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. Mercury, the innermost of the Solar system's planets, has a mass of 3.3×10^{23} kg. The average distance between Mercury and the Sun is 57,909,175 km. If the force of gravity keeping Mercury in orbit around the Sun is equal to 1.30546×10^{22} N, the mass of the Sun must be

(A) 1.98893×10^{30} kg

(B) 1.9×10^{30} kg

(C) 2.0×10^{30} kg

(D) 198×10^{28} kg

2. A meteor approaches Mercury at a speed of 2.75×10^{2} ms^{-1} when it is at an altitude of 1.3×10^{3} m from the surface. If the meteor's speed at an altitude of 550 m is 2.85×10^{2} ms^{-1}, the magnitude of the acceleration due to gravity near the surface of mercury is approximately

(A) 37.3 ms^{-2}

(B) 3.73 ms^{-2}

(C) 3.73 N

(D) 3.73 ms^{-1}

3. A space shuttle during launch has an instantaneous acceleration of 19.6 ms^{-2} up. The *g* forces experienced by the crew at that moment will be

(A) 1

(B) 2

(C) 3

(D) 0

4. The reason why the tiles underneath the space shuttles were made from ceramic material is because

(A) ceramics are relatively inexpensive.

(B) ceramics do not conduct electricity.

(C) ceramics look really cool.

(D) ceramics do not conduct heat.

5. The following image was taken inside a plane that has the nickname “vomit comet”.

The reason for the weightlessness experienced by these people is due to

(A) The plane has flown into a region of the atmosphere where there is no gravity.

(B) The Earth’s gravity is being shielded from the occupants by the advanced materials of which the plane is made.

(C) The plane and its occupants are accelerating with the same acceleration as gravity.

(D) Trick photography.

6. At the Large Hadron Collider two protons collide at velocities with a magnitude of 0.999999991 *c*.

The total kinetic energy at the instant of impact will be:

(A) 1.673×10^{23} J

(B) 1.5057×10^{-10} J

(C) 1.122×10^{-6} J

(D) 5.611×10^{-7} J

7. One of the major research projects in which Australian scientists are involved at the Large Hadron Collider is called ATLAS. This project was aimed at discovery of the Higgs boson, also sometimes called the "god particle." The Higgs boson yields the answer to which of the following questions:

(A) Why does time seem to move forward only?

(B) Why are the higher dimensions outside of human experience?

(C) What is the true nature of electric charge?

(D) How do the massive particles get their mass?

8. The role of the superconductors at the Large Hadron Collider is to

(A) Provide the electric fields used to accelerate the particles around the track.

(B) Provide the magnetic fields used to contain the particles as they accelerate, i.e. to guide them into the correct positions as they move.

(C) To keep the whole structure cold enough to operate efficiently.

(D) To provide magnetic levitation via the Meissner effect.

9. The scientist who discovered electromagnetic induction was

(A) Albert Einstein

(B) Isaac Newton

(C) Michael Faraday

(D) Stephen Hawking

10. The force experienced by a current-carrying wire in a magnetic field is proportional to the Sine of the angle between the direction of the current and the direction of the magnetic field. This is due to:

(A) The oscillating nature of an electromagnetic wave.

(B) Only the component of the magnetic field vector that is parallel to the wire will affect the current in the wire.

(C) Only the component of the magnetic field vector that is perpendicular to the wire will affect the current in the wire.

(D) Only the components of the magnetic field vector that is neither parallel nor perpendicular to the wire will affect the current in the wire.

11. A transformer which has 60 turns in the primary coil is used to convert an input of 3 V into an output of 12 V.

Which description best fits this transformer?

	Type of transformer	*Number of turns in secondary coil*
(A)	Step up	15
(B)	Step down	240
(C)	Step up	240
(D)	Step down	15

12. An electric DC motor consists of 250 turns of wire formed into a rectangular coil of dimensions 0.25 m × 0.25 m. The coil is in a magnetic field of 1.25×10^{-3} T. A current of 3.75 A flows through the coil.

What is the magnitude of the maximum torque, and the orientation of the plane of the coil relative to the magnetic field when this occurs?

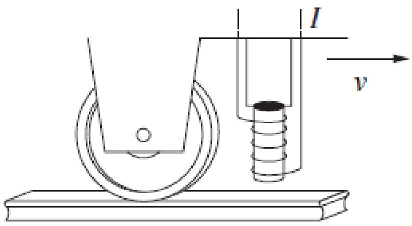
(A) 0.073 Nm, perpendicular

(B) 0.73 Nm, perpendicular

(C) 0.073 Nm, parallel

(D) 0.73 Nm, parallel

13. An electromagnet is attached to the bottom of a light train which is travelling from left to right, as shown.



When a large current is passed through the coils of the electromagnet, the train slows down as a direct result of the law of conservation of energy. In which of the following devices is the law of conservation of energy applied in the same way?

(A) DC Motor

(B) Loudspeaker

(C) Induction Motor

(D) Induction cooktop

14. In a DC electric motor there are two currents: the supply current (I_s) and the current due to the back EMF (I_b). Which of the following pairs of statements is correct?

(A) The magnitude of $I_s < I_b$ AND their directions are the same

(B) The magnitude of $I_b < I_s$ AND their directions are the same

(C) The magnitude of $I_s < I_b$ AND their directions are opposite

(D) The magnitude of $I_b < I_s$ AND their directions are opposite

15. In an AC induction motor the *stator* provides

(A) The supply current

(B) The moving magnetic fields

(C) Kinetic energy

(D) Static electric charge

16. Planck's constant, *h*, has the value of 6.626×10^{-34} Js. The reason why the unit of this constant is J × s is

(A) *h* is the constant of proportionality between the energy of a photon in Joules and its frequency in Hz.

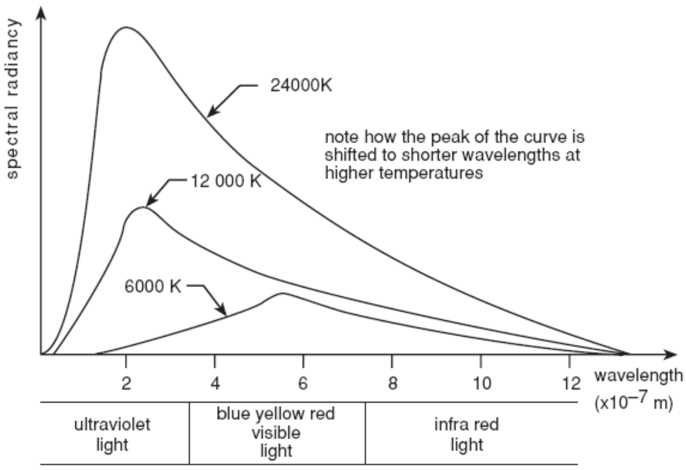
(B) *h* is the constant of proportionality between the energy of a photon in Joules and its wavelength in metres.

(C) *h* is the constant of proportionality between the energy of a photon in Joules and its frequency in kHz.

(D) *h* is the constant of proportionality between the energy of a photon in Joules and its frequency in MHz.

Exam continues on the next page

17. The family of curves below shows the relationship between the intensity of black body radiation and its wavelength for various Kelvin temperatures.



Radiant intensity of an ideal solid for different temperatures. Note how the curve peak is shifted at higher temperatures.

Who was the first to correctly explain this relationship?

(A) Planck, in 1900, when he suggested energy at the atomic level was quantised.

(B) Einstein, in 1905, when he suggested light was a stream of particles called photons

(C) Rutherford, in 1911, when he suggested the nuclear model of the atom

(D) Bohr, in 1913, when he suggested electrons exist in stationary states

18. X-rays diffract in crystals because

(A) Their wavelengths are of the same size as the sizes of atoms.

(B) Their wavelengths are very much longer than the distances between atoms in crystals.

(C) Their wavelengths are very much shorter than the distances between atoms in crystals.

(D) Crystals have magical healing powers.

Exam continues on the next page

19. During 1888 Heinrich Hertz conducted experiments using an apparatus such as is illustrated below.

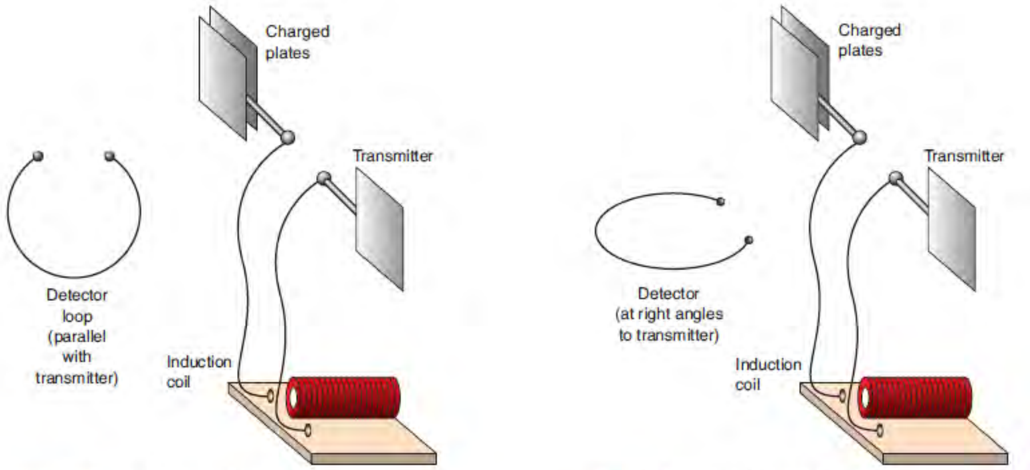


Figure 11.7 *No spark was detected when the detector loop was rotated.*

Figure 11.8 *Hertz detected the waves when the detector loop was placed like this.*

Which of the following deductions can be made about the nature of radio waves from the above result?

(A) Radio waves travel in straight lines

(B) Radio waves travel at 3×10^8 ms^{-1}.

(C) Radio waves carry electric charge

(D) Radio waves are polarisable.

20. Which row of the following table is correct in relation to the doping of silicon in the production of semiconductors?

	Impurity atom used	***Type of semiconductor formed***	***Majority charge carriers***
(A)	boron	n-type	electrons
(B)	boron	p-type	electrons
(C)	aluminium	p-type	holes
(D)	aluminium	n-type	electrons

End of Section 1 Part A

2012 Trial Higher School Certificate

Name:	
Class:	
Teacher:	

Physics

Section I (Continued)

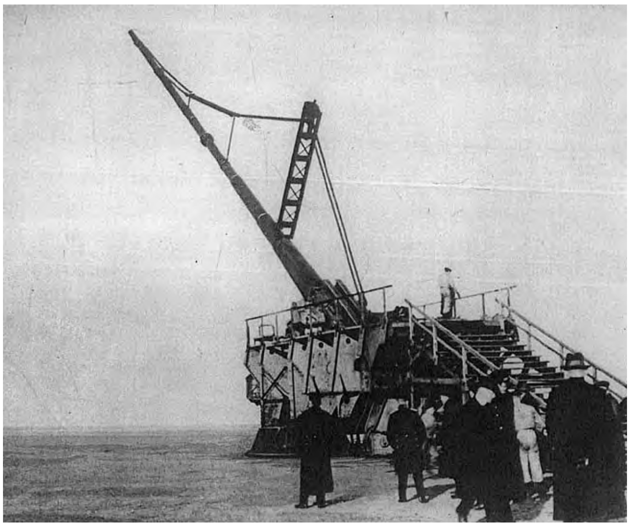
Part B – 55 Marks
Attempt Questions 21 – 36
Allow about 1 hour and 40 minutes for this part.

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

Show all relevant working in questions involving calculations.

Question 21 (5 Marks)

The image below shows a gun used during the first World War by the Germans to shell Paris.



The Paris Gun: used by the German Army to shell Paris during WW1.

The Paris Gun had the following specifications:

Range = 120 km. Time of flight = 3 minutes. (assume that the initial height and that of the target were both ground level, i.e. $\Delta s_y = 0.0$ m)

a) Determine the maximum altitude that the projectile reached. **1**

____

____

b) Determine the vertical and horizontal components of the projectile's velocity as it struck the target. **2**

c) Determine the muzzle velocity of the projectile. **2**

Question 22 (2 Marks)

Derive an expression for the acceleration due to gravity at the surface of Mars given that the mass of Mars is 6.4×10^{23} kg, and its radius is 3396.2 km. Hence, determine the value for g there.

Question 23 (2 Marks)

Explain the relationship between changes in gravitational potential energy and the performance of work.

Question 24 (3 marks)

Outline the how our understanding of time and space have changed since the publication of the theory of Special Relativity. How is this theory "special"?

Question 25 (4 Marks)

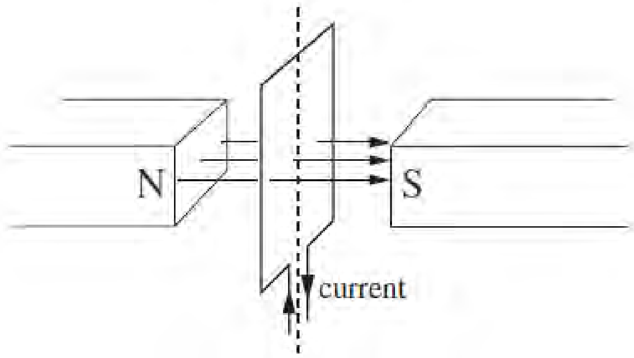
If the period of a geostationary Satellite over the equator is 86164 s, calculate the altitude above the Earth's surface at which the satellite will be positioned.

Question 26 (3 Marks)

Describe one of Einstein's famous thought experiments involving trains and mirrors. Use your example to explain the relationship between a thought and reality.

Question 27 (3 Marks)

Identify the following image as either a motor or generator and explain your answer.



Question 28 (1 Mark)

Why do some electrical appliances in the home that are connected to the mains domestic power supply use a transformer?

Question 29 (2 Marks)

How are transmission lines:

a) protected from lightening strikes? **1**

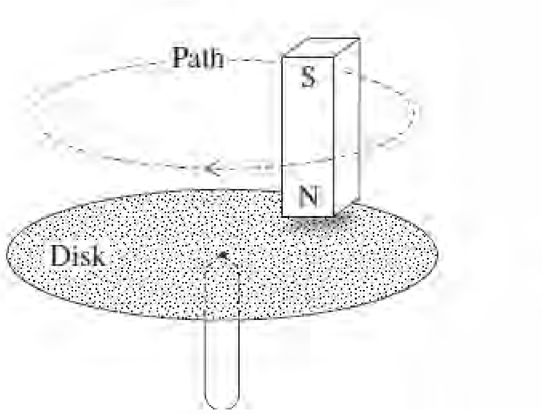
b) insulated from supporting structures? **1**

Question 30 (4 Marks)

Account for Lenz's Law in terms of conservation of energy and relate it to the production of back emf in motors.

Question 31 (5 Marks)

A non-magnetic metal disk is balanced on a support as shown in the diagram below. The disk is initially stationary. A magnet is moved in a circular path just above the surface of the disk, without touching it.



The above illustration models a device you have studied. Describe what that device is and outline how it works, using the illustration to help you. In your response you must consider the strengths and weaknesses of this model.

Question 32 (1 Mark)

Two identical current carrying wires exert forces on each other with a magnitude of 3.28×10^{-7} N. The current running through one wires is 0.75 A, while the other is 1.25 A. If the separation distance between the wires is 20 cm, calculate the length of the two wires that are interacting.

Question 33 (2 Marks)

Explain why voltage transformations are related to conservation of energy.

Question 34 (6 Marks)

Semiconductors have revolutionised electrical devices since the beginning of the Twentieth Century.

a) Use a pair of energy band diagrams to compare n-type and p-type semiconductors indicating the different positions of the fermi level and identify the majority charge carriers in each case. **3**

b) Why has germanium been replaced by silicon as the preferred material for semiconductor manufacture? **1**

c) Thermionic devices (valves) can perform many of the same functions as solid state devices. Outline two advantages that solid state devices have over their thermionic versions. **2**

Question 35 (6 Marks)

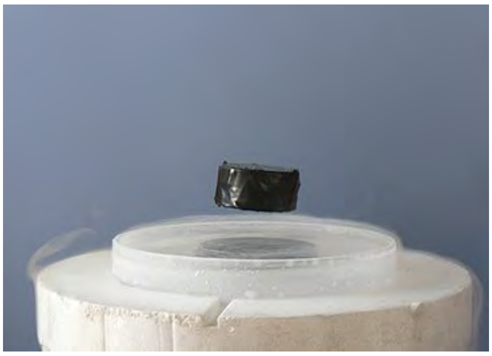
Investigations into the nature of cathode rays led to a deeper understanding of the atom and the development of many modern devices.

a) Which property of cathode rays is demonstrated by the Crooke's tube that contains a glass wheel such as the one shown below? **1**

b) Thomson, and others, conducted experiments to determine the nature of cathode rays. Use diagrams to show how cathode rays are affected by electric and magnetic fields. In each case indicate the direction of the field, and also the direction of the force experienced by the electrons. **2**

c) How are the effects you described in part (b) applied in a Cathode Ray Oscilloscope? **3**

Question 36 (6 Marks)



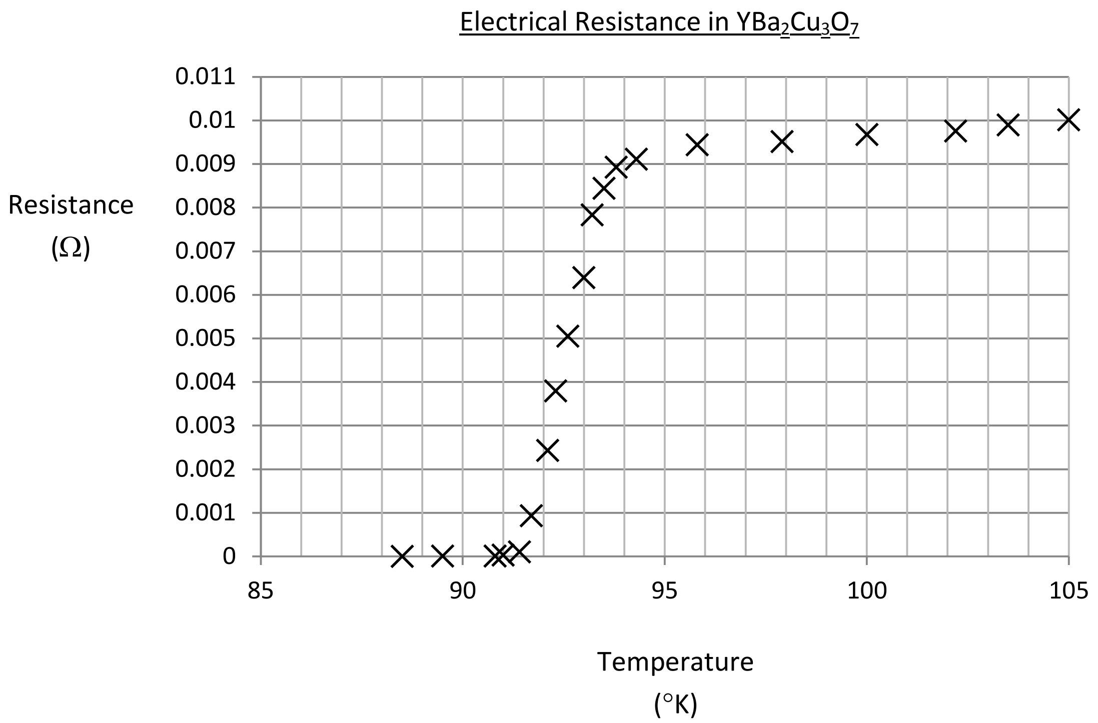
a) The above image shows the Meissner effect, which demonstrates the exclusion of magnetic fields from the interior of a superconductor. Briefly explain how this occurs. **3**

b) Critical temperature is a characteristic feature of superconducting materials below which the electrical resistance drops to zero.

The table below contains two data points not plotted on the graph of electrical resistance against temperature for the superconductor $YBa_2Cu_3O_7$.

i. You are to plot these missing points on the graph. **1**

Temperature (°K)	Resistance (Ω)
95	0.00918
90	0.00000



ii. From the graph, determine the critical temperature for this material. **1**

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iii. From the graph, identify this material as either a Type I or Type II superconductor. **1**

End of Section I

Name:

Class:

Teacher:

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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.

Show all relevant working in questions involving calculations.

Medical Physics

Question 37 (25 Marks)

a).

i. Use the information contained in the table of values for the acoustic impedances of several types of tissue to compare the proportion of a signal reflected from a water/muscle boundary to the proportion of a signal reflected from a brain/bone boundary. **3**

Acoustic impedances for different tissue/materials

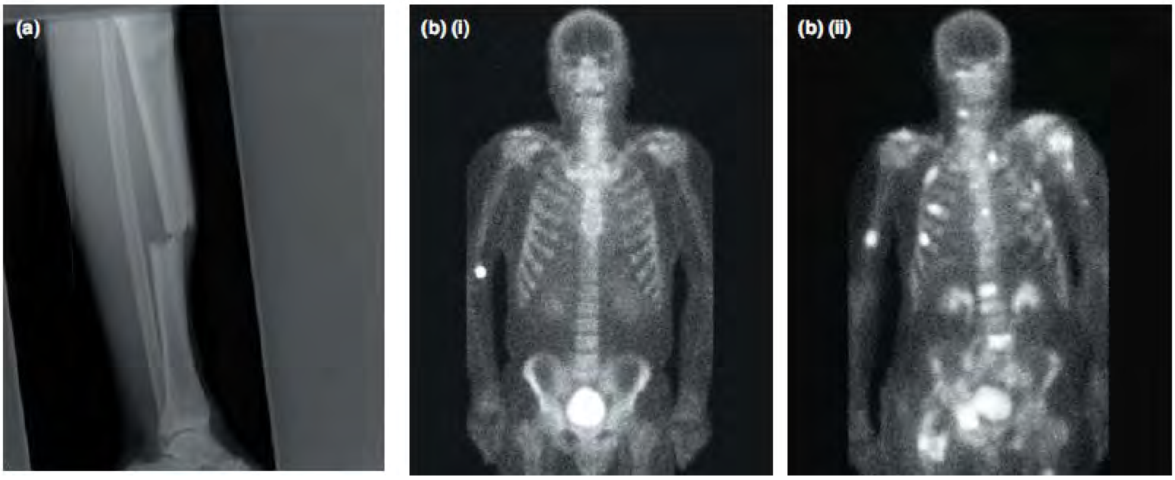
Tissue/material	**Acoustic Impedance ($kg\ m^{-2}\ s^{-1}$)**
water	1.54×10^6
muscle	1.66×10^6
brain	1.58×10^6
bone	6.51×10^6

ii. Describe how the piezoelectric effect is used in the production of ultrasound scans. **2**

b). Describe how radio-labelling of specific molecules can be used to target specific organs and explain why this characteristic is desirable. **4**

Exam continues on next page

c). The following images are (a) an x-ray of a broken leg and bone scan images of a healthy person (b)(i) and a person with advanced bone cancer (b)(ii).



i. Outline the procedure followed when a bone scan is obtained. **2**

ii. Outline ONE advantage and ONE disadvantage of bone scans compared to X-rays. **2**

iii. Outline *one* difference between PET scans and other imaging techniques. **1**

d). The image below is umbilical cord blood flow taken using Doppler ultrasound.

With reference to the Doppler effect in sound waves, describe how such images are made and how they are used to obtain information about blood flow through blood vessels in the body. **4**

Exam continues on next page

e). Discuss how major advances in scientific understanding and technology have changed the direction of medical imaging methods over the past few decades. **7**

End of exam

2012 Trial HSC Physics

Marking Guidelines

Section I, Part A

Multiple-choice Answer Key

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

Section 1 Part B

Question 21

Marking Criteria	Marks
a) max alt • Uses falling half of trajectory • Uses $s = ut + \frac{1}{2}at^2$, with u=0, • t=90 (1/2 of time of flight is the fall time) • a=9.8 • $s = 0.5 \times 9.8 \times 90^2 = 39690\ m$ = 40 km (2sf)	**2**
One error	**1**
b) Horizontal component = range/time = 120 000/180 = 666.66 m/s = 670 m/s (2sf) Vertical component = v achieved during fall = 9.8 × 90 = 882 m/s	**4**
One error (e.g. missing unit, math error), or does not write out steps	**3**
Two errors or One error AND does not write out steps	**2**
One attempted answer only	**1**
c) muzzle velocity • Realizes that by symmetry the components of the final velocity can be used for the muzzle too • Uses Pythagoras: $v = \sqrt{v_x^2 + v_y^2} = \sqrt{666.67^2 + 882^2} = 1105.61 =$ 1100 m/s • Uses trig $\theta = \tan^{-1}\left(\frac{882}{666.667}\right) = 52.92 = 52°$ • Calculates both magnitude AND direction with correct units	**4**
As above with one error or does not write out steps	**3**
Two errors or As above with one error AND does not write out steps	**2**
Three errors or As above with two errors AND does not write out steps	**1**

Question 22

Marking Criteria	Marks
Uses 1 kg mass to determine little g $g = G\frac{M_{Mars}}{R_{Mars}^2} = 6.67 \times 10^{-11} \times \frac{6.4\times10^{23}}{(3396.2\times10^3)^2}$ = 3.7 m/s^2	**2**
One error (e.g. no unit)	**1**

Question 23

Marking Criteria	Marks
Explains that the doing of work (cause) produces changes in potential energy (effect) and writes down $F \times s = mgh = mg(r_2 - r_1) = G\frac{M_{planet}M_{other}}{r_2} - G\frac{M_{planet}M_{other}}{r_1}$	**2**
Writes down either the algebra OR the sentence	**1**

Question 24

Marking Criteria	Marks
• Outline – detailed examples not needed • Previously understanding of space and time noted • New understanding of space and time noted • "Special" is correctly defined • Details are correct	4
As above BUT • Too much detail OR • Distinction between past and present understanding not made clear OR • "Special" not defined correctly OR • One factual error	3
Two errors OR No attempt to define "special"	2
One sensible relevant statement only	1

Question 25

Marking Criteria	Marks
• Determines Kepler constant for earth • Writes correct expression for orbit radius of satellite • Calculates value for radius • Determines altitude correctly • Correct units	4
• Does the math but no algebra AND • No errors OR • As Above + 1 error	3
1 error and no algebra AND correct value	2
One sensible relevant statement only	1

Question 26

Marking Criteria	Marks
• Correctly ID's one of the thought experiments • Gives a clear account of the relationship between thought and reality • Gives a detailed account of the relationship between thought and reality	3
As above BUT • Reasoning is weak OR • Use of language is weak	2
Correct ID of a thought experiment only	1

Question 27

Marking Criteria	Marks
• Correct ID (motor) • Correct reason • Appropriate linking words used	3
As above BUT • Reasoning is weak OR • Use of language is weak	2
Correct ID but no reason	1

Question 28

Marking Criteria	Marks
Correctly identifies the reason why	1

Question 29

Marking Criteria	Marks
a) Correctly identifies the reason why	1
b) Correctly identifies the reason why	1

Question 30

Marking Criteria	Marks
• Correct statement of Lenz's Law • Correct statement of the Law of Conservation of Energy • Relates energy creation to work done • Correctly relates the direction of the induction to the conservation law	4
• One of the laws not stated OR • States both laws, AND • Omits to relate energy created to work done in moving the magnet OR • Confuses the explanation	3
• Does not state either Law OR • ONLY states the Laws	2
One sensible relevant statement only	1

Question 31

Marking Criteria	Marks
• Device is correctly described • Description is **detail** • How it works it correctly **outlined** • Reference is **directly** made to the illustration, • using appropriate linking words • > 1 strength of the model noted • > 1 weakness of the model noted	**5**
• Device is correctly described • Description is **brief** • How it works it **not outlined** (too much detail, or too little) • Reference is made **indirectly** to the illustration, • Occasional use of appropriate linking words • > 1 strength of the model noted • > 1 weakness of the model noted	**4**
• Device is correctly described • Description is **brief** • How it works it **not outlined** (too much detail, or too little) • Reference is made **indirectly** to the illustration, • Occasional use of appropriate linking words • 1 strength of the model noted • 1 weakness of the model noted	**3**
• Device is correctly described • Description is **brief** • How it works it **not outlined** (too much detail, or too little) • Reference is made **indirectly** to the illustration, • Occasional use of appropriate linking words • 0 strength of the model noted • 0 weakness of the model noted	**2**
One sensible relevant statement only	**1**

Question 32

Marking Criteria	Marks
• Correct formula used • Correct substitutions made • Value correctly calculated • Answer given with correct units	**2**
• Max one error OR omission	**1**

Question 33

Marking Criteria	Marks
• Correctly describes the reason in detail	**2**
• Correctly describes the reason in brief	**1**

Question 34

a)

Marking Criteria	Marks
• Two diagrams; one for p-type one for n-type • Fermi levels in each indicated in the correct position • Diagrams include relevant information (i.e. valence band, conduction band, energy axis) • Correct charge carriers identified in each case	3
• One missing or incorrect element of the above e.g. Incorrect charge carriers, incorrect Fermi levels, etc	2
• Two missing or incorrect elements of the above OR • Missing one diagram	1

b)

Marking Criteria	Marks
Answer includes reference to: • Ge easier to purify than Si • But Ge gets hot • Improvements in refinement of Si meant Si could be used instead	1

c)

Marking Criteria	Marks
Answer includes reference to any TWO of the following: • Better Durability of solid state devices • Smaller Size of solid state devices • faster • Lower cost • Ease of manufacture • Reduced heat output/Improved energy efficiency	2
• Answer contains ONE advantage listed above.	1

Question 35

a)

Marking Criteria	Marks
attributes possession of momentum to cathode rays.	1

Question 35

b)

Marking Criteria	Marks
Answer includes TWO diagrams which: • Clearly indicated as Electric and Magnetic Fields (either by name or by variable e.g. E-field, B-field). • Shows correct forces applied based on the field direction	**2**
Answer includes ONE diagram which: • Clearly indicates either an electric or magnetic field AND shows the correct force applied OR The answer contains ONE error (e.g. an incorrect force indicated)	**1**

c)

Marking Criteria	Marks
Answer includes the following: • Two perpendicular fields can control path of beam • Varying the fields can target different parts of the screen • Varying the fields can be done with an input signal such as a sound or other wave	**3**
Answer contains at most ONE factual error OR Answer omits one of the three points above.	**2**
Answer contains TWO factual errors OR Answer omits at least two of the above.	**1**

Question 36

a)

Marking Criteria	Marks
Answer correctly explains the Meissner effect. AND is brief	**3**
Answer contains ONE factual error. OR is long-winded	**2**
Answer contains MORE THAN ONE factual error.	**1**

b) i)

Marking Criteria	Marks
Both points correctly plotted on graph provided.	**1**

b) ii)

Marking Criteria	Marks
A correct value of 93.5K ±0.5K including units.	**1**

b) iii)

Marking Criteria	Marks
Correctly identifies material as Type 2 Semiconductor	**1**

Question 37 (i)

Marking Criteria	Marks
• Piezoelectric effect described • Piezoelectric effect's role in both transmission and reception of ultrasound signal outlined	**2**
• Piezoelectric effect described in general	**1**

The piezoelectric effect occurs when an electric field, when applied to a crystal (made from ceramic material), causes a deformation – contraction or expansion. The converse occurs too – a mechanical deformation of the material results in an electric field. In ultrasound transducers, an electric field causes the crystal to vibrate and thus is the source of the ultrasound waves. The reflected waves cause the crystal to deform, producing a small electric signal with can be amplified – the received signal.

a. (ii)

Marking Criteria	Marks
• Correct comparison made using available data and appropriate equations	**3**
• Response provides valid method for determining proportion of signal reflected	**2**
• Affect of different acoustic impedances of materials on proportion of signal reflected is identified	**1**

For water/muscle boundary:

$$\frac{I_r}{I_o} = \frac{[Z_2 - Z_1]^2}{[Z_2 + Z_1]^2}$$
$$= \frac{\left[1.66\times10^6 - 1.54\times10^6\right]^2}{\left[1.66\times10^6 + 1.54\times10^6\right]^2}$$
$$= 0.0014$$
i.e. 0.14% reflected

For brain/bone boundary:

$$\frac{I_r}{I_o} = \frac{[Z_2 - Z_1]^2}{[Z_2 + Z_1]^2}$$
$$= \frac{\left[6.51\times10^6 - 1.58\times10^6\right]^2}{\left[6.51\times10^6 + 1.58\times10^6\right]^2}$$
$$= 0.37$$
i.e. 37% reflected

The reflected signal from a brain/bone boundary is some 264 times greater than for the same signal from a water/muscle boundary.

Question 37 b.

Marking Criteria	Marks
• specific example of a suitable radioisotope provided • binding or accumulation in correct organ described • metabolising process described • desirability of characteristic explained (half-life and specific accumulation)	**4**
• Three of the above	**3**
• example of a medical radioisotope named • specific targeting described	**2**
• example of a medical radioisotope named OR • specific targeting described	**1**

e.g. Only the thyroid gland in the neck absorbs iodine-123 after it is injected into the bloodstream. This radioisotope is gamma-ray active, and shows up when a gamma camera image of the thyroid is made. It can be injected as the natural element as it is transported around the body in this state, unlike many other radioisotopes that need to be chemically combined to organic substances in order to be transported within the body. An over-active thyroid shows up as a hot spot, thyroid cancer shows up as an under-active gland – a cold spot. Iodine-123 has a short half-life of 13.1 hours, so that its radioactivity becomes less than 1/8th of the original within 2 days of the injection.

Question 37 c. (i)

Marking Criteria	Marks
• Procedure is outlined in full	2
• An aspect of a bone scan procedure is identified	1

A bone scan is performed when a radioactive gamma emitting dye is injected into the patient and the dye is taken up by the bone biologically. A gamma camera is used to form an image of the bone.

Question 37 c. (ii)

Marking Criteria	Marks
• An advantage AND a disadvantaged outlined	2
• One advantage OR disadvantage outlined	1

A bone scan shows areas which are more biologically active, where a greater concentration of dye is evident by the brighter area on the image. X-rays only show the structure of the bone. X-rays take less time to produce and are cheaper.

Question 37 c. (iii)

Marking Criteria	Marks
• A relevant difference between PET scans and other imaging techniques identified	1

The way in which the gamma radiation is produced, by the annihilation of a positron and an electron, is different to other techniques which have either externally-sourced penetrating radiation (or sound) or the radiation is produced from radioactive decay.

Question 37 d.

Marking Criteria	Marks
• Doppler effect in sound referred to • description of image production provided • how images are interpreted to provide information relating to blood flow is provided • Response is made in a clear and logical manner	4
• Two of the above dot points	3
• Ultrasound image production is outlined • how images are interpreted to provide information relating to blood flow is provided	2
• Doppler effect outlined OR ultrasound image production outlined OR how image may provide information related to blood flow is outlined	1

Ultrasound waves which reflect off moving blood return with slightly varied frequencies which depend upon the relative motion of the blood. This is analysed and colour-coded by the computer when producing the image so that the speed and relative direction of blood flow can be determined. Blockages or abnormalities can thus be detected.

Question 37 e.

Marking Criteria	Marks
• Response provides evidence of a thorough and broad knowledge of the various methods used to produce medical images • response links the advances in scientific understanding and technology to the development of particular examples of medical imaging methods in the past few decades • nuclear physics and computer processing power are referred to as examples	6-7
• Advances in scientific knowledge and technology are linked to the development of particular medical imaging methods with examples of scientific knowledge and technology referred to	4-5
• An example of an advance in scientific knowledge or technology is linked to the development of a medical imaging method or methods	2-3
• A medical imaging method is used as an example	1

Sample answer:

• Advance in scientific understanding or technology	• How advance changed direction of medical imaging methods
• piezoelectric technology	• production and reception of ultrasound → modern ultrasound techniques
• increased computer processing power	• ability to produce o 3 dimensional, o high resolution, o real-time images for CT scans, PET scans and for MRI scans

2012 Physics Trial HSC Worked Solutions

Section 1 – Multiple Choice Questions

1. use $F_{gravity} = G\frac{m_1 m_2}{d^2}$

Let

m1 = mass of sun

m2 = mass of Mercury

d = ave Sun-Mercury distance

solve for m1: $\frac{F_{gravity} \times d^2}{G \times m_2} = m_1$

$m_{sun} = \frac{1.30546\times10^{22}\times(5.7909175\times10^{10})^2}{6.67\times10^{-11}\times3.3\times10^{23}} = 1.98893 \times 10^{30}$ kg

The data has a minimum of 2 sig fig (Mercury's mass data) so the answer is 2.0×10^{30} kg (the zero is significant)

2. The change in velocity is equal to the change in gravitational potential energy, so

$$\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = mg(h_2 - h_1),$$

so

$$\frac{1}{2}m(v^2 - u^2) = mg(h_2 - h_1),$$

And

$$g = \frac{v^2 - u^2}{2(h_2 - h_1)} = \frac{(2.85 \times 10^2)^2 - (2.75 \times 10^2)^2}{2([-1.3 \times 10^3] - [-5.5 \times 10^2])} = 3.7333 \text{ ms}^{-2}$$

The data has a minimum of 3 sig fig, so the answer is 3.73 ms^{-2} towards the centre of Mercury's mass

The trick is to remember that altitude is increasing away from the surface, while the velocity is increasing as the meteor gets closer and usually g is positive down so the altitude displacement vectors point in the negative direction.

3. $g\ force = \frac{apparent\ weight}{normal\ true\ weight} = \frac{mg+ma}{m\times9.8} = \frac{g+a}{9.8} = \frac{9.8+19.6}{9.8} = 3$

4. The role of the ceramic tiles on the underneath of the space shuttles was to protect against the heat generated by friction with the atmosphere, so the choice of material was governed by the need to prevent that heat from contacting the fuselage. A ceramic is a poor conductor of heat.

5. The “vomit comet” is used to familiarise astronauts with the effects of weightlessness by flying in a roller coaster like manner with the downward journey basically falling freely. As the plane and its occupants accelerate towards the earth under the influence of gravity alone their weight cannot be measured.

6. The protons and anti-protons have equal masses of 1.673 × 10^{-27} kg. With speeds of 0.999999991 *c*, we have to calculate the relativistic mass.

$$m_v = \frac{m_o}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{1.673 \times 10^{-27}}{\sqrt{1-\frac{(0.999999991\,c)^2}{c^2}}} = 1.24698 \times 10^{-23}\text{kg}$$

As there are two particles in collision there will be the sum of their kinetic energies:

$$\sum KE = 2 \times \frac{1}{2} \times 1.24698 \times 10^{-23} \times (0.999999991 \times 3 \times 10^8)^2 = 1.2228 \times 10^{-6}\text{J}$$

7. The Higgs boson is the proposed mechanism by which mass is acquired.

8. The superconductors provide the magnetic fields that are used to direct the charged particles around the track.

9. It was in 1831 that Faraday discovered electromagentic induction.

10. $F = BIl\sin\theta$, and B, F and and the direction of I are all perpendicular to each other.

11. As $\frac{v_p}{v_s} = \frac{n_p}{n_s}$ the transformer is a step up and the number of turns in the second coil is given by $n_s = n_p \times \frac{v_s}{v_p} = 60 \times \frac{12}{3} = 240$

12. torque on a coil is given by $\tau = nBIA\cos\theta$ and this maximises when θ = 0°. The value is found by $250 \times 1.25 \times 10^{-3} \times 3.75 \times 0.25 \times 0.25 \times \cos 0 = 0.073$ Nm.

13. The induction cooktop is similar since the geometry of the wheel is the same as that of the pot.

14. The back emf must be less than the supply emf or energy will be created from nothing, which does not happen. The current directions are opposite and consistent with Lenz’s law in that the direction of the back emf current is such that it opposes the change that induced it.

15. In an induction motor the stator provides the moving magnetic fields.

16. Plack’s constant relates energy in Joules to Hz, which equal 1/s, so the unit of the constant must be Js to ensure consistency on both sides of the equal sign.

17. Planck.

18. for diffraction to occur the size of the scattering centres’ must be the same as the wavelength of the scattered wave.

19. The absence of an induced spark when the orientation of the transmitter gap was at right angles to the receiver gap indicates that radio waves are polarisable, i.e. that they have a preferred orientation.

20. the use of either boron or aluminium will result in a p-type semiconductor, in which the majority charge carriers are positive holes.

Longer Response Questions

21. The information we have is the range (120 km = 120 ×10^3 m) and the time (3 minutes = 180 seconds) and the acceleration is only in the y direction and is 9.8 m/s^2 down.

a) to calculate the maximum altitude we can use the falling height calculation,

$$s = ut + 0.5at^2$$

so we can take the down direction to be positive, so a = 9.8 m/s^2 and s is a positive number of metres. U is zero as we are starting from a fall. T is 90 seconds since we know the time of flight and we know that projectile motion is symmetrical in that the upwards journey is a mirror of the downwards.

$$alt = 0.5 \times 9.8 \times 90^2$$
$$= 39\ 690 \text{ metres}$$

b) We are given the range and the time of flight so it is possible to use that to determine what the horizontal component of the velocity is:

$$v_x = \frac{1.20 \times 10^5}{1.80 \times 10^2} = 666.67 \text{ m/s}$$

For the vertical component we know the fall height so we can calculate the vertical component of the velocity from that:

$$v_y = u + at$$

$$v_y = 0 + 9.8 \times 90 = 882.0 \text{ m/s}$$

c) the muzzle velocity is the launch velocity, which by symmetry is equal to the impact velocity so we can use the components we have just calculated.

Magnitude:

$$|v| = \sqrt{v_x^2 + v_y^2}$$

$$= \sqrt{(666.67)^2 + (882.0)^2}$$

$$= 1105.61 \text{ m/s} = 1100 \text{ m/s}$$

Angle:

$$\tan^{-1}\theta = \frac{882}{666.67}$$

$$\theta = 52.9° = 53° \text{ to the horizontal}$$

22. since $F_g = G\frac{M_{planet}M_{other}}{r^2} = M_{other} \times g$ then g can be calculated by letting the mass of the "other" to be just 1 kg and setting r to be the planet radius.

$$g = G\frac{M_{mars}}{(r_{mars})^2} = 6.67 \times 10^{-11} \times \frac{6.4 \times 10^{23}}{(3396.2 \times 10^3)^2} = 3.71 \text{ m/s}^2$$

23. The performance of work upon a body in a gravitational field will result in changes to that body's GPE that exactly equal the amount of work done.

$$F \times s = mgh = mg(r_2 - r_1) = G\frac{M_{planet}M_{other}}{r_2} - G\frac{M_{planet}M_{other}}{r_1}$$

24. Classically, space and time are fixed and velocities are relative depending on the motion of observers. Special relativity fixes the velocity of light in a vacuum to be constant and independent of the motion of any observer. Hence it is space and time that become relative. Special refers to inertial frames of reference only.

25. To obtain the Kepler constant we do

$$k = \frac{6.67 \times 10^{-11} \times 5.97 \times 10^{24}}{4\,\pi^2} = 1.00865 \times 10^{13}$$

Then we use the data to calculate the radius of the satellite orbit:

$$\frac{r^3}{T^2} = k = 1.00865 \times 10^{13}$$

T = 86164 sec.

$$r = \sqrt[3]{kT^2} = \sqrt[3]{1.00865 \times 10^{13} \times 86164^2} = 4.215 \times 10^7 \text{m}$$

$$alt = orbit\ radius - earth\ radius$$

$$= 4.215 \times 10^7 - 6.38 \times 10^6$$

$$= 3.5772 \times 10^7 \text{ m}$$

26. Imagine sitting on a train which is travelling at the speed of light and you have a mirror that you hold out in front you. Can your reflection be seen?

This thought experiment enables examination of a situation which would otherwise be impossible, as no train can travel at such a speed. If the principle of relativity holds, then the reflection is seen, as its disappearance would be a way to detect motion without reference to the external world, which is impossible in the inertial frame of reference of the train travelling with a constant velocity.

27. It is a motor, as the input is electrical energy, and also no external mechanical power source is drawn. Motors convert input electric power into mechanical power.

28. Domestic appliances often need a supply voltage much less than the 240 V mains supply, so the voltage needs to be stepped down.

29. Transmission lines are protected from lightening strikes by the use of an extra wire suspended above the main group of transmission lines. This wire is earthed. They are insulated from the support structure by stacks of ceramic discs.

30. Lenz's Law: An induced emf always gives rise to a current that creates a magnetic field that opposes the original change in flux through the circuit.
If the direction of the induced flux was the same as the direction of the inducing flux that would mean a feedback loop of ever more flux being created, which clearly does not happen. (see Jacarnda Ch7, p 129).

31. The device is an AC induction motor. It works by using moving magnetic fields in the stator to induce current into a cylindrical structure called a 'squirrel cage' (the rotor), thus producing motion in the rotor.

The operation of AC induction motors

As the magnetic field rotates in the cylindrical space within the stator, it passes over the bars of the cage. This has the same effect as the bars moving in the opposite direction through a stationary magnetic field. The relative movement of the bars through the magnetic field creates a current in the bars. Bars carrying a current in a magnetic field experience a force. The discussion on the opposite page shows that the force in this case is always in the same direction as the movement of the magnetic field. The cage is then forced to 'chase' the magnetic field around inside the stator.

32. the force felt by two current carrying wires is given by

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

With

F = 3.28×10^{-7} N

$I_1 = 0.75$ A

I_2 = 1.25 A

d = 0.2 m

solving for l

$$l = \frac{Fd}{kI_1 I_2} = 0.35 \text{ m}$$

33. Voltage transformation are related to conservation of energy in that when voltage is transformed it is the electrical power that remains the same. Since power is the rate at which energy is used/produced and power is the product of voltage and current, any change in voltage will produce a change in current also, as energy can not be gained in this process, only maintained (ideally) or partially lost (actually).

34. a)

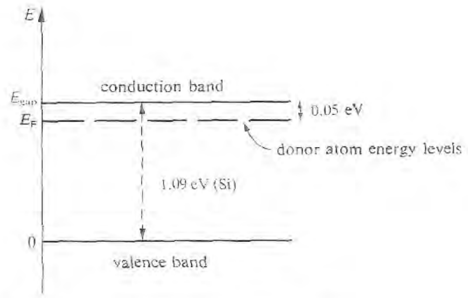


FIGURE 4.10 n-type semiconductor energy level diagram.

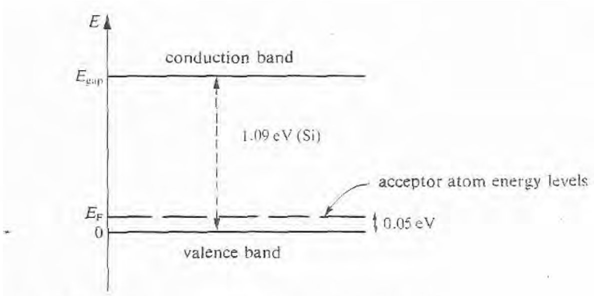


FIGURE 4.11 p-type semiconductor energy level diagram.

n type majority charge carriers are e^-, *p* type are holes.

b) Silicon has better semiconducting properties, but germanium crystals could be made more easily than silicon. When we learned how to make silicon of sufficient purity we dropped germanium because germanium develops too much waste heat.