Candidate Number _____
Centre Number _____

Ascham School

Trial Examination 2002

Physics

Time allowed: 3 hours (plus 5 minutes reading time)

SECTION 1

PART A 15 one mark multiple choice questions.
Write your answers in pencil on the Part A answer sheet. (15 marks)

Write your Candidate number and Centre number on the Part A answer sheet.

PART B Short response questions.
Write your answers in the space provided. (75 marks)

Write your Candidate number and Centre number on each section.

SECTION 2

Option: Medical physics (10 marks)

Write your answers to this section in the writing booklet.

Write your Candidate number and Centre number on each booklet you use.

A Periodic Table, A Data sheet and a Formula sheet are provided.

Section 1

Total marks (90)

Part A

Total marks (15)

Attempt questions 1 to 15

Allow about 30 minutes for this part

Use the multiple choice answer sheet.

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

Sample 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.

(A) ● (B) ✗ (C) ○ (D) ○

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

correct

(A) ✗ (B) ● (C) ○ (D) ○

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1. On Earth an astronaut has a mass of 80 kg. The astronaut is sent into space on a mission which, for a short time, involves a circular orbit of the Earth at an altitude of one Earth radius above the Earth's surface.

   In this weightless environment, the weight of the astronaut will be approximately

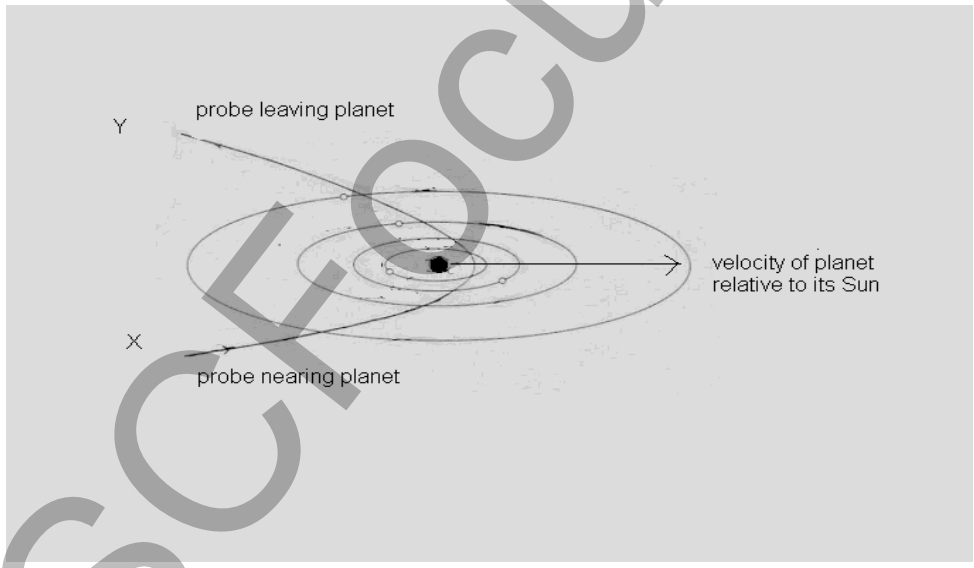
   (A) 196 N

   (B) 0 N

   (C) 784 N

   (D) 392 N

2. On a particular mission to a manned Space station, a space probe collides with a large planet which is close to the space station. The collision is shown in the diagram below. The Sun around which the planet revolves is not shown but is found somewhere near to the bottom of the diagram.



   As a result of the collision, the velocity of the probe relative to its Sun

   (A) has increased

   (B) has decreased

   (C) has remained the same

   (D) is impossible to determine since length contraction effects need to be considered

3. Two square coils of iron, X and Y, each of cross-sectional area 100 cm^2, are lying perpendicular to a uniform magnetic field of strength 5 x 10^{-4}T. Coil X has 10 turns and coil Y has 50 turns. The ratio of the magnetic flux through coil X to that through coil Y is

(A) 1:5

(B) 5:1

(C) 1:1

(D) 1:25

4. Two beams of electrons are close to one another and are travelling in the same direction. In this situation

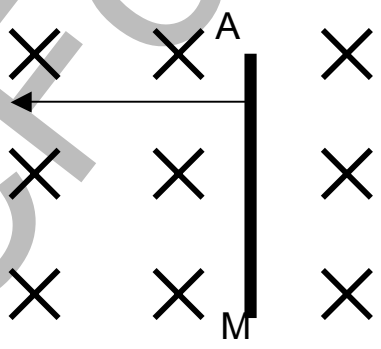
(A) there would be a resultant magnetic force of repulsion between the two beams

(B) the two beams would have no effect upon each other

(C) the two beams will decelerate to a final speed of zero.

(D) there would be a resultant magnetic force of attraction between the two beams

5. The diagram below shows a conductor being moved to the left through a magnetic field.



Which of the following is true?

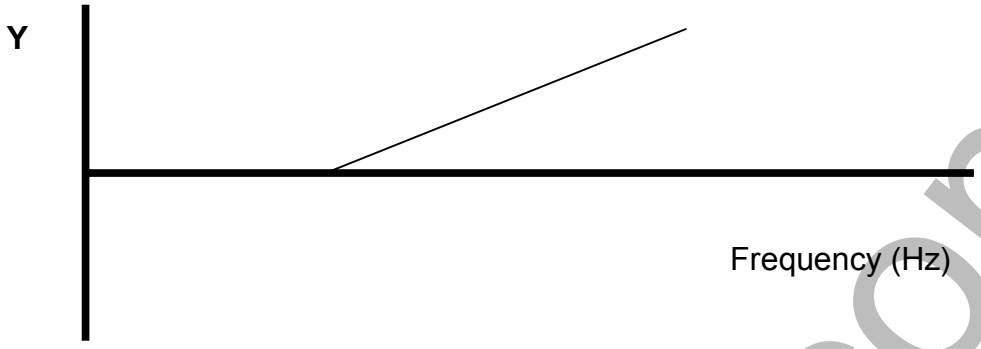
(A) the conductor experience a force and will move down the page

(B) a potential difference will be induced and current will flow from A to M

(C) a potential difference will be induced and current will flow from M to A

(D) the conductor experience a force and will move up the page

6. The graph below shows the results from a photoelectric effect experiment.



The quantity labelled Y, for each value of frequency, is found by

(A) multiplying the value of the stopping potential by the charge of an electron.

(B) determining the work function value.

(C) calculating the speed of the photoelectrons.

(D) measuring the wavelength of the light being used in the experiment.

7. The scientist who was responsible for introducing the concept of the quanta was

(A) Hertz

(B) Einstein

(C) Planck

(D) Galileo

8. In a Cathode Ray Oscilloscope, which of the following statements is correct?

(A) The electric fields from the X and Y deflection plates can cancel each other out so that electrons are not deflected.

(B) The part of the signal which is used to determine its frequency or period is sent to the horizontally deflecting plates.

(C) By reducing the brightness on the screen, the potential of the grid is being made less negative.

(D) No vacuum is needed since the electrons are strongly attracted by an anode.

9. A muon is a short-lived radioactive particle usually produced in the Earth's atmosphere, but can also be produced in a laboratory. A scientist is studying the life-times of muons and makes the following observations:

- When the muons are at rest in the laboratory their lifetime is 2×10^{-6} s.
- If the muons are travelling at a very high speed in the laboratory their lifetime is then measured to be 4×10^{-5} s.

With regard to the above information and using the ideas of Einstein's theory of relativity, which of the following statements is correct?

(A) Regardless of their velocity, a clock placed in the frame of reference of the muons will always measure a lifetime of 2×10^{-6} s.

(B) Measured by a clock in the laboratory, the lifetime of the muons will decrease as the velocity of the muons increase.

(C) The mass of the muon will remain constant regardless of its velocity.

(D) Due to the combined effects of time dilation and length contraction, a length measuring device placed in the laboratory will always measure the same distance travelled by the muons before they decay.

10. Which of the following conditions must be true in order for a satellite to remain in orbit around the Moon?

(A) The velocity of the satellite must be greater than the velocity of an identical satellite placed in an orbit the same distance above the surface of the Earth.

(B) The mass of the satellite must not exceed half the mass of the moon.

(C) The weight force of the satellite must exactly equal the resultant force acting on the satellite.

(D) The small motors on the satellite must provide sufficient thrust to provide the necessary centripetal force.

11. A photon of light with a wavelength 600 nm contains the minimum amount of energy required to release an electron from the surface of a particular material. The work function of the material, in Joules, is

(A) 1.1×10^{-27}.

(B) 3.3×10^{-22}.

(C) 5×10^{14}.

(D) 3.3×10^{-19}.

12. Which of the following devices relies on the motor effect to operate?

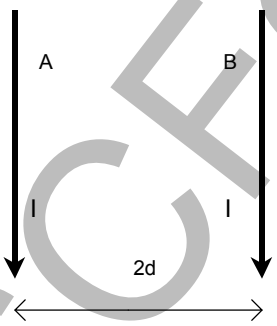
(A) A D.C. generator

(B) A galvanometer.

(C) A transformer

(D) An A.C. induction motor

13. Two wires A and B, both carrying a current I are shown below. They are separated by a distance 2d, and they exert a force per unit length F on each other.



The separation between the two wires is doubled and the current in one of the wires is quadrupled and reversed. The force per unit length between the wires is now

(A) F / 16

(B) F / 2

(C) 2 F

(D) 8 F

14. In medical ultrasound the transducer operates on the principle of

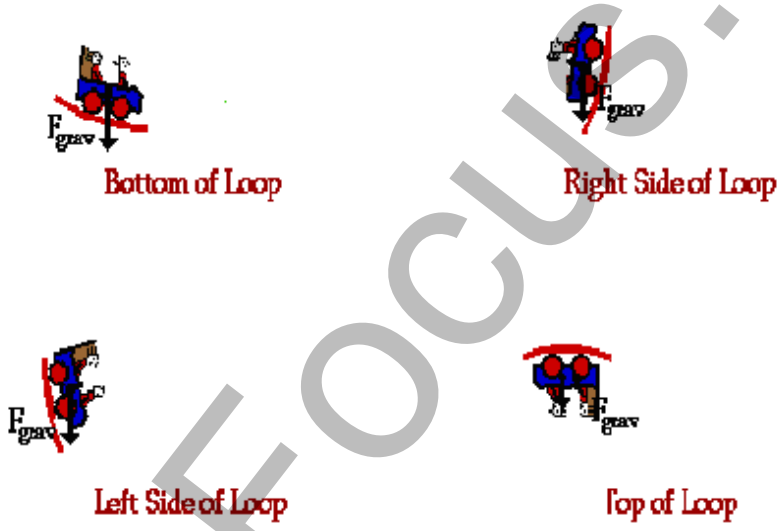
(A) the piezoelectric effect

(B) the photoelectric effect

(C) electromagnetic damping

(D) a potential difference being generated between different organs in the body.

15. On her day off from a rigorous training schedule from astronaut school, Mary Ellen, mass 60 kg, relaxes by enjoying a roller coaster ride. She takes her younger brother Owen, of mass 20 kg, along for the ride. As they complete one loop on the ride, one of the forces acting on Mary Ellen are shown below.



In the diagram F_{grav} represents Mary Ellen's weight. The Reaction force R, acting on her is not shown.

As one loop is completed it is true that

(A) Mary Ellen's acceleration is greater than Owen's acceleration.

(B) At the bottom of the loop the magnitude of R acting on Mary Ellen is much less than R acting on her at the top.

(C) $R + F_{grav}$, taking into account their vector natures, must equal the centripetal force acting on Mary Ellen.

(D) On the left side of the loop the Reaction force R points directly to the left.

Section 1(continued)

Part B - 75 marks

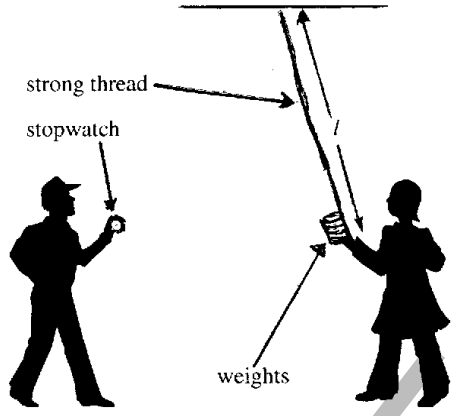
Attempt questions 16 - 29

Allow about 2 hours to answer this part

Answer questions in the spaces provided.
Show all relevant working in questions involving calculations.

Question 16 (7 marks)

During your study of *Space* you completed an investigation in order to calculate the acceleration due to gravity, g. The diagram below shows a possible setup in order to do this. The students timed 10 complete oscillations for a particular length of pendulum.



Theory suggests that, for such a pendulum, the time, T, for one oscillation is given by

$$T = 2\pi\sqrt{\frac{l}{g}}$$

where l is the length of string. The times for several lengths of string are shown in the table below.

Trial	Length of pendulum (cm)	Time for 10 oscillations (s)		
1	100	20.1		
2	75	17.4		
3	60	15.5		
4	50	14.2		
5	25	10.0		

(a) Using the expression for T above, complete the table above by determining appropriate column headings and calculating appropriate values, in order to help evaluate a value for g. (2)

(b) Construct an appropriate graph on the next page in order to calculate a value of g. In the space below the graph show all your working and clearly indicate your value for g. (4)

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(c) How could the students have made their results more reliable? (1)

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Question 17 (6 marks)

The simplest theory for the motion of a satellite assumes a circular orbit where the centripetal force required to keep the satellite in its orbit is provided by the gravitational pull of the central body. The centripetal force is given by:

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

where m is the mass of the satellite, v is its velocity and r is radius of orbit.

The gravitational pull is given by:

$$F_G = G\frac{M_1 m}{r^2}$$

where G is the Gravitational constant and M_1 is the mass of the central body.

(a) Use the equations above to derive Kepler's Third Law relating the radius of the orbit to the orbital period of the satellite. (2)

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(b) What are two of the most important characteristics of a geostationary orbit? (2)

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(c) Many Earth-monitoring satellites have near-polar orbits and periods of 100 minutes. Suggest a specific use to which near-polar orbit satellites can be put. (1)

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(c) Calculate the required orbit for a satellite with a period of 100 minutes. (1)

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Question 18 (6 marks)

(a) If a space vehicle, some time after launch, is accelerating vertically at 27.5 ms^{-2}, how many g's would the astronauts inside be experiencing? (1)

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(b) How would the astronauts be positioned so as to minimise the chances of them blacking out? (1)

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(c) Define the weight of an object. (1)

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(d) Justify the statement that an object moving in a circle at constant speed is accelerating. (1)

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(e) Predict what would happen to an orbiting satellite if the force of gravity suddenly ceased to act. (1)

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(f) If astronauts are on board the International space station for a period of four months, then they would receive the radiation equivalent of 100 chest x-rays.

Identify the source of the radiation that astronauts receive on such a mission. (1)

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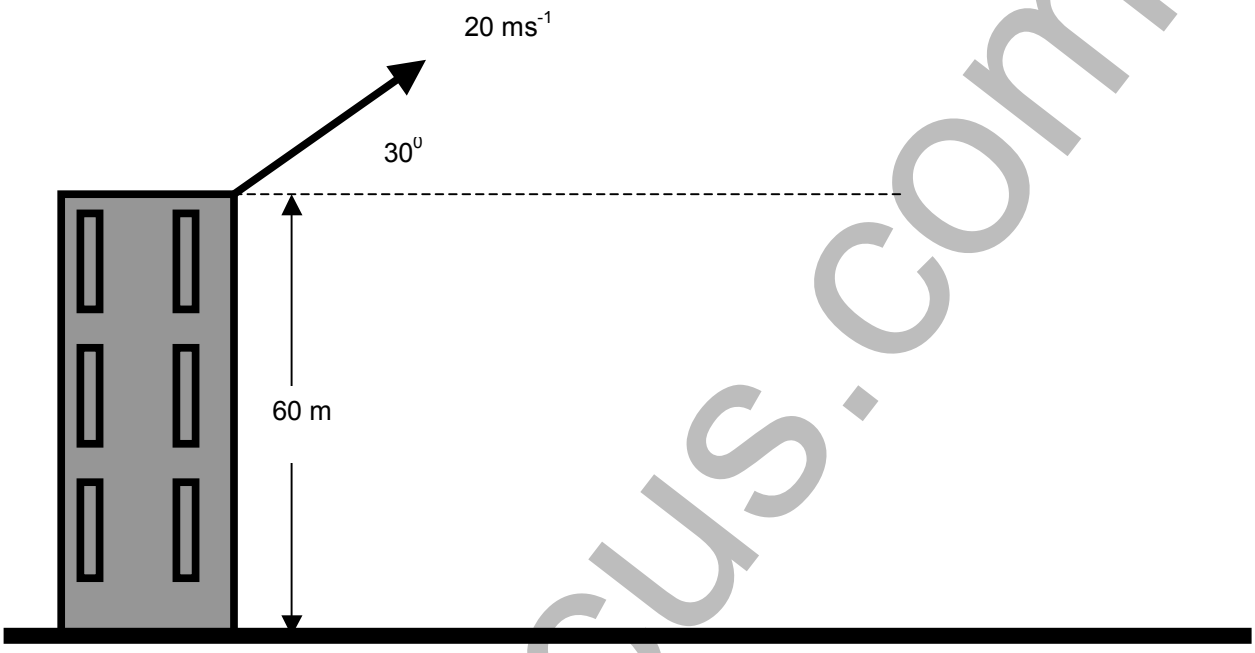
Question 19 (4 marks)

The moon has been colonised by earthlings. In the city of UnitedStatesofAmerica2, a softball is projected from the top of a building at a speed of 20 ms^{-1} at an angle of 30^o to the horizontal, as shown in the diagram below. The building is 60 m high.



On the moon the acceleration due to gravity is 1.63 ms^{-2}.

(a) Determine the time it will take for the softball to hit the ground. (3)

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(b) On the diagram above trace the path you would expect the ball to take if it was projected with the same velocity from a similarly sized building on Earth. (1)

Question 20 (4 marks)

An observer, Owen, in a manned space vehicle which is swooping low over the Earth's surface at 0.8 c, sees two simultaneous explosions below him at points A and B. At this instant he is just over a point C, halfway between A and B. Mary Ellen is at rest at B.

(a) Will Mary Ellen agree with Owen that the explosions were simultaneous? Discuss. (2)

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(b) Mary Ellen is now sitting at a railway station whose platform is 100 m long. Owen is now in a train which, at rest, is 150 m long.

(i) At what speed must the train be travelling so that Mary Ellen observes the whole length of the train to fit exactly along the platform? (1)

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(ii) Owen's train continues at the same speed onto the next station, Einstein Place. On his watch he measures the time to travel from Mary Ellen's station to Einstein Place as 3 seconds. In Mary Ellen's frame of reference, what length of time passed for the train to reach Einstein Place? (1)

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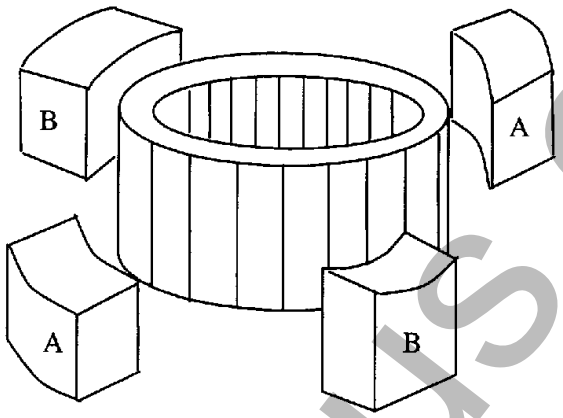
Question 21 (5 marks)

In an A.C. induction motor the squirrel cage rotor is a copper cylindrical cage, mounted in a region where magnetic fields can be applied from two or three sets of electromagnets. The diagram below shows two such sets, labelled A and B.



(a) Alternating current is supplied to both A and B. What is different about the currents supplied? (1)

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(b) Explain how the rotor is caused to rotate. (2)

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(c) Describe the advantages of induction motors over conventional motors. (2)

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Question 22 (8 marks)

(a) Describe an experiment which you carried out to demonstrate the production of an electric current using the principle of electromagnetic induction. (3)

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(b) A circular coil of radius 5 cm is placed in a magnetic field of strength 2.0×10^{-2}T.The plane of the coil is at right angles to the field. The radius of the coil is then reduced at the constant rate of 0.5 cm s^{-1} until its area is reduced to a half of its former value. A voltmeter attached to the coil records that an e.m.f. is produced while the coil's dimensions are being changed.

(i) Briefly explain why an e.m.f. is induced while the coil's area is being changed. (1)

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(ii) Sketch a graph showing how the induced e.m.f. varies with time. No numerical values are required, but account for the shape of your graph. (2)

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(ii) Calculate the average induced e.m.f. while the coil's area is changed (2)

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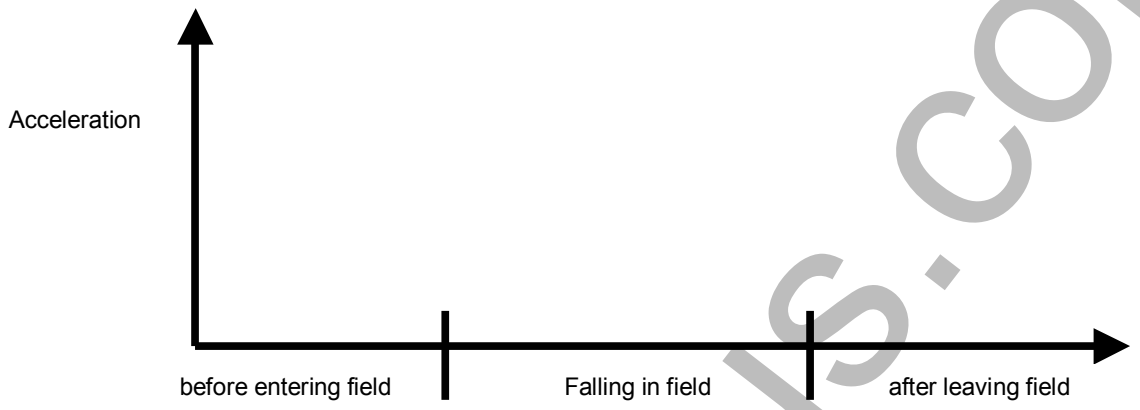
Question 23 (4 marks)

A square sheet of aluminium is held horizontally and then dropped so that it enters a vertical uniform magnetic field. It then leaves the field and continues to fall to the floor.

(a) Complete the graph below showing the acceleration of the aluminium sheet. (2)



(b) Briefly, account for the shape of your graph. (2)

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Question 24 (4 marks)

(a) Statement 1 A D.C. motor is used to convert electrical energy into mechanical energy.

Statement 2 However, it is inevitable that, in the normal operation of such a motor, the reverse energy conversion will also occur.

Justify statement 2. (2)

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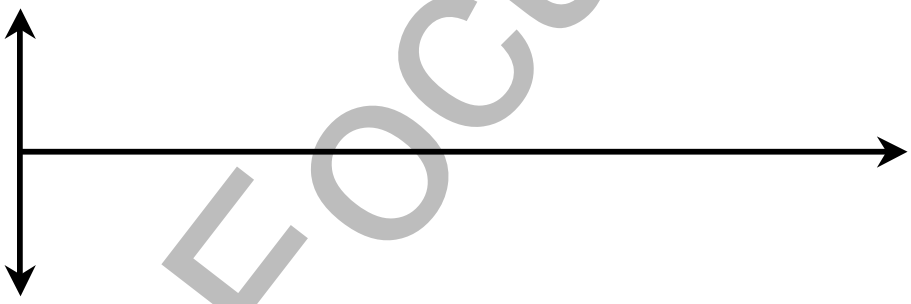
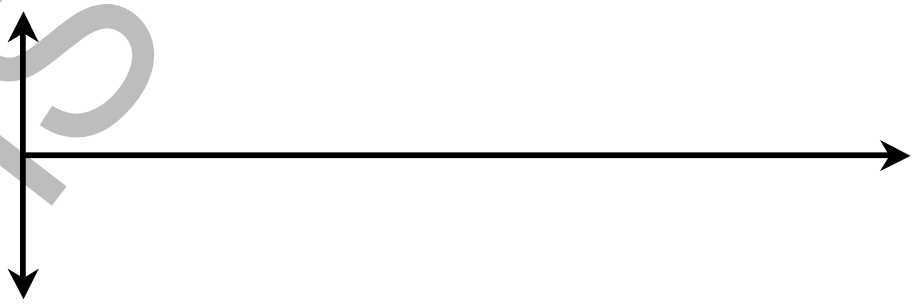
(b) (i) Sketch the output from an A.C. generator with a single coil in the space below. (1)



(ii) A triple phase A.C. generator has three coils spaced equally apart. Sketch the output from such a generator, on the graph below. (1)



Question 25 (4 marks)

(a) Explain why transformers do not operate on D.C. (2)

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(b) A transformer is used on a 240 V A.C. line to produce an output of 4800 V. If the primary coil has 80 turns, how many turns will the secondary coil have? (2)

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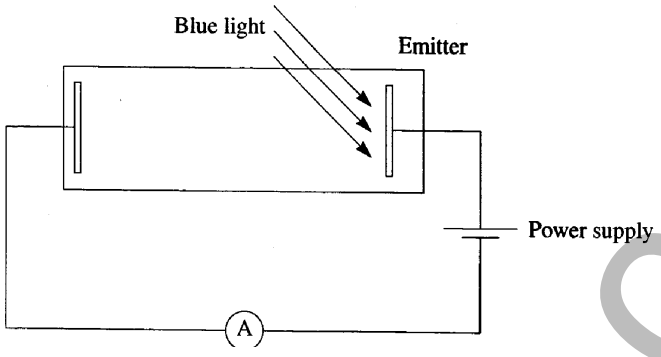
Question 26 (9 marks)

An evacuated tube is set up as shown below to demonstrate the photoelectric effect.



(a) Describe what happens to the atoms on the emitter when blue light hits it. (1)

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(b) What happens to the reading on the voltmeter when the voltage on the power supply is decreased? Explain your answer. (2)

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(c) Predict what would happen to the reading on the ammeter if the blue light was replaced with a red light. (1)

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(c) From a classical physics point of view, predict would happen if light of any frequency is incident on a metal surface. Explain your answer. (3)

Classical Prediction .....

Explanation .....

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(d) Explain how quantum theory can be used to account for the fact that a minimum frequency of radiation is required to produce the photoelectric effect. (2)

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Question 27 (4 marks)

Although Einstein and Planck never had a direct debate regarding the nature of scientific research, both had views on "whether or not it is possible to remove scientific research from both political and social forces."

Debate this issue with specific reference to both social and political influences on scientific research. (4)

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Question 28 (5 marks)

(a) Describe an investigation you carried out to demonstrate the production and reception of radio waves. (3)

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(b) Identify some specific safe work practices that should be carried out during this investigation. (2)

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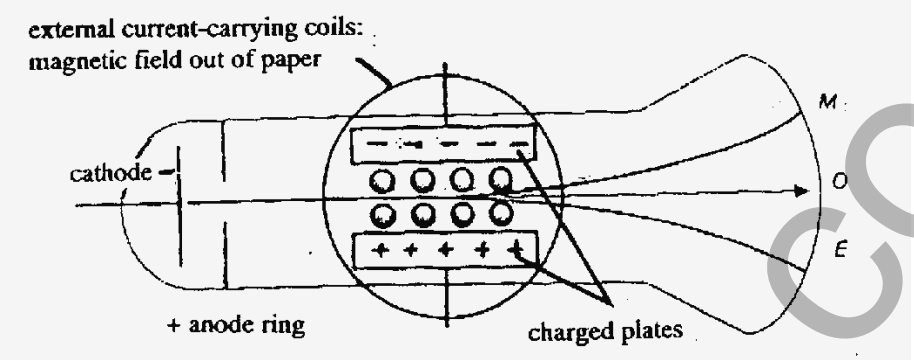
Question 29 (5 marks)

J. J. Thomson added significantly to the knowledge of cathode rays by his investigations into their charge to mass ratio. A simplified diagram of Thomson's cathode ray tube is shown below.



(a) Use your understanding of the behaviour of cathode rays in magnetic and electric fields to outline how Thomson measured the value of $\frac{q}{m}$. (The strength of the electric and magnetic fields are E and B respectively and the cathode ray moves with velocity v in a circular path of radius r) (3)

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(b) A television picture tube is a modern application of cathode rays moving in an evacuated glass container. Explain how the deflection of the cathode rays is achieved differently in a television compared with a cathode ray oscilloscope. (1)

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(c) Colour televisions have three electron guns. What does each gun do? (1)

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Section 2 Options - Medical Physics

This section is worth 10 marks

Answer all parts of this question in a writing booklet.

Show all relevant working in questions involving calculations.

(a) Define acoustic impedance. (1)

(b) The velocity of sound in the human kidney is 1560 ms^{-1}. If the kidney has a density of 1104 kg m^{-3}, calculate its acoustic impedance. (1)

(c) Before an ultrasound examination to examine the progress of an unborn child, the mother is advised not to urinate before the procedure. Explain the reasoning for this request. (2)

(d) Describe how medical X-rays are currently produced. (2)

(e) Describe one difference between “hard” and “soft” X-rays. (1)

(f) Compare the processes involved in computerised axial tomography (CAT or CT scans) with the production of a radiograph. (3)