GIRRAWEEN HIGH SCHOOL
2015
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

Total marks – 100

Section I **Pages 4 – 21**

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 - 36**
- Allow about 1 hour and 40 minutes for this part

Section II **Pages 22 – 25**

25 marks

- Attempt **Question 37**
- Allow about 45 minutes for this section

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.

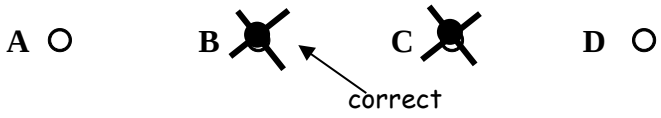
Sample 1: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

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.



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 Which is the best description of Newton's thought experiment explaining the principle of escape velocity?

(A) All cannon balls fall at the same rate no matter what their composition.

(B) A cannon ball fired vertically upwards can achieve a circular orbit of the Earth.

(C) A cannon ball fired horizontally from a high mountain can achieve a circular orbit of the Earth if fired fast enough.

(D) A cannon ball fired horizontally from a high mountain can achieve a trajectory which is unbounded to the Earth if fired with sufficient velocity.

2 What is the weight of a 24 kg mass on Mars, where the local acceleration due to gravity is equal to 3.5 ms^{-2}?

(A) 6.86 N

(B) 24 N

(C) 84 N

(D) 235.2 N

3 Which statement below was *not* one of Einstein's findings in the theory of Special Relativity?

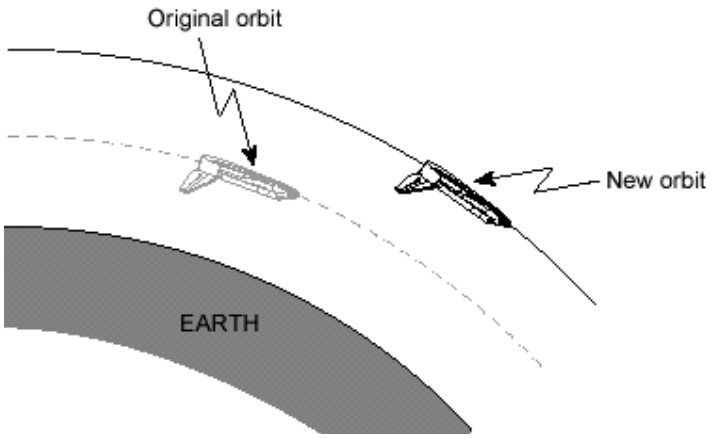
(A) The aether is unnecessary to explain the propagation of light through space

(B) The speed of light in a vacuum is constant

(C) The photoelectric effect can be explained in terms of the quanatisation of light energy

(D) Measurements of distance and time can't be agreed on by any two observers

4



A space shuttle is placed in a circular orbit around the Earth. It then thrusts its engine and moves to a new orbit, as shown above. Which statement is true about the shuttle's speed in this new higher orbit, if the new orbit is also circular?

(A) The speed will have to be greater than in the lower orbit

(B) The speed will have to be less than in the lower orbit

(C) The speed will have to be the same as in the lower orbit

(D) The speed will have to increase continuously in the new orbit

5 A radioactive particle used in a linear accelerator. Measured at rest relative to the laboratory it has a half life of 2.5 μs. When measured at constant speed by an observer in the laboratory, its half life has increased to 10 μs.

What is the speed of the particle relative to the laboratory?

(A) $\mathbf{1.68 \times 10^{8}\ ms^{-1}}$

(B) $\mathbf{2.90 \times 10^{8}\ ms^{-1}}$

(C) $\mathbf{290\ 000\ 000\ ms^{-1}}$

(D) $\mathbf{2.60 \times 10^{8}\ ms^{-1}}$

6 There are a number of reasons which contribute to variations in the value of the local acceleration due to gravity at specific locations on the surface of the Earth.

Which of the following pairs of reasons would **not** be responsible for such variations?

(A) Crustal variations and the shape of the Earth.

(B) The shape of the Earth and the height above sea level.

(C) Height above sea level and the Earth's rotation.

(D) Crustal variations and the Earth's orbit around the Sun.

7. The effect on the magnitude of the force on a current-carrying wire in a magnetic field due to the angle between the direction of current flow and the orientation of the magnetic field is best described by which of the following?

(A) The magnitude of the force varies exponentially with the angle.

(B) The magnitude of the force varies proportionally with the angle.

(C) The magnitude of the force varies proportionally with the sine of the angle.

(D) The magnitude of the force is independent of the angle.

8. Choose the option which most correctly states how torque is defined.

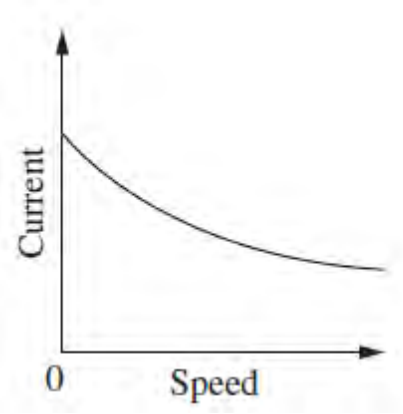
(A) The torque is the twisting force applied to an object.

(B) The torque is the turning force applied to an object.

(C) The torque is any force applied to a oject that can rotate.

(D) The torque is the turning moment of a force.

9. The graph below depicts the variation in current in the coil of a DC electric motor as a function of the rotation speed of the coil.



Choose the option that best explains this behaviour.

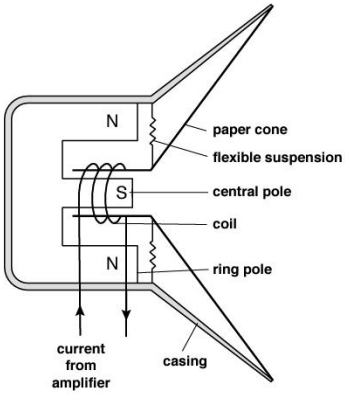
(A) As the speed of the motor increases the energy begins to run out.

(B) As the speed of the motor increases the back emf induced in the coil increases.

(C) As the speed of the motor increases the resistance of the coil increases.

(D) As the speed of the motor increases the effect of the magnetic field decreases.

10. The image below depicts a loudspeaker.



Identify the physics principle that is exploited by this device:

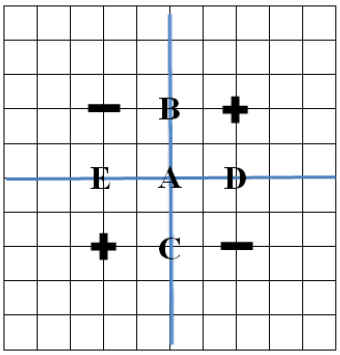
(A) The law of conservation of matter.

(B) The motor effect.

(C) Electromagnetic induction.

(D) The photoelectric effect.

11. The image below depicts four point charges. The magnitude of the charge on each is identical and their signs are as indicated.



The position at which the electric field strength will be zero will be:

(A) A.

(B) B.

(C) C.

(D) D.

12. An AC induction motor is compared to a DC motor. Both motors are operating without a load on them. When the supply voltage is increased, the effect on the motors will be:

	Effect on AC induction motor	**Effect on DC motor**
(A)	no effect	no effect
(B)	speeds up	no effect
(C)	no effect	speeds up
(D)	speeds up	speeds up

13. The laminated core of a transformer is arranged so that:

(A) eddy currents are prevented from forming.

(B) eddy currents are minimised.

(C) eddy currents are changed to assist the production of the secondary current.

(D) no magnetic field is lost to the surrounding area.

14. Which statement best describes a reliable investigation?

(A) The method allows for a fair test.

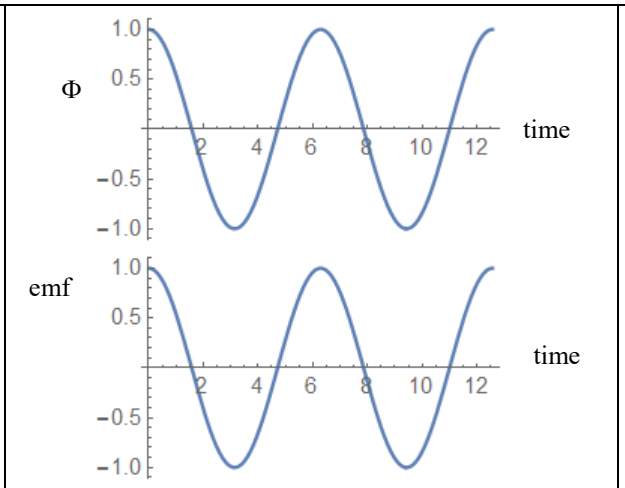
(B) Repetition of the method will produce consistent results with each iteration.

(C) The method allows for the results to be accurate.

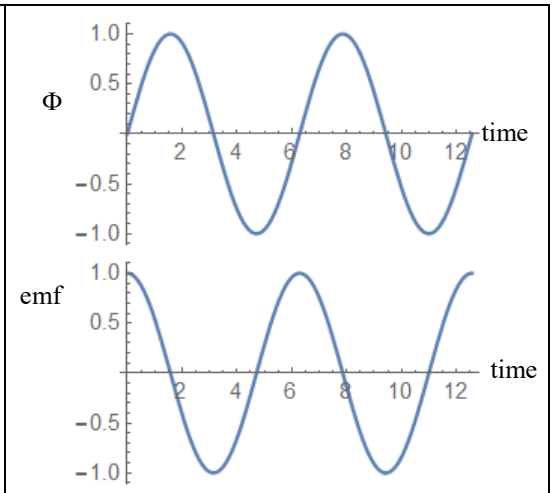
(D) The hypothesis will be supported.

15. Which of the following pairs of graphs correctly shows the relationship bvetween the magnetic flux through a coil in a generator and the induced voltage in the coil?

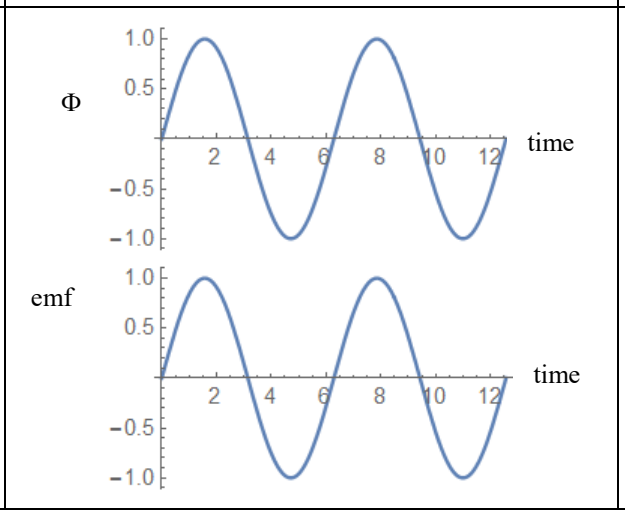
(A)



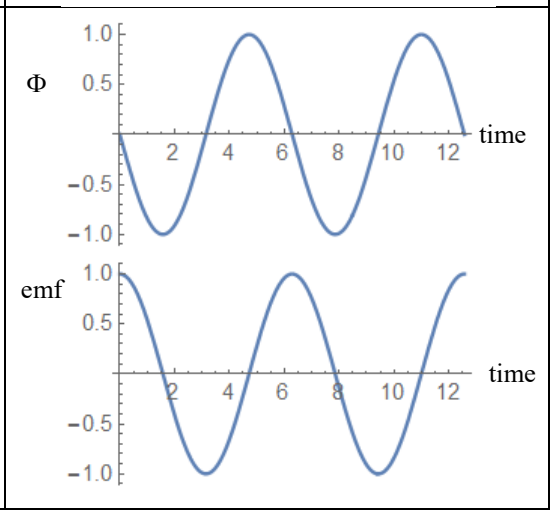
(C)



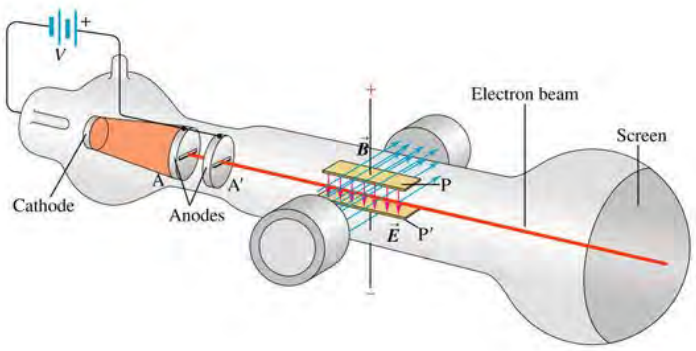
(B)



(D)



16. Thompson's experiment is illustrated below.



Which option gives a valid algeraic expression for the velocity of the cathode ray particles?

(A) $v = \dfrac{E}{B}$

(B) $v = BE$

(C) $B = vE$

(D) $v^2 B = E$

17. If the value of Planck's constant, h, was higher than it is, the effect on a photo-electric effect experiment would be:

(A) the threshold frequency, f_o would be lower for all metals.

(B) the energy of incident photons would be less.

(C) the threshold frequency, f_o would be greater for all metals.

(D) the photoelectric current would be greater.

18. Hertz's measurement of the speed of radio waves was not performed by directly measuring their speed. The feature of radio waves that Hertz actually measured to find their speed was:

(A) frequency

(B) amplitude

(C) period

(D) wavelength

19. Which analogy best describes electron arrangement in an n-type semiconductor?

(A) A bus with a few empty seats takes on another passenger.

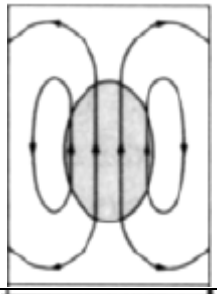
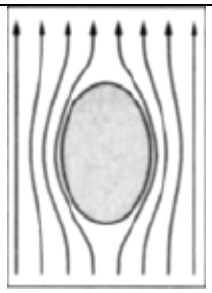
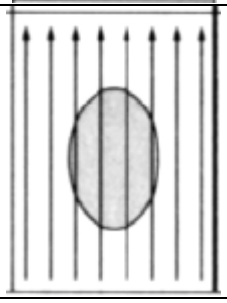
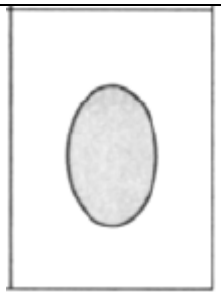
(B) A bus with no empty seats takes on another passenger.

(C) A bus with no passengers.

(D) A bus with so many passengers that there is no standing room left.

20. A superconducting material experiences a magnetic field.

Which of the following images shows what happens to the magnetic flux within the superconductor (shaded) at temperatures below the superconductor's critical temperature?

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

Name ……..

Class/Teacher: . . . . . .

GIRRAWEEN HIGH SCHOOL

PHYSICS

2015

TRIAL HSC EXAMINATION

Part A Answer Sheet

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

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** ⬭

2015 Trial Higher School Certificate

Physics

Section I (Continued)

Part B – 55 Marks

Attempt Questions 21 – 36

Allow about 1 hour and 40 minutes for this part.

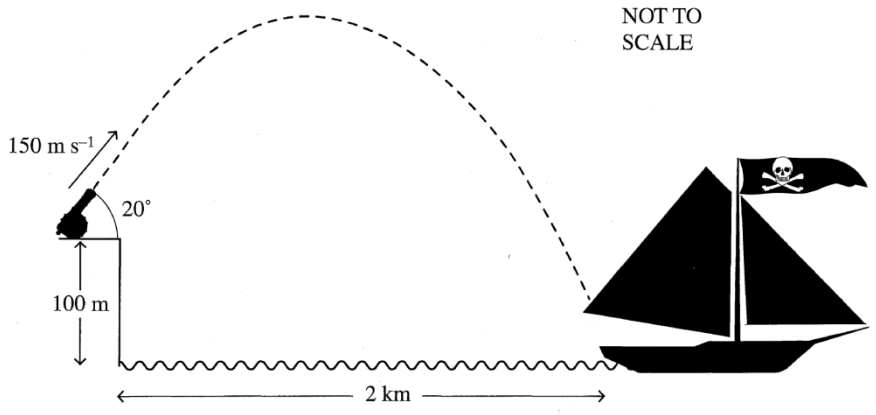
Name:
Class:
Teacher:

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 (8 marks)



An enemy ship was sailing 2km from the coast. A cannon on a 100 metre-high cliff fired a projectile at an angle of 20^{O} to the horizontal, at a speed of 150 m/s.

(a) Determine the vertical and horizontal components of the initial velocity. (2 marks)

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Question 21 *Continued*

(b) Calculate the time taken for the cannon ball to reach the maximum height. (1 mark)

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(c) Calculate the maximum height of the cannon ball above the water. (2 marks)

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(d) Under the firing conditions stated does the cannon ball hit the enemy ship? Justify your response by using appropriate calculations and values. Show all working out. (3 marks)

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Question 22 (4 marks)

With the aid of a labelled diagram, outline the Michelson and Morley experiment, including the predicted result.

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Question 23 (2 marks)

Calculate the altitude required above the Earth's surface for a geostationary satellite to remain in orbit. (Diameter of Earth = 12 742 km.)

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Question 24 (2 marks)

Show how the escape velocity of a rocket is independent of its mass. Use appropriate equations and physics principles to support your response.

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Question 25 (3 marks)

Compare the motor effect with electromagnetic induction.

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Question 26 (4 marks)

Outline an experiment that could be used to examine the force interaction between a current-carrying wire and a magnetic field.

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Question 27 (5 marks)

Two vertical parallel current-carrying wires, A and B, of length 1.5 m are separated by a distance of 25 cm. Both carry currents of 1.5 A in opposite directions.

(a) Draw a labelled diagram to illustrate this situation. Place wire A on the left with its current directed up the page. Include in your diagram the magnetic field due to wire B and the force experienced by wire A. (3 marks)

(b) Determine the magnitude and direction of the force experienced by wire A. (2 marks)

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Question 28 (2 marks)

Compare the structure and function of a split ring commutator to a slip ring commutator.

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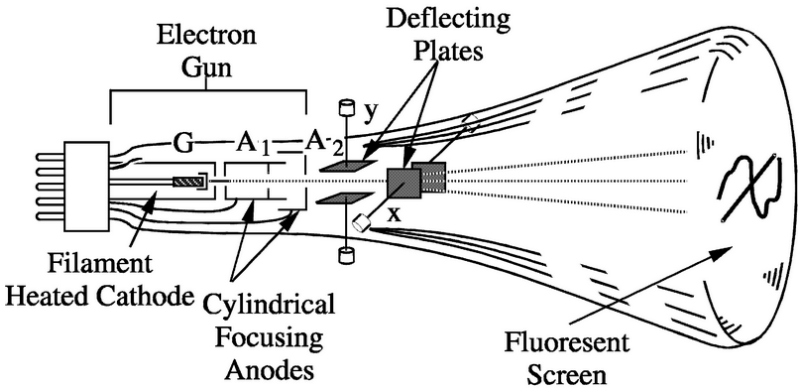
Question 29 (4 marks)
The diagram below depicts a cathode ray tube.



(a) Describe how the electron gun works.(2 marks)

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(b) If the charged plates at ***y*** are at a potential difference of 100 V and are separated by 15 mm, determine the force experienced by an electron. (2 marks)

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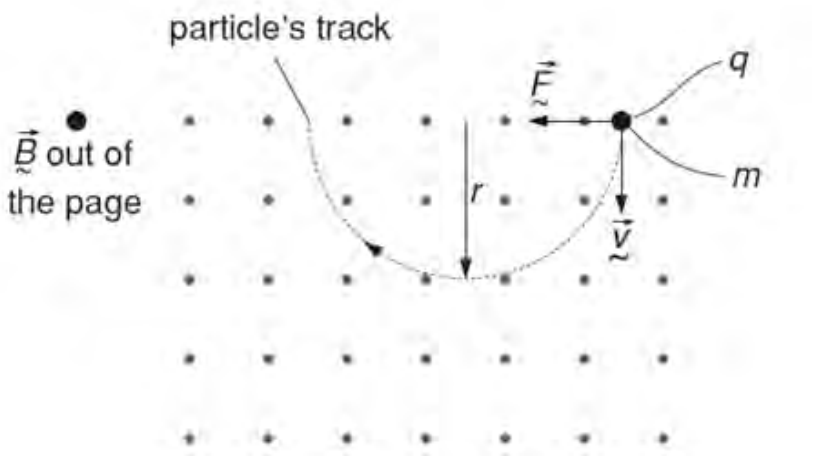
Question 30 (2 marks)

The diagram below depicts the trajectory of a charged particle through a magnetic field. Determine the sign of the electric charge on the particle and hence explain the shape of the trajectory.



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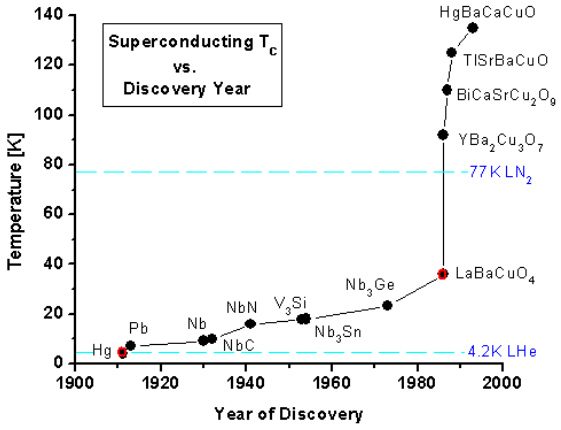
Question 31 (5 marks)

Consider the information provided in the following graph.



(a) Identify a recent trend in the development of superconductors. (1 mark)

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(b) Discuss the effect of temperature on the conducting properties of both Type I and Type II superconductors with reference to the BCS theory. (4 marks)

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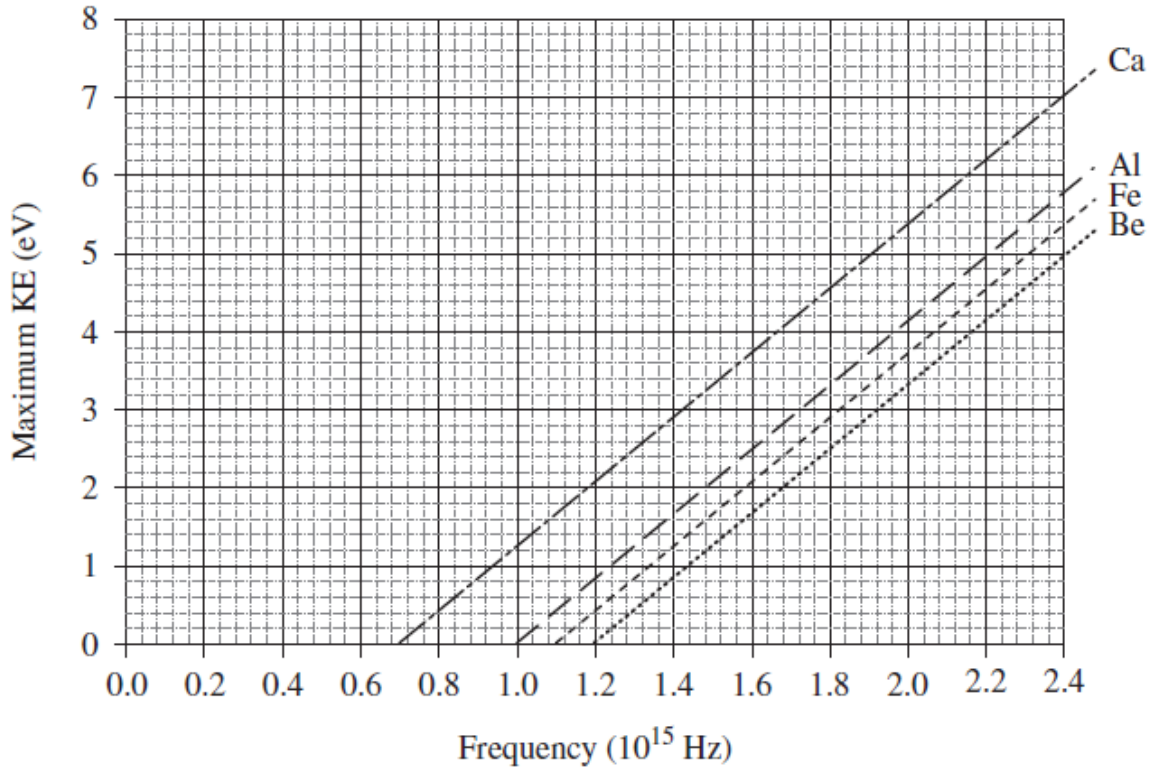
Question 32 (4 marks)

When electromagnetic radiation shines on metals, photoelectrons may be emitted. The maximum kinetic energy of emitted photoelectrons is plotted against radiation frequency for four metals as shown in the graph.



(a) Describe how the maximum KE of photoelectrons is detemined experimentally. (2 marks)

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(b) Using data from the graph identify the values of:

- The threshold frequency of iron. (in hertz) (1 mark)

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- The work function of calcium. (in Joules) (1 mark)

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Question 33 (5 marks)

The diagrams below show the energy bands in *p*–type and *n*–type semiconductors. The diagrams are not fully labelled.

Diagram X

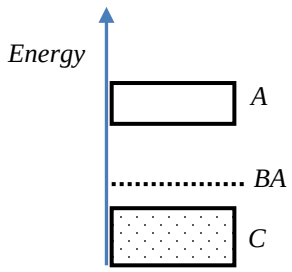
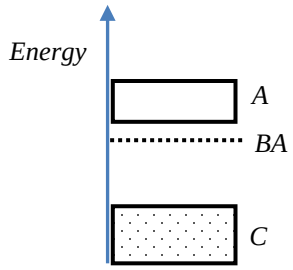


Diagram Y



(a) Identify what the label A represents in these diagrams. (1 mark)

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(b) Which diagram, X or Y, best represents the energy levels in a p-type semiconductor? Explain your answer. (2 marks)

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(c) Use diagram Y to explain how an electron in band C can be promoted to band A, and the effect this has on the conductivity of the bulk material. (2 marks)

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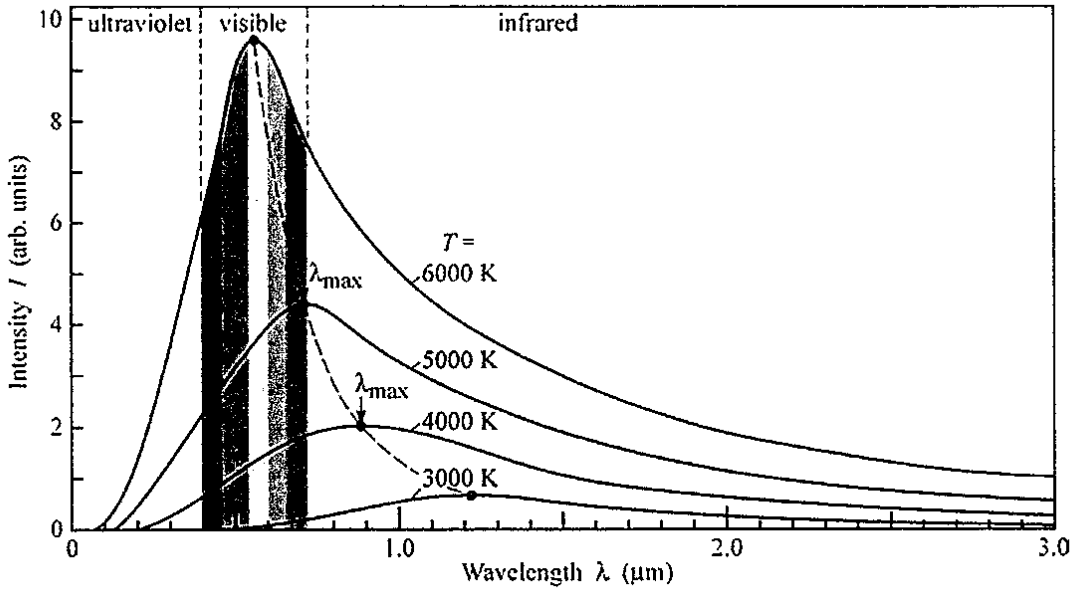
Question 34 (4 marks)

Around the 1860s, many scientists observed the light being emitted by hot objects, such as tungsten filaments in light globes. The graph below indicates the measured radiation emitted.



(a) Why was this a problem to the scientific community of the time, and what was Max Planck's contribution to the solution of this problem? (2 marks)

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(b) Outline Einstein's contribution to Quantum theory. (2 marks)

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End of Section I

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Name:
Class:
Teacher:

2015 GIRRAWEEN HIGH SCHOOL
TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Physics

Section II

25 marks
Allow about 45 minutes for this section

Answer all questions.
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)

Material	*Acoustic impedance* ($kg\ m^{-2}\ s^{-1} \times 10^6$)	*Density* ($kg\ m^{-3}$)
Fat	1.38	9.25×10^2
Skin	1.52	1.00×10^3
Ultrasound Gel	1.54	1.01×10^3
Air	0.0004	1.3

(i) Explain how ultrasounds are produced, and the energy transfer which occurs at production. (3 marks)

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(ii) Describe what occurs to the ultrasound waves which are not detected for imaging.

(2 marks)

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(iii) The acoustic impedance and density of a number of different types of material are given in the table above. Use the information to calculate the transmittance ratio between ultrasound gel and skin tissue.(2 marks)

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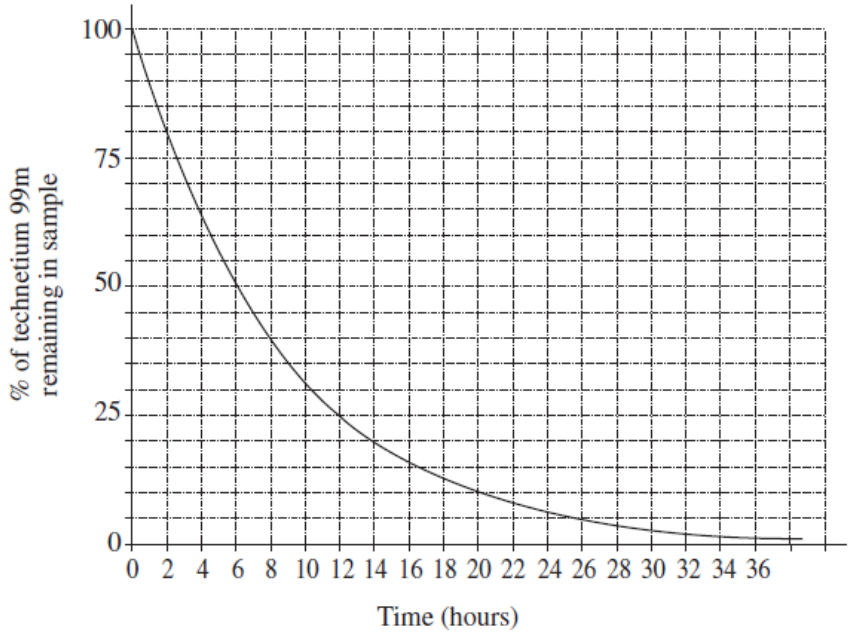
(c) Technetium 99m is an artificial isotope which is frequently used to obtain a scan of the human body.



(i) Using the graph, determine the half-life of technetium 99m. (1mark)

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(ii) A patient is given an injection containing $6.0 \cdot 10^{18}$ kg of technetium 99m. The scan is taken four hours after the injection.

How much technetium 99m remains un-decayed when the scan is taken?
(Give your answer in kilograms.) (2 marks)

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(iii) Describe how the positron emission tomography (PET) technique is used for diagnosis (3 marks)

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(iv) Identify an advantage of PET over other diagnostics techniques for imaging the body (1 mark)

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(d)

(i) Describe the sequence of events and associated processes of physics by which an image is produced using magnetic resonance imaging. (4 marks)

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(ii) Explain why MRI scans can be used to detect cancerous tissues in the human body (2 marks)

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(e) Assess the impact of medical applications based on ultrasound, radioactivity and the magnetic field of particles within the body on modern society. (5 marks)

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End of Section II

GIRRAWEEN HIGH SCHOOL
2015
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

Total marks – 100

Section I **Pages 4 – 21**

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 - 36**
- Allow about 1 hour and 40 minutes for this part

Section II **Pages 22 – 25**

25 marks

- Attempt **Question 37**
- Allow about 45 minutes for this section

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.

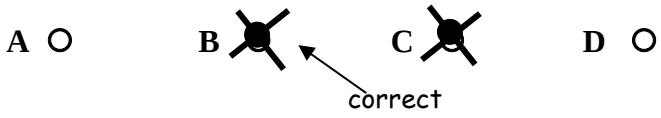
Sample 1: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

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.



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 Which is the best description of Newton's thought experiment explaining the principle of escape velocity?

(A) All cannon balls fall at the same rate no matter what their composition.

(B) A cannon ball fired vertically upwards can achieve a circular orbit of the Earth.

(C) A cannon ball fired horizontally from a high mountain can achieve a circular orbit of the Earth if fired fast enough.

(D) A cannon ball fired horizontally from a high mountain can achieve a trajectory which is unbounded to the Earth if fired with sufficient velocity.

2 What is the weight of a 24 kg mass on Mars, where the local acceleration due to gravity is equal to 3.5 ms^{-2}?

(A) 6.86 N

(B) 24 N

(C) 84 N

(D) 235.2 N

3 Which statement below was *not* one of Einstein's findings in the theory of Special Relativity?

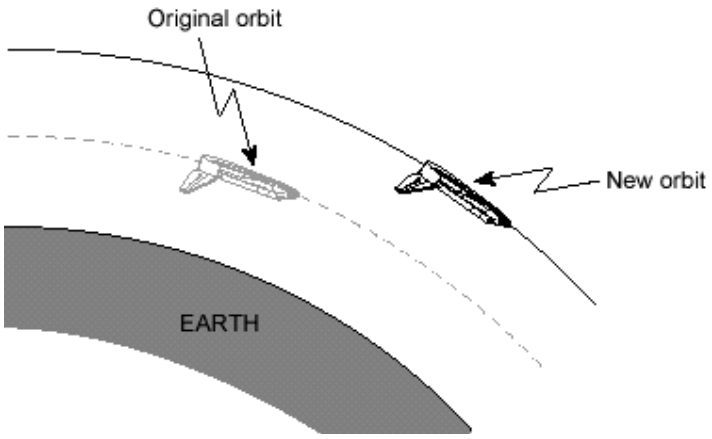
(A) The aether is unnecessary to explain the propagation of light through space

(B) The speed of light in a vacuum is constant

(C) The photoelectric effect can be explained in terms of the quanatisation of light energy

(D) Measurements of distance and time can't be agreed on by any two observers

4



A space shuttle is placed in a circular orbit around the Earth. It then thrusts its engine and moves to a new orbit, as shown above. Which statement is true about the shuttle's speed in this new higher orbit, if the new orbit is also circular?

(A) The speed will have to be greater than in the lower orbit

(B) The speed will have to be less than in the lower orbit

(C) The speed will have to be the same as in the lower orbit

(D) The speed will have to increase continuously in the new orbit

5 A radioactive particle used in a linear accelerator. Measured at rest relative to the laboratory it has a half life of 2.5 μs. When measured at constant speed by an observer in the laboratory, its half life has increased to 10 μs.

What is the speed of the particle relative to the laboratory?

(A) 1.68×10^8 ms $^{-1}$

(B) 2.90×10^8 ms $^{-1}$

(C) 290 000 000 ms $^{-1}$

(D) 2.60×10^8 ms $^{-1}$

6 There are a number of reasons which contribute to variations in the value of the local acceleration due to gravity at specific locations on the surface of the Earth.

Which of the following pairs of reasons would **not** be responsible for such variations?

(A) Crustal variations and the shape of the Earth.

(B) The shape of the Earth and the height above sea level.

(C) Height above sea level and the Earth's rotation.

(D) Crustal variations and the Earth's orbit around the Sun.

7. The effect on the magnitude of the force on a current-carrying wire in a magnetic field due to the angle between the direction of current flow and the orientation of the magnetic field is best described by which of the following?

(A) The magnitude of the force varies exponentially with the angle.

(B) The magnitude of the force varies proportionally with the angle.

(C) The magnitude of the force varies proportionally with the sine of the angle.

(D) The magnitude of the force is independent of the angle.

8. Choose the option which most correctly states how torque is defined.

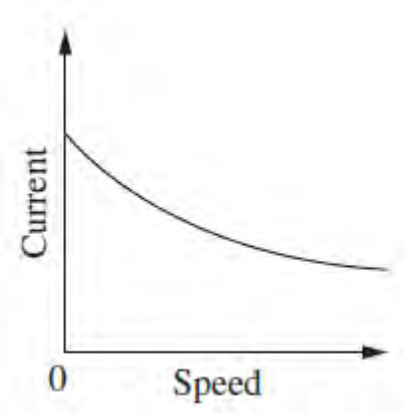
(A) The torque is the twisting force applied to an object.

(B) The torque is the turning force applied to an object.

(C) The torque is any force applied to a oject that can rotate.

(D) The torque is the turning moment of a force.

9. The graph below depicts the variation in current in the coil of a DC electric motor as a function of the rotation speed of the coil.



Choose the option that best explains this behaviour.

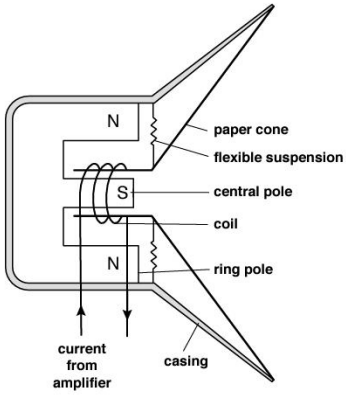
(A) As the speed of the motor increases the energy begins to run out.

(B) As the speed of the motor increases the back emf induced in the coil increases.

(C) As the speed of the motor increases the resistance of the coil increases.

(D) As the speed of the motor increases the effect of the magnetic field decreases.

10. The image below depicts a loudspeaker.



Identify the physics principle that is exploited by this device:

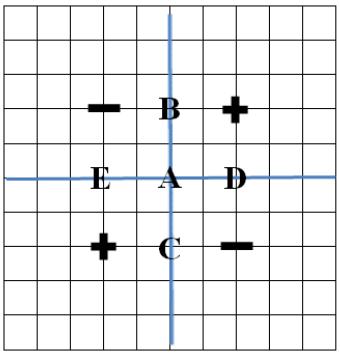
(A) The law of conservation of matter.

(B) The motor effect.

(C) Electromagnetic induction.

(D) The photoelectric effect.

11. The image below depicts four point charges. The magnitude of the charge on each is identical and their signs are as indicated.



The position at which the electric field strength will be zero will be:

(A) A.

(B) B.

(C) C.

(D) D.

12. An AC induction motor is compared to a DC motor. Both motors are operating without a load on them. When the supply voltage is increased, the effect on the motors will be:

	Effect on AC induction motor	**Effect on DC motor**
(A)	no effect	no effect
(B)	speeds up	no effect
(C)	no effect	speeds up
(D)	speeds up	speeds up

13. The laminated core of a transformer is arranged so that:

(A) eddy currents are prevented from forming.

(B) eddy currents are minimised.

(C) eddy currents are changed to assist the production of the secondary current.

(D) no magnetic field is lost to the surrounding area.

14. Which statement best describes a reliable investigation?

(A) The method allows for a fair test.

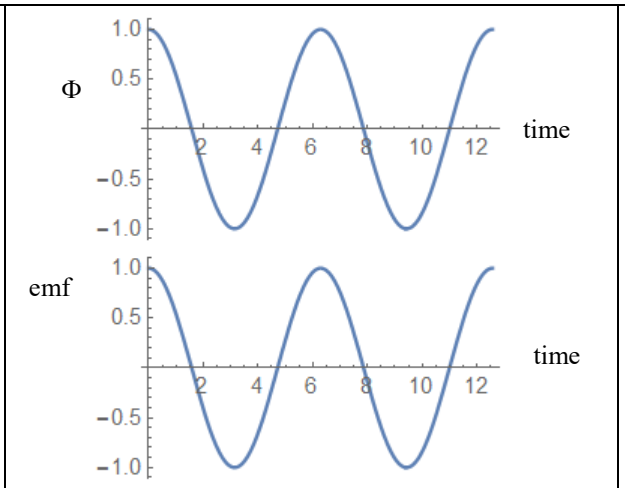
(B) Repetition of the method will produce consistent results with each iteration.

(C) The method allows for the results to be accurate.

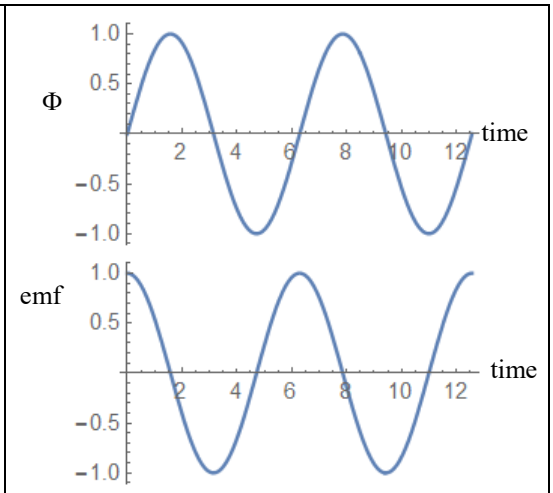
(D) The hypothesis will be supported.

15. Which of the following pairs of graphs correctly shows the relationship bvetween the magnetic flux through a coil in a generator and the induced voltage in the coil?

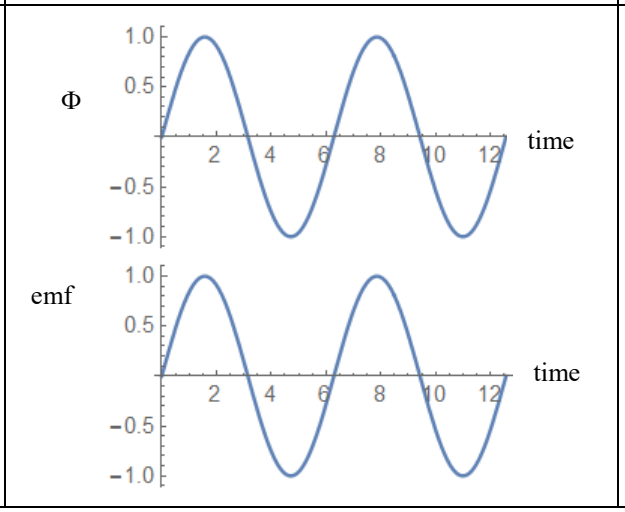
(A)



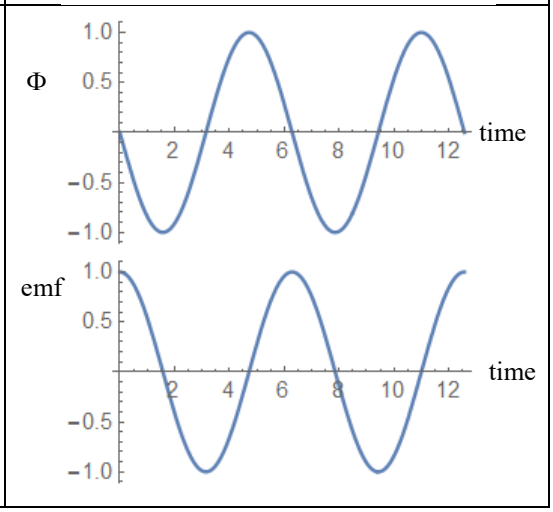
(C)



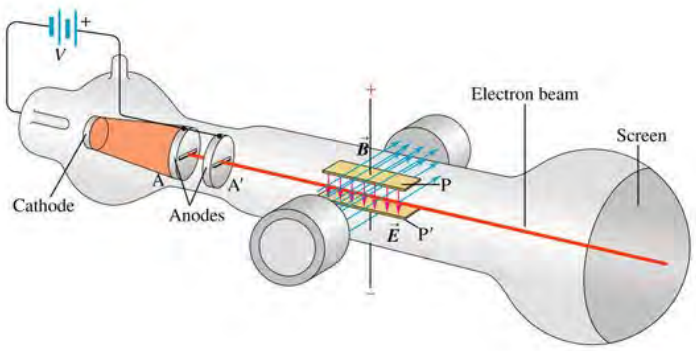
(B)



(D)



16. Thompson's experiment is illustrated below.



Which option gives a valid algeraic expression for the velocity of the cathode ray particles?

(A) $v = \frac{E}{B}$

(B) $v = BE$

(C) $B = vE$

(D) $v^2 B = E$

17. If the value of Planck's constant, h, was higher than it is, the effect on a photo-electric effect experiment would be:

(A) the threshold frequency, f_o would be lower for all metals.

(B) the energy of incident photons would be less.

(C) the threshold frequency, f_o would be greater for all metals.

(D) the photoelectric current would be greater.

18. Hertz's measurement of the speed of radio waves was not performed by directly measuring their speed. The feature of radio waves that Hertz actually measured to find their speed was:

(A) frequency

(B) amplitude

(C) period

(D) wavelength

19. Which analogy best describes electron arrangement in an n-type semiconductor?

(A) A bus with a few empty seats takes on another passenger.

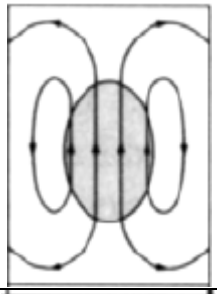
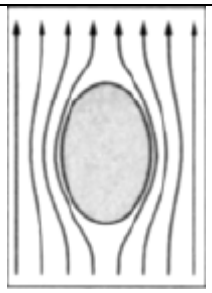
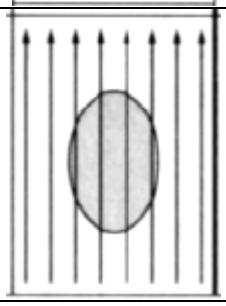
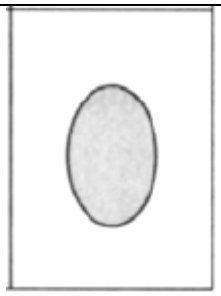
(B) A bus with no empty seats takes on another passenger.

(C) A bus with no passengers.

(D) A bus with so many passengers that there is no standing room left.

20. A superconducting material experiences a magnetic field.

Which of the following images shows what happens to the magnetic flux within the superconductor (shaded) at temperatures below the superconductor's critical temperature?

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

Name ……..

Class/Teacher: . . . . . .

GIRRAWEEN HIGH SCHOOL

PHYSICS

2015

TRIAL HSC EXAMINATION

Part A Answer Sheet

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

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** ⬭

2015 Trial Higher School Certificate

Physics

Section I (Continued)

Part B – 55 Marks

Attempt Questions 21 – 36

Allow about 1 hour and 40 minutes for this part.

Name: **Class:**
Teacher:

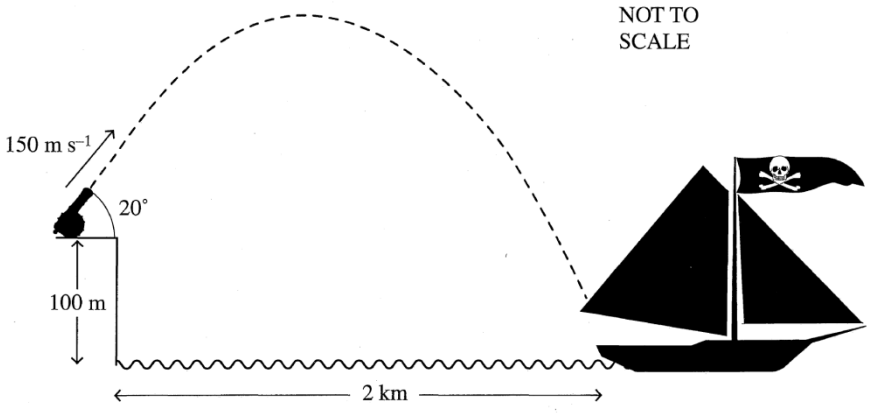
Answer the questions in the spaces provided. These spaces provide guidance for the expected length of the response.

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

Show all relevant working in questions involving calculations.

SEE PAGE 29 FOR COMMENCEMENT OF MARKING GUIDELINES

Question 21 (8 marks)



An enemy ship was sailing 2km from the coast. A cannon on a 100 metre-high cliff fired a projectile at an angle of 20^{O} to the horizontal, at a speed of 150 m/s.

(a) Determine the vertical and horizontal components of the initial velocity. (2 marks)

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Question 21 *Continued*

(b) Calculate the time taken for the cannon ball to reach the maximum height. (1 mark)

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(c) Calculate the maximum height of the cannon ball above the water. (2 marks)

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(d) Under the firing conditions stated does the cannon ball hit the enemy ship? Justify your response by using appropriate calculations and values. Show all working out. (3 marks)

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Question 22 (4 marks)

With the aid of a labelled diagram, outline the Michelson and Morley experiment, including the predicted result.

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Question 23 (2 marks)

Calculate the altitude required above the Earth's surface for a geostationary satellite to remain in orbit. (Diameter of Earth = 12 742 km.)

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Question 24 (2 marks)

Show how the escape velocity of a rocket is independent of its mass. Use appropriate equations and physics principles to support your response.

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Question 25 (3 marks)

Compare the motor effect with electromagnetic induction.

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Question 26 (4 marks)

Outline an experiment that could be used to examine the force interaction between a current-carrying wire and a magnetic field.

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Question 27 (5 marks)

Two vertical parallel current-carrying wires, A and B, of length 1.5 m are separated by a distance of 25 cm. Both carry currents of 1.5 A in opposite directions.

(a) Draw a labelled diagram to illustrate this situation. Place wire A on the left with its current directed up the page. Include in your diagram the magnetic field due to wire B and the force experienced by wire A. (3 marks)

(b) Determine the magnitude and direction of the force experienced by wire A. (2 marks)

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Question 28 (2 marks)

Compare the structure and function of a split ring commutator to a slip ring commutator.

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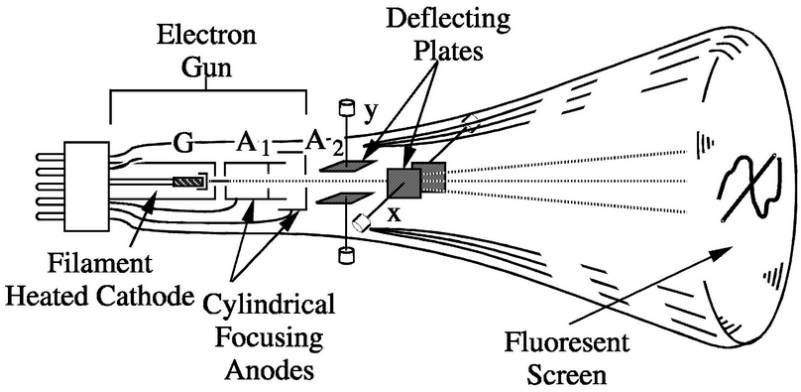
Question 29 (4 marks)
The diagram below depicts a cathode ray tube.



(a) Describe how the electron gun works.(2 marks)

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(b) If the charged plates at ***y*** are at a potential difference of 100 V and are separated by 15 mm, determine the force experienced by an electron. (2 marks)

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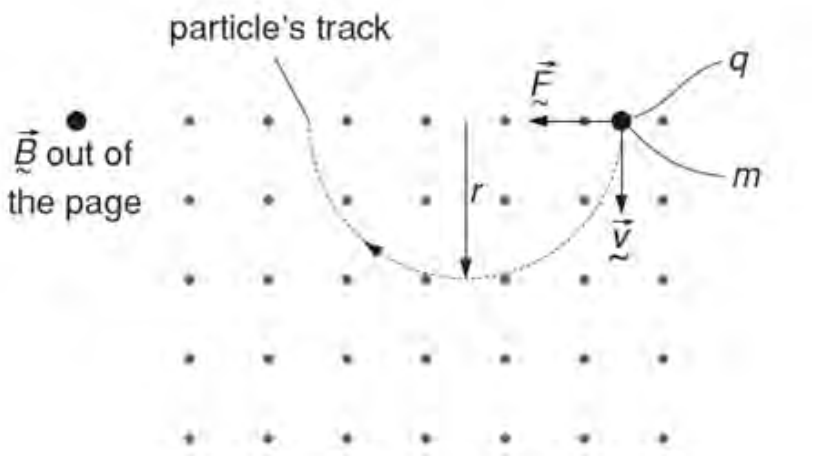
Question 30 (2 marks)

The diagram below depicts the trajectory of a charged particle through a magnetic field. Determine the sign of the electric charge on the particle and hence explain the shape of the trajectory.



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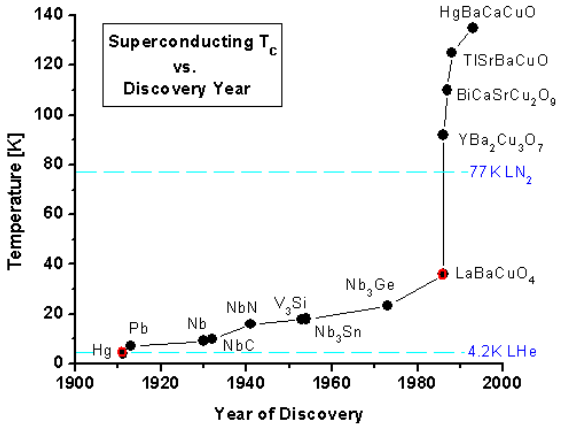
Question 31 (5 marks)

Consider the information provided in the following graph.



(a) Identify a recent trend in the development of superconductors. (1 mark)

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(b) Discuss the effect of temperature on the conducting properties of both Type I and Type II superconductors with reference to the BCS theory. (4 marks)

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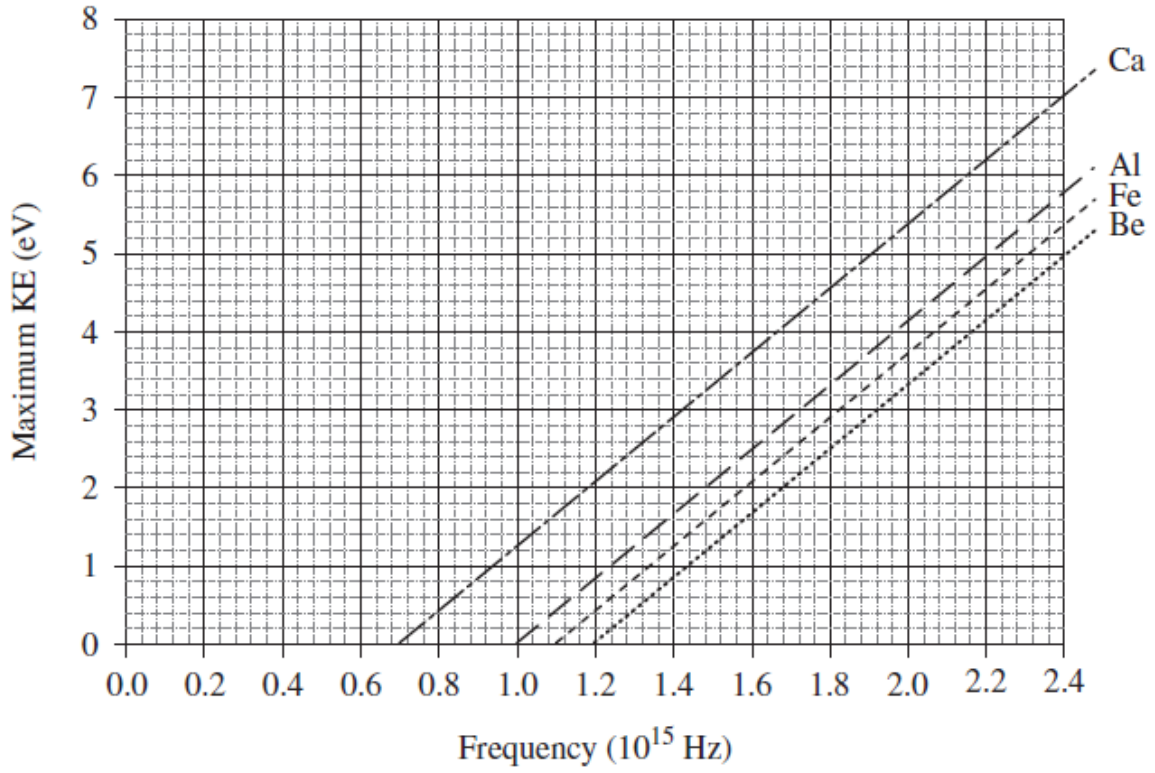
Question 32 (4 marks)

When electromagnetic radiation shines on metals, photoelectrons may be emitted. The maximum kinetic energy of emitted photoelectrons is plotted against radiation frequency for four metals as shown in the graph.



(a) Describe how the maximum KE of photoelectrons is detemined experimentally. (2 marks)

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(b) Using data from the graph identify the values of:

- The threshold frequency of iron. (in hertz) (1 mark)

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- The work function of calcium. (in Joules) (1 mark)

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Question 33 (5 marks)

The diagrams below show the energy bands in *p*–type and *n*–type semiconductors. The diagrams are not fully labelled.

Diagram X

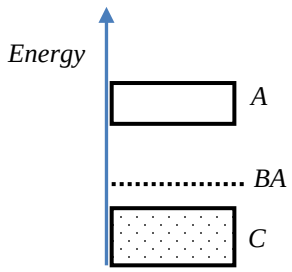
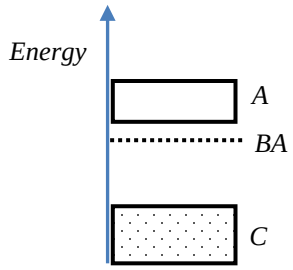


Diagram Y



(a) Identify what the label A represents in these diagrams. (1 mark)

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(b) Which diagram, X or Y, best represents the energy levels in a p-type semiconductor? Explain your answer. (2 marks)

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(c) Use diagram Y to explain how an electron in band C can be promoted to band A, and the effect this has on the conductivity of the bulk material. (2 marks)

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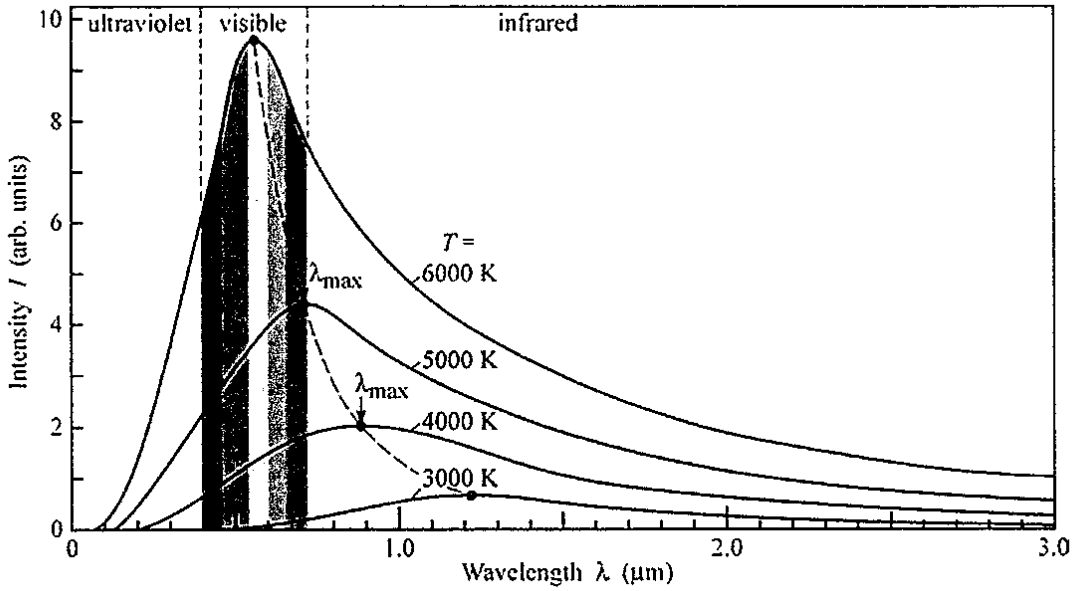
Question 34 (4 marks)

Around the 1860s, many scientists observed the light being emitted by hot objects, such as tungsten filaments in light globes. The graph below indicates the measured radiation emitted.



(a) Why was this a problem to the scientific community of the time, and what was Max Planck's contribution to the solution of this problem? (2 marks)

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(b) Outline Einstein's contribution to Quantum theory. (2 marks)

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End of Section I

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Name:
Class:
Teacher:

2015 GIRRAWEEN HIGH SCHOOL
TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Physics

Section II

25 marks
Allow about 45 minutes for this section

Answer all questions.
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)

Material	*Acoustic impedance* ($kg\ m^{-2}\ s^{-1} \times 10^6$)	*Density* ($kg\ m^{-3}$)
Fat	1.38	9.25×10^2
Skin	1.52	1.00×10^3
Ultrasound Gel	1.54	1.01×10^3
Air	0.0004	1.3

(i) Explain how ultrasounds are produced, and the energy transfer which occurs at production. (3 marks)

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(ii) Describe what occurs to the ultrasound waves which are not detected for imaging.

(2 marks)

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(iii) The acoustic impedance and density of a number of different types of material are given in the table above. Use the information to calculate the transmittance ratio between ultrasound gel and skin tissue.(2 marks)

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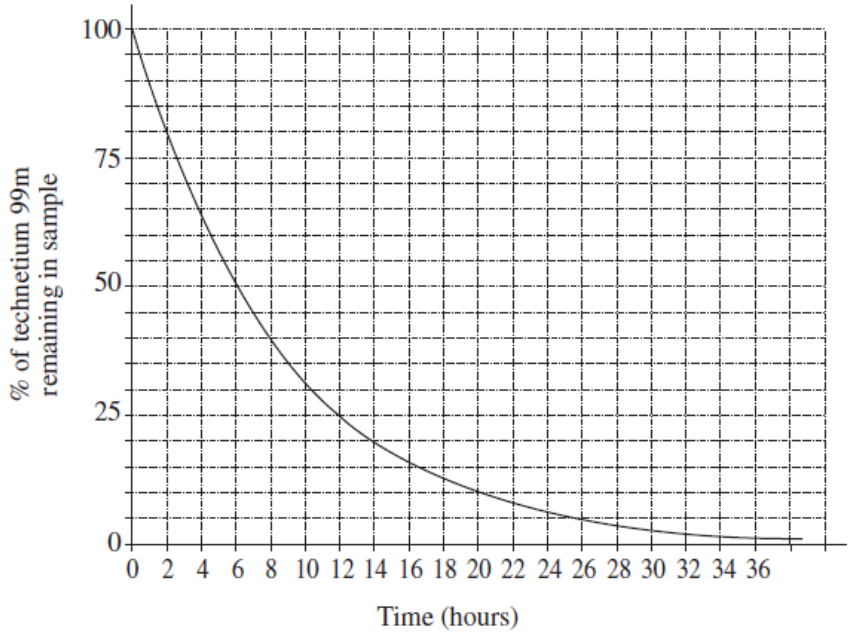
(c) Technetium 99m is an artificial isotope which is frequently used to obtain a scan of the human body.



(i) Using the graph, determine the half-life of technetium 99m. (1mark)

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(ii) A patient is given an injection containing $6.0 \cdot 10^{18}$ kg of technetium 99m. The scan is taken four hours after the injection.

How much technetium 99m remains un-decayed when the scan is taken?
(Give your answer in kilograms.) (2 marks)

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(iii) Describe how the positron emission tomography (PET) technique is used for diagnosis (3 marks)

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(iv) Identify an advantage of PET over other diagnostics techniques for imaging the body (1 mark)

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(d)

(i) Describe the sequence of events and associated processes of physics by which an image is produced using magnetic resonance imaging. (4 marks)

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(ii) Explain why MRI scans can be used to detect cancerous tissues in the human body (2 marks)

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(e) Assess the impact of medical applications based on ultrasound, radioactivity and the magnetic field of particles within the body on modern society. (5 marks)

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End of Section II

2015 HSC Physics Marking guidelines and sample answers

Section I:

Question 21

a) Uy = Sin20 ×150
= 51.30m/s
Ux = Cos20 × 150
= 140.9m/s

Criteria	marks
• Both correct answers with correct units	2
• Both correct answers with units not used OR • ONE correct response with units	1

b) V = u + at
0 = Sin20 ×150 – 9.8t
t = Sin20 ×150 / 9.8
t = 5.24 secs

Criteria	marks
• Correct answer	1

c) $S = ut + ½ at^2$

$S = Sin20 \times 150 \times Sin20 \times 150/9.8 – ½ \times 9.8 \times (Sin20 \times 150/9.8)^2$
= 134.29m
Therefore height above water = 134.29 + 100
= 234.29m

Criteria	marks
• Correct answer	2
• Correct height calculated but height of cliff not taken into account	1

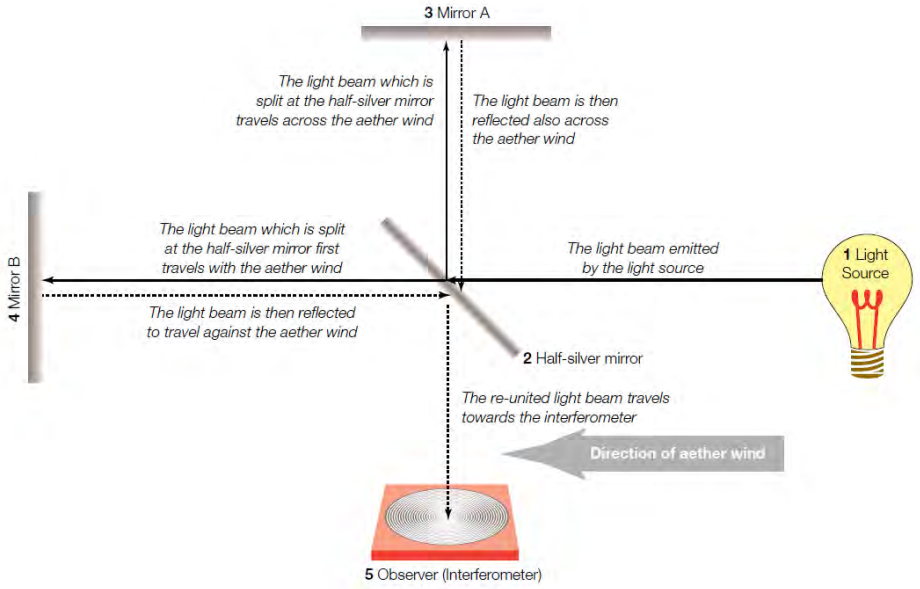
d) Time to fall from height above water

$S = ut + ½ at^2$
$234.29 = 0 + ½ \times 9.8 \times t^2$
$t = \sqrt{}\ 234.29 / 4.9$
= time equals 6.91 secs
Total time equals
5.24 + 6.91
= 12.15 secs
DeltaX = Ux t
= Cos20(150) ×12.15
= 1713.26

Ship is 2km away , therefore the cannon ball lands 286.74m short

Criteria	marks
• Correct total time calculated • Correct range found • Conclusion made based on results	3
• Single error made in calculation	2
• Two errors made in calculation	1

Question 22



1. A light beam is emitted at the light source and travels towards the half-silver mirror.
2. The half-silver mirror is a device that splits the light beam into two paths: one that will travel with and against the aether wind; the other that will travel across the aether wind. Note that the aether wind is created as a result of the Earth moving through the stationary background aether.
3.One light beam travels across the aether wind to reach mirror A, and then reflects back also across the aether wind.
4. The other light beam travels first with the aether wind to reach mirror B and then reflects back to travel against the aether wind. (If the aether wind is to 'blow' in the opposite direction, then this beam will first travel against the aether wind, then with the aether wind.)
5. The two light beams re-unite at the half-silver mirror and are reflected to the interferometer. If aether exists, then the velocity of the light beam that has travelled with ,then against, the aether wind would be affected.
However, the velocity of the light that has travelled across the aether wind is affected to a different extent. Therefore, when the two beams re-join, they should be out of phase to each other, and an interference pattern can be observed at the interferometer.

Criteria	marks
• Diagram is labelled including , ½ silvered mirror, block on Mg, mirrors, light source • Correctly outlines features included o Light splitting by mirror o Light travels to 2 mirrors set equal distance away o Instrument is rotated 90 degrees • Expected results stated	3
• Single error made in calculation	2
• Two errors made in calculation	1

Question 23

$R = 3\sqrt{GM/4\pi^2} \text{ X } t^2$

$= (3\sqrt{\ } 6.67 \text{ X } 10^{-11} \text{ X } 6.0 \text{ X } 20^{24} / 4\pi^2) \text{ X } (24 \text{ X } 60 \text{ X } 60)^2$
$= 44\ 02271.876$ m

Radius of Earth equals = 6371 000

Altitude = 44 02271.876 - 6371 000

= 1968728.124m

Criteria	marks
• Correctly subs into Correct equation in SI units • Correct altitude given	2
• Single error made in calculation	1

Question 24

$Fc = Fg$

$m_1v_2/r = Gm_1M_2/d^2$

$v = \sqrt{GM_2/r}$

From the above equation shows that orbital speed is only dependant on G , mass of planet and radius. SO therefore is independent of mass of satellite

Criteria	marks
• Correctly shows orbital velocity formulae •	2
• Single error made in derivation	1

Question 25

Solution

Both phenomena are interactions between current-carrying wires and magnetic fields.

The motor effect force on a wire can be calculated as $F = BIl\sin\theta$, that is, the product of the magnetic field intensity B, the current in the wire I and the sine of the angle between the current direction and the magnetic field direction. In contrast the potential difference that is induced in a wire is calculated as $V = -\frac{\Delta\Phi}{\Delta t}$, the time rate of change of the magnetic flux experienced by the wire.

The motor effect involves supplying a current to a circuit in presence of a magnetic field in order to convert electrical energy to kinetic energy, whereas Electromagnetic induction involves supplying kinetic energy to a circuit in the presence of a magnetic field in order to convert kinetic energy to electrical energy.

In the ME, the elctrical energy does work on the wire wheras in EM the changing magnetic flux does work on the charges in the wire.

Criteria	Marks
• Both are identified as electromagnetic interactions involving wires and magnetic fields. • Each interaction is described correctly • Energy conversions are correctly described • Correct equations are given	**3**
• Each interaction is described correctly AND • Energy conversions are correctly described • OR • Both are identified as electromagnetic interactions involving wires and magnetic fields AND the energy conversions are correct Or • As above but only one equation is given	**2**
• One correct relevant statement only	**1**

Question 26
Solution
Answers could contain:
A current balance can be used. A conducting rod can be placed upon an electronic balance in proximity to magnetic field in such a way that the weight force of the rod can be opposed by the motor effect force. The rod is to be connected in series to a circuit with a variable DC power supply. The weight of the rod as a function of applied DC current, magnetic fiels strength, angle between B and I, can be measured to increase or decrease as the independent variable is varied.
A spring balance connected to a coil in such a way as to measure the force applied as a function of I, B or angle could also work.

Criteria	Marks
• A valid **experiment** is outlined • The proposed method is unambiguous • The IV's and DV are clear, and examines ΔI, ΔB, Δorientation • The nature of the relationship between the motor effect force and the observed/measured variable is clearly made • The equipment needed is clearly described • The need for DC current is identified	4
• A valid experiment is outlined AND • two of the above supplied only OR • If either current strength or magnetic field strength or orientation is not varied	3
• A valid experiment is identified AND • one of the above supplied only OR • If distance of movement is observed without direction of movement being considered OR • Distance of movement is not linked to applied force	2
• A valid experiment is identified • the procedure is is demonstration of the effect only	1

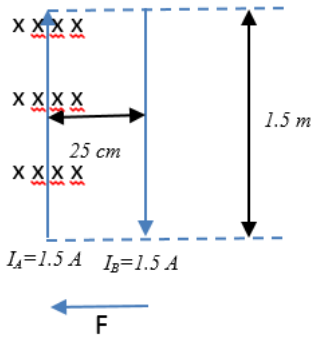
Best responses established a clear link with the measured quantity and the variation of one of the following: current, B field strength, length of conductor in the field. Use of a force measuring instrument such as an electronic balance or a spring balance showed an understanding that it was force that was the appropriate DV.

Weaker responses relied on observation of the movement of the wire. They did not require specific observation of the acceleration of the wire as would be expected from an F = ma situation. Measurement of the distance moved by the wire need to be linked to how the force realtes to the distance. This could be done by using the wire in a way that would see it displaying some kind of spring-like response to the applied force and making the case that the degree of deflection then corresponded to the applied force.
Weakest responses

- left ambiguity in their procedures that would make execution of the procedure impossible.
- Did not vary I or B except in a binary way, thus reducing their procedure to a demonstration rather than an experiment.

A **Valid Experiment** is more than just controlling variables and having clear IV and DV. The phenomeon in question has to be actually guaranteed to operate without any interference that could confuse the interpretation of the results.

Question 27
Solution



In[1]:=
$$k = 2.0 \times 10^{-7};$$
$$ia = ib = 1.5;$$
$$l = 1.5;$$
$$d = 0.25;$$
$$f = \frac{k\ ia\ ib\ l}{d}$$

Out[5]= 2.7×10^{-6}

directed to the left

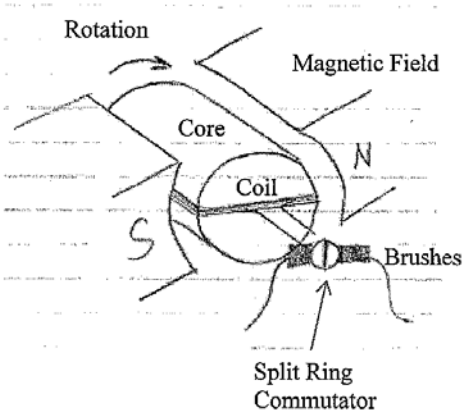
Criteria	Marks
(a)	
• Wire A is on the left • Both currents are in the correct direction • Both currents are labelled correctly • Both distances are labelled correctly • Magnetic field drawn correctly • Force indicated correctly	3
• One error in the above	2
• Two errors in the above	1
(b)	
• Correct direction • Correct value determined	2
• Correct value only	1

Question 28

(a) (3 marks)
Outcomes Assessed: H9, H13
Targeted Performance Bands: 3-4

Criteria	Mark
• Provides a complete labelled diagram including: magnetic field, type of current generated and coils AND • A clear description of the role of all labelled parts	3
• Provides a complete labelled diagram including MOST parts AND • A description of the role of some of the parts	2
• Provides an incomplete diagram OR • A description of the role of some of the parts	1

Sample answer:



In a simple DC generator, a coil of wire is rotated through a magnetic field. This rotation generates current, as the coil experiences a changing magnetic flux threading it. A laminated iron core, may be included, to enhance the magnitude of the magnetic effect experienced by the coil surrounding it. The split ring commutator conducts the current from the rotating coil to the output voltage terminals, to the external circuit.

(b) (2 marks)
Outcomes Assessed: H7, H9
Targeted Performance Bands: 3-4

Criteria	Mark
• Identifies that most structural features are similar AND • Identifies the reverse nature – electric energy production versus use to describe differences	2
• Identifies some of the similar structural features OR • Describes differences in energy use and production	1

Sample answer:
The structure of an electric motor and a generator are similar except for their connections to an external circuit. A generator produces electrical energy and is connected to an external load circuit to deliver its current. A motor uses electrical energy and is connected to a supply of electricity to power the device.

Question 29

(a) (2 marks)

Outcomes Assessed: H7, H9

***Targeted Performance Bands*: 3-4**

Criteria	Mark
• Describes the role of both the filament AND the electrodes	2
• Describes the role of either the filament OR the electrodes	1

Sample answer:

The electrons are initially released from a heated filament at the cathode and then accelerated towards the high voltage anode. The anode is positive and has a central hole for the electrons to pass through towards the screen.

(b) (2 marks)

Outcomes Assessed: H9

***Targeted Performance Bands*: 3-4**

Criteria	Mark
• Selects correct equation and substituted correctly AND • Indicated correct force direction	2
• ONE of the above	1

Sample answer:

$F_B = qvB\sin\theta = 1{\cdot}6\times10^{-19}\times4200ms^{-1}\times0{\cdot}5T = 3{\cdot}36\times10^{-16}N$ (down the page).

(c) (2 marks)

Outcomes Assessed: H6, H9

***Targeted Performance Bands*: 3-4**

Criteria	Mark
• Selects the correct equation and substitutes into it correctly AND • Correctly identifies charge on a plate	2
• ONE of the above	1

Sample answer:

$F_E = -F_B$, so F_E needs to be up the page, so plate Q must be -ve.

$V = qF_Bd = vBd = 4200ms^{-1}\times0.5T\times0{\cdot}01m = 21V$.

Question 30

(a) (1 mark)

Outcomes Assessed: H10, H14

***Targeted Performance Bands*: 3-5**

Criteria	Mark
• Identifies a recent trend in superconductivity research, with reference to the graph	1

Sample answer:

Scientific research is endeavouring to increase the critical temperature (T_C) of superconducting materials.

(b) (3 marks)

Outcomes Assessed: H9, H10

***Targeted Performance Bands*: 3-5**

Criteria	Mark
• Discusses MOST aspects of the effects of temperature on superconductivity, including an outline of the BCS theory AND • Links critical temperature to: formation of Cooper pairs → the distortion of the lattice → unimpeded movement of the Cooper pairs through the lattice → zero resistance	3
• Discusses SOME aspects of the effects of temperature on superconductivity AND • Links critical temperature to: formation of Cooper pairs → the distortion of the lattice → unimpeded movement of the Cooper pairs through the lattice → zero resistance	2
• Discusses AN aspect of the effects of temperature on superconductivity, linking critical temperature to AN aspect of the BCS theory	1

Sample answer:

When a superconductor is cooled to temperatures below its critical temperature, the lattice of positively charged ions is slightly distorted by the passing electrons. This distortion of the lattice is associated with the emission of phonons which effectively form a positive charge. A second electron is attracted to this positive charge, forming Cooper pairs, which are able to pass through the lattice unimpeded. Phonons and Cooper pairs can only form at temperatures below critical temperature.

(c) (3 marks)

Outcomes Assessed: H5

***Targeted Performance Bands*: 3-5**

Criteria	Mark
• Describes an advantage AND limitation of an application of superconductors	3
• Identifies an application of superconductors AND • Describes an advantage OR a limitation	2
• Identifies an application OR • Identifies an advantage OR identifies a limitation	1

Sample answer:

Superconductors can be used for power distribution, reducing energy loss from transmission lines and replacing the need for transformers in the electricity grid. This will reduce the production of electricity and greenhouse gases in the atmosphere. This application is not yet viable, as the low critical temperature required for superconductors prohibits widespread use in the distribution grid.

Question 31

(a)

Criteria	Mark
• An answer that correctly defines stopping voltage	1

Sample answer

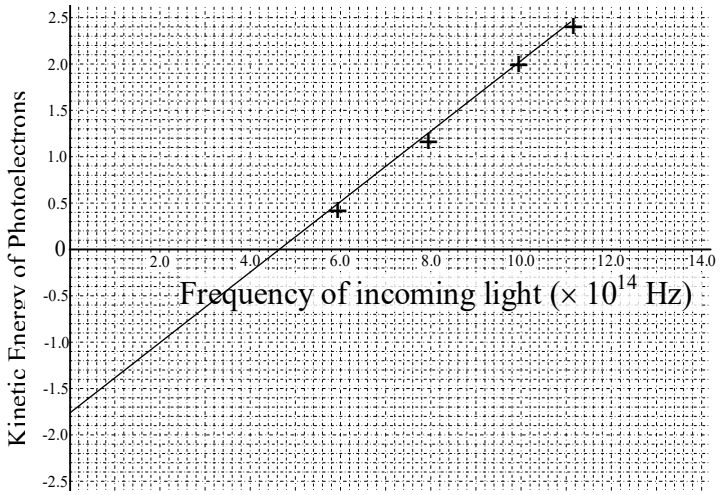
The stopping voltage is the lowest potential difference applied between the anode and cathode plates such that it stops any electrons emitted from the anode from crossing the tube against the electric field between them, so the galvanometer measures zero.

(b)

Criteria	Marks
• Correctly completing all values on the table • Correctly positioning all four points on the graph • Drawing an appropriate line of best fit • Extending the line of best fit to reach (or cross) the *y*-axis	4
• Succeeding in all but one of the above outcomes	3
• Succeeding in only two of these outcomes	2
• Succeeding in only one outcome	1

Sample answer

Light frequency	Reading 1	Reading 2	Reading 3	Average
3.9×10^{14} Hz	None	None	None	—
5.9×10^{14} Hz	0.44 eV	0.47 eV	0.44 eV	0.45 eV
7.9×10^{14} Hz	1.23 eV	1.21 eV	1.17 eV	1.20 eV
9.9×10^{14} Hz	1.99 eV	2.10 eV	1.99 eV	2.03 eV
11.1×10^{14} Hz	2.48 eV	2.51 eV	2.47 eV	2.49 eV



(c)

Criteria	Mark
• Identifying the improved reliability of the results	1

Sample answer

It was necessary to take several readings of each test in order to check that each of the results is reliable. This is shown when they are all very similar.

(d)

Criteria	Marks

• The student correctly reads off the point where the lobf crosses the f-axis • The student correctly reads off the point where the lobf touches the y-axis	2
• One correct reading from those above	1

Sample answer
Reading off from the graph, the threshold frequency is 4.7×10^{14} hertz;
The value of the work function of the metal is 1.8 eV
[Note: The minus sign can be ignored if a student includes it. Also, the precise values depend upon the line of best fit drawn by the student in Part (b), and should be marked accordingly.]

(e)

Criteria	Mark
• Correctly substitutes into the correct relationship to get an answer	1

Sample answer
Since 1 eV = 1.602×10^{-19} joules, $\therefore$ 1.8 eV = 2.9×10^{-19} J

Question 32

(a) (1 mark)

Criteria	Mark
• Correct identification	1

Sample answer

The label A represents the conduction band of a substance in Band Theory.

(b) (2 marks)

Criteria	Marks
• Identifying Diagram X as the one representing p-type semiconductors • Explaining the reasoning for the choice	2
• One of the above	1

Sample answer

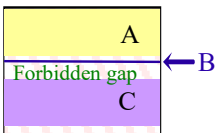
A p-type semiconductor has what is called an acceptor level slightly in the forbidden gap just above the valence band, as shown in **Diagram X**.

P-type semiconductors have increased conductivity due to the presence of 'holes' which can migrate through the crystal. Although there is no excess positive charge there, these holes are regarded as being positive because they do attract electrons. If an electron enters a hole, it is therefore slightly repelled by the negative charge it brings with it, hence is slightly closer to the conduction band than is a normal electron in the valence band – it is in the acceptor-level.

(c) (3 marks)

Criteria	Marks
• Correct labelled diagram, as required in the question • Explanation of the donor level, and how it increases conductivity • Reduction of electrical resistance identified	3
• One of the above missing	2
• One of the above present	1

Sample answer



This diagram shows the Band Theory diagram of an n-type semiconductor, which contains valence-5 impurity. It results in the presence of electrons that are almost delocalised (free of their 'parent atom') in the crystal; in fact they are found in a 'donor level' just below the conduction band. Such electrons need very little energy to escape into the conduction band, in which case the material now acts quite like a conductor.

This energy can be provided by light, heat, or the application of even fairly low voltage. The place of an electron that has jumped into the conduction band and been released is quickly occupied by another electron, because the escaped electron leaves a positive charge behind, so the process continues, the donor level acting like a sort of energy spring-board, so clearly the electrical resistance of the semiconductor is reduced.

Question 33

(a) (3 marks)

Criteria	**Mark**
• States that the graph could not be explained with the existing (classical) theory at the time OR • Directly refers to specific aspects of the graph that were a problem to explain AND • Describes Planck's explanation (Quantum Theory) OR E=hf AND relates this to the problem	3
• Describes the problem with blackbody radiation AND • Describes Planck's explanation (Quantum Theory) as a solution to the problem	2
• Outlines blackbody radiation OR • Outlines the change in scientific thinking	1

Sample answer:

The accepted theory of the time was that radiation (energy) was emitted as a wave and would continuously be emitted as the body got hotter and therefore the intensity would continuously increase as the wavelength decreased. The experimental data (graph) did not indicate this, as the intensity peaked and then diminishes for all temperatures as the wavelength decreases.

Planck suggested that the radiation (heat energy) was being emitted in discrete amounts (packets) later called quanta. He suggested the atoms of a blackbody could oscillate back and forth to emit energy consistent with the equationE = ***hf ,*** whereby only whole numbers of quanta could be absorbed or emitted.

(b) (2 marks)

Sample answer:

Criteria	**Mark**
• Describes Einstein's application of the quantum theory to explain the photoelectric effect AND • Describes the relationship between frequency and emitted photoelectrons	2
• Identifies the photoelectric effect OR • Describes the quantum nature of light	1

Einstein extended Planck's quantum theory of energy to light. He applied it to explain the results of the photoelectric effect, where once again it was the frequency that determined the energy of the light, not the intensity of the light. Einstein suggested light was made up of packets of energy called photons, and that a minimum (threshold) frequency of light was required for photoelectrons to be emitted during the photoelectric effect.

Section II: Medical Physics

a) I

(a) (i) (3 marks)
Outcomes Assessed: H3, H7, H8
Targeted Performance Bands: 3-5

Criteria	Marks
• The PZ crystal is identified, the changing PD and effects on crystal is linked in and the energy transformation is identified	3
• The PZ crystal is identified **AND** the effects on crystal **OR** • The PZ crystal is identified **AND** the energy transformation is identified OR • The effects on crystal is identified **AND** the energy transformation	2
• One correct statement about the PZ crystal	1

Sample answer
The ultrasound is produced inside a transducer using a piezoelectric crystal. The PZ crystal is supplied with a changing potential difference across its contacts, which makes the crystal deform, expanding and contracting in phase with the signal, and so outputting a high frequency pressure wave (ultrasound). The energy transformation is electrical energy → sound energy (or KE).

29 (a) (ii) (2 marks)
Outcomes Assessed: H3, H7, H8
Targeted Performance Bands: 3-5

Criteria	Marks
• Two correct options identified	2
• One correct option identified	1

Sample answer
The ultrasound waves not detected are either absorbed by the body, scattered, refracted, or transmitted through the body.

29 (a) (iii) (2 marks)
Outcomes Assessed: H3, H7, H14
Targeted Performance Bands: 3-5

Criteria	Marks
• correct calculation	2
• partially correct calculation	1

Sample answer
The reflectance ratio is $\frac{I_r}{I_0} = \frac{[Z_2 - Z_1]^2}{[Z_2 + Z_1]^2}$

So $I_r/I_0 = [(1.54 - 1.52) \times 10^6]^2 / [(1.54 + 1.52) \times 10^6]^2 = 4.27 \times 10^{-5}$

b) i

Outcomes assessed: H14

MARKING GUIDELINES

Criteria	Marks
• Correct reading of half life from the graph	1

Question 29 (b) (ii)

Outcomes assessed: H14

MARKING GUIDELINES

Criteria	Marks
• Correctly determines the quantity of technetium 99 m remaining after 4 hours (in kg)	2
• Correctly determines the percentage of technetium 99 m remaining after 4 hours	1

i) 6 hours

ii) 62.5% remaining

62.5/100 X 6.0 X 10^{18}

= 3.75 X 10^{18} Kg

iii)

The first step in making a PET image is to give the patient a radioisotope (also called a *radiopharmaceutical*) that closely resembles a natural substance in the body.
During a scan, the patients head, or body part being scanned, is placed inside a large doughnut-shaped ring (gantry) of gamma ray detectors.

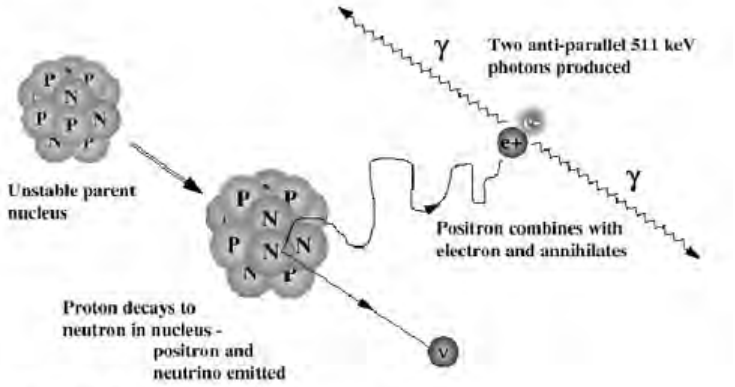


Figure 1.1. Positron emission and annihilation.

Since the gamma rays are emitted with the same energy and in opposite directions, a pair of detectors placed at 180° to each other will detect the two rays.
Computers calculate the point from which they emerged by comparing the arrival times of the two photons.

Criteria	Marks
• Identifies *radiopharmaceutical* is needed And • B + decay • Identifies annihilates and production of 2 gamma rays in opposite directions •	3
• Missing one point from above	2
• Missing two points from above	1

iv)

Criteria	Marks

• correct answer	1

provides a functional scan of a organ rather than a structural

d) i)

Patient – initially proton spins are randomly orientated. Spins are created as protons are moving charge and create their own magnetic field.
• Magnetic field applied – proton spins align with the external field
• RF pulse is applied – Provided the frequency of the pulse is the same as that of the nuclear – larmor frequency – resonance will occur. The energy causes the protons to process around magnetic field lines.
• RF signal is turned off
• Patient produces RF signal – protons lose the absorbed energy. As they relax, return to their lower energy state, the energy is transferred into radio waves of the same frequency as the incident wave
• Receiving ion detects weak RF signal – the alternating em wave sets up an alternating electric potential
• Computer reconstructs image – image is produced on a computer screen

MARKING GUIDELINES

Criteria	Marks
• Demonstrates thorough knowledge and understanding of producing an MRI image • Provides a detailed sequence of events involved with specific reference to the physics involved • Demonstrates coherence and logical progression and includes correct use of scientific terms	5–6
• Demonstrates sound knowledge and understanding of producing an MRI image • Communicates some scientific principles and ideas in a clear manner AND EITHER • Provides a detailed sequence of events with some reference to the physics involved OR • Provides a simple sequence of events and demonstrates sound knowledge of the physics involved in these	3–4
• Demonstrates a basic knowledge of MRI images • Communicates simple ideas AND EITHER • Provides a simple sequence of events with no reference to the physics involved OR • Provides one to two steps with some physics involved	1–2

ii)

Criteria	marks
• Describes how cancerous tissue is detected, with reference to MRI process and water content of tumour	2
• States tumour has higher water content •	1

e)

Criteria	marks
• Makes an appropriate judgement based on a demonstrated extensive knowledge and understanding of the use of the medical applications of physics on modern society	5
• Makes an appropriate judgement based on a demonstrated thorough knowledge and understanding of the use of the medical applications of physics on modern society	4
o Makes an appropriate judgement based on a demonstrated sound knowledge and understanding of the use of the medical applications of physics on modern society OR o Makes an appropriate judgement based on a demonstrated extensive knowledge and understanding of the use of one medical application of physics on modern society	3
• Makes an appropriate judgement based on a basic knowledge and understanding of the use of the medical applications of physics on modern society	2
Correctly states the two medical applications of physics and how they are utilised as diagnostic tools	1