GIRRAWEEN HIGH SCHOOL

2014

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 3 – 20**

75 marks

This section has two parts, Part A and Part B

Part A – 20 marks

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

Part B – 55 marks

- Attempt Questions **21 - 36**
- Allow about 1 hour and 40 minutes for this part

Section II **Pages 21 – 24**

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.

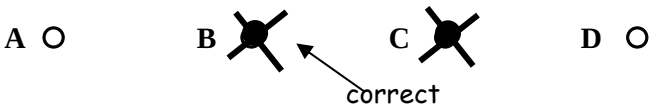
Sample 1: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

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. Planet X has twice the mass and half the radius of planet Y. What is the ratio of the weight of a 10 kg mass on planet X to its weight on planet Y?

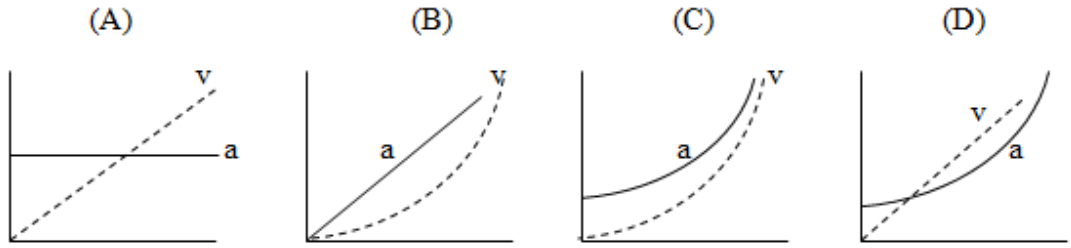
   (A) 1:1

   (B) 2:1

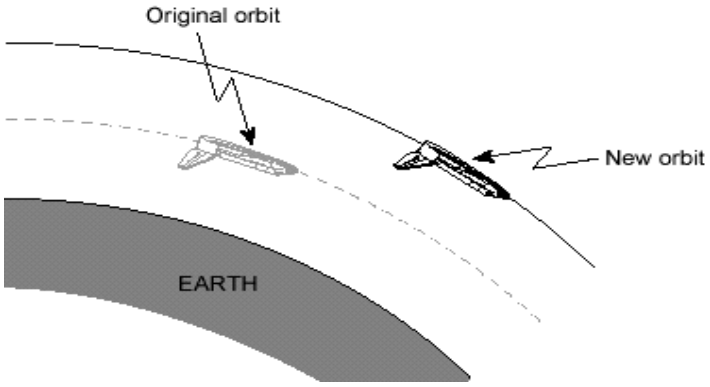
   (C) 4:1

   (D) 8:1

2. A rocket takes off from the launch pad with constant thrust. Which graph best shows how its acceleration and velocity change as it rises? Note: for the graphs below, the horizontal axis represents time and the vertical axis represents either the acceleration or velocity of the rocket.



3. A space shuttle is placed in a circular orbit around the Earth. It then applies a thrust from its engine and moves to a new orbit, as shown below.



   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

4. Two astronauts landed on a very small asteroid orbiting the Sun between Mars and Jupiter. They experienced almost negligible weight force. Which of the following statements best explains this?

(A) Because the asteroid is in a stable orbit around the Sun it will have zero mass.

(B) Because the asteroid is in a stable orbit around the Sun, the astronauts will apparently be weightless.

(C) Because the asteroid is very small it will have a very small gravitational force.

(D) The gravitational force on the asteroid is balanced by an equal and opposite gravitational force on the astronauts.

5. Which of the following is one of Einstein's postulates?

(A) The laws of physics are the same in all non-inertial frames of reference.

(B) The measured speed of light depends on the motion of the observer.

(C) The measured speed of light is independent of the motion of an observer.

(D) The luminiferous aether is unneccessary in explaining the propagation of light through space.

6. Planets A and B orbit the same star.

The orbital radius of planet B is four times that of planet A.

Which of the following is the magnitude of the orbital period for planet B, compared to the orbital period for planet A?

(A) 4

(B) 8

(C) 16

(D) 64

7. The Michelson-Morley experiment is sometimes regarded as the most important null result in the history of Physics because the expected observations did not occur.

What observation were Michelson and Morley expecting in their experiment?

(A) The Earth moving through the aether.

(B) Interference patterns on a screen caused by light reflecting off parallel mirrors.

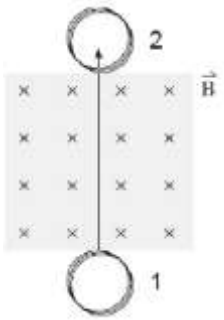
(C) Light waves passing through the vacuum of space in perpendicular directions.

(D) Changing interference patterns as the direction of the interferometer was changed.

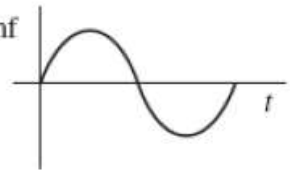
8. An AC motor is compared to a DC motor. Both motors are operating without a load on them. What is the effect on each of these motors when the supply voltage is increased?

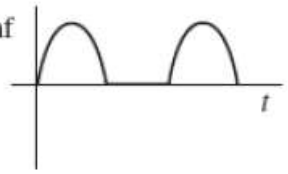
	Effect on AC motor	Effect on DC Motor
(A)	none	none
(B)	speeds up	speeds up
(C)	none	speeds up
(D)	speeds up	none

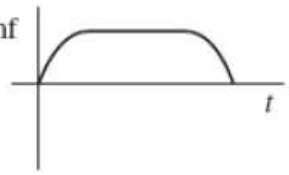
9. A coil moves at a constant velocity across a region of magnetic field as shown.

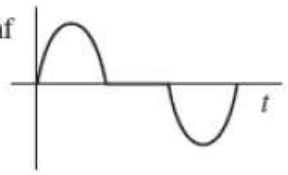


Which of the following best shows the emf vs. time graph for the emf induced in the coil as it moves from 1 to 2?

A. 

B. 

C. 

D. 

10. In which of the "motors" shown below would there be most chance of torque on the coil when the power was turned on? Note: images (C) and (D) show the plane of the coil is perpendicular to the axis of rotation

(A)

(C)

(B)

(D)

11. Which of the following statements describes the motor effect?

(A) A charged particle at rest experiences a force when a magnetic field is brought nearby.

(B) A charged particle experiences a force when an electric field is brought nearby.

(C) A turning moment acts on a loop of wire due to a mechanical force acting on it.

(D) A current in a conductor experiences a force when a magnetic field is brought nearby.

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

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

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

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

(D) the number of flux lines.

13. A square coil with dimensions12 cm × 12 cm which is perpendicular to the magnetic field has a force of 42 N acting on each side. What is the total torque acting on the coil if there are 16 turns of wire in the coil?

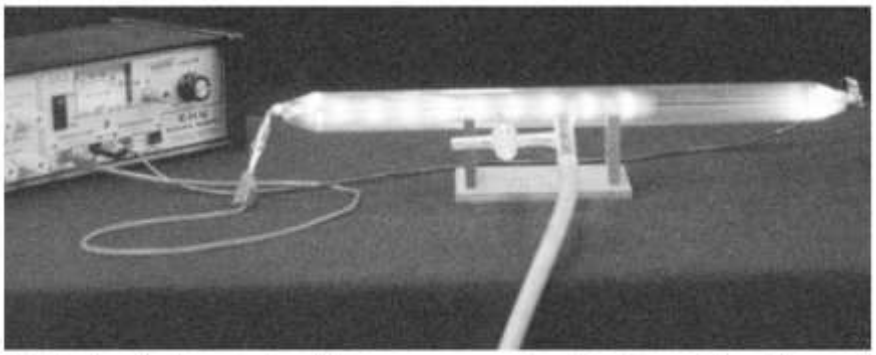
(A) 2.52 Nm

(B) 48.3 Nm

(C) 80.6 Nm

(D) 4032 Nm

14. The following image depicts a discharge tube experiment. The gas pressure in the tube is 0.1 mm Hg.



The glowing area at the right hand end of the tube is called

(A) Faraday's dark space.

(B) the anode glow.

(C) the cathode glow.

(D) Crooke's dark space.

15. The debate over the nature of cathode rays concerned which of the following possibilities?

(A) Cathode rays are either abstract concepts or actually exist.

(B) Cathode rays are either electromagnetic waves or streams of particles.

(C) Cathode rays are either light or matter.

(D) Cathode rays are an optical illusion or hallucination.

16. The significance of Heinrich Hertz's discovery of radio waves was this

(A) was the first experiment showing the existence of a subatomic particle.

(B) experiment provided the evidence needed to explain the interaction between light and matter.

(C) was the first experiment to identify an electromagnetic wave that was invisible.

(D) experiment confirmed Maxwell's theory of electromagnetic radiation.

17. What is the energy of a photon of wavelength 750 nm expressed in units of eV?

(A) 1.04×10^{-29} eV

(B) 2.66×10^{-19} eV

(C) 0.00166 eV

(D) 1.66 eV

18. The relative number of free electrons that can drift from atom to atom in conductors, semiconductors and insulators can be described as:

(A) conductors > semiconductors > insulators.

(B) conductors > insulators > semiconductors.

(C) insulators > conductors > semiconductors.

(D) all have about the same numbers of free electrons.

19. Electrical resistance in metals is increased by the presence of

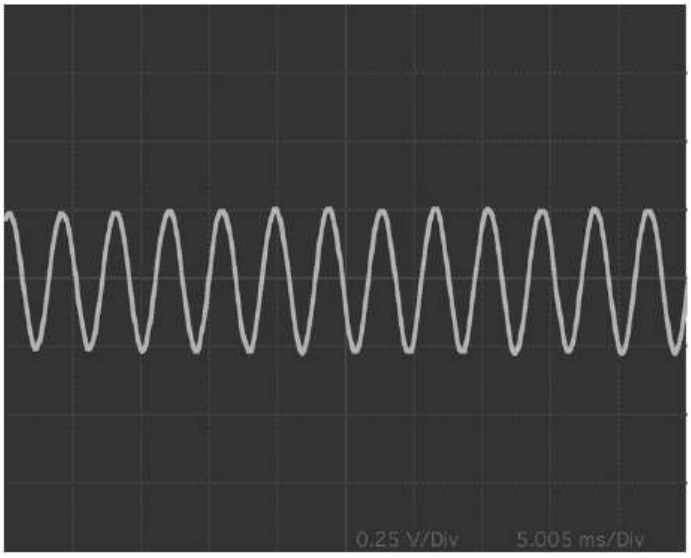
(A) impurities in the lattice.

(B) increased temperature.

(C) increased length.

(D) all of the above.

20. A sinusoidal pattern is produced on the screen of a cathode ray oscilloscope, as shown below.



The trace from a CRO produced by an AC current.

This pattern is produced by which of the following?

(A) A vertical electric field which is oscillating and a constant horizontal electric field.

(B) A vertical electric field which is constant and an oscillating horizontal electric field.

(C) A vertical magnetic field which is oscillating and a constant horizontal electric field.

(D) A vertical electric field which is oscillating and a constant horizontal magnetic field.

Name ……..

Class/Teacher: . . . . . .

GIRRAWEEN HIGH SCHOOL

PHYSICS

2014

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** ⬭

2014 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 (6 marks)

A 4.00×10^2 kg satellite completes one orbit around Earth in 2 hours exactly.

(a) Calculate the radius of this satellite's orbit. (2 marks)

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(b) What is the gravitational force acting on this satellite? (2 marks)

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(c) Explain the nature of the force acting on the satellite in relation to its subsequent motion. (2 marks)

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Question 22 (3 marks)

A large rock is dropped from a plane flying horizontally at an altitude of 4.00×10^3 m and with a speed of 900 km h^{-1}.

(a) Calculate the distance that the rock will move horizontally before hitting the ground. (1 mark)

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(b) Find the velocity of the rock just before it hits the ground. (2 marks)

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Question 23 (3 marks)

Discuss the reasons why spacecraft need to re-enter Earth's atmosphere at the correct angle and explain how the problem of excess heat is dealt with.

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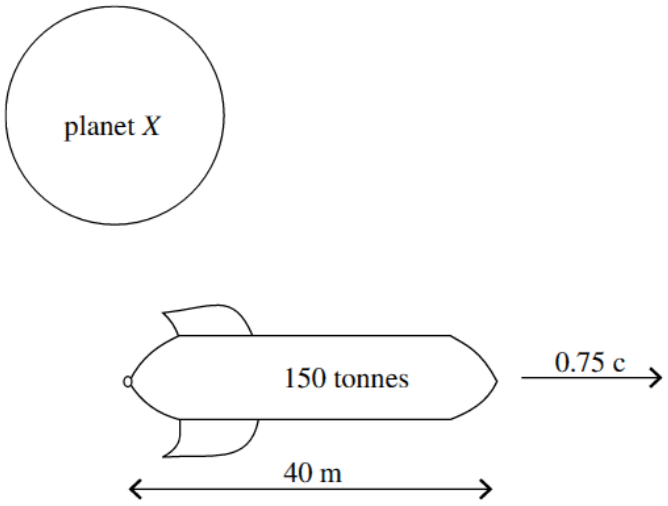
Question 24 (4 marks)

A rocket of mass 150 tonnes and length 40 m passes planet X at 0.75 c.



(a) What is the length of the rocket as measured by observer Alice, on planet X? (1 mark)

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(b) What is the mass of the rocket as measured by one of the crew, Bob, on the rocket? (1 mark)

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(c) As the rocket passes planet X, it fires its engines, producing a constant net force on the rocket. State why, from the point of view of Alice on planet X, this constant force results in a decreasing acceleration of the rocket. (2 marks)

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Question 25 (2 marks)

Explain how the 'slingshot effect' can increase the speed of a rocket without using fuel or violating the law of conservation of energy.

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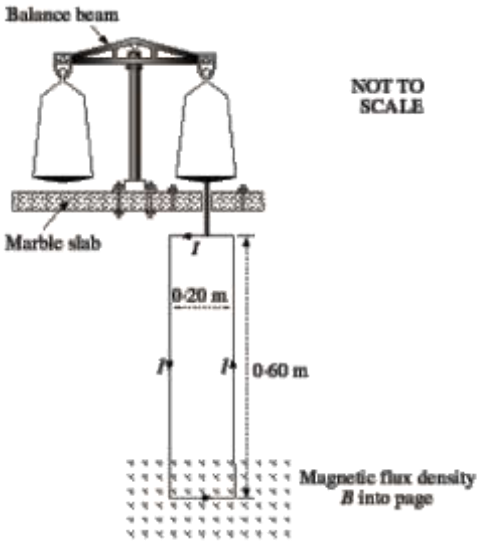
Question 26 (5 marks)

An apparatus, shown below, is designed to measure the magnetic flux density B of a magnet.



The rectangle is a coil of 7 turns of width 0.20 m and length 0.60 m. A current I of 0.30 A flows anticlockwise around the loop. Under these conditions the balance is in equilibrium.

(a) What is the direction of the magnetic force on the lower horizontal section of the loop? (1 mark)

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(b) The force on the lower, horizontal section of the loop may be written $F = \alpha B$. Calculate the value of α using the information given above. (2 marks)

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Question 26 *Continued*

(c) The current is reversed so that it now flows clockwise with unchanged magnitude. It is found that an 8.0 gram mass needs to be added to the left pan of the balance to restore equilibrium. Calculate the magnetic flux density B. (2 marks)

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Question 27 (2 marks)

An electric motor is rotating at its maximum rate. The net current across the motor is measured at 2 A. When a force is applied to the motor to stop the rotation, the net current increases. Explain this observation.

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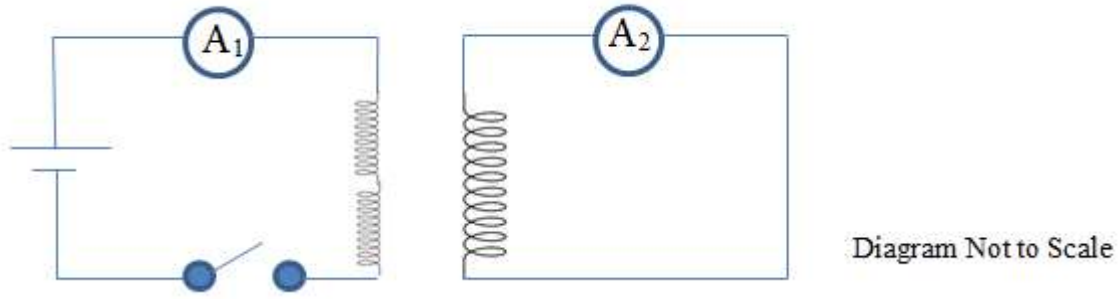
Question 28 (3 marks)

A D.C power source was set up in series with an ammeter, a solenoid (20 turns) and an open switch. Another circuit was setup with an ammeter and solenoid (10 turns). Both circuits were positioned as shown in the diagram below.



When the switch was turned on ammeter 1 measured a steady current. Ammeter 2 initially measured a smaller current compared to the value in ammeter 1, before returning to zero.

Explain these observations with reference to appropriate physics principles.

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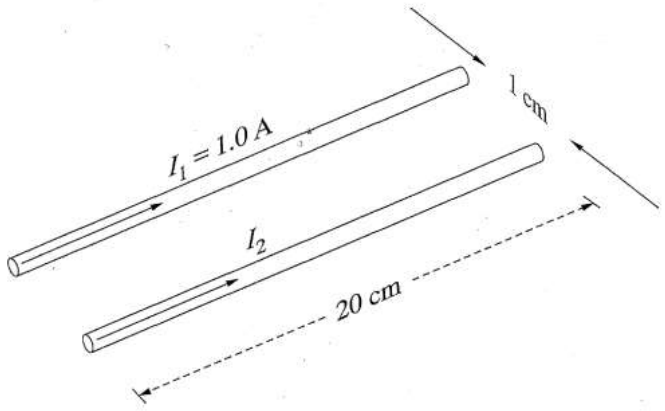
Question 29 (5 marks)

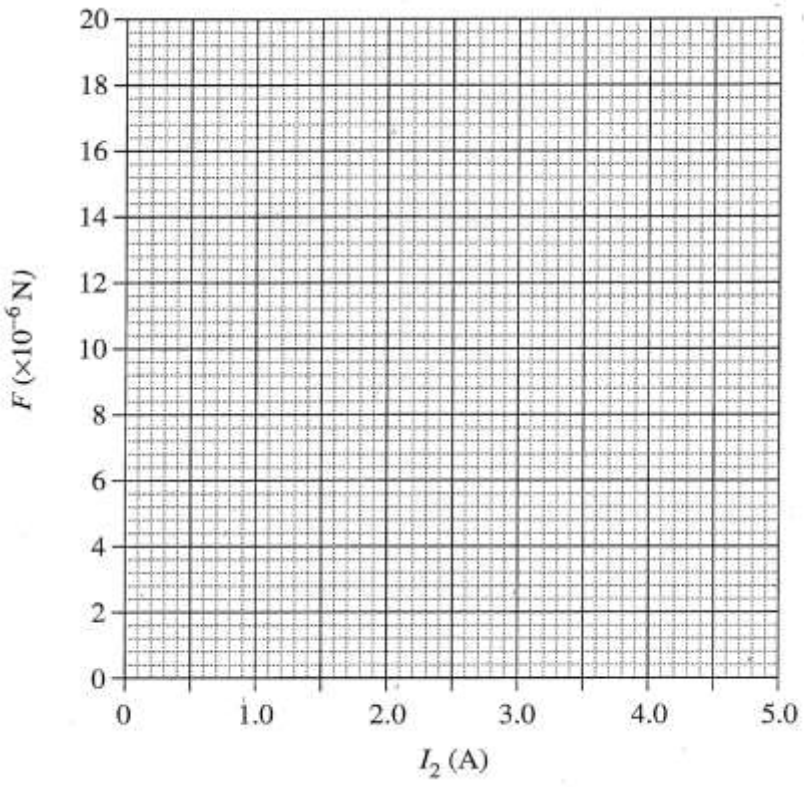
The diagram shows part of an experiment designed to measure the force between two parallel current-carrying conductors.



The experimental results are tabulated below:

I_2 (A)	Force ($\times 10^{-6}$ N)
0	0
2.0	7
3.0	11
4.0	14
5.0	18

(a) On the grid below, plot the data and draw in a line of best fit. (2 marks)



Question 29 *Continued*

(b) Calculate the gradient of your line of best fit (show all working). (1 mark)

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(c) Determine the value of *k*, the magnetic force constant. (2 marks)

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Question 30 (3 marks)

Propose arguments that Westinghouse could have used to convince authorities of the advantages of his system of generation and distribution of electrical energy over Edison's.

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Question 31 (2 marks)

Explain, using appropriate equations, how the law of conservation of energy applies to an ideal transformer.

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Question 32 (5 marks)

An electron is released from a cathode by thermionic emission and then accelerated in an electric field. The separation distance between the cathode and anode is 0.12 m and the potential difference is 150 volts.

(a) Describe the process of thermionic emission. (1 mark)

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(b) Determine the strength of the electric field. (1 mark)

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(c) Determine the acceleration that the electron will experience due to the field. (1 mark)

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(d) Determine the work done on the electron by the field. (1 mark)

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(e) Determine the velocity of the electron when it reaches the anode. (1 mark)

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Question 33 (3 marks)

Superconductors can be formed from several types of materials and are classified into two categories based on their composition.

(i) Define critical temperature. (1 mark)

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(ii) State the typical critical temperature ranges for each of the two major categories of superconductors. (1 mark)

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(iii) Describe the type of materials that form each type of superconductor. (1 mark)

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Question 34 (3 marks)

In 1905 Einstein suggested *"the energy of a light ray spreading out from a point source is not continuously distributed over an increasing space but consists of a finite number of energy quanta which are localized at points in space, which move without dividing, and which can only be produced and absorbed as complete units."*

Identify the model of light being proposed in the above statement and explain the significance of this model.

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Question 35 (3 marks)

Summarise, using an appropriate labelled diagram and text, the effect of light on semiconductors in photovoltaic solar cells.

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Question 36 (3 marks)

Outline the methods used by the Braggs to determine crystal structure.

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Name:
Class:

Teacher:

2014 GIRRAWEEN HIGH SCHOOL
TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Physics

Section II

25 marks
Allow about 45 minutes for this section

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

Show all relevant working in questions involving calculations.

Question 37 — Medical Physics (25 marks)

(a) Sound is used as a diagnostic tool in modern medicine.

(i) Identify which property of sound is used to produce an ultrasound measurement. (1 mark)

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(ii) Identify the frequency range which is defined as ultrasonic. (1 mark)

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(iii) Outline how a piezoelectric crystal is used to detect an ultrasound wave. (3 marks)

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(iv) Describe two advantages of ultrasound diagnostic technology. (2 marks)

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(b) The images below show a bone scan on the left and a PET of a different person on the right.

(i) Compare the two techniques used in producing these images. (4 marks)

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(ii) Evaluate the usefulness of radioactivity in medicine. (4 marks)

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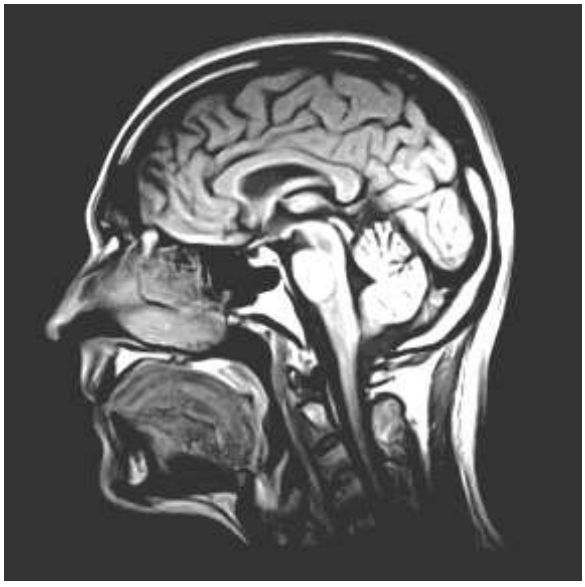
(c) In a MRI machine nuclear magnetic resonance is exploited to produce highly detailed structural and functional images of tissues such as that shown below.



(i) Explain the concept of resonance. (2 marks)

. . . . . .

. . . . . .

(ii) Identify which structures in the body resonate. (1 mark)

. . . . . .

(iii) Explain why protons precess in the presence of a magnetic field. (2 marks)

. . . . . .

. . . . . .

. . . . . .

(iv) Define relaxation time. (1 mark)

. . . . . .

. . . . . .

(v) What type of data is used to construct an image in a MRI machine? (1 mark)

. . . . . .

. . . . . .

. . . . . .

(vi) Describe the relationship between the gradient field, the radio frequency pulses and the position within the volume of the patient that is being measured. (3 marks)

. . . . . .

. . . . . .

End of exam

2014 Trial HSC Physics

Marking Guidelines

Section I, Part A

Multiple-choice Answer Key

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

MC worked solutions

1.

$$\frac{G2M}{\left(\frac{1}{2}r\right)^2} : \frac{GM}{(r)^2}$$

$$\frac{G2M}{\left(\frac{1}{4}r^2\right)} : \frac{GM}{(r)^2}$$

$$\frac{8GM}{r^2} : \frac{GM}{r^2}$$

$$8 : 1$$

2. With a constant thrust there is constant force. The rocket consumes some of the mass of the fuel so the constant force produces an hyperbolically increasing acceleration. The velocity will also be inceasing nonlinearly but not in the same way.

3. the orbit velocity eqn should be examined $v = \sqrt{\frac{GM}{r}}$ and so $v \propto \frac{1}{\sqrt{r}}$ and as r inceases v **decreases**.

4. look at $F = G\frac{m_1 m_2}{r^2}$....$F \propto m$, so less mass means less gravity means less weight

5. The correct postulate refers to light speed as constant and independent of the motion of an abserver. Option D, while true, is not a postulate but a statement.

6. if rb = 4 ra then $\left(\frac{1}{4}\right)^3 = \left(\frac{T_a}{T_b}\right)^2 \; so \; \frac{T_a}{T_b} = \sqrt{\left(\frac{1}{4}\right)^3} = \frac{1}{8}$

7. Had the aether effect been real, the MM experiment would have shown that the interference pattern changes upon change of orientation of the experiment.

8. AC and DC motors are the same apart from the commutator, so they will both respond in the same way. When voltage is increased the available energy do work is increased and the rotation speed will increase.

9. The coil has an emf induced only as there is a non-zero rate of change of magnetic flux, which is occurring only as it enters and leaves the field. Since entering and leaving are opposite actions the polarity of the induced emf will also be opposite. Option D.

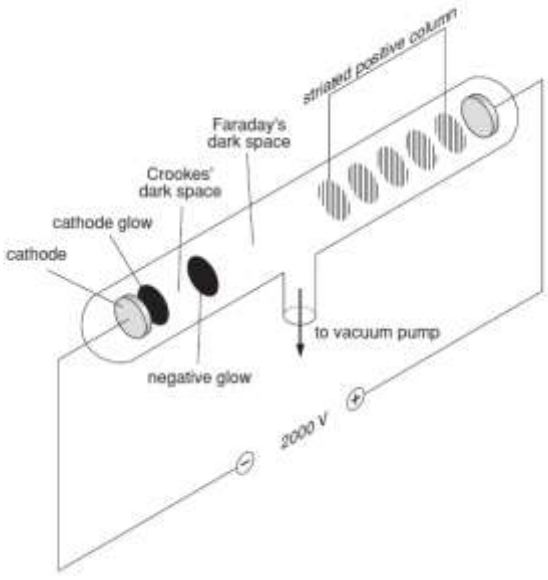
10. Option D works since the coil is currently in the plane of the magnetic field and the relative position of the coil and magnet will provide the current at the correct angle for the motor effect.

11. The motor effect occurs when a current-carrying wire interacts with a magnetic field oriented at 90° to the current direction. A force will be experienced by the wire. The direction of this force is at 90° to both the directions of the B field and the current in the wire, and can be found using the right hand push rule.

12. $\frac{\phi}{A} = B$

13. if the coils experiences the force per turn, then t = $2 \times 16 \times 42 \times 0.06$ = 80.64 Nm

14.



option c

15. The problem was identification of the nature of a cathode ray: wave or particle?

16. Hertz was able to identify the phenomena of produced in his experiment as electromagnetic waves after determining the wavelength and find the wave speed to be *c*. This was the first EMR that was not visible light to be identified.

17. in eV, $E = \frac{hc}{q\lambda} = \frac{6.626\times10^{-34}\times3\times10^{8}}{1.6\times10^{-19}\times750\times10^{-9}} = 1.66$

18. option A because conductors by definition have large populations of free electrons, Semiconductors only have small populations but can be manipulated to increase conductivity, whereas insulators do not possess free electrons at all.

19. $R = \frac{\rho L}{A}$ at a given T, so option D.

20. option A. To make the sine wave pattern we need vertical oscillation combined with a constant sweep horizontally.

Section 1 Part B

Question 21

Marking Criteria	Marks
(a)	
• Correct answer calculated.	**2**
• Answer calculated with error made in units and one other error OR • Two steps of the calculation performed correctly	**1**
(b)	
• Answer calculated correctly	**2**
• Calculation made with an error	**1**
(c)	
• All appropriate reasons given + correct angle to the motion direction + correct identification of force direction	**2**
• One appropriate reason given	**1**

Solutions

a)

T = 2 x 60 x 60 = 7200 s

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

$$r = \sqrt[3]{\frac{GM}{4\pi^2} \times T^2}$$

$$= \sqrt[3]{\frac{(6.67\times10^{-11})\times(6.0\times10^{24})}{4\pi^2} \times (7200^2)}$$

$$= 8.1\times10^{6} \text{ m}$$

b)

$$F = G\frac{m_1 m_2}{d^2}$$

$$= 6.67\times10^{-11}\,\frac{(4.00\times10^{2})\times(6.0\times10^{24})}{(8.07\times10^{6})^2}$$

$$= 2.46\times10^{3} \text{ N}$$

Note: check carry-over error from part (a).

c)

Satellite's orbit is circular and the net force (gravitational force) is always **perpendicular** to the direction of motion and **directed to the centre of the Earth**, i.e. the centre of the orbital path.

Question 22

Marking Criteria	Marks
(a)	
• Correct answer	**1**
(b)	
• Correct velocity given with correct units and correct angle	**2**
• Calculations performed with an arithmetic error OR • Correct speed given without angle	**1**

Solutions

a)

$900 \text{ km h}^{-1} = 250 \text{ m s}^{-1}$

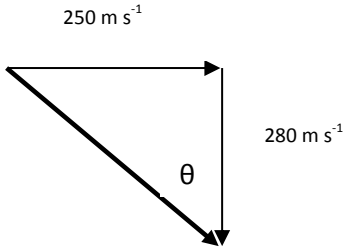
$$\Delta y = u_y t + \frac{1}{2} a_y t^2$$
$$4000 = 4.9t^2$$
$$t = 28.57 \text{ s}$$

$$\Delta x = u_x t$$
$$= 250 \times \text{t}$$
$$= 7142.5 \text{ m}$$
$$= 7.14 \times 10^3 \text{ m}$$

b)

$$v_x = u_x$$
$$= 250 \text{ m s}^{-1}$$
$$v_y = u_y + a_y t$$
$$= 0 + 9.8 \times 28.57$$
$$= 280 \text{ m s}^{-1}$$

$v_y^2 = 250^2 + 280^2$



$$v_y = 375 \text{ m s}^{-1}$$
$$\tan \Theta = \frac{250}{280}$$
$$\theta = 42^o \text{ from vertical (or } 48^o \text{ from horizontal)}$$

Question 23

Marking Criteria	Marks
• Identifies correct reasons for approach angle+ identify correctly the angles of entry • Heat shield use is explained (cause + effect)	**3**
• One error	**2**
• Two errors	**1**

Solutions

The carft must approach at an angle of **between 5° & 7°.** Too shallow an approach and the shuttle bounces off the atmosphere like skimming stones on water. Too steep and the friction with the atmosphere will be too much and the shuttle will be destroyed. The heat shield consis of its of cermaic tiles which insulate the base of the craft from the heat of atmospheric friction. The shape of the nose (blunt) creates a shockwave in front of the nose which keeps most of the heat from being in direct conact with the surface of the shuttle.

Question 24

Marking Criteria	Marks
(a)	
Correct answer to appropriate number of significant figures	**1**
Incorrect answer or not rounded to appropriate number of significant figures	**0**
(b)	
Correct answer with correct units	**1**
Incorrect answer or Incorrect units	**0**
(c)	
Correct statement of mass dilation and explanation of how this affects acceleration and hence velocity	**2**
Correct statement of mass dilation OR partial explanation of effect on acceleration	**1**

Solutions

(a) Lorenz contraction:

$$L_v = L_o\sqrt{1-\frac{v^2}{c^2}}$$

$$= 26 \text{ m}$$

b) 150 tonnes

c) In Alice's frame of reference, the mass of the rocket increases as its speed increases. a=F/m so as the rocket's speed increases, its acceleration decreases – approaching zero as its speed approaches the speed of light.

Question 25

Marking Criteria	Marks
Identifies: • that a slingshot manoeuver is an elastic collision • that the speed of the rocket is increased while the speed of the planet is decreased • that the much greater mass of the planet means that its speed is decreased by a negligible amount	**2**
A complete explanation of two of the above points or an incomplete explanation of all three	**1**

Solution

The slingshot effect involves an elastic interaction between planet and rocket – the total momentum and kinetic energy of the planet–rocket system is the same before and after. The velocity of rocket and planet, with respect to the Sun, both change as a result of the interaction. However, because the mass of the rocket is many orders of magnitude smaller than that of the planet, the interaction causes a change in the rocket's velocity many orders of magnitude larger than that of the planet.

Question 26

Marking criteria	Marks
(a)	
• Correct answer given	1
(b)	
• Correctly identifies and substitutes in all correct values • Correct Answer given	2
• Single error in substitution AND corresponding answer is correct based on working	1
(c)	
• Correctly calculates value of B WITH units	2
• Single error in calculation	1

Solution

a) Up

b)_ n = 7 , Width = 0.2m , length = 0.6m, current = 0.3 A

F = nBILsinϴ

Were α = nILsinϴ

= 7 × .3 × 0.2 × Sin90

= 0.42 Ampere metres

c) w = mg

= 8 × 10-3 × 9.8

= 0.0784 N

Fw = FB

F = B α

B = 0.0784 / 0.42

= 0.1866 T

Question 27

Marking criteria	Marks
• Identifies link between back emf and rotation of motor • Demonstrates understanding that back e.m.f opposes supply e.m.f. • Concluding statement that when the coil stops rotating the net emf increases and so does the current	3
• Only 2 of the above criteria mentioned.	2
• Back emf identified with no link to theory	1

Solution

- The net current measured across a motor is given by : Currentnet = CurrentSuplly – Back e.m.f.
- As the motor is spinning a maximum, the rate in change in flux resulting in a back e.m.f, which is in the opposite direction to the supply (In accordance with Len's Law)
- When the motor is stopped, there is no Back E.M.F, due to no change in flux experience in the coils. The current measured now would only be the supply current. This supply would be larger as the Back emf is zero.

Question 28

Marking criteria	Marks
• Identifies initially there is a change in flux due to switched turned on. Results in a current in the 2nd circuit. • Correct reasoning for current being less • Ammeter 2, will return to zero, when current is a maximum → no change in flux → no current	3
• Only 2 of the above criteria mentioned.	2
• Does not mention flux	1

Solution

- When the switch is initially turned on, D.C. current flows through the solenoid 1, the current is approaching a maximum; there is a changing magnetic field that is initially changing.

- This initial change in the B field results in the 2nd solenoid experiences a change in flux, which results in a induced current.

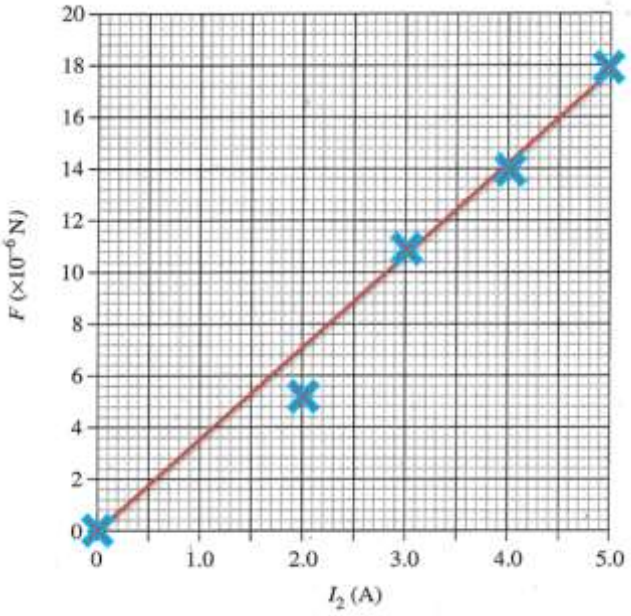
- From faraday law e.m.f = -n $\Delta\Theta/\Delta t$, the current in the 2nd coil should be less than the original as it as a smaller number of coils (number of turns). A reason for this can be a different resistance in the second circuit or due to energy losses.

- Once the D.C is at a maximum value, the B field will not change. As a result there will be no change in flux, resulting in no e.m.f generated in the second coil. (no current)

Question 29

Marking criteria	Marks
(a)	
• points correctly plotted using X • LOBF drawn correctly	2
• Single error	1
(b)	
• Correct answer given using LOBF with correct scientific notation	1
(c)	
• Correct value for k calculated using gradient value	2
• Value calculated not using gradient OR • Single error in substitution into correct equation	1

Solution



b) M = rise/run = 18 × 10-6 / 5

= 3.6 × 10-6

c)

$\frac{F}{l} = k\frac{I_1 I_2}{d}$

$m = \frac{kI_1 l}{d}$

$k = \frac{dm}{I_1 l} = \frac{0.01\times3.6\times10^{-6}}{1.0\times20\times10^{-2}} = 1.8 \times 10^{-7}$

Question 30

Marking criteria	Marks
• Outlines advantages of A.C OVER D.C; - Ability to be step-up and down - $P = I^2R \rightarrow$ reduce power loss with (equation) - Ability to be transmitted long distances - Reduced infrastructure	4
• As above without equation OR • Outlines ONLY advantages of A.C.	3
• Answer gives attributes of AC but has no references to DC • Supporting statements not expanding upon	2
• Features of AC discussed with brief outline but no clear evidence of understanding why it is an advantage	1

Question 31

Marking criteria	Marks
• Uses equations to explain answer • Conservation of power – conservation of energy is linked to answer • Identifies some energy could be lost to heat	2
• states equations only or no reference to law of conservation of energy	1

Solution

- In a prefect transformer power is conserved. When the voltage is stepped up the current is decreased.
- Pin = P out → Vin Iin = Vout I out

If the voltage is increased current will decrease accordingly, in this way energy is conserved. Any small lost is in the form of energy, but the overall energy of the system is conserved.

Question 32

Criteria	Marks
a)	
• Correct description of the phenomenon	**1**
b)	
• Correct value obtained.	**1**
c)	
• Correct value obtained.	**1**
d)	
• Correct value obtained.	**1**
e)	
• Correct value obtained.	**1**

Solution

(a) Thermionic emission involves passing an electric current through a filament (thin wire) which will be heated by resistive heating and causing electrons to "boil" off the surface.

(b) $E = \frac{V}{d} = \frac{150}{0.12} = 1250\ V/m$

(c) $a = \frac{q\,V}{m\,d} = \frac{1.6\times10^{-19}\times150}{9.1\times10^{-31}\times0.12} = 2.22\ \times 10^{15}\ \frac{m}{s^2}$

(d) $W = q\,V = \ 1.6 \times 10^{-19} \times 150 = 2.4 \times 10^{-17}\ J$

(e) $q\,V = \frac{1}{2} m\,v^2$, so $v = \sqrt{2\frac{q\,V}{m}} = 2.3 \times 10^{7}\ m/s$

Question 33

Criteria	Marks
i)	
• Correct definition	**1**
ii)	
• Correct ranges given	**1**
iii)	
• Correct material categories given.	**1**

Solution

I. Below the critical temperature of a superconductor its electrical resistance is zero.

II. Type I < 5° Kelvin (will accept < 10° K or "close to zero Kelvin"
Type II 40° K < Tc < 130° K

III. Type I are typically pure metals
Type II are typically ceramic compounds

Question 34

Criteria	Marks
• Response shows a deep understanding of the issue • Model is correctly identified as the wave_and_particle model and discriminated from wave_or_particle debate • Significance is well explained in detail • "Photons" is mentioned	**3**
• Response shows a sound understanding of the issue • Model is identified as the wave_and_particle model • Significance is outlined • "Photons" is mentioned	**2**
• Response shows a minimal understanding of the issue AND makes • One relevant correct statement only	**1**

Solution

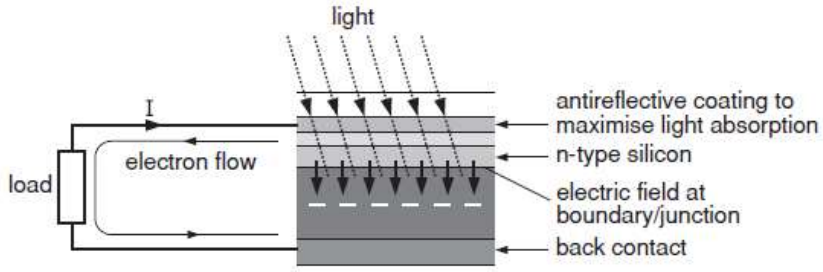
The model being proposed here is the wave-particle model of light. This is significant because it is the first time anyone had proposed that light might have a particle-like nature in addition to its wave-like nature. Previous proposals involved light being either a wave or a particle. Its was the radical step of suggesting that light is both wave and particle and then being able to explain all interactions between light and matter that earned Einstein his Nobel Prize. Light particles were later called *photons,* a term not used by Einstein or Planck.

Question 35

Criteria	Marks
• Response includes diagram and text • All features of the PV cell are shown including external circuit • Text has correct detailed explanation of PV function • All appropriate labels exist	**3**
• Response includes diagram and text • Most Features of the PV cell are shown (must haves: p-layer, n-layer on top, light enters and penetrates to junction, current direction indicated) • Text has correct brief explanation of PV function • All illustrated features have labels	**2**
• Draws a p-n junction only AND makes some indication that light energy is converted to electrical energy	**1**

Solution

When light strikes the cell, some of the electrons in the p–type are freed up by the photoelectric effect. They are accelerated by the electric field across the boundary into the n–type layer. Holes are then formed in the p–type layer.



The photoelectrons that are now in the n–type layer travel around the circuit to the p–type layer; that is, they return to the layer from where they came. They could not travel across the boundary, but could travel around the external circuit. This current is able to do work.

Question 36

Criteria	Marks
• Response indicates a deep understanding of the question • Diffraction is well described • Size-similarity between x-ray wavelength and inter-atomic distances is mentioned • Uniqueness of diffraction patterns is mentioned OR non-destructive nature of measurement is mentioned	**3**
• Response indicates a sound understanding of the question • Diffraction is described • Mention of Size-similarity between x-ray wavelength and inter-atomic distances is attempted • Uniqueness of diffraction patterns is mentioned OR non-destructive nature of measurement is mentioned	**2**
• Diffraction is mentioned	**1**

Solution

The Braggs invented the technique of x-ray diffraction to investigate the structure of crystals. Diffraction is a phenomenon involving the interaction between a wave and a series of regularly arranged barriers. When a wave passes through an array of barriers that are separated by distances that are of the same order of magnitude as the wavelength of the wave there will be a characteristic interference pattern on the other side when the waves recombine after passing through the array. The inter-atomic distances in crystals are of the right size to allow the use of x-rays to produce diffraction patterns. This enabled a technique of materials analysis that could measure internal structures in a non-destructive manner.

Question 37 a (ultrasound)

Criteria	Marks
i)	
• Correct property given	**1**
ii)	
• Correct value given and unit	**1**
iii)	
• Correct function of PZ • Id's that pressure from echo wave will cause voltage • Voltage gets amplified • Signal is measured	**3**
• Id's that pressure from echo wave will cause voltage only PLUS one of • Correct function of PZ • Voltage gets amplified • Signal is measured	**2**
• Id's that pressure from echo wave will cause voltage only	**1**
iv)	
• Two valid advantages given	**2**
• Only one valid advantage given	

Solutions

(f) Ultrasound Questions

a. Reflection
b. Ultrasound f > 20 kHz
c. A PZ will generate a measurable voltage when compressed by the returning echo. This voltage is amplified to produce the signal.
d. 1 – inexpensive, 2 – fast, 3 – non invasive, 4 – safe

Question 37 b (radioactivity)

Criteria	Marks
i) comparison of BS & PET	
• 3 similarites • 3 differences	**4**
• One item missing	**3**
• Two items missing	**2**
• 3 items missing	**1**
ii) evaluation of nuclear medicine	
• Response shows a deep understanding of the issue • Gives detailed examples linking techniques to isotopes and conditions tested • Indicates extent of the problem of cancer • Implicit or explicit judgement is offered	**4**
• Response shows a thorough understanding of the issue • Gives examples linking techniques to isotopes and conditions tested • Indicates extent of the problem of cancer • Implicit or explicit judgement is offered	**3**
• Response shows a sound understanding of the issue • Gives one example linking techniques to isotopes and conditions tested • No Implicit or explicit judgement is offered	**2**
• One sensible relevant idea only	**1**

Solutions

(a) Radioactivity Questions

a. Comparison of Bone Scan (BS) and Positron Emission Tomography (PET) scan

similarities	differences
Both use radioactivity	BS uses flat gamma camera PET uses ring camera
Both locate tumours and tissue abnormality	PET isotope produces p+ when then produce γ rays BS isotope produces γ directly
Same resolution of image	BS scan bones PET scans soft tissue

b. Evalution of the usefulness of nuclear medicine.

Judgement: Nuclear medicine saves lives, its safe to use, and nuclear waste is not such a problem here. That is the primary reason why we use it.

Cancer has become one of the leading causes of death in Australia, with death rates in the 10'000s nationwide each year. (43000 in 2011)

NM can detect a wide range of cancers (brain, kidney, liver, skeletal) via a number of techniques e.g. Bone Scanning and PET. Early detection has become possible through the use of advanced scanning techniques such as high resolution mammograms (breast cancer) and PSA measurement (prostate cancer). As cancers can be located and treated earlier many lives are saved.

Clever use of ½ lives means that the radioactive isotopes themselves cause no harm to patients. (e.g. I 131 [thyroid] = 8 days, Technetium99 [thyroid, liver, blood] = 6 hours)

Only some isotopes require a nuclear reactor. Many can be made in cyclotrons at hospitals.

Nuclear reactors do generate radioactive waste but new ones are very safe. The problem of waste disposal is not so difficult that it prevents the use of nuclear isotopes.

Question 37 c (MRI)

Criteria	Marks
i)	
• Concept is explained i.e. cause is related to effect	**2**
• Concept is described	**1**
ii)	
• Correct structure identified	**1**
iii)	
• Concept is explained i.e. cause is related to effect	**2**
• Concept is described	**1**
iv)	
• Term is defined correctly	**1**
v)	
• Term is described correctly	**1**
vi)	
• Relationship is described correctly	**1**

Solutions

MRI Questions

i. The resonant frequency of an object is a characteristic of its structural properties. Pulsing at object at its resonant frequency will cause large vibration amplitudes and can destroy it.
ii. Protons are resonating
iii. Precession is the movement in a conical path of the axis of rotation of a spinning object. Protons precess due to the interaction of their charge (and hence their magnetic moment) and the magnetic field that they are algning to. Charges feel forces due to magnetic fields and hence are accelerated by them. The forces are perpendicular to the velocity of the charge and produce circular motion.
iv. Relaxation time is the time it takes for the proton precession to realign itself to the strong magnetic field after the application of the RF pulse.
v. What is measured is the voltage induced in the receiving coil by the RF signal coming from the relaxing protons. It shows how the signal dies away in time and is a function of the physical interactions between protons (t2) and between protons and surrounding molecules(t1).
vi. The gradient field is added to the main magnetic field to enable location of volume element by field strength. Since the Lamour frequency is a function of the field strength, particular RF frequencies will locate specific volume elements in the patient's body.

NOTE: MRI works on the principle that your body (brain included) consists largely of water, which in turn is made up of oxygen and hydrogen molecules. The hydrogen molecules have a magnetic spin that can be aligned by a strong burst of radio-frequency waves. Once this is done, a second pulse knocks the hydrogen molecules out of spin alignment. A computer then records how long the atoms of different tissues take to realign themselves. As they realign themselves the protons emit radio frequency EM signals that die away in a manner characteristic of the interactions they have with either each other or the surrounding tissue.

These EM signals induce electric currents in the coils at specific frequencies. Since the gradient field is used to map the RF frequency onto the body volume elements via the Lamour equation, it is possible to use the induction information to construct images of the structures and even over time to observe functionality of structures.