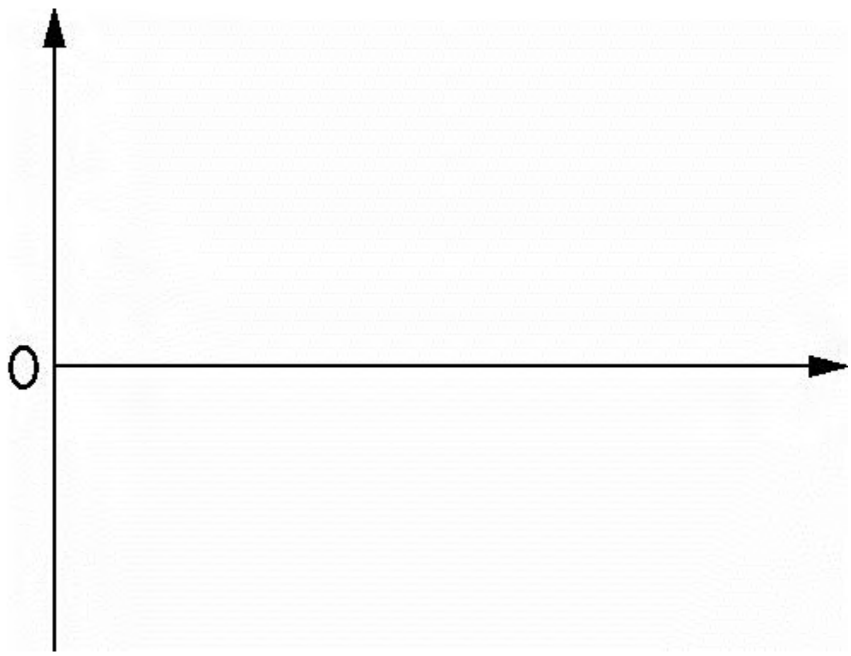
(c) Sketch a graph of the vertical displacement (y) of the parcel against the square of time (t^2). Include the values where the line intercepts each axis. **3**



Question 23 (4 Marks)

Justify the unit of length being defined in terms of time and the speed of light in a vacuum rather than it being a physical object.

Question 24 (2 Marks)

The weight exerted by an 85.0 kg mass when it is 8.00×10^3 km away from the centre of a planet is 4.25×10^2 N. Calculate the mass of this planet.

Question 25 (4 Marks)

The Michelson-Morley experiment attempted to measure the relative velocity of the Earth through the aether without success.

With the aid of a diagram, explain why the Michelson-Morley experiment apparatus was rotated through 90° in an attempt to observe the effect of the aether wind.

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Exam continues on next page

Question 26 (3 Marks)

A student connects a voltmeter across the ends of the coil of a DC electric drill, connected to a 12 volt battery. At t = 0s, he starts to drill a hole in a brick wall and records the voltmeter readings every minute. The results are shown below.

Time (min)	Voltage (V)	Depth of hole (cm)
1	5	0.5
2	5	1.0
3	9	1.2
4	10	1.3
5	4	2.0
6	5	2.5

Account for the readings being less than 12 V and varying as the hole is drilled.

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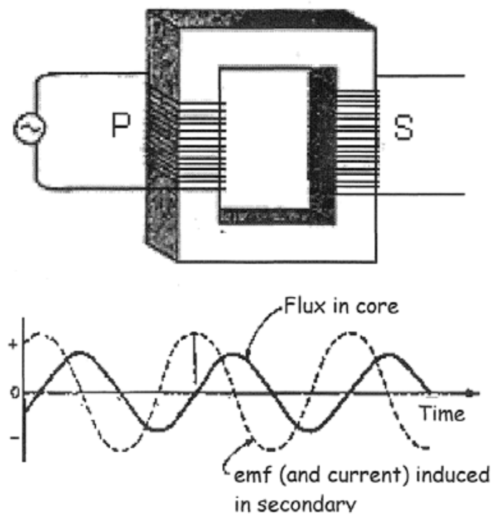
Question 27 (4 Marks)

The transformer below has 14 turns in the primary coil and 28 turns in its secondary coil. The graph shows how the flux in the iron core of the transformer is related to the emf and current induced in the secondary coil.



(a) If the voltage across the secondary coil is 60 volts, what is the input voltage? **1**

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(b) The graph shows that the emf across the secondary coil is a maximum when flux through the iron core is zero. Explain this relationship. **1**

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(c) Explain one way the heating problems of transformer cores can be overcome. **2**

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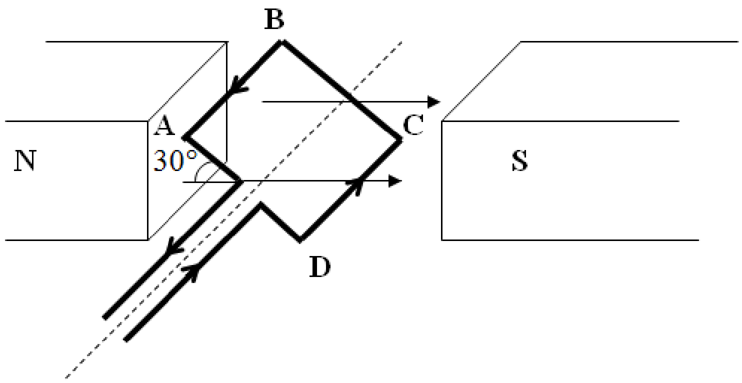
Question 28 (5 Marks)

A rectangular coil of 20 loops is positioned between the poles of bar magnets and its plane makes an angle of 30° with the direction of the magnetic field as shown. The side AB measures 15 cm while the side BC measures 18 cm. The magnetic field between the poles of the magnets is 5.0 mT and the current through the coil is 25 mA.



(a) Calculate the magnitude and direction of the force on side AB when the coil is at an angle of 30° with the direction of the magnetic field as shown. **1**

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(b) Define *torque.* **1**

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(c) Calculate the torque acting on the coil when it is at an angle of 30° with the direction of the magnetic field as shown. **2**

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(d) Many motors do not contain permanent magnets. State how the magnetic field is produced in such motors. **1**

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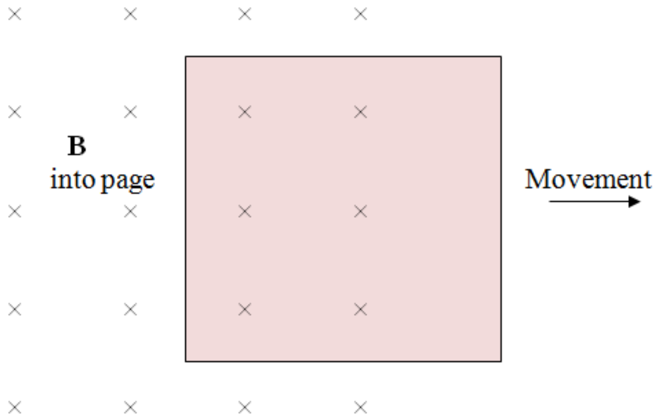
Question 29 (3 Marks)

Part of a flat horizontal metal sheet is perpendicular to a magnetic field into the page, as shown. The sheet is moved out of the magnetic field at constant speed.



(a) Draw on the diagram the eddy current that is produced in the sheet as it moves out of the magnetic field. Include the direction of the current. **1**

(b) Explain the production of the eddy current in the sheet. **2**

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Question 30 (4 Marks)

In your course you performed an investigation to demonstrate the production of an alternating current. **2**

(a) Briefly describe an experiment you did to produce alternating current with particular reference to how you verified that alternating current was actually produced.

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(b) Describe ONE advantage of using AC generators for large-scale electrical power production. **2**

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Question 31 (8 Marks)

In 1897, J. J. Thomson conducted an experiment that enabled determination of the ratio of the electric charge to the mass for what would later become known as the electron.

a) Derive an expression for the ratio of the electric charge to the mass of the electron in terms of the electric field E, the magnetic flux density B, and the radius of curvature r. **3**

Hint: begin by equating the magnetic and electric field forces.

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b) Draw a labelled scientific diagram illustrating how a sinusoidal pattern is produced on the screen of a Cathode Ray Oscilloscope (CRO). **3**

c) The separation between the horizontal electric plates was 1.5 cm and the applied potential difference between them was 200 V. Determine the distance travelled in 1.1 ns assuming the particle was initially at rest. **2**

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Question 32 (4 Marks)

In 1900 Max Planck had an idea that changed science. Outline the nature of the problem that he solved, and describe his solution to this problem. Explain what was revolutionary about his solution.

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Question 33 (2 Marks)

In 1905 Einstein solved the problem of the photoelectric effect with the following equation:

$$hf = \Phi + KE$$

where

Φ = the work function of the metal

Setting the photocell up so that a potential difference will produce an electric field that will oppose the motion of the photoelectron. At the right level the motion of the electron is stopped. The voltage required is equal to the quotient of the kinetic energy and the charge of the electron.

In a photocell, light with a wavelength of 450 nm is shone onto a metal surface. If the work function of this metal is 2.56×10^{-19} J, what will be the required voltage needed to reduce the photocurrent to zero?

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Question 34 (3 Marks)

Using appropriate energy band diagrams explain how doping silicon with Group III or Group V atoms will change the conductivity of the resultant material.

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End of Section I

Name:
Class:

Teacher:

2013 GIRRAWEEN HIGH SCHOOL
TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Physics

Section II

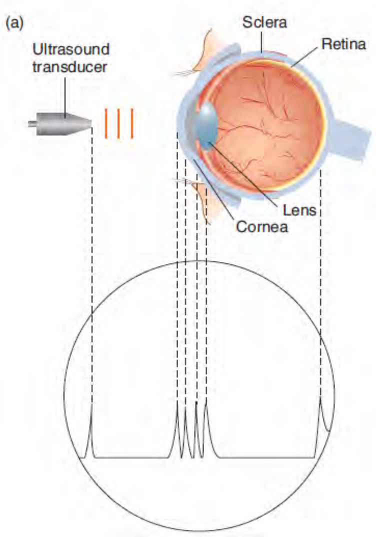
25 marks
Allow about 45 minutes for this section

Answer the parts of the question as indicated in Section II Answer Booklet.
Extra writing booklets are available.
Write your name, class and teacher at the top of this page

Show all relevant working in questions involving calculations.

Question 35 — Medical Physics (25 Marks)

(a) (i) The image below is an A scan ultrasound data set of a normal human eye.



If the acoustic impedance of the vitreous humour in the eye cavity (i.e. between the post lens signal and the retinal signal) is 1.52×10^6 kg m^{-2} s^{-1} and the density of this region is 1000 kg m^{-3}, determine the speed of sound in the eye cavity. **3**

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(ii) The acoustic impedances of bone and brain tissue are 6.4×10^6 kg m^{-2} s^{-1} and 1.6×10^6 kg m^{-2} s^{-1} respectively. **3**

With the aid of a calculation, explain why an ultrasound scan is not sensible procedure for imaging a patient with suspected head/brain injuries.

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(iii) Outline how the piezoelectric effect is used in the production of ultrasound scans. **3**

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b) (i) The following table compares common isotopes used in PET scans. **4**

RADIOISOTOPE	SYMBOL	HALF-LIFE
Carbon-11	${}^{11}_{6}C$	20.4 minutes
Nitrogen-13	${}^{13}_{7}N$	10.0 minutes
Oxygen-15	${}^{15}_{8}O$	2.13 minutes
Fluorine-18	${}^{18}_{9}F$	109.8 minutes

Discuss the effect of the length of the half - life of these isotopes upon their use in obtaining a PET image. Explain why of the four isotopes listed only Fluorine-18 is able to be made available to facilities not located at the site of production.

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(ii) The half-life of Carbon-11 is 20.4 minutes. How long will it take 1 g of Carbon-11 to decay to 0.125 g? **2**

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(iii) Contrast using a radioisotope for the purpose of obtaining a bone scan with using a radioisotope in PET scanning. **4**

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(c) Construct a flow chart detailing the sequence of events that take place during the process of obtaining an MRI scan of a person's head. Begin with the production of the magnetic fields and end with the formation of the digital image. **6**

End of exam

Worked solutions

Section A Part One: Multiple Choice Questions

1. The net forces on the astronaut have to be zero to be weightless, so at the point where the force of gravity from the Earth is equal in size and opposite in direction the net force is zero.
2. Not knowing the masses means we know nothing about the strength of the gravitational force. The orbital velocity of a satellite does not depend upon the mass of the satellite but is a function of the radius. The closer satellite orbits faster.
3. It's a relativity length contraction problem. L_0=100, L_v=50 and use the equation to solve for v.
   use $l_v = l_0\sqrt{1-\frac{v^2}{c^2}}$
   $50 = 100\sqrt{1-\frac{v^2}{c^2}}$ and solve for v
   $$v = \frac{c\sqrt{l_0^2 - l_v^2}}{l_0} = \frac{c\sqrt{100^2 - 50^2}}{100} = 0.87\ c$$
4. The postulate was that the speed of light is constant and will be measured to be same independent of the motion of the observer making the measurement.
5. Since the only force acting on a projectile is gravity, and gravity only acts in the vertical direction, then only the vy component will change. Since gravity is constant then vy will change in a linear manner will a slope of -9.8. Option c.
6. This is a kepler's law question, so use
   $$\frac{T_A^2}{R_A^3} = \frac{T_B^2}{R_B^3}$$
   Tt = 16452.6
   altitude of s = 630 000 m
   altitude of t = 7 630 000 m
   Earth radius = 6370 000 m

   so $T_s = \sqrt{R_S^3 \frac{T_T^2}{R_T^3}}$
   $$T_s = \sqrt{(630000 + 6370000)^3 \times \frac{(16452.6)^2}{(7630000 + 6370000)^3}} = 5816.9\ s$$
7. Use $e = mc^2$
   we have a starting mass and an amount of energy:
   m_o = 2.75 kg
   e = 1.20 × 10^{17} J

so $m_{lost} = e/c^2$

$m_{lost} = \frac{1.2\times10^{17}}{9\times10^{16}} = 1.333$ kg

Mass remaining = original mass – lost mass

2.75 – 1.33 = 1.42 kg

8. If the net force on wire Y is zero, then Fxy = -Fzy

$$F_{xy} = \frac{k \times 3 \times 2 \times l}{dx}$$
$$F_{zy} = \frac{k \times 1 \times 2 \times l}{dz}$$
$$\frac{6kl}{dx} = \frac{2kl}{dz}$$

$$3\,dz = dx$$

9. This is an electromagnetic breaking question, and the critical aspect here is the ability of eddy current to form in the tubes as a result of the changing magnetic flux coming from the falling magnet. Plastic is not a conductor, so no current is induced and the magnet falls the fastest. The conducting tube with a slot in it can form eddy currents but not as successfully as the complete conductor, so the slotted tube will be the second fastest, with the complete conducting tube will be the slowest. The eddy currents have magnetic fields in opposition to those responsible for the induction, and that is the source of the breaking effect.
10. If the magnet moves right then the force on the wire is to the left.
    The only option that gets the force in the correct direction is if the current flows from X to Y with the field pointing up.
11. As the magnetic flux is the product of the magnetic flux density (filed strength) and the area, then option A is the answer.
12. Since we can transform voltages we can transmit at High voltage, where the power losses are reduced, and then step back down for usage at the other end. Option A.
13. The winner of the contract offered the lower price. This was the AC bid, since the AC grid would not need as many substations due to the ability to transmit over longer distances than DC.
14. Use $E = hf$ and $c = f\lambda$ and recall that 1 eV = 1.6×10^{-19} J

    so you calculate $\lambda = \frac{h\,c}{E\,q_e} = \frac{6.626\times10^{-34}\times 3.0\times10^{8}}{0.75\times1.6\times10^{-19}} = 1.65\ \times 10^{-6}\text{m}$

15. Thomson's experiment had E and B field producing equal and opposite forces so that $qE = qvB$ and hence $v = \frac{E}{B} = \frac{50}{3.2} = 15.6\ \text{m/s}$

16. It's a positron so q = 1.6×10^{-19} C
    Work done = qV but you have realise that this V is the potential difference that the particle is accelerated through, so its not the full 250 V but only 125 V, since the particle is fired into the plates exactly at the halfway mark .

$$W = qV = 1.6 \times 10^{-19} \times 125 = 2.00 \times 10^{-17}\, J$$

17. The expression relating the force applied to a charge by a magnetic field refers to a force directed at right angles to the direction of motion, i.e. circular motion, so we can write

$$F_{Magnetic} = F_{circular}$$

$$qvB = \frac{mv^2}{r}$$

So with two particles of identical charge travelling in a magnetic field with the same velocity but different masses a and b we can write:

$$\frac{m_a}{r_a} = \frac{m_b}{r_b}$$

Which would mean that if the mass of one is doubled, then its radius will be also doubled.

18. Einstein's ethnic Jewish background and his political pacifism meant that he took a different approach to the problem of Nazi persecution to that taken by Planck. Planck, who was German but not a Jew, thought that he could conduct his scientific research without supporting the politics of the Government. Planck did not emigrate but chose to remain in Germany. He did not, however, join the Nazi party, even though many German scientists did so.

19. The stopping voltage is a function of the frequency of the incident light since it supplies the energy of the photocurrent and the work function energy. The photocurrent is a measure of number of electrons which are participating in the current, which is related to the number of incident photons of sufficient energy to overcome the work function of the metal.
20. The meissner effect is produced by the expulsion of the flux from the core of the superconductor once it is cooled below its critical temperature. Option c.

Section A Part II: Longer Response questions

Question 21

Criteria	Marks
• Correct numerical answer.	1

a) use $U = -G\frac{m_1 m_2}{r}$, where r = radius + altitude

G = 6.67 × 10^{-11}

Radius = 6370 000 m

Alt = 8000 000 m

Me = 6.0 × 10^{24}

ms = 2000

$$U = -6.67 \times 10^{-11} \frac{6.0 \times 10^{24} \times 2.0 \times 10^{3}}{6.37 \times 10^{6} + 0} = -1.26 \times 10^{11} J$$

b)

Criteria	Marks
• Clear statement relating the energy required to place a satellite in orbit to the various types of work that must be done. Hence, in addition to the energy required to lift the satellite to correct height, (PE) energy is also required; to give the satellite the correct velocity to keep it in orbit (i.e. KE), to overcome air friction when travelling through the atmosphere, and some energy is lost as heat (because rocket engines are not 100% efficient).	3
• Clear statement that energy is required for one of above in addition to the energy required to raise the satellite to the correct height (PE) or a poorly expressed response that mentions two of the factors above.	2
• A response that mentions one of the factors above in addition to PE.	1

A good response would include:

In addition to the work required raising the satellite to the correct height, work must be done to give the satellite the correct horizontal velocity to keep it in orbit at this height.

Work must also be done to overcome air friction and some energy is lost as heat because the rocket engines are not 100% efficient.

Question 22

a) use $s = ut + 0.5gt^2$, u = 0

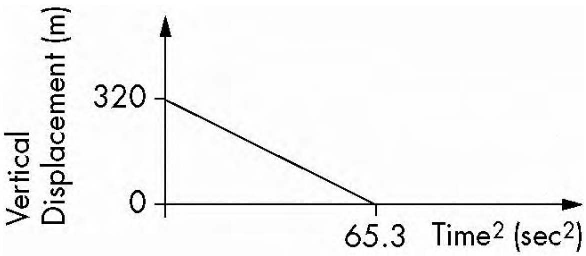
$$320 = 0.5 \times 9.8t^2$$

$$t = \sqrt{\frac{2 \times 320}{9.8}}$$

t = 8.08 seconds

b) range = ux × t = 120 × 8.08 = 969.6 m = 970 m (3 sf)

c)



Question 23

Marking Criteria	Marks
• Constancy of c identified • Relative nature of time identified • Problems with physical object described • Justification given in a logical, sequential manner	4
• Justification made using most of the information listed above	3
• A reason supplied using some of the information above	2
• Constancy of c identified OR • Relative nature of time identified OR • problems with physical object identified	1

A physical object such as a length of metal will expand and contract with temperature variations, as well as wear down each time it is handled. It also must be compared directly (physically). Basing length standard on the universal constant of c (the same anywhere) and time (even though relative, will be the same to an observer within the same frame of reference) will yield universally identical results without the need for direct comparison to an object.

Question 24

Marking Criteria	Marks

• Correct equation used • Values assigned to variables correctly • Correct answer with units	**2**
• ONE of the above	**1**

$$F = G\frac{m_{mass} \times m_{planet}}{r^2}$$

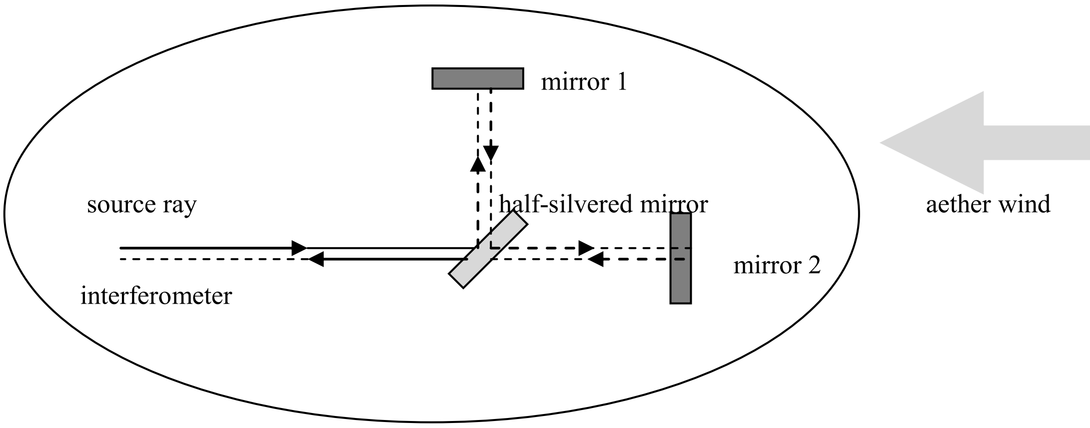
$$4.25\times10^2 = 6.67\times10^{-11}\frac{85.0\times m_{planet}}{\left(8.00\times10^6\right)^2}$$

$$m_{planet} = \frac{4.25\times10^2\times\left(8.00\times10^6\right)^2}{6.67\times10^{-11}\times85}$$

$$= 4.80\times10^{24}\text{ kg (3 sig. figs)}$$

Question 25

The time taken for a ray of light moving into the aether wind and back will be slightly longer than the same ray moving perpendicular to the same aether wind. This is at the heart of the physics of the M-M experiment. Timing such a ray to the necessary precision is not possible, but splitting one ray into two at right angles and then re-combining them will produce an interference pattern which would be seen to change as the direction of the rays relative to the aether wind changed by rotating the apparatus.. It is this rotation of the apparatus that would enable any detection of the effect of the aether wind on the speed of light.



whole apparatus can be rotated through 90^0

Question 26

As the motor coil in the drill rotates, it cuts magnetic field and induced emf is produced in the coil. The direction of this emf (Len's Law) opposes the supply emf (it is a back emf) so the net voltage across the coil reduces.

The size of the emf and voltage drop increases with speed of rotation. Therefore if the drill speed is slowed by harder material in the wall, the voltage reading will be higher.

Question 27

a) Vp / 60 = 14/28

Vp = 30V

b) The emf generated is proportional to the rate of change of flux. So when the flux is changing most rapidly the emf is a maximum and when there is zero change in the flux the emf is zero.

c) The heating effect of the eddy currents are greatly reduced by:

1 - The use of a laminated core, made up of thin sheets insulated from each other, reducing the size of the eddy currents produced. This results reduced heat being produced within the transformer.

2 – the use of ferrite material in the core. These materials conduct the magnetic flux well but have a grain structure that impedes electron flow, thus reducing the eddy current formation.

Question 28

a) F = nBIl = 3.75 × 10-4 N up the page.

b) Torque is the turning moment of a force OR is a twisting force. OR $\tau = Fd$ where F is the applied force and d is the perpendicular distance to the pivot point.

c) $T = nBIA\cos\theta = 20 \times 5.0 \times 10^{-3} \times 25 \times 10^{-3} \times 0.15 \times 0.18 \times \cos 30° = 5.85 \times 10^{-5}$ Nm

d) A solenoid or coil provides the magnetic field i.e. an electromagnet.

Question 29

a) Clockwise current

b) Lenz's law states that the induced current will have an effect that opposes the change that caused it. The clockwise current has a magnetic field into the page, interacting with the existing field and producing a force to the left opposing the motion.

Or

The system will respond to counter the change that it is experiencing. With the number of field lines into the page reducing, more field lines in the same direction will be added to compensate for the loss. An eddy current that will do this will be rotating in a clockwise direction.

Question 30

a)

1) School demonstration AC generator consisting of permanent magnets , coil and a slip ring commutator. Rotating coil within a magnetic field connected to a CRO to see out put OR

2) Connect a solenoid (a wire coil with a few hundred turns) to a zero-centered galvanometer. Move a bar magnet slowly in and out of the coil and observe what happens.

b) no sliding contacts to attain generated current out of generator, therefore reduced wear; AC can be transformed to HV for transmission (stepped up) and then stepped down at the point of use;

Question 31

a) start with

$$F_{magnetic} = F_{electric}$$

Due to geometry sin θ = 1

$$qvB = qE$$

$$v = \frac{E}{B}$$

Then use

$$F_{magnetic} = F_{centripetal}$$

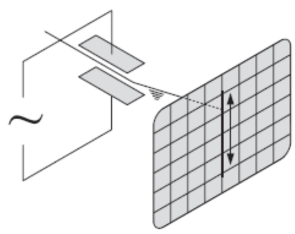
$$qvB = \frac{mv^2}{r}$$

$$qB = \frac{mv}{r}$$

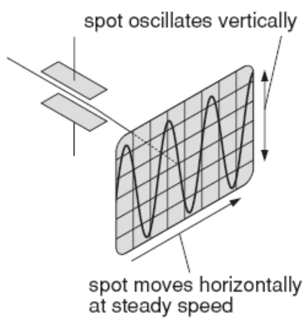
$$qB = \frac{mE}{rB}$$

$$\frac{q}{m} = \frac{E}{rB^2}$$

b)



❸ a constant AC current across the vertical deflection plates produces a line



❹ A combination of a constant horizontal deflection and a AC deflection on the vertical plates produces a sine curve

c)

V = 200 V

d = 1.5 cm

t = 1.1 ns

use $s = ut + \frac{1}{2}at^2,\ E = \frac{F}{q},\ E = \frac{V}{d},\ F = ma$

u = 0

so we need a

$$a = \frac{F}{m} = \frac{qE}{m} = \frac{qV}{md}$$

So

$$s = \frac{1}{2}\frac{qV}{md}t^2$$

$$s = 0.5\ \frac{1.6 \times 10^{-19}200}{9.109\ \times\ 10^{-31} \times 1.5\ \times 10^{-2}} \times (1.1\ \times 10^{-9})^2 = 1.418\ \times 10^{-3}\mathrm{m}$$

Question 32

Black Bodies absorb all incident radiation and re-radiates only characteristic frequencies. Attempts to explain this failed and resulted in what became described as the “ultraviolet catastrophe” as the short wavelength end of the BB spectrum was particularly troublesome. Max Planck successfully explained this by assuming that each atom in a cavity radiator acts as an oscillator that can only oscillate with certain frequencies. This explanation breaks with previous scientific thinking in the introduction of “quanta” or packets of energy. The amount of energy in a given quantum of electromagnetic radiation could be calculated from E = hf, where f is the EMR frequency in Hz and h is the constant of proportionality. Only these quanta of energy can be absorbed or emitted by atoms, and since then the physics of atoms is called “quantum physics.”

Question 33

Use einstein's eqn

$$hf = KE + \phi$$

KE is equal to qV so $\frac{hf-\phi}{qe} = V$

λ = 450 nm

ϕ = 1.6 eV

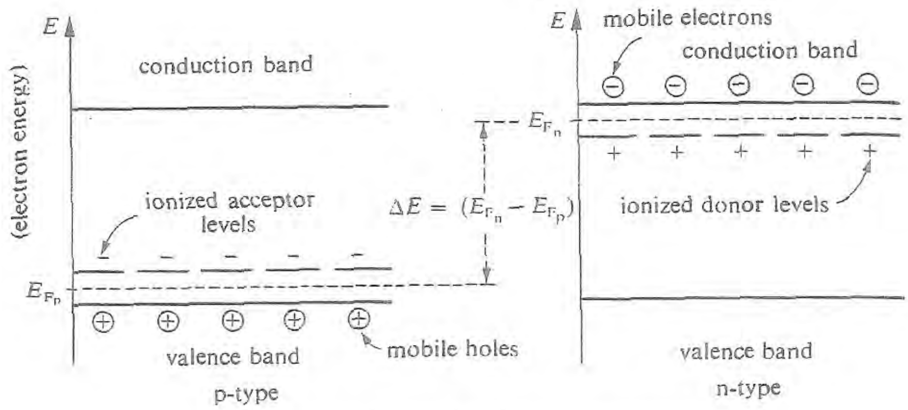
First thing to do is determine how much energy is in a photon of 450 nm wavelength

E (in eV) = $\frac{h\,c}{qe\,\lambda} = \frac{6.626 \times 10^{-34} \times 3.0 \times 10^{8}}{1.6 \times 10^{-19} \times 450 \times 10^{-9}} = 2.75739$

This leaves $hf - \phi = 2.75739 - 1.6 = 1.15739$ eV

Which means that the stopping voltage will be 1.2 V (2 sf)

Question 34



(a) *separate p-type and n-type materials*

Option Paper Solutions

Question 36

a) i) use $Z = \rho v$

$v = \frac{Z}{\rho} = \frac{1.52 \times 10^6}{1000} = 1.52\ \times 10^3$ m/s

a) ii) First calculate the reflection coefficient for the boundary in question.

Z_{bone} = 6.4 × 10^6 kg m^{-2} s^{-1}

Z_{brain} = 1.6 × 10^6 kg m^{-2} s^{-1}

$$\frac{I_r}{I_0} = \left(\frac{Z_2 - Z_1}{Z_2 + Z_1}\right)^2 = \left(\frac{6.4 \times 10^6 - 1.6 \times 10^6}{6.4 \times 10^6 + 1.6 \times 10^6}\right)^2 = 0.36$$

So each time a sound wave crosses the boundary 67% of the signal is lost. This degree of attenuation means that the data will be too noisy to be useful.

a) iii) The piezoelectric effect occurs in certain types of crystals where the application of a potential difference across the crystal will produce an expansion or contraction of the crystal. The process is reversible, with applied pressure inducing a voltage. Hence the application of an AC voltage will produce oscillations in the crystal at the same frequency which will then create oscillating pressure differences in the adjacent material – i.e. sound waves. The reflected sound wave, when incident upon the crystal will induce an AC voltage which can be measured – hence the same crystal can function as both sound source and detector.

b) i) The half-life of an isotope (how long it takes for 50% of the parent material to decay) dictates its usefulness in medical diagnosis. Too long and the radioactivity is able to damage tissue, which is undesirable. Too short and the activity level will decrease too quickly to obtain a clear scan.

Of the four isotopes, only Flourine-18 is able to be transported within the same city, as its half-life is long enough to allow enough time to enable a delay of an hour or so with compromising the ability to obtain a clear scan.

b) ii) 0.125 = $\frac{1}{8} = \frac{1}{2^3}$, so 3 half lives, so t = $3 \times 20.4 = 61.2$ minutes

b) iii)

Scanner geomentry: Bone scans involve laying the patient on a table with a gamma camera vertically above. Whereas PET involves inserting the head only into a ring shaped scanner.

Part of the body imaged: Bone scans can be of any part (or all) of the body, whereas PET is the head only.

Isotopes: Different isotopes are used in each.

PET gamma emission results from positron-electron annihilation, whereas in other scans the gamma emission results form the α or β emission process.

c)