Girraween High School

2017

HIGHER SCHOOL CERTIFICATE

TRIAL 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 Student Number at the top of the Part A Answer Sheet, the Part B Written Answer Booklet and the Section II Answer Booklet*

Total marks – 100

Section I

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 - 31**
- Allow about 1 hour and 40 minutes for this part

Section II

25 marks

- Attempt **Questions 32-34**
- Allow about 45 minutes for this section

Section I

75 Marks

Part A - 20 Marks

Attempt Questions 1-20 **Allow 35 minutes for this part**

Use the Part A Answer Sheet for questions 1-20

Instructions for answering questions in Section 1 Part A

- Complete your answers 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.

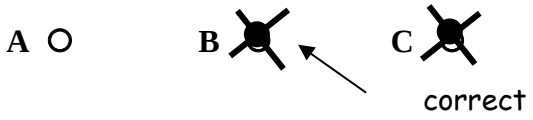
Sample 1: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

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.

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.



1. The relationship between the force experienced by a current carrying wire due to a magnetic field and the strength of that field is best described as which of the following?

   (A) The magnitude of the force is directly proportional to the strength of the magnetic field.

   (B) The magnitude of the force is inversely proportional to the strength of the magnetic field.

   (C) The magnitude of the force is directly proportional to the square of the strength of the magnetic field.

   (D) The magnitude of the force is inversely proportional to the square of the strength of the magnetic field.

2. Light emitted by a globe obeys the inverse square law. This means that if the distance from the globe is doubled, the light energy per unit area drops by a factor of four.

How does the particle model of light explain this?

(A) As they travel further from the globe, photons gradually lose energy in proportion to the radial distance from the globe.

(B) The same number of photons pass through the same fraction of the surface area of a sphere at all radial distances but the actual area through which they pass decreases with the square of the radial distance.

(C) The same number of photons pass through the same fraction of the surface area of a sphere at all radial distances but the actual area through which they pass increases with the square of the radial distance.

(D) As they travel further from the globe, photons gradually lose energy in proportion to the square of the radial distance from the globe.

3. In a motor, as the supply voltage is increased the rotation speed increases. Which of the following options correctly describes the impact upon the magnitude of the current in the coil due to increasing the supply voltage?

(A) The current will increase due to the decrease of the back EMF.

(B) The current will increase due to the increase of the back EMF.

(C) The current will decrease due to the decrease of the back EMF.

(D) The current will decrease due to the increase of the back EMF.

4. A special vehicle bound for Mars is loaded aboard a capsule on a spacecraft with a powerful rocket motor and launched.

The vehicle, capsule and spacecraft have a total weight of 2.45×10^3 N at rest on the ground on Earth. The initial acceleration of the craft as it lifts from the ground is 28.4 ms^{-2}.

What is the force applied onto the vehicle by its mountings in the spacecraft at that time during the launch?

(A) 4.65×10^3 N

(B) 7.10×10^3 N

(C) 9.35×10^3 N

(D) 9.55×10^3 N

5. Silicon is doped with boron to produce a sample of p-type semiconductor.

Which one of the following statements about the p-type semiconductor is correct?

(A) It has more protons than electrons.

(B) It has more protons than a sample of pure silicon.

(C) It has fewer protons than a sample of pure silicon.

(D) It has the same number of protons as a sample of pure silicon.

6. Why did solid-state electronic devices replace thermionic devices?

(A) Solid-state electronic devices are bigger and easier to construct.

(B) Solid-state electronic devices can operate at low voltages, last longer and are not as fragile.

(C) Thermionic devices can only operate at very low voltages.

(D) Thermionic devices cannot modify or switch electrical signals.

7. Both motors and generators exploit the rotation of a coil in a magnetic field. In all cases, the current in the coil is always

(A) moving clockwise around the coil loops.

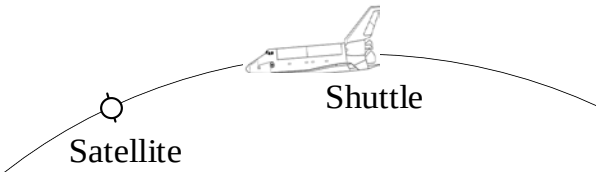
(B) moving counterclockwise around the coil loops.

(C) alternating its direction every ½ turn.

(D) stationary.

8. A space shuttle has entered the orbit of a satellite in need of repair, but it is 200 m behind the satellite, too risky for the astronauts to attempt a 'space-walk' to carry out the task.

Firing the retro-rocket exerts a force on the shuttle to the right in the frame of reference of the page, whereas firing the booster-rocket exerts a force to the left.



In order to approach the satellite more precisely, which of the following manoeuvres would produce the desired result?

(A) Fire the booster-rocket to approach the target, then the retro-rocket to slow down when close enough.

(B) Fire the booster-rocket to enter a higher, faster orbit, and when close enough fire the retro-rocket to drop back to the original orbit.

(C) Fire the retro-rocket to enter a lower, faster orbit, and when close enough fire the booster-rocket to rise back to the original orbit.

(D) Fire the booster-rocket to enter a lower, faster orbit, and when close enough fire the retro-rocket to rise back to the original orbit.

9. X-rays are useful for investigating crystal structure because

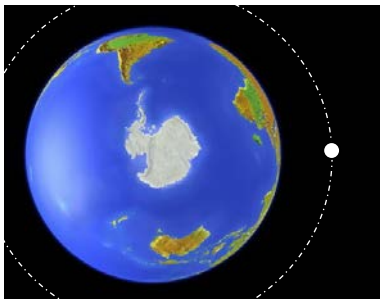
(A) their wavelength is similar in size to the gaps between atoms in a crystal lattice.

(B) their frequency is close to the resonant frequency of the crystal lattice.

(C) they carry enough energy to break the crystal into its component parts for analysis.

(D) they are absorbed by some atoms but can pass through others, generating an image.

10. Earth's equatorial radius is 6380 km.



What is the defined gravitational potential energy of a 500 kg satellite placed in a circular orbit around the Earth at an altitude of 970 km?

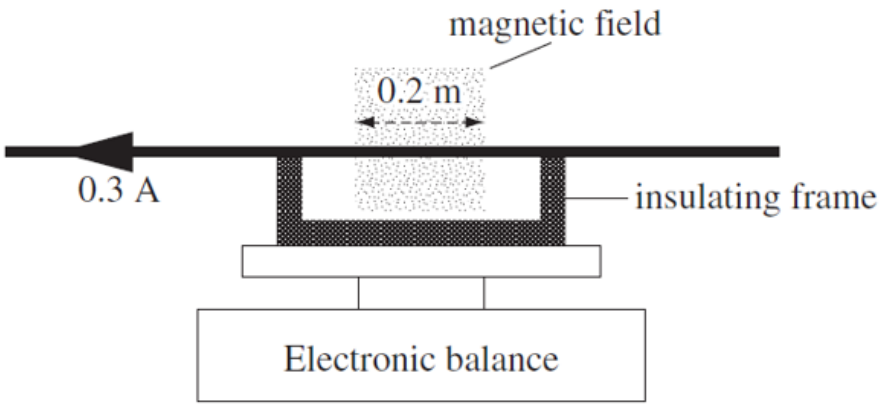
(A) 3.13×10^{13} joules

(B) -2.72×10^{10} joules

(C) 4.75×10^{9} joules

(D) -3.69×10^{9} joules

11. A copper rod is placed on a wooden frame, which is placed on an electronic balance. A length of 0.2 m of the rod passes at right angles to a horizontal magnetic field as shown below.



When a current of 0.3 A is passed through the rod, the reading on the balance increases by 7.5×10^{-4} kg.

What is the strength and direction of the magnetic field?

(A) 0.0125 T into the page

(B) 0.0125 T out of the page

(C) 0.123 T into the page

(D) 0.123 T out of the page

12. According to the BCS theory, superconductivity occurs in certain substances below a critical temperature because

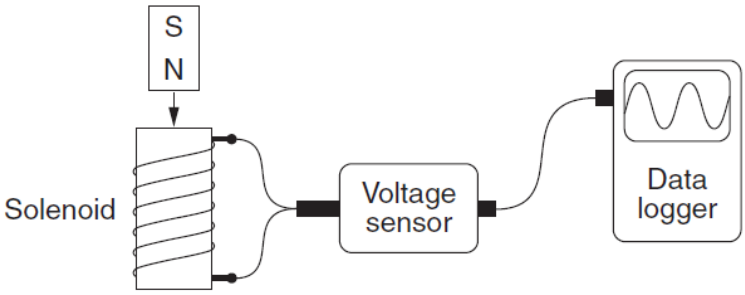
(A) pairs of electrons can move through a cold lattice without any collisions with the lattice phonons and experience no electrical resistance.

(B) electrons can exploit quantum tunnelling and avoid lattice ions, thus having no collisions and hence no electrical resistance.

(C) Cooper pairs and phonons interact in such a way that the electrons move through the lattice without electrical resistance.

(D) Cooper pairs move through the uniform unmoving lattice without electrical resistance.

13. A magnet is moved relative to a solenoid and the output voltage is displayed on a data logger screen as shown.



What type of motion by the magnet produces this output?

(A) The magnet moves vertically down at a constant speed.

(B) The magnet falls vertically down.

(C) The magnet's motion is alternating between up and down at random.

(D) The magnet's motion is alternating between up and down regularly.

14. Germanium is now rarely used in the manufacture of transistors.

Which of the following gives a reason for this?

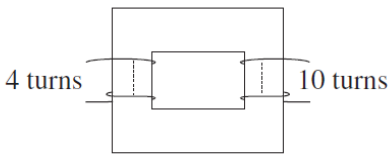
(A) Germanium is very rare and expensive and silicon is cheap.

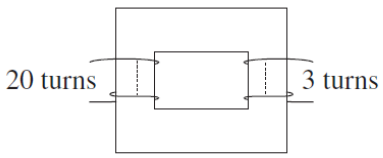
(B) Germanium cannot be purified to a suitable level and has poor thermal characteristics.

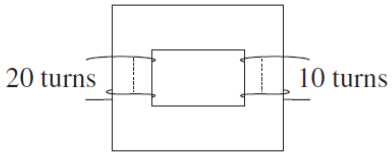
(C) Silicon is cheaper, easier to produce and has better thermal characteristics.

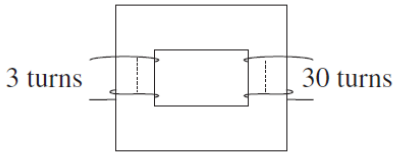
(D) Silicon is more abundant and even though not easy to produce has better thermal characteristics.

15. Which of the following ideal transformers could be used to convert an input current of 0.2 amps AC to an output current of 2.0 amps AC?

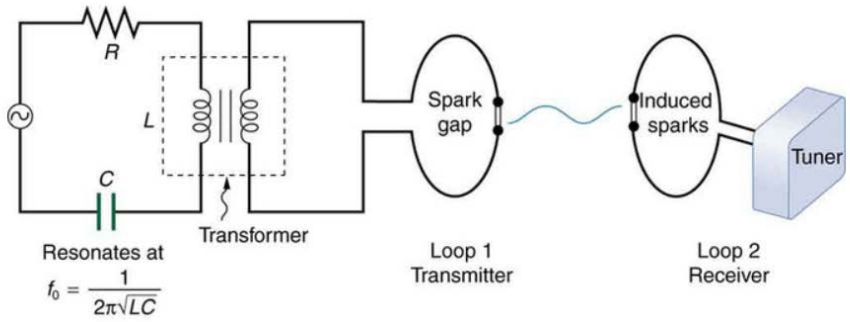
(A)


(B)


(C)


(D)


16. In 1887 Hertz discovered radio waves while researching Maxwell's prediction of the existence of electromagnetic waves. The type of apparatus he used is shown.



How did he identify that the waves he produced were electromagnetic?

(A) The observation that a spark was induced in the second loop (coil). To make sparks a voltage has to be induced and there was no other source of a voltage except for the waves he had produced.

(B) By using interference to determine the wavelength and then combining that with the frequency used in the primary coil via $v = f\lambda$ and showing that the wave speed was close to Maxwell's calculated velocity for electromagnetic waves.

(C) He found the speed of the waves by measuring the distance between the two spark gaps and timing how long it took for the second spark to appear. Dividing distance by time gave the speed, which he then compared to Maxwell's prediction.

(D) Hertz found that the waves he produced could be reflected by metals, yet pass straight through non-metals, and hence he identified the waves as being electromagnetic.

17. What is the energy of a photon of electromagnetic radiation of wavelength 650 nm in units of eV?

(A) 650×10^{-9}

(B) 1.602×10^{-19}

(C) 1.91×10^{-9}

(D) 1.91

18. Planck's concept of quantisation of thermal radiation was adapted by Einstein to apply to light. The problems being solved by each scientist were

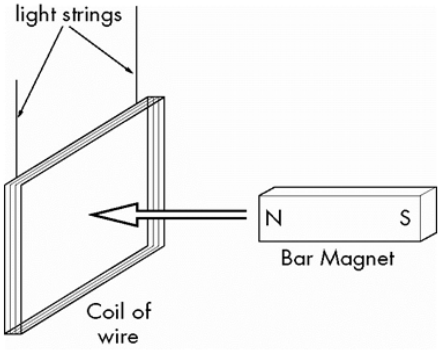
(A) Both scientists worked on different aspects of the black body radiation problem.

(B) Both scientists worked on different aspects of the photoelectric effect.

(C) Einstein solved the black body radiation problem while Planck explained the photoelectric effect.

(D) Einstein explained the photoelectric effect while Planck solved the black body radiation problem.

19. A permanent magnet is moved rapidly towards a coil of wire suspended from lightweight strings as shown below. The wires from each end of the suspended coil are connected together.



What will happen to the coil when the magnet is moved towards it?

(A) A current will be induced in the coil in a clockwise direction and the coil will be repelled by the approaching magnet.

(B) A current will be induced in the coil in a clockwise direction and the coil will be attracted by the approaching magnet.

(C) A current will be induced in the coil in an anticlockwise direction and the coil will be repelled by the approaching magnet.

(D) A current will be induced in the coil in an anticlockwise direction and the coil will be attracted by the approaching magnet.

20. Two particles of the same net charge but different masses are observed to be moving in a magnetic field. Which of the following statements is correct?

(A) They experience the same forces and therefore their accelerations are the same and their motion is identical.

(B) They experience different forces and therefore their accelerations are the same and their motion is identical.

(C) They experience the same forces and therefore their accelerations are not the same and their motion is not identical.

(D) They experience different forces and therefore their accelerations are not the same and their motion is not identical.

End of Part A

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Girraween High School

2017

HIGHER SCHOOL CERTIFICATE

TRIAL EXAMINATION

PHYSICS

PART A ANSWER SHEET

Write your Student Number at the top of this 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 ○
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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 ○

Student Number	

Write your Student Number at the top of this Part B Answer Booklet.

Section I (continued)

Part B – 55 marks

Attempt Questions 21 - 31

Allow about 1 hour and 40 minutes for this part

Answer the questions in the spaces provided

Question 21 (2 marks)

An electric generator has a coil with 5 turns and when rotated through 10 revolutions in 1 second produces an EMF of 2.5 V. Determine the maximum magnetic flux threading through the coil as it rotates.

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Question 22 (2 marks)

A motor has a coil comprising 500 turns with a diameter of 0.15 m and an area of 0.01 m^2. The coil rotates in a magnetic field of 0.75 T.

If this motor is to exert a force of 2.2 N, what current must be running through it?

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Question 23 (7 marks)

Early observations of the behaviour of cathode rays led to the discovery of their nature and to the advances in models of the structure of the atom.

(a) Describe the observations made that led to the determination of the sign of the charge on cathode ray particles. (2 marks)

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(b) Cathode ray observations were the same regardless of the metal used for the cathode.

What inferences were made from these particular observations? (2 marks)

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(c) With the aid of a labelled diagram, explain how Thomson used electric and magnetic fields to cancel any deflection of a cathode ray. (3 marks)

Question 24 (8 Marks)

The Earth and the Moon are often called a 'double planetary system'.
The Moon's mass is 7.35×10^{22} kg and its equatorial radius is 1 738 km.
The moon's average distance away from Earth is 384 400 km and its rotational period around Earth is 27.322 days.

(a) Sketch the gravitational field between the Earth and the Moon. (2 marks)





[Sizes and distance not to scale]

(b) Explain the shape of the gravity field between the Earth and the Moon. (2 marks)

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(c) Calculate the Moon's orbital velocity around the Earth. (2 marks)

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(d) The Moon revolves around the Earth – but does the Earth also revolve around the Moon? Justify your answer. (2 marks)

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Question 25 (5 marks)

Using the law of conservation of energy in your response, compare an ideal transformer with a real transformer. Discuss the sources of energy loss in real transformers and how these losses can be minimised.

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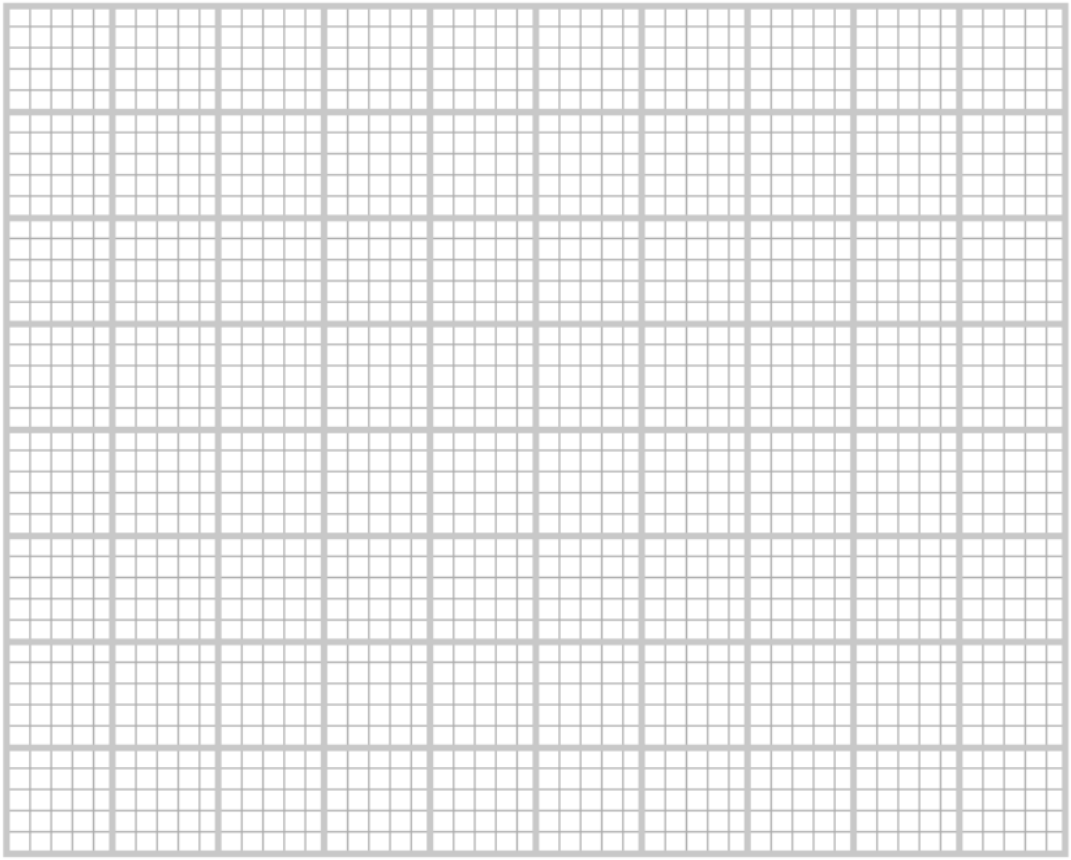
Question 26 (9 marks)

A student carried out an experiment on the photoelectric effect. The frequency of incident radiation and the energy of the photoelectrons were both determined from measurements taken during the experiment.

The results are shown below in the table.

Frequency of incident radiation ($\times 10^{14}$ Hz)	Energy of photons ($\times 10^{-19}$ J)
7.0	1.22
8.3	1.90
9.0	2.70
10.0	3.00
10.7	3.32
12.5	3.85

(a) Plot a graph of this data on the following grid. (3 marks)



Question 26 *Continued*

(b) Using the graph, determine the threshold frequency of the cathode metal. (1 mark)

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(c) Determine the work function of the metal in units of eV. (2 marks)

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(d) Determine the stopping voltage needed to stop the photocurrent if the incident photons have a wavelength of 420 nm. (3 marks)

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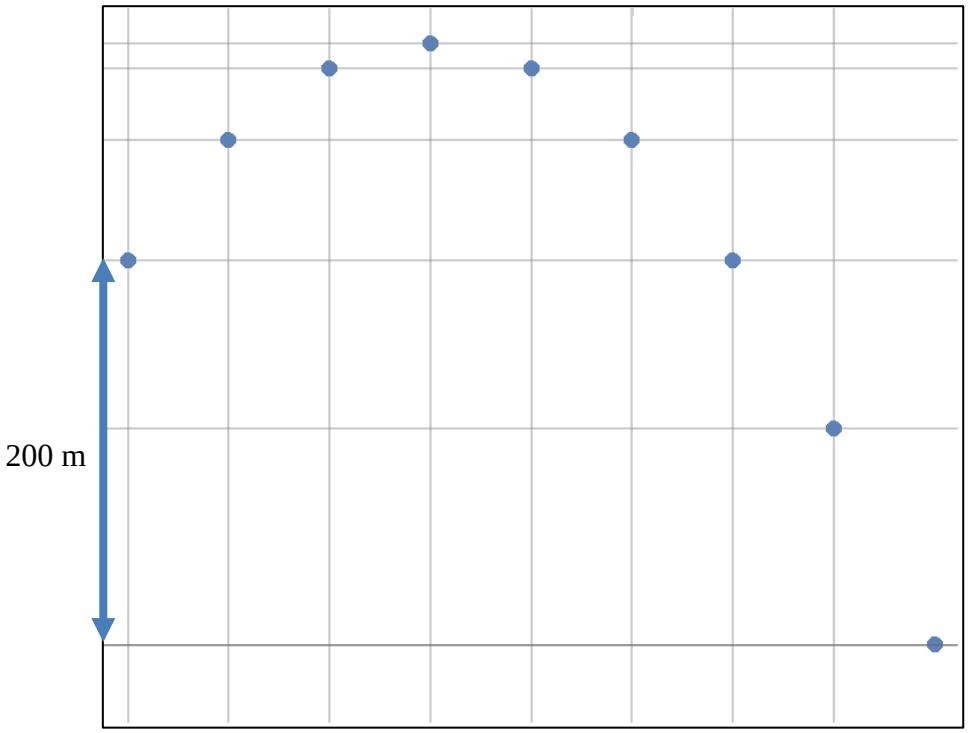
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Question 27 (6 marks)

The diagram below depicts the path of a projectile fired on Earth from a platform with an altitude of 200 m.

The dots are the positions of the projectile at equal time intervals.



(a) Justify the ratio of the distances on the diagram between the dots in the horizontal direction. (2 marks)

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(b) Predict the ratio of the vertical displacements during the first three seconds of the downward part of the journey.
That is: displacement in the first second:displacement in the second second:displacement in the third second. (2 marks)

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Question 27 *Continued*

(c) If the projectile is launched with a horizontal velocity of 30 m/s at an angle of 30° how long does it take for it to strike the ground, 200 m below? (2 marks)

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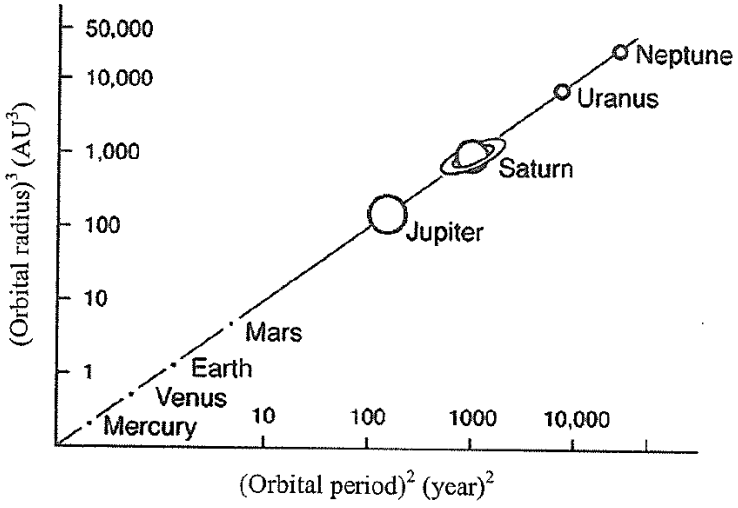
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Question 28 (3 marks)

The graph shows the relationship between the cubes of the orbital radius of the planets around the sun and the squares of their orbital periods.

Identify the law of physics illustrated by the graph and show how the relationship between orbital radius and orbital periods is predicted by Newton's law of gravitation.



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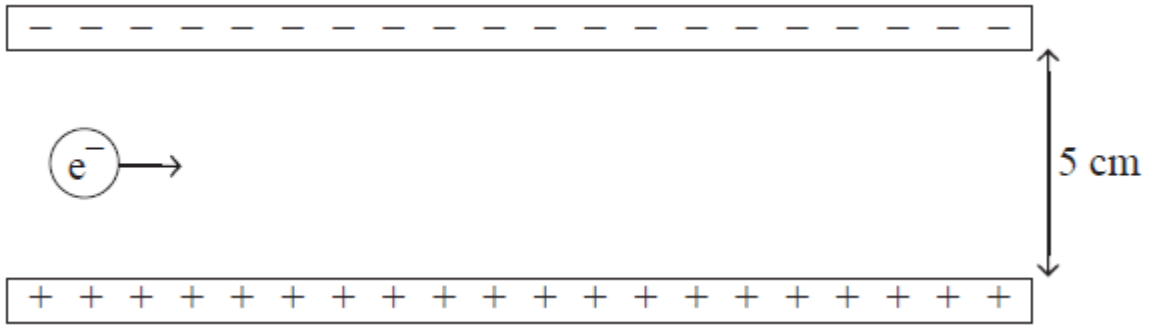
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Question 29 (4 marks)

An electron travelling in a vacuum tube moves into a region between two charged parallel plates 5 cm apart, with a potential difference of 2000 V between them, as shown in the diagram below.



(a) Calculate the strength of the electric field between the plates. (1 mark)

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(b) Calculate the size of the force on the electron due to the plates, and state its direction. (2 marks)

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(c) The same size and direction of force on the electron can be provided by replacing the charged plates with a magnetic field.

In the space below, use standard notation to show the DIRECTION of the magnetic field required. (1 mark)

Question 30 (3 marks)

The following image depicts a type of building that can be found in many suburban locations.



What is inside this building, what function does it have and what role does it play in the distribution of electrical energy?

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Question 31 (6 marks)

As part of your studies you modelled a simple transformer and demonstrated how a secondary voltage is produced.

Describe the investigation you conducted. In your answer include the equipment used, an illustration of the apparatus, the actions performed, the kind of results that were obtained and your interpretation of those results.

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End of Section I

Examiner's Use Only		

Student Number	
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Girraween High School

2017 HSC Physics Trial Examination

Write your Student Number at the top of this Section II Answer Booklet

SECTION II

Allow about 45 minutes for this part

Show all relevant working in questions involving calculations

Questions 32 – 34 **Medical Physics (25 marks)**

Question 32 (9 marks)

Ultrasound can be used as a diagnostic tool.

The table shows the density and the speed of sound in different parts of the body.

Body part	Density of body part ($kg/m^3 \times 1000$)	Speed of sound wave (m/s)
muscle	1.06	1570
fat	0.93	1480
blood	1.00	1560
liver	1.07	1549
brain	1.04	1521
kidney	1.04	1561

(a) Discuss the usefulness of ultrasound to examine the blood/brain boundary. (3 marks)

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Question 32 *Continued*

(b) Ultrasound is defined as sounds of frequency greater than 20 kHz. Explain why medical ultrasound machines use frequencies in the MHz range. (2 marks)

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(c) Compare A scans to B scans in ultrasound imaging. (4 marks)

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Question 33 (9 marks)

Radioactivity is used as a diagnostic tool.

(a) Describe how radioactive isotopes may be metabolised by the body to bind or accumulate in the target organ. (3 marks)

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(b) Describe how PET is used in diagnosis. (3 marks)

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Question 33 *Continued*

(c) Discuss issues associated with the choice of radioisotopes used in nuclear medical diagnosis. (3 marks)

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Question 34 (7 marks)

(a) Describe how proton spin can be exploited so that a detectable signal is given off during a MRI procedure. (3 marks)

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(b) Explain what is meant by the term “T1 relaxation time” as applied to MRI procedures. (2 marks)

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Question 34 *Continued*

(c) MRI scans result in three-dimensional data sets. Outline how each volume element (voxel) in the data set is assigned its value. (2 marks)

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End of Section II