GIRRAWEEN HIGH SCHOOL
2016
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

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 - 35**
- Allow about 1 hour and 40 minutes for this part

Section II

25 marks

- Attempt **Questions 36-40**
- Allow about 45 minutes for this section

Section I

75 Marks

Part A - 20 Marks

Attempt Questions 1-20

Allow 35 Minutes for this part

Use the multiple-choice answer sheet for questions 1-20

Instructions for answering questions in Section 1 Part A

- Complete your answers in either blue or black pen
- Multiple choice

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

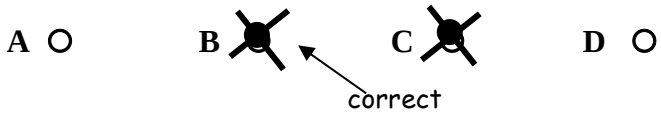
Sample 1: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

A ○ **B** ● **C** ○ **D** ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ○ **B** ⊗ **C** ● **D** ○

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



1 An object weighs 200 N at sea level on Earth. On Mars the local acceleration due to gravity is 3.75 m/s^2. What is the object's weight on Mars?

(A) $\frac{200}{9.81} \times \frac{1}{3.75}$ N

(B) $\frac{9.81}{200} \times 3.75$ N

(C) $\frac{200}{3.75} \times 9.81$ N

(D) $\frac{200}{9.81} \times 3.75$ N

2 Which of the following statements is not true?

(A) As an object's altitude is increased, work has to be done against the gravity field.

(B) As an object's altitude is altered work is always done against the gravity field.

(C) As an object's altitude is decreased, work is done by the gravity field.

(D) If an object's altitude does not change, then no work is done.

3 According to an observer at rest, an astronaut travelling at 0.99c in a spaceship will experience time dilation. What will be the length of one hour as observed by the astronaut on a clock in her spaceship?

(A) 360 s

(B) 2552 s

(C) 3600 s

(D) 25 520 s

4 The value of the local acceleration due to gravity is not uniform when measured at the same altitude at a variety of locations above the surface of a planet. What would *not* affect the measurement of this value?

(A) The distribution of mass density of the planet.

(B) The speed of the planet's rotation.

(C) The average mass density of the planet.

(D) The shape of the planet was not spherical.

5 Galileo's analysis of projectile motion includes which of the following concepts?

(A) The trajectory of the projectile is independent of its mass.

(B) The velocity of a projectile remains constant.

(C) The horizontal velocity of a projectile remains constant, while the vertical velocity of a projectile is affected by gravity.

(D) The vertical velocity of a projectile remains constant, while the horizontal velocity of a projectile is affected by gravity.

6 The moon has an escape velocity at the surface of 2375.86 m/s and a radius of 1737 km. The mass of the moon would be calculated to be

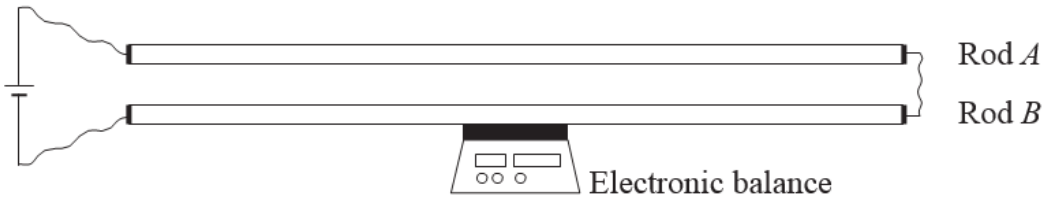
(A) 3.56×10^{19} kg

(B) 7.35×10^{22} kg

(C) 1.9×10^{23} kg

(D) 3.8×10^{23} kg

7 A student performed an experiment using two identical metal rods connected to a power supply. Rod B sits on an electronic balance. Rod A was kept fixed at a constant height above Rod B, and the current flowing through the rods was varied. The measurements on the electronic balance were recorded as shown below.



Which dependent variable is measured in this experiment?

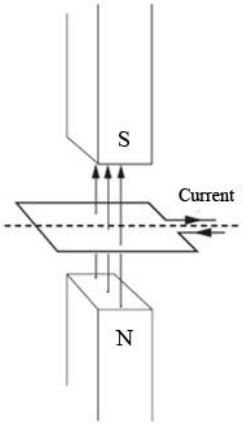
(A) The voltage on the power supply.

(B) The force exerted on rod *A* by rod *B*.

(C) The force exerted on rod *B* by rod *A*.

(D) The length of the rods.

8 An electric motor is set up as shown.



When current is supplied the coil does not turn. Which of the following is required for the coil to start turning?

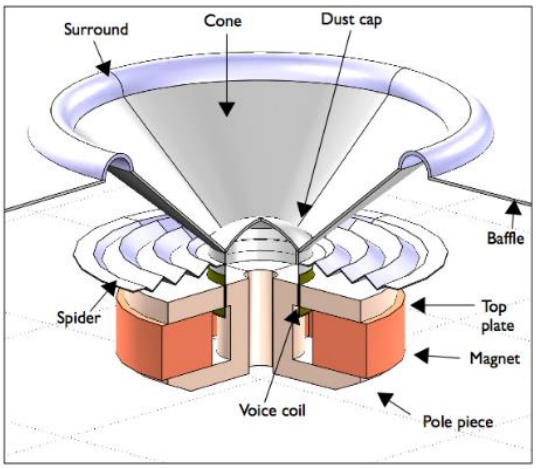
(A) The magnetic field must be increased.

(B) The direction of the current must be reversed.

(C) The magnitude of the current must be increased.

(D) The orientation of the coil must be changed.

9 The image depicts a loudspeaker.



The loudspeaker exploits which of the following?

(A) Electromagnetic induction

(B) The Meissner effect

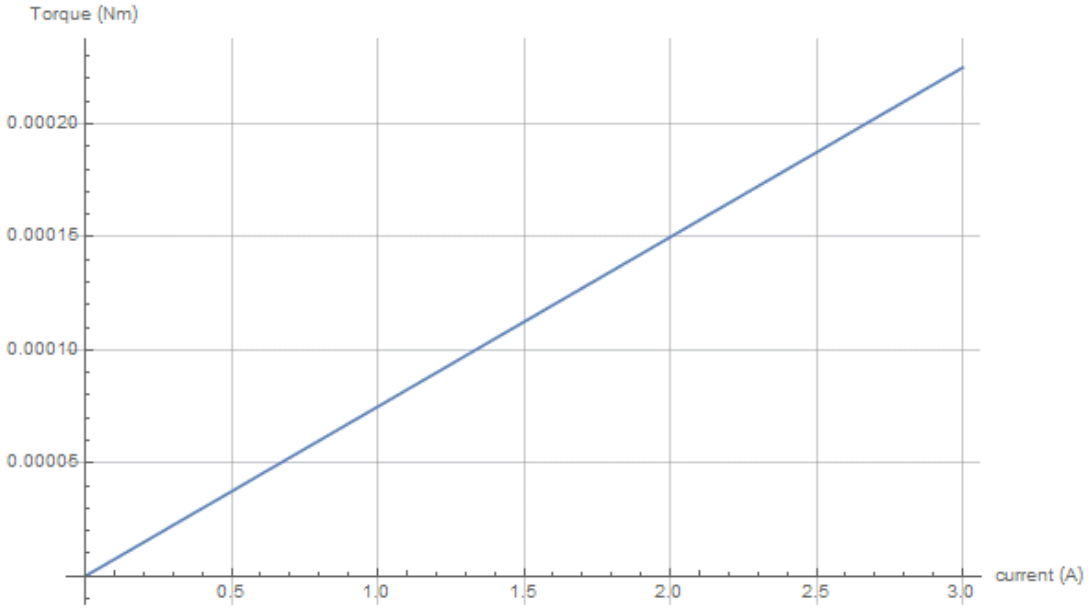
(C) The motor effect

(D) Ohm's Law

10 Which option *incorrectly* matches the part and its function in an AC generator?

	part	**function**
(A)	magnet	Provides the magnetic field
(B)	coil	Provides a conduction path into which the current induced
(C)	slip ring commutator	Reverses the polarity of the current as it emerges from the coil every half turn
(D)	brushes	Provides the connection between the external circuit and the commutator

11 The graph shows the variation of maximum torque in a motor as the current in the coil is varied.



Given that the magnetic field strength is 0.15 T and the geometry of the coil is 0.01×0.01 m, determine the number of turns in the coil.

(A) 1

(B) 5

(C) 10

(D) 15

12 What is analogous to magnetic flux and magnetic flux density?

(A)	Water moving through a pipe: The velocity of water per unit area of pipe represents the flux density. The volume of water moving in this area represents the flux.
(B)	A spring with a mass hanging from it: The displacement of the mass represents the flux density, the mass represents the flux.
(C)	A roller coaster: The change in altitude for the cart represents the flux density; the speed of the cart represents the flux.
(D)	Rain: The number of rain drops per unit area represents the flux density, the number of rain drops is the flux.

13 Which law governs how a transformer behaves?

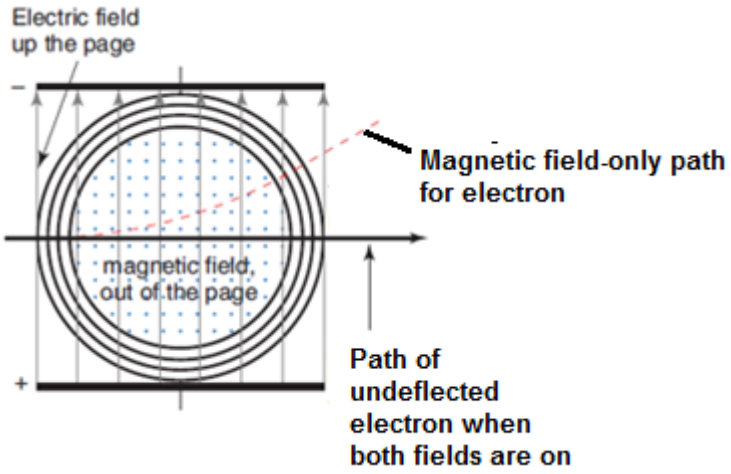
(A) Right hand grip rule

(B) The Law of Conservation of Energy

(C) The Law of Magnetism

(D) Lenz's Law

14 An electron moving at a speed of 100 m/s enters a uniform magnetic field perpendicular to the field. A research student then sets up two parallel charged plates so that the uniform magnetic field is inside the plates as shown below. The plates are separated by a distance of 10 cm with a voltage of 20 V between them.



What is the magnetic field strength required to keep the electron beam undeflected when both fields are operating?

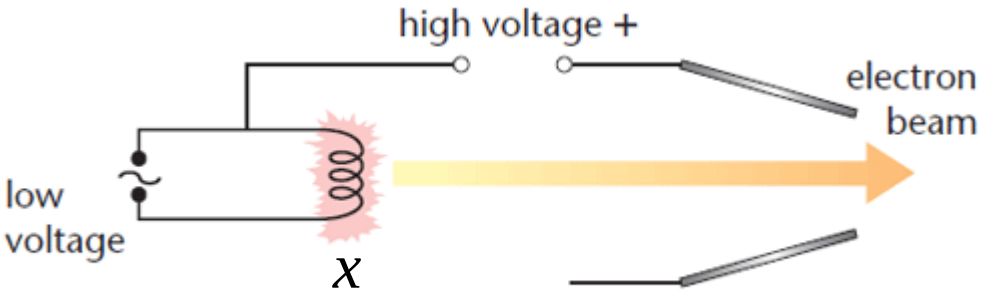
(A) 0.2 T

(B) 2.0 T

(C) 20.0 T

(D) 200 T

15 The image below depicts an electron gun.



An electron gun

What is the name and function of the component labelled *x*?

	name	**function**
(A)	anode	Source of electrons
(B)	heated filament	Produces light when struck by fast moving electrons
(C)	anode	Accelerates electrons to the right
(D)	heated filament	Source of electrons

16 What was the aim of Hertz's experiment?

(A) To measure the effect of light on the emission of electrons from a metal surface.

(B) To confirm Maxwell's prediction regarding the existence of electromagnetic waves.

(C) To determine the effect of frequency of electromagnetic waves upon their velocity.

(D) To determine the relationship between radio waves and the electromagnetic spectrum.

17 Two charged particles are fired with the same velocity into a magnetic field. The directions of the deflections are opposite while the radius of one particle's trajectory is much larger than the other. What possible combinations of particles could produce this result?

(A) a proton and a neutron

(B) a proton and an alpha particle

(C) an electron and a positron

(D) an electron and a proton

18 What is the relative numbers of free electrons in insulators, semi-conductors and conductors?

	insulators	**conductors**	**semiconductors**
(A)	least	intermediate	most
(B)	least	most	intermediate
(C)	intermediate	least	most
(D)	most	least	intermediate

19 A superconductor disc is below its critical temperature and in an external magnetic field which is above its critical field strength. When a strong but light-weight magnet is placed above this disc and and let go it would

(A) hover briefly before falling onto the disc.

(B) fall straight onto the disc.

(C) hover and begin to rotate slowly.

(D) be repelled and fly upwards.

20 Which factors were responsible for the invention of transistors?

(A)	Increased research into the electrical conductivity of solids	The need for satellite communication
(B)	The ability to produce pure silicon	The limitations of previous technologies
(C)	Increased research into the electrical conductivity of solids	The limitations of previous technologies
(D)	The ability to produce pure silicon	The need for satellite communication

End of Part A

Student Name	
Class	
Mark /	

Girraween High School

2016

HIGHER SCHOOL CERTIFICATE

TRIAL EXAMINATION

PHYSICS

PART A ANSWER SHEET

Write your Name and Class at the top of this Part A Answer Sheet

1.	A ○	B ○	C ○	D ○
2.	A ○	B ○	C ○	D ○
3.	A ○	B ○	C ○	D ○
4.	A ○	B ○	C ○	D ○
5.	A ○	B ○	C ○	D ○
6.	A ○	B ○	C ○	D ○
7.	A ○	B ○	C ○	D ○
8.	A ○	B ○	C ○	D ○
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 ○

Student Name	
Class	

Write your Name and Class at the top of this Part B Answer Booklet.

Section I (continued)

Part B – 55 marks

Attempt Questions 21 - 35

Allow about 1 hour and 40 minutes for this part

Answer the questions in the spaces provided

Question 21 (3 marks)

Two stars, A and B, are 2.75 billion km apart. Star A has a mass of 7.5×10^{30} kg, while Star B has a mass of 2.2×10^{31} kg.

(a) Determine the gravitational force that each star exerts on the other. (1 mark)

. . . . . .

. . . . . .

. . . . . .

(b) Determine the acceleration of each star towards the other (ignoring all other bodies). (2 marks)

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Question 22 (5 marks)

A projectile is launched from a cliff which is 425 m above a valley. It is launched at an angle of 35° to the horizontal with an initial velocity of 225.0 m/s. Ignore any effects due to air resistance.

(a) Draw an appropriate labelled diagram of this situation. (2 marks)

(b) Determine the total time of flight of the projectile. (2 marks)

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(c) Determine the range of the projectile. (1 mark)

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Question 23 (2 marks)

The total mass of a space shuttle at launch was 2000×10^3 kg. The thrust developed was 1.96×10^7 N. After 124 seconds the solid rocket boosters were jettisoned, reducing the mass by 1142000 kg.

Determine the g-force experienced by the astronauts at the beginning of the launch.

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Question 24 (3 marks)

Using the appropriate equations and annotations, show how Kepler's Law of Periods is derived.

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Question 25 (3 marks)

Outline one of Einstein's thought experiments and indicate the significance of this example to modern physics.

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Question 26 (2 marks)

Outline the nature of inertial frames of reference.

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Question 27 (4 marks)

Describe the effect on the magnitude of the force acting on a current-carrying conductor in a magnetic field due to variations in each of the following.

(a) The strength of the magnetic field in which it is located. (1 mark)

. . . . . .

. . . . . .

(b) The magnitude of the current in the conductor. (1 mark)

. . . . . .

. . . . . .

(c) The length of the conductor in the external magnetic field. (1 mark)

. . . . . .

. . . . . .

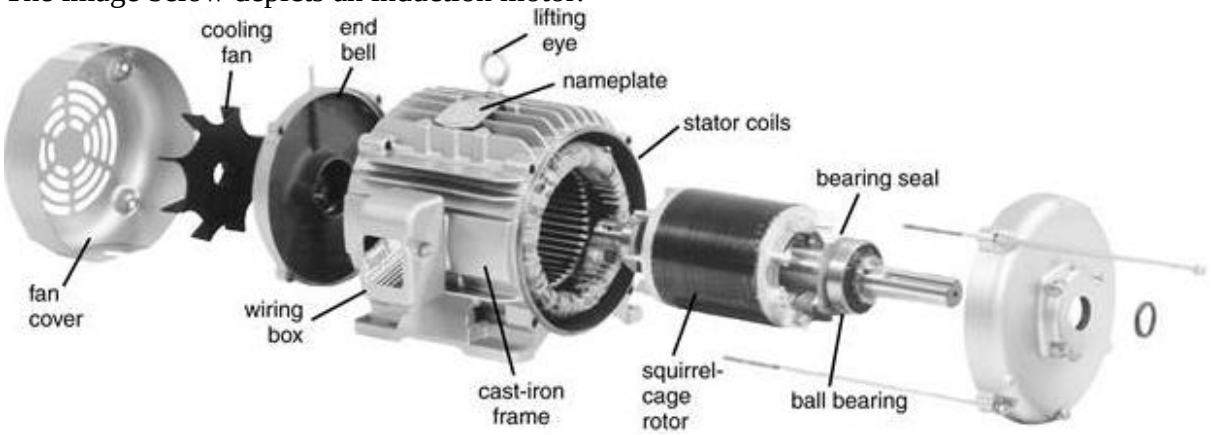
(d) The angle between the direction of the external magnetic field and the direction of the length of the conductor. (1 mark)

. . . . . .

. . . . . .

Question 28 (1 mark)

The image below depicts an induction motor.



Identify the role of the squirrel cage rotor.

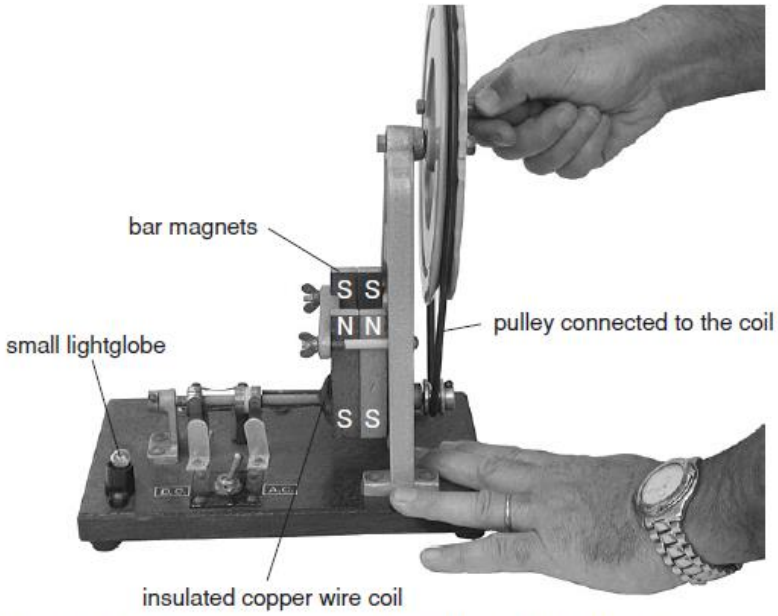
. . . . . .

. . . . . .

Question 29 (4 marks)

The following image depicts a hand-operated AC generator in action.

Using the grid below, sketch the output you would expect to display on a Cathode Ray Oscilloscope if the rotation speed gradually decreases over 4 seconds.



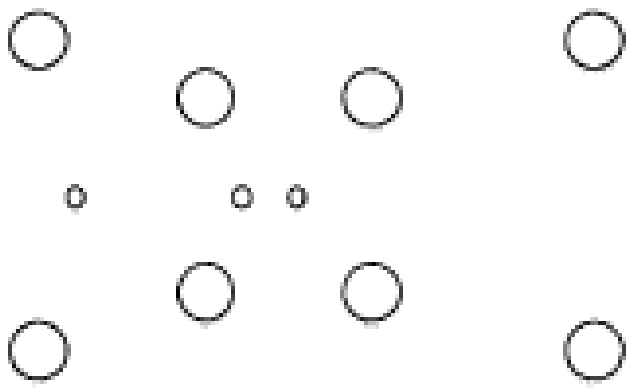
A hand generator. (Photos: Thomas Brown. Hands: Ric Morante)

Question 30 (5 marks)

Discuss advantages and disadvantages of AC and DC generators and relate these to their use.

Question 31 (4 marks)

(a) The diagram below can be used to explain the BCS theory. Label TWO features on this diagram that enables it to be used to explain the BCS theory. (1 mark)



(b) With reference to the BCS theory, explain how superconductivity occurs in metals. (3 marks)

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

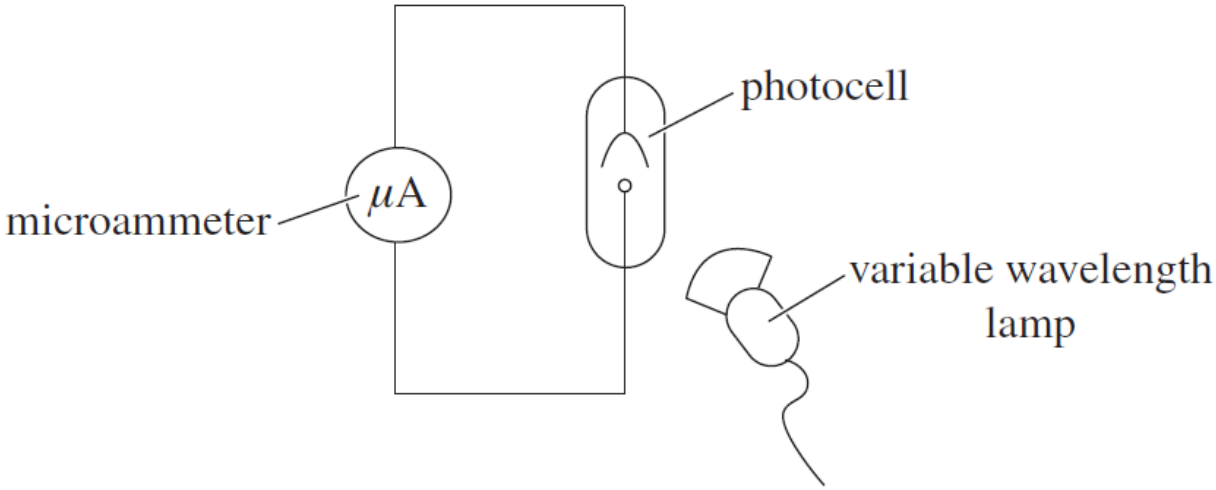
. . . . . .

. . . . . .

. . . . . .

Question 32 (7 marks)

The following apparatus is used to investigate the photoelectric effect. Photocells made of different metals are inserted into the circuit.



(a) Using the photon model of light, account for the following observations:

(i) When ultraviolet light is used, the photocurrent increases as the intensity of the light increases. (1 mark)

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(ii) Sodium produces a photocurrent with green light, but copper does not. (1 mark)

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

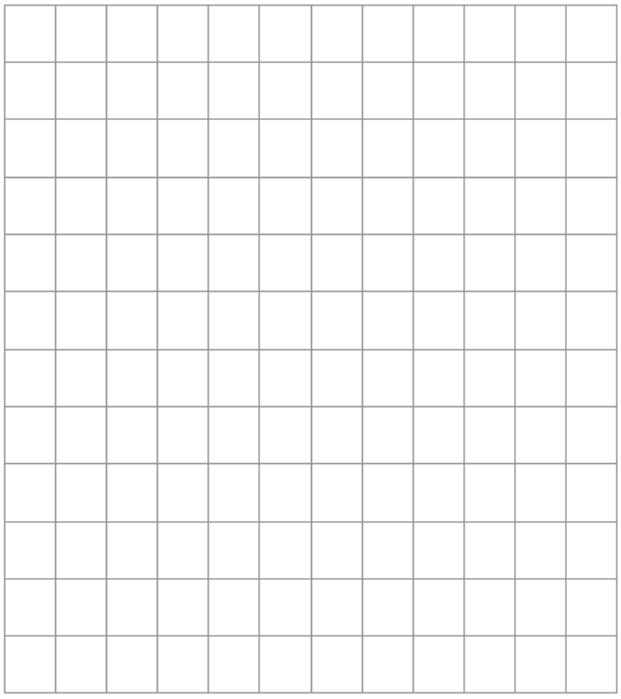
. . . . . .

Question 32 *Continued*

(b) A group of students used the apparatus to find the lowest frequency of light that will emit photoelectrons from a range of metals. For each metal, they decreased the frequency of the light until the photocurrent dropped to zero. Their results are shown in the table below.

Metal	*Frequency* ($\times 10^{14}$ *Hz*)	*Work function* ($\times 10^{-19}$ *J*)
sodium	5.6	3.6
calcium	7.1	4.6
zinc	10.5	6.9
copper	11.5	7.5
platinum	15.2	10.0

(i) Plot a graph of the data, with frequency on the *x*-axis and work function on the *y*-axis, and sketch a line of best fit. (3 marks)



(ii) Use the graph to determine a value for Planck's constant. (2 marks)

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Question 33 (5 marks)

Assess the impact of the development of transformers on society.

Question 34 (6 marks)

(a) Discuss the relationship between molecular structure, band structure and electrical resistance of the following:

(i) metallic conductors (2 marks)

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(ii) semi-conductors (2 marks)

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) Explain how doping a sample of pure silicon with arsenic increases its conductivity. (2 marks)

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

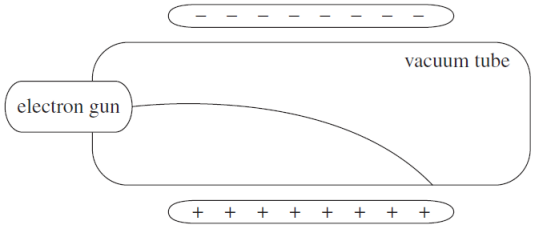
. . . . . .

. . . . . .

Question 35 (1 mark)

An electron in a vacuum tube is moving between two parallel charged plates as shown below.

With reference to the forces acting on it, explain why the electron follows a parabolic path.



. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

End of Part B

Student Name	
Class	
Mark /	

Girraween High School

Higher School Certificate Physics 2016 Trial Examination

Write your Name and Class at the top of this Section II Answer Booklet

SECTION II

Allow about 45 minutes for this part

Show all relevant working in questions involving calculations

Questions 36 – 40 **Medical Physics (25 marks)**

Question 36 (10 marks)

Ultrasound can be used as a diagnostic tool.

(a) The following table shows the density and the speed of sound in different parts of the body.

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

Calculate the ratio of reflected intensity to initial intensity when ultrasound reflects from the fat/brain boundary. (3 marks)

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Question 36 *Continued*

(b) Identify TWO differences between ultrasound and audible sound. (1 mark)

. . . . . .

. . . . . .

. . . . . .

(c) A water based gel is almost always used in the ultrasound imaging procedure. Explain the function of this gel. (2 marks)

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Question 36 *Continued*

(c) Explain how ultrasound waves can be used to provide information on blood flow characteristics through the heart. (4 marks)

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Question 37 (4 marks)

Radioactivity is used as a diagnostic tool.

(a) Define *positron*. (1 mark)

. . . . . .

(b) PET uses a ring scanner in detection. Outline what is being detected and explain why the ring geometry is used in this technique. (3 marks)

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Question 38 (4 marks)

Technetium-99m is one of the most exploited radioisotopes used in nuclear medicine.

(a) Define *radioisotope.* (1 mark)

. . . . . .

. . . . . .

(b) Identify a diagnosis that is performed using technetium-99m. (1 mark)

. . . . . .

. . . . . .

. . . . . .

(c) Discuss one issue associated with the choice of radioisotope to be used a nuclear medical diagnosis. (2 marks)

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Question 39 (4 marks)

A MRI machine is the result of many technologies converging to produce a tool. Identify three of these technologies and outline what role they play in the production of a MRI image.

Question 40 (3 marks)

Assess the impact of MRI on society.

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

End of Section II

2016 GHS Physics Marking Guidelines

Section 1A

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

Section 1 B

Question 21a

data

```
In[1]:= ma = 7.5 × 10^30;
        mb = 2.2 × 10^31;
        r = 2.75 × 10^12;
        G = 6.67 × 10^-11;
```

the gravitational force

$$\text{In[5]:= } f = \frac{G\ ma\ mb}{r^2}$$

$$\text{Out[5]= } 1.45527 \times 10^{27}$$

The acceleration of each star towards the other

```
In[8]:= accStarA = f / ma
Out[8]= 0.000194036

In[9]:= accStarB = f / mb
Out[9]= 0.0000661488
```

Criteria	Marks
(a) • Correct value determined	**1**
(b) • uses correct equations • correct substitutions • correct values	**2**
• one error	**1**

Question 22

Initial data

```
In[35]:= theta = 35.0 Degree;
         u = 225.0;
         dsy = -425.0;
         a = -9.8;
         uy = u Sin[theta];
```

Time of Flight

```
In[40]:= Solve[dsy == uy t + 0.5 a t^2, t]

Out[40]= {{t → -2.96042}, {t → 29.2981}}
```

Answer is 29.2981 s

Criteria	Marks
(a) • Launch position is indicated • Angle specified • Initial velocity specified • Range indicated • Altitude change indicated • Trajectory indicated	**2**
• one error	**1**
(b) • uses correct equations • correct substitutions	**2**
• one error	**1**
(c) • uses correct equations • correct substitutions	**2**
• one error	**1**

Many did not draw in the trajectory, or the range, or both.

Others did not substitute the data values correctly.

Often students are using the equation derived in maths, forgetting that the change in altitude is not zero.

Many taking the long way and not solving the quadratic.

Question 23

Criteria	Marks
• correct equations used for *a* and *g-force* • correct substitutions • g-force recorded as a number	**2**
• one error	**1**

Question 24

Criteria	Marks

• correct equations used
  ○ circular motion = gravity
  ○ dist/time = circumference/period
• annotations exist and are correct
• correct form of Kepler's law given
	3

• one error	**2**
• two errors	**1**

Solution

The sum of the forces acting in the vertical direction can include T (thrust directed upwards) and W (mg, that is, weight directed down)

$$\sum \frac{F}{m} = a = \frac{T - mg}{m}$$

$a = \frac{T-mg}{m} = \frac{1.96\times10^7 - 9.8\times2.03\times10^6}{2.0\times10^6} = 0$ m/s^2

So then

G force is determined by

$$\frac{g + a}{9.8} = \frac{9.8 + 0}{9.8} = 1.0$$

Many Students did not determine the sum of forces (T-mg) in order to calculate the acceleration.

Most neglected to write the correct expression for g-force determination. $g\ force = \frac{g+a}{9.8}$

The denominator is always 9.8 not 'g'.

Question 25

Criteria	Marks
• a clear account of one of Einstein's thought experiments is given • the example is explicitly linked to one of the aspects or equations of SR	**3**
• the account is not clear OR • the example is not correct OR • the significance is not established	**2**
• two errors	**1**

Solution

For example, a situation involving a train in which light clocks measure time using light reflected vertically between the ceiling and floor. Observers in the train will measure the duration of a second to be different to measurements made by observers not on the train. The significance of this thought experiment is that it is the basis of the derivation of the relativistic time dilation equation $t_v = \frac{t_o}{\sqrt{1-\frac{v^2}{c^2}}}$.

Common errors:

- *confusing two or more thoughts experiments*
- *trying to write about something you don't understand*
- *not actually describing one of Einstein's though experiments – but someone else's.*
- *not being clear in the language*
- *significance not given or not well described – need to go for the most important impacts e.g. time & space become flexible while speed of light is fixed.*

Question 26

Criteria	Marks
• inertial FOR connected explicitly to ability to verify Newton's laws • the FOR cannot itself be accelerating	**2**
• one of these points missing	**1**

Many responses confuse an IFOR with NIFOR by suggesting that an IFOR is accelerating.

Weaker responses give more attention to the secondary attributes of an IFOR without mentioning the essential, i.e. the absence of acceleration in the FOR itself.

Question 27

Criteria	Marks
• All statements correct	**4**
• Minus one for each error	**1-3**

Solution

(A) the force is linearly (or directly) proportional to the strength of the magnetic field
(B) the force is linearly (or directly) proportional to the current in the conductor
(C) the force is linearly (or directly) proportional to the length of the conductor
(D) the force varies as the sine of the angle between the direction of the magnetic field and the direction of current flow in the conductor

Weak responses did not identify the basic relationship between the variables, e.g. $F \propto B$
In particular a large fraction of the cohort could not write $F \propto \sin\theta$

Many spent unnecessary time writing more than was required.

Poor responses wrote e.g. the force increases. This does not connect with any specific change in the variable being considered. Some treated "variation" as if it meant only increase or decrease.

Few identified the direct proportionality and most only indicated some proportionality, forgetting that it could be direct, exponential, inverse etc.

Question 28

Criteria	Marks
• All statements correct	**1**

Best responses identified the role of the squirrel cage as the means by which torque is applied to the drive shaft of the motor.

Poor responses took too long to make the simple point or wasted a lot of effort describing the interactions.

Question 29

Criteria	Marks
• Time on x-axis goes from 0 - 4 s • label y axis is Amplitude • Amplitude decreases • Frequency decreases	**4**
• Minus one for each error	**1-3**

Frequent errors included:

- *No axes label*
- *No units on axes*
- *No time increment indicated*
- *Constant amplitude rather than decreasing*
- *Constant frequency rather than decreasing*

Some drew the reverse of the correct version, as if slowing the rotation increases the voltage (Did you not realise that means producing an infinite voltage when the rotation stops?)

Question 30

	advantages	disadvantages
AC	• Output can be transformed easily • Enables more flexibility in infrastructure • Can be efficiently transmitted at HV over long distances • Can be rectified to DC so can accommodate wide variety of uses • Slip-rings suffer less wear than split-rings in commutator • Well suited to driving small motors	• Dangerous • Inherent oscillation of current not useful in many devices • Skin effect making it necessary to use a cable of many wires rather than a thicker wire. • Significant power loss when used in superconductors
DC	• Single current direction useful in many devices • More useful in re-energising batteries for storage of energy • Can be transmitted at HV over long distances (HVDC) • No power loss in a superconductor • Well suited to driving large motors	• Dangerous • At constant voltage, output cannot be transformed • Enables less flexibility in infrastructure – 1 cable per voltage needed • HVDC is costly to set up and maintain • Split-rings suffer more wear than slip-rings in commutator

Criteria	Marks
• Well organized • Shows a **comprehensive** understanding of the question • Adv and disadv are considered and each is connected to an example • All examples are valid • No misconceptions	**5**
• As above BUT poorly organized OR • Shows a **thorough** understanding of the question OR • Max one adv/disadv not linked to an example OR	**4**
• Shows a **sound** understanding of the question (two valid examples) AND one of the above omissions OR • two omissions OR • includes concepts which contain misconceptions	**3**
• Shows **some** understanding of the question AND two omissions • OR • three omissions	**2**
• One valid relevant statement only	**1**

Most obvious point not being made is that the essential difference between AC and DC generators is the commutators used. DC uses the split-ring which is inherently prone to more wear and tear and produces sparking, which means higher maintenance costs and lower lifetimes compared to slip-ring commutators used in AC.

Weaker responses tended to recycle the same idea a couple of times – as if a different way of saying the same thing counts!

Some claims are not justifiable:

- *DC cannot be efficiently transmitted. (Power losses in transmission are a function of the current, not of the direction of the current so AC and DC can be transmitted at high voltage.)*

- *DC generates more power than AC. (The amount of power generated depends on the generator design and not on whether it's AC or DC.)*

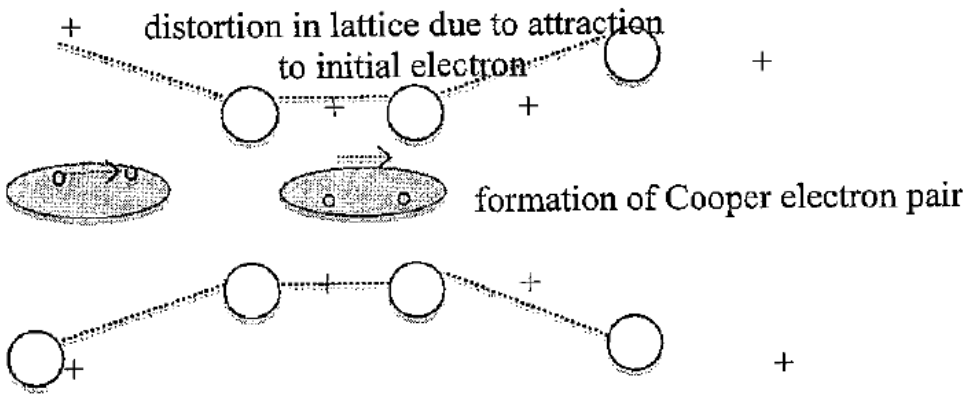
- *AC is more dangerous than DC. (no, both are lethal – it's complicated but the overall picture is clear once you are dead that's it. There are situations in which one is more dangerous than the other but you can't really justify a blanket statement like "DC is safer".)*

Question 31

(a)

Criteria	Mark
Correctly labels components of lattice distortion and formation of cooper pairs	1

Sample answer:



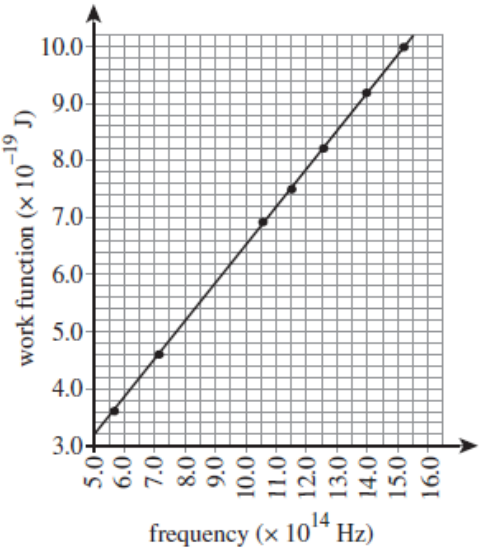
(b)

Criteria	Mark
Correctly identifies the conditions of superconductivity AND Explain lattice distortion AND The formation of cooper pairs and phonons.	3
Any CORRECT TWO of the above	2
Any CORRECT ONE of the above	1

When a superconductor is cooled to a temperature below the critical temperature, electrons can flow through the lattice structure with effectively zero resistance. The BCS theory proposes to explain this by the formation of electron pairs (Cooper pairs), where a negatively charged electron moving through the positively charged atomic crystal lattice causes an attractive distortion. This creates a net positive zone behind the first electron that the second electron can link into. There is an exchange of phonon energy between the two electrons that maintains the link at temperatures below the critical temperature.

Question 32

(a)	(i)	When intensity increases, the number of photons increases. More photons of sufficient energy release more photoelectrons, meaning a larger current.	9.4.2 H10 • Correctly accounts for the observation using the photon model of light 1
	(ii)	Copper has a higher work function (energy required to release a photon) than sodium, so each photon of green light has sufficient energy to release a photoelectron from sodium, but not from copper.	9.4.2 H10 • Correctly accounts for the observation using the photon model of light 1

(b)	(i)		9.4.2 H13 • Draws graph correctly, including scales, labels and axes. AND • Correctly plots all points. AND • Correctly identifies line of best fit that indicates the trend of the data . . . . . 3 • Any TWO of the above points . . . . . 2 • Any ONE of the above points. 1
	(ii)	gradient $= \frac{y_2 - y_1}{x_2 - x_1}$ $= \frac{9.2 - 8.2}{14.0 - 12.5} \times 10^{-33}$ $= 6.7 \times 10^{-34}$ J s Answer should be between 6.5 and 6.9×10^{-34} J s.	9.4.2 H13 • Correctly identifies formula for gradient, with substitution clearly derived from graph. AND • Identifies correct answer, including correct units . . . . . 2 • Correctly identifies formula for gradient with substitution clearly derived from graph 1

Question 33

The use of transformers has changed society dramatically. This can be seen in the increasing size of cities, the increased use of electrically powered machines replacing human labour and in the development of widespread communications.

The ability to easily transform AC electricity to high voltage (and hence low current, as P = VI) has led to a wider geographical area over which power can be supplied, since transmission of electricity at high voltages (e.g. 500,000 V) is very efficient, as power losses in transmission are proportional to the square of the current. This has lead to population centres being removed from the industrial centres of cities, improving the living conditions of residents, and allowing commercial activity also to spread out from the centres of cities to their edges.

Access to distributed electrical power means that work can be performed at a greater rate by machines, which had changed the nature of the workforce. Fewer jobs require manual labour in industry now while there has been a corresponding increase in the number of service positions, meaning that are fewer factory workers now but more consultants and administrators. Reduction in labour intensive activities has impacted the upon the health of city dwellers, whose lifestyles have become sedentary with corresponding rises in rates of obesity and type II diabetes.

The ability to transform electricity into a wide variety of voltage/current combinations has created a dramatic increase in the number and types of devices that people can use. A major new impact comes from the convergence of communications and information processing, which together with the development of the internet, have increased the number and value of commercial transactions between individuals and businesses. This has generated a great deal of new wealth and have changed many people's lifestyles – many people in developed nations now have access to internet 24/7.

Criteria	Marks
• Well organized • Shows a **comprehensive** understanding of the question • All examples given are explicitly linked to society • Adv and disadv are considered and each is connected to an example	**5**
• As above BUT poorly organized OR • Shows a **thorough** understanding of the question OR • Max one example not explicitly linked to society OR • Max one adv/disadv not linked to an example OR • Max one example not validly social	**4**
• Shows a **sound** understanding of the question AND one of the above omissions OR • two omissions	**3**
• Shows **some** understanding of the question AND two omissions OR three omissions	**2**
• One valid relevant statement only	**1**

Question 34

(a)	(i)	Metallic conductors have atoms in a lattice structure. Valence electrons are not tightly bound to individual atoms but can move under the influence of an electric field. These electrons occupy the conduction band. The ability of conduction electrons to move means that metallic conductors have low electrical resistance.	9.4.3 H7, H10 • A complete discussion which clearly relates molecular structure, band structure and electrical resistance for a metallic conductor . . . . . 2 • A partial discussion which relates two of the above concepts for a metallic conductor 1
	(ii)	Semiconductors have a lattice structure similar to metallic conductors. Their valence electrons are not all free to move, however the energy gap between the valence band and the conduction band is small. This means at room temperature, some electrons can 'jump' from the valence to conduction band. Both the electrons in the conduction band and the positively charged holes left behind in the valence band allow movement of electrons under the influence of an electric field. This means that semiconductors have higher resistance than metallic conductors.	9.4.3 H7, H10, H13 • A complete discussion which clearly relates molecular structure, band structure and electrical resistance for a semiconductor . . . . . 2 • A partial discussion which relates two of the above concepts for a semiconductor 1
(b)		Silicon has four valence electrons and arsenic has five. Doping silicon with arsenic means introducing a small proportion of that element into the silicon so that it substitutes itself randomly into the lattice without changing the lattice structure. However, only 4 of the 5 valence electrons of the arsenic can be accommodated in the bonding structure of the silicon. The fifth electron occupies the conduction band. This means that for every arsenic atom, there is one extra conduction electron, compared to pure silicon.	9.4.3 H10, H13 • Correctly describes the effects of doping silicon with arsenic, and relates this to its conductivity . . . . . 2 • Correctly describes the effects of doping silicon with arsenic OR • Partially describes the effects of doping silicon with arsenic, and relates this to its conductivity 1

Question 35

Criteria	Marks
• All statements correct	**1**

Section II Medical Physics

Question 36a

Marking Criteria	Marks
Correct calculation for the acoustic impudence for **both** mediums with correct units Correct calculation for the ratio	**3**
Only TWO of the above or missing/incorrect units	**2**
Simple calculations only	**1**

Sample answer

Z (fat) = $\rho v = 0.93 \times 1000 \times 1480 = 1\ 376\ 000$ kg.m^{-2} s^{-1} (1 mark)

Z (brain) = $\rho v = 1.04 \times 1000 \times 1521 = 1\ 582\ 000$ kg.m^{-2} s^{-1} (1 mark)

The ratio $I_r/I_0 = (1\ 657\ 000 - 1\ 376\ 000)^2 \div (1\ 657\ 000 + 1\ 376\ 000)^2 = 8.584 \times 10^{-3}$ (1 mark)

Question 36b

Criteria	Marks
• Identifies two correct differences : ultra sound has higher frequency, smaller wavelength, not audible, less scattering	2
• Identifies one correct difference (above)	1

Question 36c

Marking Criteria	Marks
• Correctly explain the role of the water based gel. • Link it to the properties of ultrasound (reflection and acoustic impedance	**2**
• Only ONE of the above	**1**

Sample answer

The ultrasound wave is partially reflected from the layers between different tissues. The water based gel placed between the patient's skin and the probe allows impedance matching to occur so that the reflected beam intensity is not large, allowing clear imaging of the lower layers to occur.

Question 36d

Marking Criteria	Marks
Application of Doppler effect is described thoroughly for this application AND Explains the Doppler effect and how it is used to measure velocity of blood flow including imaging of velocity by computers AND Explain the relative motion between the source of sound and a receiver AND Explain how the velocity changes TWICE as it moves close and as it moves away.	**4**
Any THREE of the above	**3**
Any TWO of the above	**2**
Any ONE of the above	**1**

In Doppler scans, the ultrasound waves which are reflected from the moving blood (through the heart) are returned with slightly different frequency/wavelength. The difference is measured and used to calculate the speed of the moving blood which can then be colour-coded on a monitor. Abnormalities in the blood flow are quickly detected using this method.

Explanation:

An ultrasound wave is emitted by the transducer unit and is directed towards the blood vessel in which a red blood cell is flowing towards the transducer.

The red blood cell can be viewed as the 'receiver', is moving closer towards the sound source. This will result in an increase in the frequency of the ultrasound wave proportional to the speed of the moving red blood cell. After the ultrasound strikes the red blood cell and is reflected off, the red blood cell will act as the 'source', which is again moving closer towards the 'receiver'—the transducer. This will result in a further increase in the wave frequency. The conclusion drawn for this scenario is that the ultrasound wave, after reaching the red blood cell and then being reflected back to the transducer, will have increased its frequency twice. As a consequence, the detected echo (reflected ultrasound) will have a higher frequency compared to the original wave. This difference enables the computer to calculate the speed at which the red blood cell is moving towards the transducer unit, thereby providing information about the blood flow. A similar but opposite process will take place in cases where the red blood cell is moving away from the transducer. The frequency of the ultrasound wave will be reduced twice, resulting in a lower frequency of the detected echo. The reduction in frequency will be interpreted by the computer as being the blood flowing away from the transducer unit and the magnitude of the change will be used to calculate this receding speed

Question 37a

Positron is an anti-electron, electron with as positive charge.

Criteria	mark
• Correct definition	1

Question 37b

In PET a radioisotope that produces a positron is used. The positron will combine with an electron and annihilate, resulting in the emission of a pair of gamma rays that travel with equal and opposite momenta. Since the orientation of the gamma emission is not predictable, a ring scanner ensures that all emissions are detected. The pairs of detections are then used to locate the source of the gamma emissions, locating the affected area of the patient's body.

Criteria	mark
• Gamma rays are detected • Gamma rays produced as a result of positron-electron annihilation • Gamma rays emitted at 180° to each other and random orientation • Circular detector needed to detect all emissions • Gamma source is located	3
• Missing one	2
• One correct statement only	1

Question 38a

Radioisotopes are unstable and emit particles and/or gamma rays.

Criteria	mark
• correct definition	1

Question 38b

Solution

Used to investigate bone metabolism and locate bone disease; assess thyroid function; study liver disease and disorders of its blood supply; monitor cardiac output, blood volume and circulation clots; monitor blood flow in lungs; assess blood and urine flow in kidneys and bladder; investigate brain blood flow and function; estimate total body plasma and blood count.

Criteria	mark
• correct diagnosis	1

Question 38c

Issue: ½ life of the isotope

The ½ life of an isotope is the average time it takes for the activity of a radioactive sample to decrease by 50%. If the ½ life of an isotope is too short then the activity could decrease below a useful level before the image is acquired. Some practitioners may be tempted to increase the dose to compensate, increasing the risk of toxicity in the patient. If the ½ life is too long then the radioisotope remains active in the body and could cause further tissue damage.

Criteria	mark
• valid issue is identified • discussion is sufficiently clear and detailed	2
• discussion is not sufficiently clear and detailed	1

Question 39

tech	role
radio wave production and detection	Means of communication with the protons in the body
computers	Processing of data and construction of image data
displays	Enables human interface with data
Magnetic fields	Determines local Lamour frequencies, provides orientation axis for proton alignment
gantry	Platform for patient to lie on while surrounded by the MRI apparatus
electricity	Provides the energy required to produce the radio waves and operate the apparatus

Criteria	mark
• 3 valid technologies are identified • Roles of each is correctly described	4
• 2 tech only OR • 3 tech and roles described with insufficient detail	3
• 2 tech and roles described with insufficient detail	2
• One valid statement only	1

Question 40

MRI is a technique which is safe, non-invasive, can image structure as well as function. It yields high resolution data but is slow (1 hour) compared to CT (1 minute), but is considerably less dangerous due to use of radio waves rather than x-rays. EM induction in conductors, however, means that patients with metallic implants cannot be scanned.

MRI machines have saved lives in two ways – first by enabling early detection of otherwise lethal conditions, and second by enabling more accurate diagnosis of acute conditions, resulting in higher survival rates and fewer errors in surgical procedures.

MRI's have enable accurate diagnosis of many soft tissue injuries, which were previously very difficult to measure. This has had an impact on medical insurance claims being reduced.

MRI machines are expensive and not available in poor communities, which is inequitable.

Criteria	mark
• Judgment exists • At least two examples are explored • Each example is explicitly connected to society	3
• 1 example only OR • No judgement	2
• One valid statement only	1