STUDENT NUMBER: | | | | | |

PYMBLE LADIES' COLLEGE

2007

TRIAL EXAMINATION

Physics

General Instructions
- Reading time - 5 minutes
- Working time - 3 hours
- Write using black or blue pen
- Draw diagrams in pencil
- Board-approved calculators may be used
- A data sheet, formulae sheets and Periodic Table are provided
- Write your Student Number at the top of this page and other pages where indicated, including the multiple choice answer sheet

Total marks – 100

Section I
75 marks
This section has two parts, Part A and Part B

Part A – 15 marks
- Attempt Questions 1-15
- Allow about 30 minutes for this part

Part B – 60 marks
- Attempt Questions 16 – 26
- Allow about 1 hour and 45 minutes for this part

Section II
25 marks
- Attempt all sections of Question 27
- Allow about 45 minutes for this section

Section I
75 marks

Part A Multiple choice 15 marks
Attempt Questions 1–15.
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.

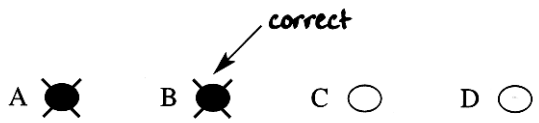
Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

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.

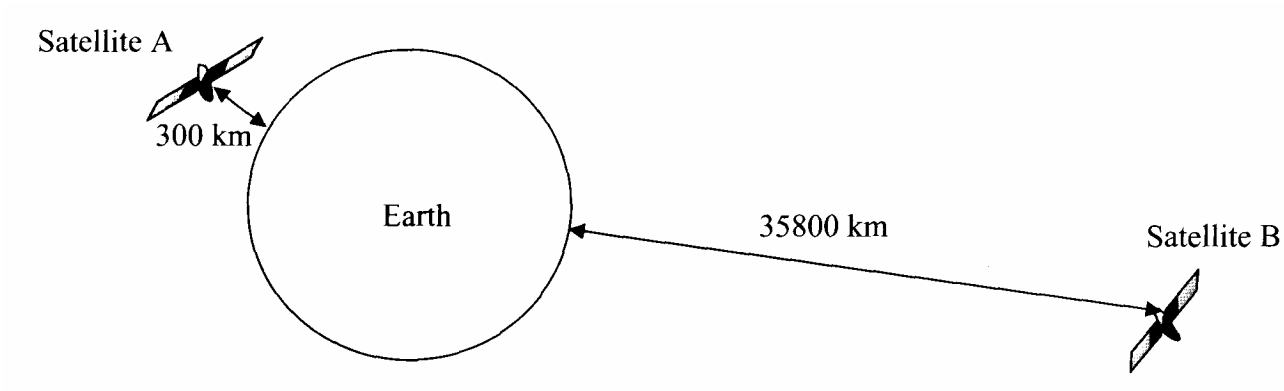
A ● B ⊗ C ○ D ○

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



Question 1

The diagram below shows two satellites (A and B) orbiting the Earth at different altitudes.



Which is the most correct statement?

(A) Satellite A will travel at a faster speed than Satellite B

(B) Satellite A is in a geostationary orbit

(C) The period of Satellite A is equal to the period of Satellite B

(D) The centripetal force on Satellite A is equal to the centripetal force on Satellite B

Question 2

A spacecraft of mass 5.0 x 10^3 kg is orbiting the Earth at a radius of 6.5 x 10^6 m.

What is the amount of additional energy that must be given to the spacecraft for it to completely escape the gravitational force of the Earth?

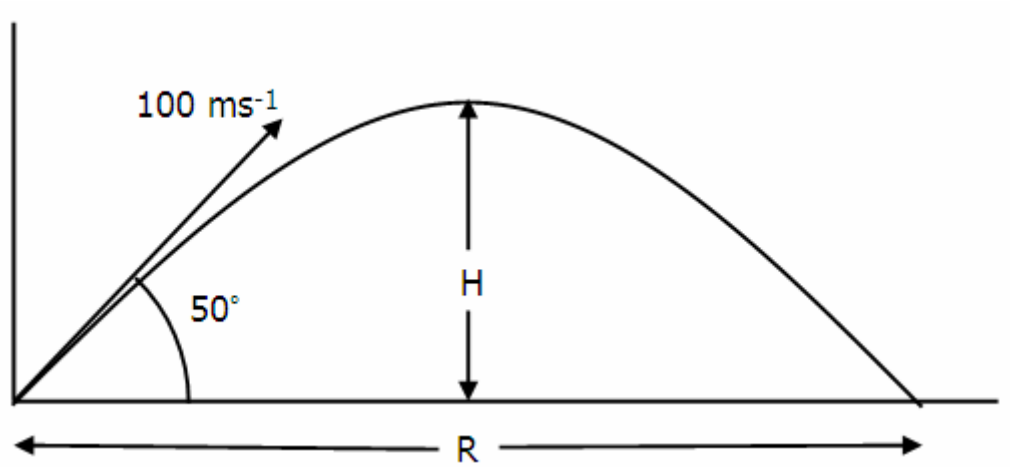
(A) 4.74 x 10^4 J

(B) - 4.74 x 10^4 J

(C) 3.08 x 10^{11} J

(D) - 3.08 x 10^{11} J

Question 3 and 4 refer to the diagram of a projectile's path, shown below:



Question 3

What time does it take for the projectile to reach its maximum height, H?

(A) 6.56 s

(B) 7.82 s

(C) 13.1 s

(D) 15.6 s

Question 4

What is the range, R, of the projectile?

(A) 502.7 m

(B) 782.0 m

(C) 1,004.9 m

(D) 1,560.0 m

Question 5

Before the Michelson-Morley experiment, the aether was proposed as the medium through which light travelled.

Which of the following was a property of the proposed ether?

The ether

(A) was partially transparent

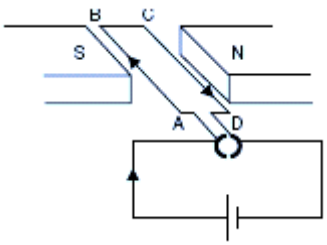
(B) had high elastic stiffness

(C) had high viscosity

(D) had lower density in matter than in free space

Question 6

A rectangular loop of wire carrying a current of 2.5 A is in a uniform magnetic field of 1.0 T.
AB = CD = 0.050 m, BC = 0.010 m



What is the torque when the coil is at 30^{o} to the field?

(A) 1.25×10^{-3} Nm

(B) 1.08×10^{-3} Nm

(C) 4.33×10^{-4} Nm

(D) 2.24×10^{-4} Nm

Question 7

Work must be done on an electric generator because:

(A) The generator induces a current which assists the motion

(B) Kinetic energy must be conserved

(C) Momentum must be conserved

(D) The generator induces a current which opposes the motion

Question 8

The figure below shows two parallel wires carrying currents.

A ⟶ 0.5 A

B ⟶ 10 A

Which statement about the forces between the wires is correct?

(A) repulsive, force on A greater than force on B

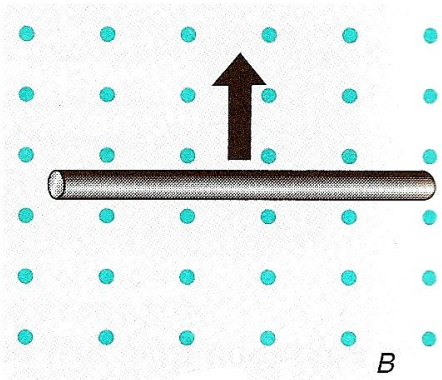
(B) repulsive, force on A and B equal

(C) attractive, force on A equal to that on B

(D) attractive, force on A smaller than that on B

Question 9

Determine the direction of the induced current in the conductor moving in the direction shown by the arrow.



(A) To the left

(B) To the right

(C) Out of the page

(D) Into the page

Question 10

Transmission towers are big and stand out in the landscape and so are vulnerable to lightning strikes. Which of the following is NOT a feature used to protect transmission towers from lightning strikes?

(A) step down transformers in towers

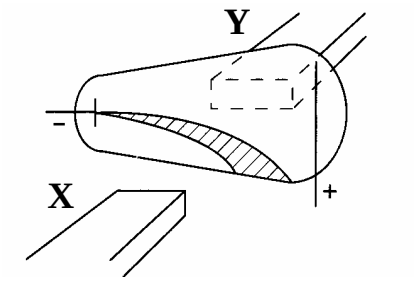
(B) ceramic insulating stacks

(C) metal towers

(D) distance between towers

Question 11

The diagram below shows cathode rays being deflected by two magnets of equal strength.



Which of the following statements about the poles of the magnets (X and Y) is correct?

(A) X and Y are both North poles

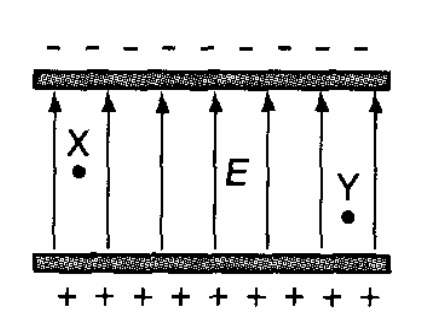
(B) X and Y are both South poles

(C) X is a North pole and Y is a South pole

(D) X is a South pole and Y is a North pole.

Question 12

The diagram below shows two negative point charges (X and Y) in an electric field between two parallel plates. The magnitude of the electric charges on X and Y are the same.



Which of the following statements is correct?

(A) The forces on X and Y are both in the upward direction

(B) The force on X is greater than the force on Y

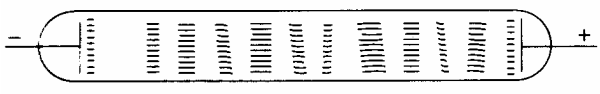
(C) The force on Y is greater than the force on X

(D) The forces on X and Y are equal

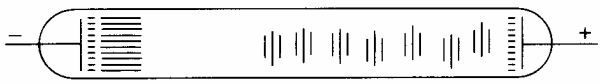
Question 13

The diagrams below show gas discharge tubes containing air at different pressures, when a constant high voltage is passed across their electrodes.

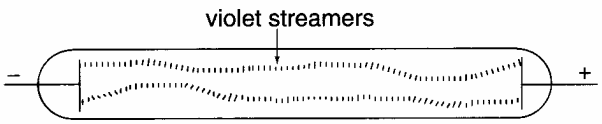
W



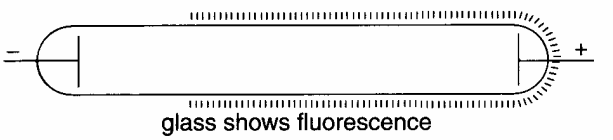
X



Y



Z



Which is the correct order of the tubes, from lowest pressure to highest?

(A) Z X W Y

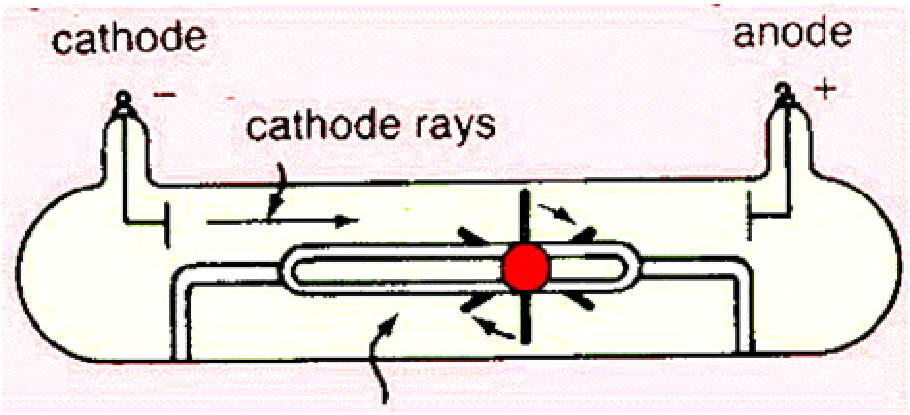
(B) X W Y Z

(C) Y X W Z

(D) Y W X Z

Question 14

The diagram below shows one of the experiments performed by Crookes when he was investigating the nature of cathode rays.



Which property of cathode rays can be deduced from this experiment?

Cathode rays

(A) are negatively charged

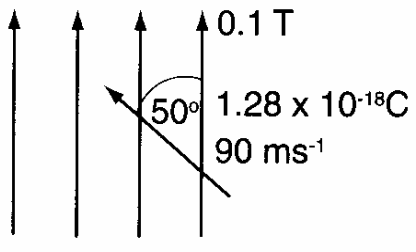
(B) have momentum

(C) travel in straight lines

(D) are deflected by electric fields

Question 15

The diagram below shows the path of a charged particle in a magnetic field of strength 0.1 T. The charge on the particle is $+1.28 \times 10^{-18}$ C and it is travelling at a speed of 90 ms^{-1}.



What is the force on the particle due to the magnetic field?

(A) 1.15×10^{-17} N into the page

(B) 8.82×10^{-18} N at an angle of 50° to the magnetic field

(C) 1.15×10^{-17} N at an angle of 50° to the magnetic field

(D) 8.82×10^{-18} N into the page

Section I (Continued)

Part B Extended Answers - 60 marks
Attempt Questions 16 – 26
Allow about 1 hour and 45 minutes for this part

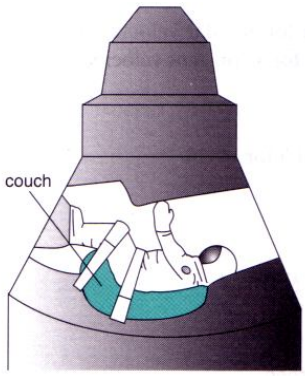
Answer the questions in the spaces provided.

Show all relevant working in questions involving calculations.

Question 16 (9 marks)

Marks

The diagram below shows a 70 kg astronaut during launch in a three stage spacecraft.



(a) Explain the term ‘g force’ in terms of the forces acting on an astronaut during launch. **2**

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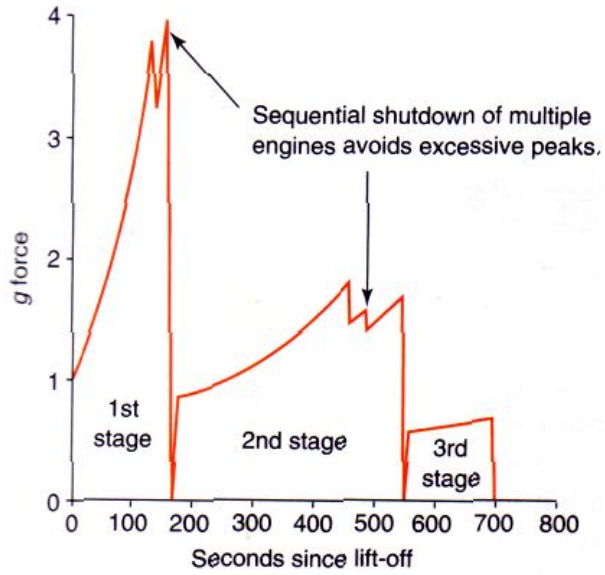
Question 16 continues

The graph below shows how the g-force experienced by the astronaut changed during the launch.



(b) Account for the pattern observed for g force shown by the graph between 0 and 100 s since lift-off. **3**

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Question 16 continues

The third stage rocket was shutdown after 700 s since lift-off. The altitude of the space craft is then 190 km.

(c) (i) Calculate the weight of the astronaut at this altitude. **2**

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(ii) Justify the assertion that the astronaut is 'weightless' at this point. **1**

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(d) Identify why g force is an important issue during re-entry of a spacecraft into the Earth's atmosphere. **1**

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End of Question 16

Question 17 (6 marks) **Marks**

Sometime in the distant future, a rocket may be launched to visit the solar system's nearest star, proxima Centauri. The distance to proxima Centauri is 4.2 light years. Assume that the rocket is able to travel at 0.7 c (0.7 of the speed of light).

(a) Compare quantitatively (calculate values) the time it would take the rocket to reach proxima Centauri as measured by observers on Earth and observers in the rocket. (Ignore any time required to accelerate the rocket after leaving Earth). **4**

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(b) Compare qualitatively (do not calculate values) the distance measured between Earth and proxima Centauri as measured by observers on Earth and observers on the rocket. Justify your answer. **2**

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Question 18 (5 marks)

(a) Outline the nature of inertial frames of reference. **2**

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(b) Discuss the role of Michelson and Morley's experiment, to measure the relative velocity of the Earth through the aether, in making determinations about competing theories that were proposed at the time. **3**

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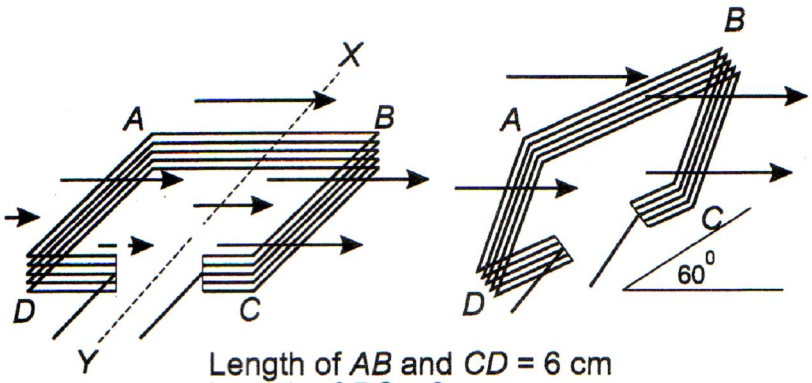
Question 19 (3 marks) **Marks**

A rectangular coil, 3 cm x 6 cm and consisting of 100 turns, is placed in a magnetic field of strength 0.15 T. Initially the coil lies in a plane parallel to the magnetic field. It is then rotated about the axis XY through an angle of 60^o as shown.



Length of *AB* and *CD* = 6 cm
Length of *BC* = 3 cm
Number of turns = 100

(a) Identify the initial magnetic flux through the coil. **1**

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(b) Calculate the final magnetic flux through the coil. **1**

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(c) Faraday's Law states that the induced emf is proportional to the rate of change of magnetic flux through the coil, that is $\varepsilon = -n\frac{\Delta\Phi}{\Delta t}$ (where n is the number of coils).
Calculate the induced emf if the coil is rotated through 60^o in 0.01s. **1**

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Question 20 (5 marks)

Assess the effects of the development of AC generators on society and the environment. **5**

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Question 21 (5 marks)

During your course, you performed a first-hand investigation to verify the effect on a generated current when the relative motion between a coil and a magnet is varied.

Outline the method you used and the results you obtained. Include a diagram to illustrate your answer. **5**

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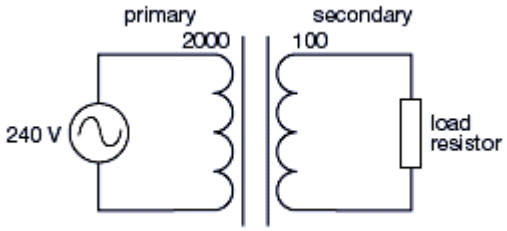
Question 22 (4 marks)

A transformer has 2000 turns in its primary coil and 100 turns in its secondary coil. Assume the transformer has 100% efficiency. The load resistance is 120 ohms.



(a) Calculate the output voltage when the input voltage is 240 V. **1**

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(b) Calculate the current that flows through the primary coil. **2**

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(c) Identify one reason why, in practice, the power output of the transformer is less than the power input. **1**

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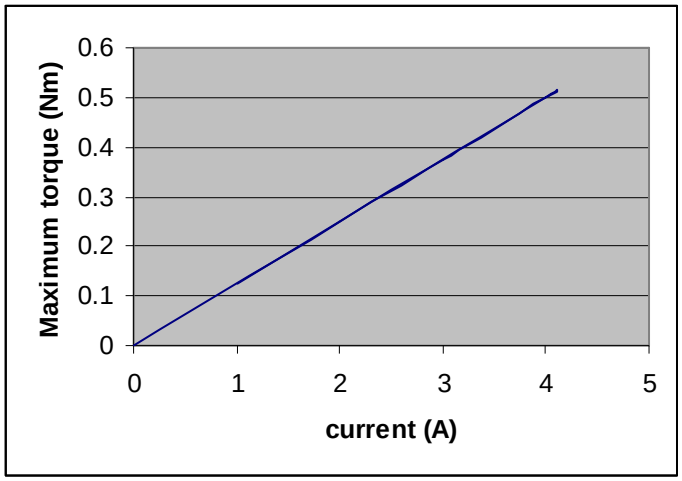
Question 23 (3 marks)

A square coil with 5 cm sides is placed in a uniform magnetic field of strength 0.05 T. The figure below shows how the maximum torque on the coil changes with the current through it.



(a) Predict the position of the coil relative to the magnetic field when the torque is at its maximum. **1**

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(b) Calculate the number of turns in the coil. **2**

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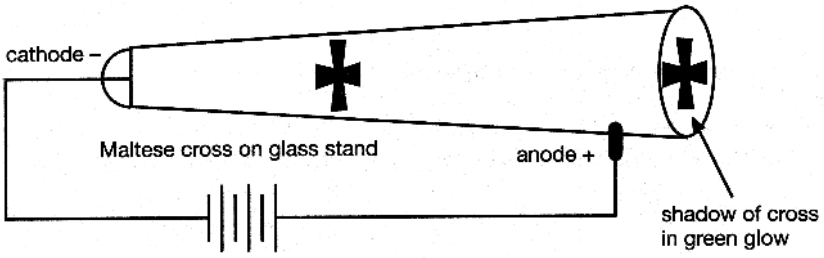
Question 24 (5 marks) **Marks**

The diagram below shows one of the experiments performed by Crookes when he was investigating the nature of cathode rays.



(a) Identify two pieces of information about cathode rays that can be gained from this experiment. **2**

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(b) When cathode rays were first investigated, there was a debate as to whether they were negatively charged particles or electromagnetic waves. Outline one experiment that was interpreted as showing that cathode rays were electromagnetic waves. Include a diagram to illustrate your answer. **3**

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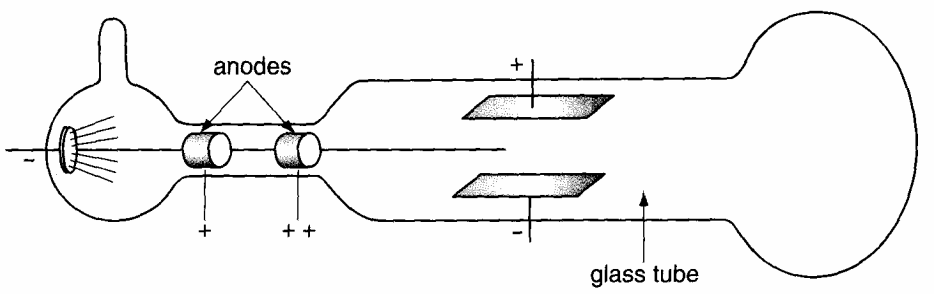
Question 25 (8 marks) **Marks**

The diagram below shows a cathode ray tube similar to that used by J.J. Thomson in his experiment to determine the charge to mass ratio of cathode rays (electrons).

Initially, the electron beam hit the centre of the front of the cathode ray tube.

Thomson then deflected the electron beam with an electric field produced between two horizontal, parallel plates with a voltage applied across them, as shown.



(a) On the diagram, draw

(i) the electric field produced between the parallel plates. **1**

(ii) the path followed by the electron beam. **1**

The plates are separated by a distance of 15 mm and the voltage across them is 550 V.

(b) Calculate the strength of the electric field between the plates. **2**

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(c) Calculate the force on each electron in the beam as a result of the electric field. **2**

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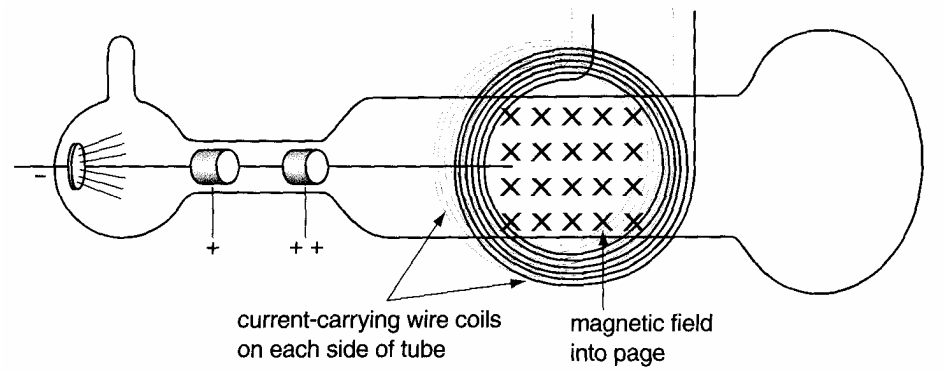
A magnetic field is now applied across the tube as shown below (with the same electric field still in place).



The strength of the magnetic field is adjusted until the electron beam again hits the centre of the front of the cathode ray tube.

The strength of the magnetic field is now 0.35 T.

(d) Calculate the speed of the electrons in the beam. **2**

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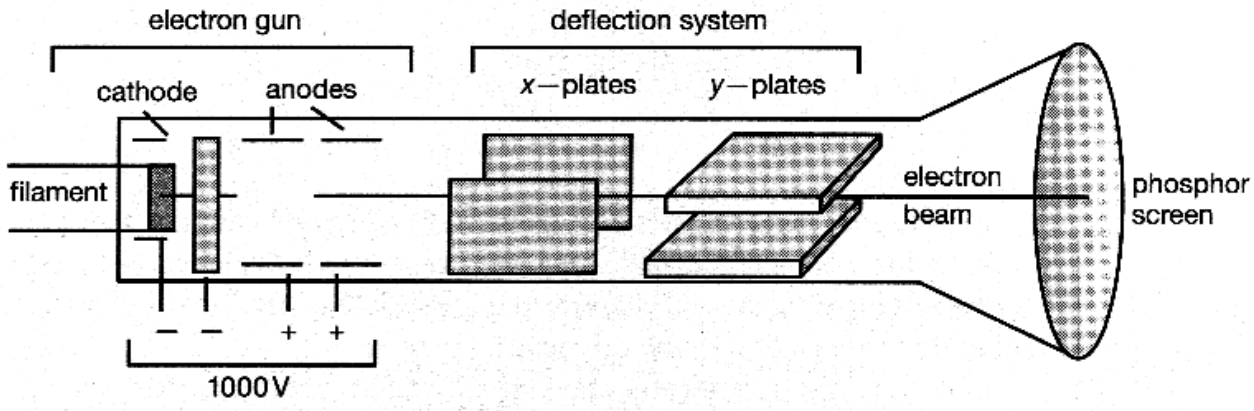
Question 26 (7 marks)

The diagram below shows the main components of a cathode ray oscilloscope.



(a) Outline the role of the electrodes in the electron gun. **3**

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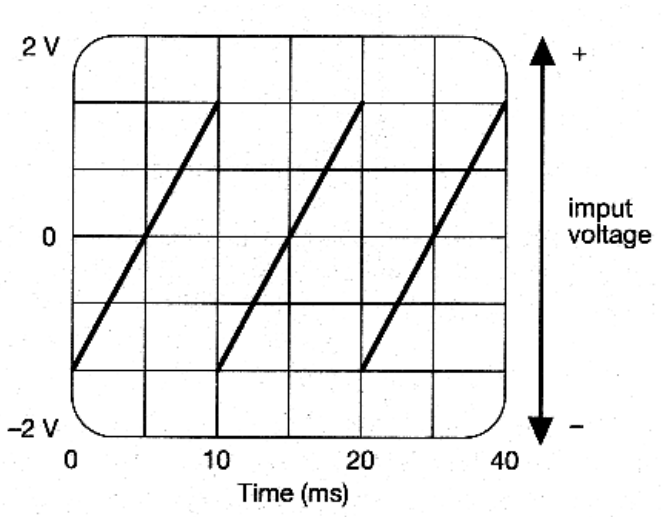
Question 26 continues

The graph below shows the voltage applied between the x-plates of the cathode ray oscilloscope shown above. (Assume that the voltage in the graph indicate the voltage of the front plate relative to the back plate in the diagram).



(b) Describe the path of the electron beam on the phosphor screen during the time shown on the graph. (Assume that the electron beam is in the centre of the phosphor screen before the varying voltage is applied.) **3**

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(c) Television sets typically use magnetic coils rather than electric plates to guide the path of the electron beam(s). Identify one advantage of magnetic coils compared with electric plates for television sets. **1**

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End of Question 26

Section II - From Quanta to Quarks (25 marks)

Answer Question 27 - Sections (a) – (h)

Allow about 45 minutes for this section

Answer the question on the writing paper provided. Extra writing paper is available.

Write your student number on every piece of writing paper.

Show all relevant working in questions involving calculations.

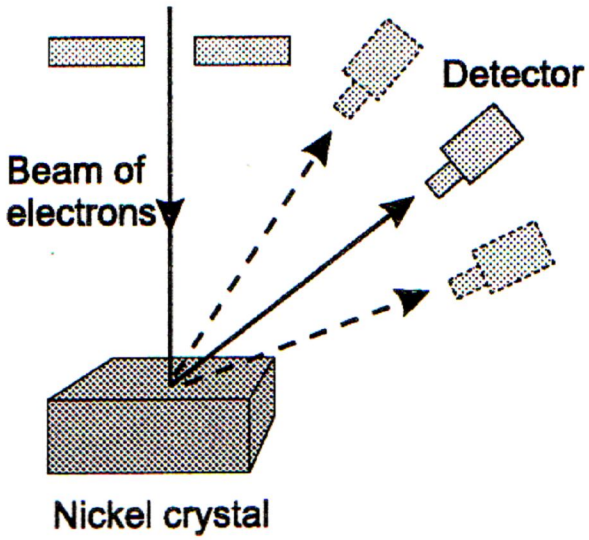
Marks

(a) A photon of visible light is emitted when an electron in hydrogen undergoes a transition from the fifth energy level to the second energy level.

(i) Calculate the frequency of the emitted photon. **2**

(ii) Calculate the photon's energy. **1**

(b) In a series of experiments in the early twentieth century, the Americans Davisson and Germer fired electrons at a nickel crystal as shown in the diagram below and detected the intensity pattern of the reflected electrons.



Identify two characteristics of the electrons that Davisson and Germer were able to deduce from this experiment. **2**

(c) Following is a quotation from a best selling HSC physics study guide!

> *In 1930 the Austrian physicist Wolfgang Pauli proposed the existence of a particle with properties unlike anything known at the time. It would be a particle with no electric charge, no mass, and no magnetic properties and would have almost no interaction with matter. It would, however, have energy, linear momentum and angular momentum (the momentum associated with a rotating body). As such, it was 'something' rather than 'nothing'!*

(i) Identify the particle to which this quote refers. **1**

(ii) Explain why Pauli proposed the existence of such a particle. **2**

(d) Consider the following nuclear reaction:

$$ {}^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + {}^{b}_{a}X + energy\ \ Q $$

(i) Calculate the numbers represented by *a* and *b* and hence deduce what particle is represented by *X*. **2**

(ii) Calculate the mass of *X* in (i) above, given the following data: **3**

mass ${}^{2}_{1}H$ = 3.3443 x 10^{-27} kg
mass ${}^{3}_{1}H$ = 5.0079 x 10^{-27} kg
mass ${}^{4}_{2}He$ = 6.6460 x 10^{-27} kg
energy Q = 2.82 x 10^{-12} J
speed of light = 3.0 x 10^{8} m.s^{-1}

(e) An important component of a nuclear fission reactor is the *moderator*.

(i) Describe the purpose of the moderator. **1**

(ii) Identify one possible material used as a moderator. **1**

(f) A significant problem associated with nuclear reactors is the disposal of the radioactive material they produce. One proposal currently under consideration to eliminate this waste is to irradiate it with neutrons. This would convert it into other non-radioactive isotopes. One major waste isotope is technetium-99, ${}^{99}_{43}Tc$. When irradiated with a neutron, technetium-99 is converted into technetium-100. This technetium-100 has a half-life of 15 s and decays into stable ruthenium-100, ${}^{100}_{44}Ru$.

(i) Write a nuclear equation showing the *production* of technetium-100. Indicate the nature of any particle involved in the reaction. **1**

(ii) Write a nuclear equation showing the *decay* of technetium-100. Indicate the nature of any particle involved in the reaction. **1**

(g) Neutron scattering is a powerful method for analysing the internal structure and properties of matter. Explain, by referring to two of their properties, why neutrons are useful for this purpose. **4**

(h) Discuss the key features and components of the standard model of matter. **4**

End of Question
End of Paper