Section I

75 Marks

Part A – 20 Marks

Attempt Questions 1 – 20

Allow 35 Minutes for this part

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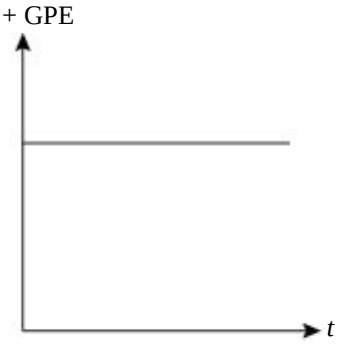
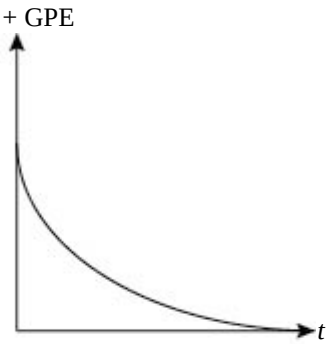
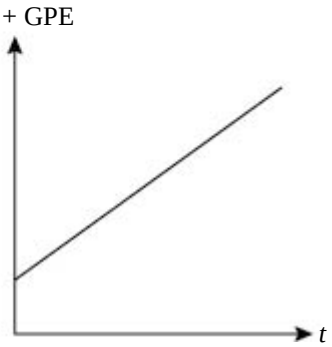
1 A satellite orbits a planet of mass **m** at a distance **d** from its centre of mass. If the mass of the planet were to decrease by 50%, the slope of the satellite's Gravitational Potential Energy curve at the same distance will become

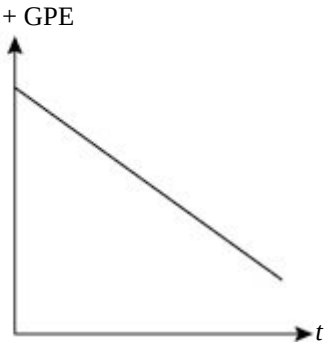
(A) More positive.
(B) More negative.
(C) Remain exactly the same.
(D) Zero.

2 An object is dropped from a height and allowed to fall freely through a vacuum. Which of the following graphs correctly shows the sum of the object's kinetic and gravitational potential energies as a function of time?

(A)


(B)


(C)


(D)


3 The mass of the Earth is 5.98×10^{24} kg. The radius of the Earth is 6378.1 km. The Mass of Mars is 6.42×10^{23} kg. The radius of Mars is 3397.2 km. The ratio of the acceleration due to gravity at the surface of Mars to that on earth is

(A) 1:1
(B) 1:2.63
(C) 2.63:1
(D) 2:5

4 A cup has a hole made in the side. A student holds the cup with a finger covering the hole and fills it with water. Once the level of the water reaches the hole the student is surprised to feel his finger is wet and drops the cup. Which of the following best describes what happens next?

(A) Water flows out of the hole and falls more slowly than the cup falls.
(B) Water flows out of the hole and falls more quickly than the cup falls.
(C) Water flows out of the hole and falls at the same rate as the cup.
(D) No water flows out of the hole and the cup and the water fall at the same rate.

5 Which of the following lists of factors can all affect the strength of gravity measured at the surface of Earth?

(A) Variation in altitude, variation in the thickness and composition of the crust; variation in distance to the centre of Earth's mass due to the planet not being a perfect sphere; the rotation of the Earth.

(B) Variation in altitude, variation in the thickness and composition of the crust; the mean temperature at the surface; the rotation of the Earth.

(C) Variation in altitude, variation in the thickness and composition of the crust; variation in the composition of the atmosphere; the rotation of the Earth.

(D) Variation in altitude, variation in the thickness and composition of the crust; variation in the local ecosystem; the rotation of the Earth.

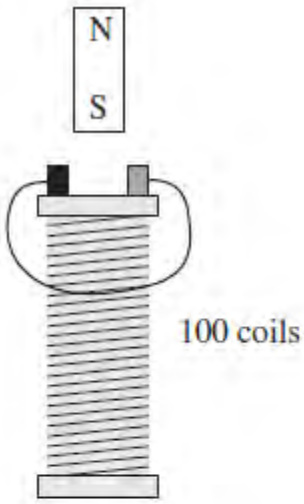
6 The mass of Venus is 4.87×10^{24} kg with a radius of 6051 km. Compared to that of Earth, the escape velocity of the planet Venus is

(A) Much greater
(B) Much less
(C) About 0.92
(D) The same

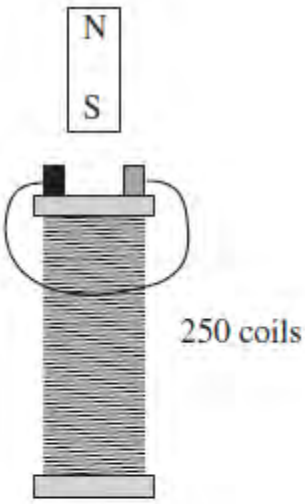
7 A permanent bar magnet is dropped from rest through a number of hollow solenoids, as shown in the diagrams below. All solenoids have the same length. Two of the solenoids have a connecting wire between the ends of the solenoid.

In which case would the magnet take the longest time to pass through the solenoid?

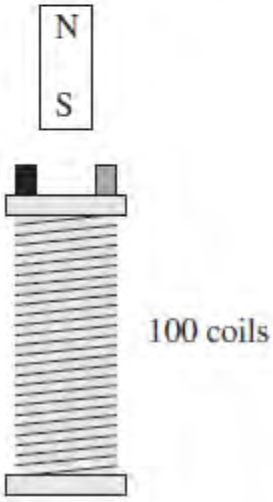
(A)



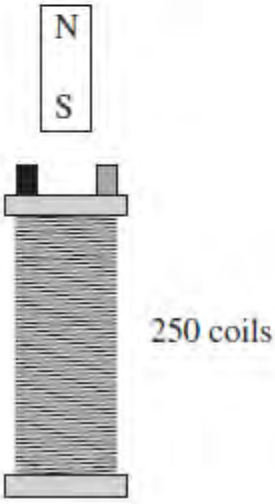
(B)



(C)

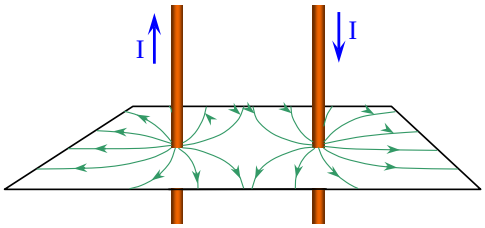


(D)

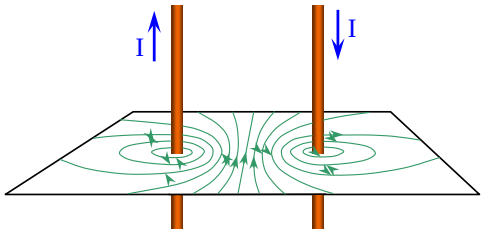


8 Which of the following diagrams best represents the magnetic field around two long. straight, parallel wires carrying an equal current, but in opposite directions?

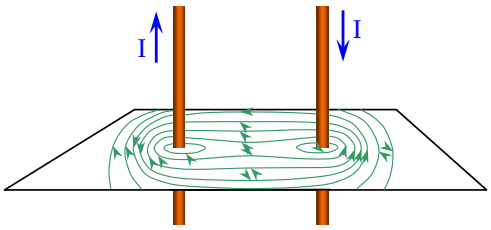
(A)



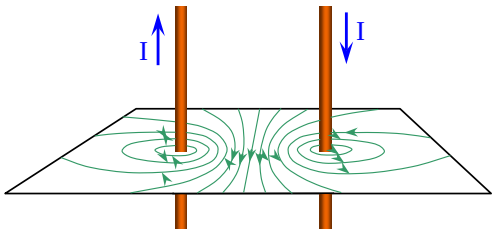
(B)



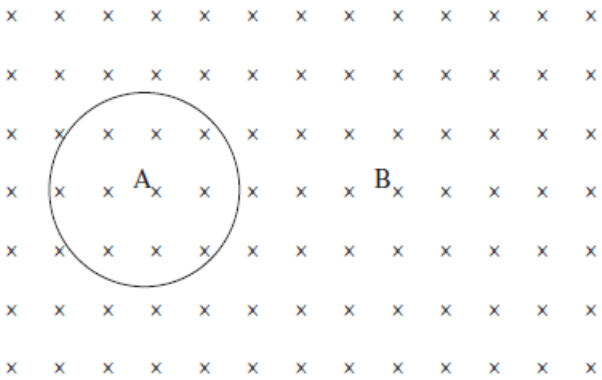
(C)



(D)



9 The diagram below shows a circular loop of conducting wire in a uniform magnetic field directed into the page.



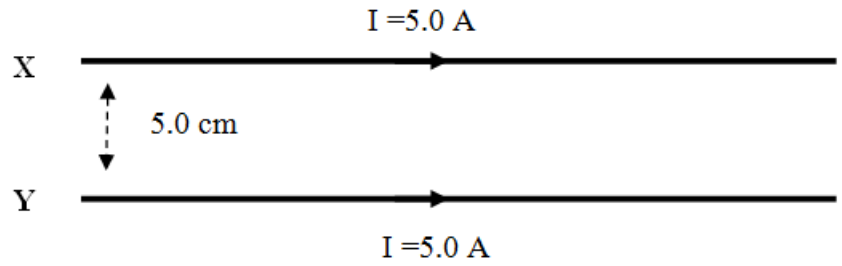
Which of the following actions will not affect the magnetic flux passing through the loop?

(A) removing the loop from the field
(B) changing the strength of the magnetic field
(C) reducing the circle to half the original radius
(D) moving the coil right, from *A* to *B*

10 Magnetic flux is most closely associated with the:

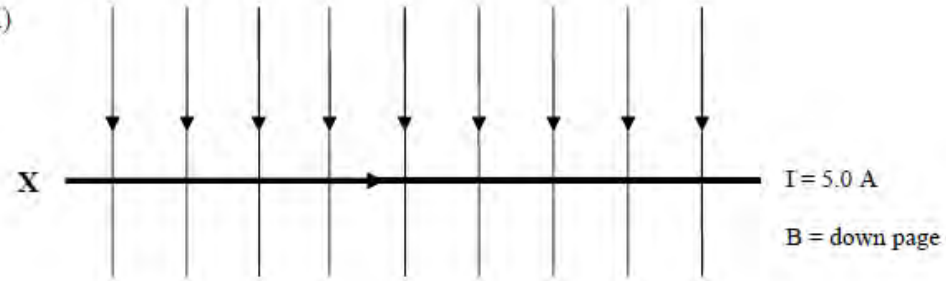
(A) number of lines of magnetic force.
(B) density of the lines of magnetic force.
(C) direction of the lines of magnetic force.
(D) size of the area that the magnetic lines of force pass through.

11 Two long, straight parallel conductors, X and Y, each have a current of 5.0 amps flowing in the same direction, as shown. They are 5.0 cm apart.

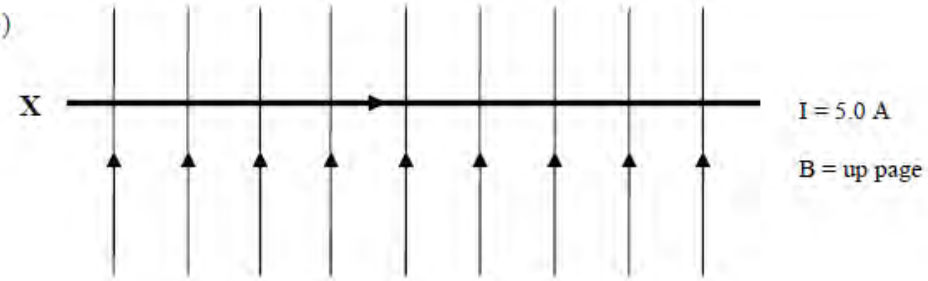


In which one of the following situations could conductor X experience the same force per length as when it is parallel to conductor Y?

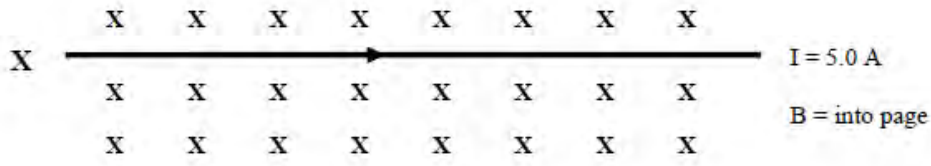
(A)



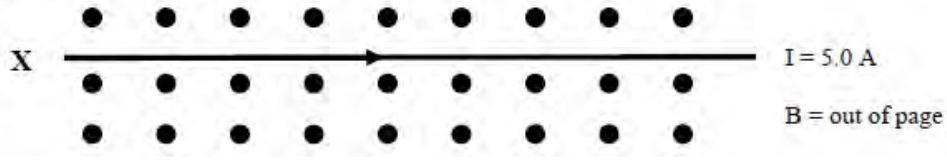
(B)



(C)



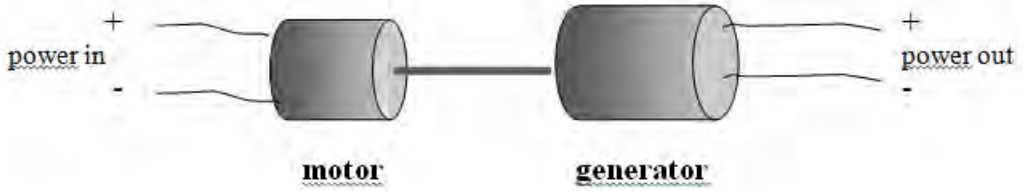
(D)



12 The speed of an electric motor which has no load is limited by:

(A) the current that can flow through the motor's coils.
(B) the area of the motor's coils.
(C) the resistance in the motor's coils.
(D) the back EMF produced in the motor.

13 A motor connected to a power source, in turn drives a generator, as shown.



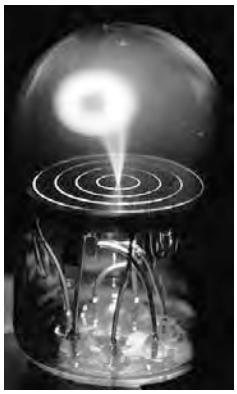
The most correct statement about this arrangement is

(A) The motor will be hotter than the generator.
(B) The power into the motor is greater than the power out of the generator.
(C) The generator is more efficient than the motor.
(D) The generator produces a higher voltage than the motor uses.

14 Planck's constant is the ratio between which two of the following quantities associated with electromagnetic radiation:

(A) f and λ
(B) f and ϕ
(C) v and λ
(D) Energy and f

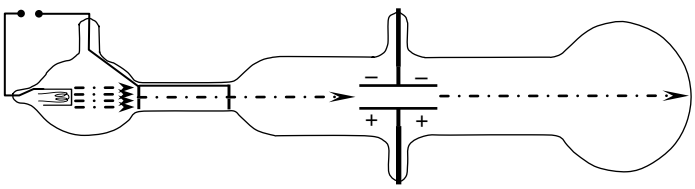
15 The following image shows one of the Crooke's tubes you observed during the course.

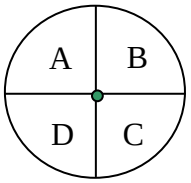


This specific tube enables demonstration of the fact that the cathode ray can be deflected by an electric field. The direction of this deflection is opposite to the direction of the electric field. The interpretation of this result is:

(A) Cathode rays have no electric charge.
(B) Cathode rays have positive electric charge.
(C) Cathode rays have negative electric charge.
(D) Cathode rays are actually waves.

16





In a variation of the Thomson experiment, an experimenter fires a beam of electrons through the apparatus. When both the electric and magnetic fields are switched off, the beam strikes the centre of the fluorescent bulb of the tube, as shown on the right. When the electric field is switched on the upper plate becomes negatively charged. But in this variation a magnetic field is also established vertically, with the north pole located in the same position as the negative plate, with the south pole located on the lower plate.

As the electron beam *inside the tube* approaches the end of the bulb, the letters marked on the diagram divide the bulb into sectors A, B, C and D. Into which sector of the bulb will the electron beam be deflected by this combination?

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

17 When Heinrich Hertz produced radio waves, he needed to prove they were one type of the electromagnetic radiation that James Maxwell had predicted must exist, identical to visible light in all ways apart from their frequency/wavelength.

How did he show his radio waves were transverse waves rather than longitudinal?

(A) He checked the radio waves reflected by using polished copper plates.
(B) He checked the waves were polarised by rotating his detector loop through 360°.
(C) He measured the frequency and wavelength of the waves to find their speed.
(D) He tested that the waves underwent refraction by passing them through pitch.

18 An electron moving with a velocity of 0.1*c* passes at 90° through a magnetic field of strength 2×10^{-4} T.
Identify which expression gives the magnitude of force on the electron due to the magnetic field.

(A) $F = 1.6 \times 10^{-19} \times 0.1 \times 3 \times 10^{8} \times 2 \times 10^{-4} \sin 90°$
(B) $F = 1.6 \times 10^{-1} \times 2 \times 10^{-4} \sin 90°$
(C) $F = 1.6 \times 10^{-19} \times 0.1 \times 3 \times 10^{8} \times 2 \times 10^{-4} \cos 90°$
(D) $F = 1.6 \times 10^{-19} \times 2 \times 10^{-4}$

19 Which of the following statements best describes our current understanding of the nature of an electron:

(A) Electrons are really waves.
(B) Electrons are really particles.
(C) Electrons don't actually exist at all, they are just a useful idea.
(D) Electrons are neither waves nor particles, but possess wavelike properties and particle-like properties.

20 BCS theory describes an explanatory mechanism for low temperature superconductivity. One of the predictions of this theory is that superconductivity should not be possible at temperatures above about 40 Kelvin. In the 1990's a series of new materials were developed that would superconduct at temperatures above 40 Kelvin. The logical inference that can be drawn from this is:

(A) BCS theory is completely wrong.
(B) BCS theory is correct below only below 40 K.
(C) BCS theory is not correct but captures some of the essential features of the physics of superconductivity.
(D) All of the above might be equally correct, we just don't know enough yet to answer that question definitively.

Name: _____

Teacher:_____

Class:_____

Physics

Section 1 (continued)

Part B - 55 Marks
Attempt Questions 21 – 34
Allow 1 hour and 40 minutes for this part

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

Show all relevant working in questions involving calculations.

Question 21. (2 Marks)

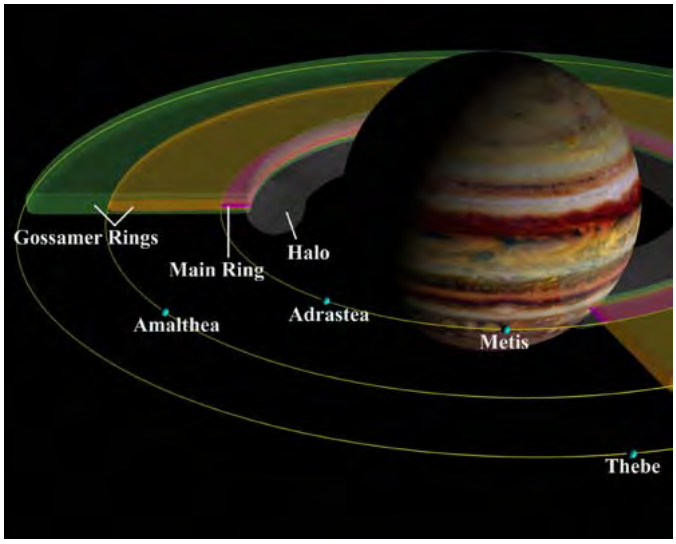
Derive an expression for the escape velocity of a projectile from any given planet**.**

Question 22. (2 Marks)

Explain why the exterior shape of the lunar landing modules used in the Apollo missions to the moon were not streamlined.

Question 23. (2 Marks)

The following image shows the inner rings and moons of Jupiter.



Amalthea's period takes 0.498 Earth days, and orbits Jupiter at a distance of 181 400 km from Jupiter's centre of mass. Thebe orbits at 222 000 km. What is the period of Thebe in units of earth hours?

This exam continues on next page

Question 24. (6 Marks)

Analyse the relationship between available technology, data, and the subsequent interpretations of that data. Use examples drawn from your studies of the history of physics.

Question 25. (6 Marks)

(a) Two protons are accelerated in an electric field to 0.999*c* from rest over a distance 0f 7.5 km. Calculate the strength of the electric field. 3

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(b) The protons enter a chamber where they will cover a distance of 1500 m. Determine the distance covered in the frame of reference of one of the protons. 3

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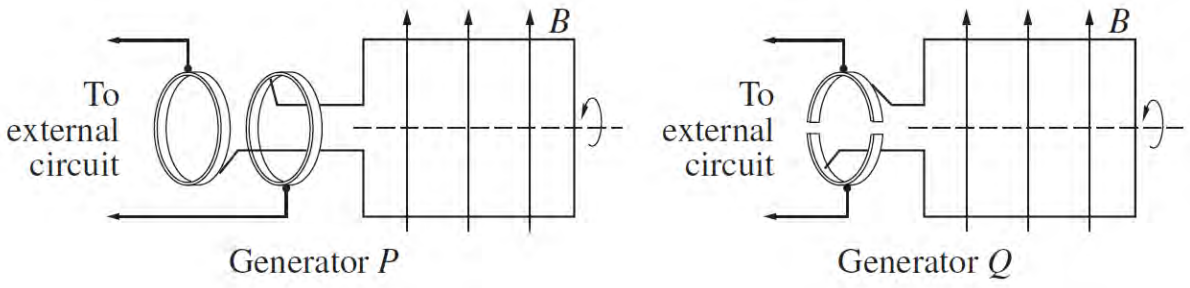
Question 26. (4 Marks)

Two types of generator are shown in the diagram.



(a) What does the dashed line represent? **1**

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(b) Which of these generators will produce AC electricity? Justify your choice. **3**

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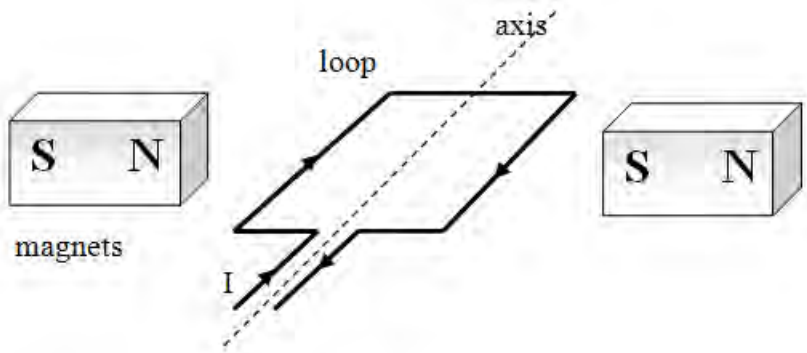
Question 27. (5 Marks)

A Rectangular loop of wire lies in the same plane as a magnetic field as shown.



(a) The loop begins to rotate due to the torque produced when a current I flows. Describe the changes to the torque on the loop as the loop rotates through one-quarter of a revolution starting from the position shown above. **2**

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(b) Compare the *force* experienced by a coil to the *torque* on the coil. **3**

Question 28. (4 Marks)

(a) Induction cooktops have a heat control just like conventional cooktops. Describe a method by which an induction cooktop could be made to produce more heat. **2**

(b) Explain why induction cooktops are more efficient than conventional cooktops. **2**

This exam continues on next page

Question 29. (5 Marks)

When Oersted and Faraday made their discoveries no-one knew that electrical power would transform the world. One of the difficulties faced by Scientists today is the need to find funds to pay for their basic research. Outline two arguments, one economic and one scientific, that could be used to promote basic research. Drawing on your studies in Physics, use real historical examples to support your case.

This exam continues on next page

Question 30. (3 Marks)

Outline how Hertz confirmed the following predictions based on Maxwell's equations that:

- Electromagnetic waves exist at many different frequencies
- All such waves would propagate through space at the speed of light.

Question 31. (2 Marks)

Describe how Hertz was able to determine the wavelength of the electromagnetic radiation he was producing.

This exam continues on next page

Question 32. (6 Marks)

Explain the concept of electron energy bands and describe how this concept can be used to explain the conductivities of *conductors*, *insulators*, and *semiconductors*.

This exam continues on next page

Question 33. (6 Marks)

Einstein's Nobel Prize was awarded for his work on the photoelectric effect.

(a) Outline Einstein's explanation of the photoelectric effect. **2**

(b) Identify one technology that has the photoelectric effect as it basis. With the aid of a diagram, explain how that technology works. **3**

This exam continues on next page

Question 34. (3 Marks)

Explain how investigations into the relationship between temperature and electrical conductivity led to the development of semiconductors and superconductors.

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End of Section 1

Physics

Section II Option: Medical Physics [25 Marks]

Answer this question in a separate answer booklet.

Question 35.

(a)

i. Identify how ultrasound differs from sound in normal human hearing. **1**

ii. Explain how a sound wave can be produced when a current is applied to a piezoelectric crystal. **2**

(b) Below is a table of speed and densities of a number of tissues in the body.

Medium	***Speed (m/s)***	***Density (kg/m^3)***
fat	1475	925
bone	3800	1550
blood	1570	1060
brain	1560	1025

i. Determine the acoustic impedance of brain tissue. **1**

ii. The acoustic impedance of bone is 5.89×10^6 kg m^{-2} s^{-1}

Determine the ratio of reflected to transmitted intensity between brain and bone and explain how this affects the image produced by an ultrasound of the brain. **3**

iii. Explain the Doppler effect and how this is used in the context of ultrasound. **2**

(c)

i. Write an expression relating the intensities of the incident, reflected, and transmitted ultrasound waves at any tissue interface. **2**

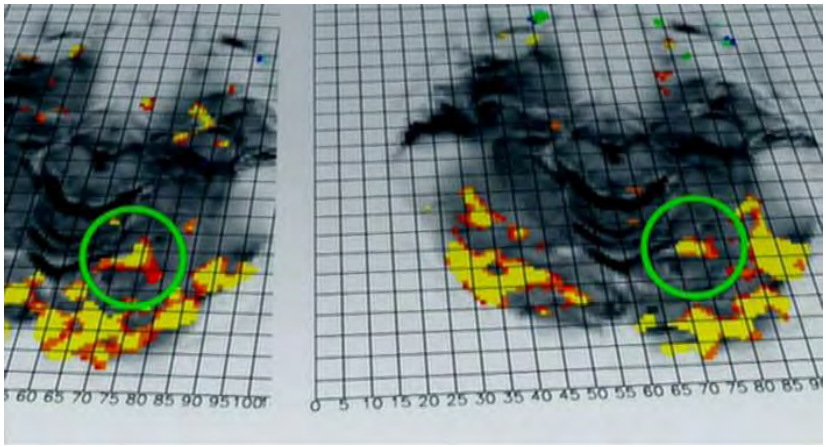
ii. "*The drawback of the continuous Doppler signal is that it does not convey clear information about deep blood vessels due to scattering and reflection from soft tissues encountered by the ultrasound as it penetrates the body*." (Jacaranda p 354)

Explain what is meant by scattering in this context and hence explain why a discontinuous Doppler signal is a more useful technique. **4**

(d) With reference to endoscopy, explain what is meant by the term "coherent light" and give one example each of how both coherent and incoherent light is used in an endoscope. **3**

(e) Define the term "relaxation time" and explain how this is used to provide contrast in an MRI Image. **3**

(f) The image below shows chess player Susan Polgar's brain. The scan on the left was taken while she was looking at pictures of faces while that on the right was acquired while she was looking at a chess board.



i. What type of information (*structural*, *functional* or *both*) is being extracted from the MRI in the above experiment? **1**

ii. Do the circles in both scans indicate the same area of her brain? Describe how you can tell. **2**

iii. What do these scans tell us about how Susan Polgar plays chess? **1**

2011Trial HSC Physics
Marking Guidelines

Section I Part A

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

Section I Part B

Question 21.

Marking Criteria	Marks
• Equates KE to GPE • Algebraic steps shown • Correct expression for escape velocity	**2**
Any two of the above	**1**

Question 22.

Marking Criteria	Marks
• External surface of lunar module is not streamlined • …Because the vehicle does not have to encounter atmospheric friction	**2**
Mentions "no atmosphere" or "no friction"	**1**
No mention of friction or atmosphere	**0**

Question 23.

Marking Criteria	Marks
• Uses Kepler"s Law, shows eqn • Correct calculation • Answer in terms of Earth hours = 55.94 hours	**2**
Answer given correctly, but no working shown OR Answer not given in correct units (hours)	**1**

Question 24.

Marking Criteria	Marks
• Analyse scaffold is followed: an attempt is made to thoroughly examine the relevant issues by identifying them and then elucidating how they relate to each other • Response shows that the student has a deep understanding of the topic • 3 or more examples are given • All examples are described in detail • Relationships between examples are described in detail	**5-6**

As above, except • 2 examples only given in full detail OR 3 examples with brief descriptions OR • 3 detailed examples, but relationships between them are only briefly described OR • Response shows that the student has a satisfactory understanding of the topic	**3-4**
As above, except • 1 example only given in full detail OR 2 examples with brief descriptions OR • 2 detailed examples, but relationships between them are only briefly described OR Response shows that the student has a only a basic understanding of the topic	**1-2**
Response shows that the student has misunderstood the topic/question	**0**

e.g. Modelled response

The data we have about the world is a function of the means by which we collect it. The interpretation of the data cannot occur if the data does not exist. Available technology can enable only the collection of a limited variety of data types, and so is a limiting factor on what can be known about the world.
Example technologies include the glass lens, the Galilean telescope, the reflecting telescope, and the satellite-based telescopes such as the Hubble and Chandra telescopes.

The Galilean telescope was the first instrument that enabled resolution of objects too far away to be seen by the naked eye. Galileo used his telescope to discover the first four moons of Jupiter, that moon was covered in ipact craters, that Venus has phases similar to those of our Moon. These new discoveries led to the abandonment finally of the geocentric model of the universe.

With greater resolving power, the reflecting telescopes used by Hallee and Herschel enabled the discovery of the planets Uranus and Neptune, expanding our view of the Solar system. Analysis of the orbits of the bodies we could see enabled prediction of the existence of bodies that we could only infer. By predicting where to look the possibility became that with the right telescope one could find what had not been found before. When Edwin Hubble imaged the Andromeda Galaxy he discovered that there are other Galaxies apart from the Milky Way and immediately expanded the size of the known Universe by may orders of magnitude. Using the new technology of spectroscopy he was able to measure the red shift of the galaxies and determine that the Universe is expanding – ending forever the idea that the Universe is static.

Freed from the attenuating effects of the atmosphere, the space telescopes have enabled us to determine that there are over 100 billion galaxies, each containing about 100 billion stars just like the Sun, and that the age of the universe is about 13.7 billion years.

The relationship between technology and data and knowledge is one of strict dependence: if you cannot detect a phenomenon, then it remains unknown and therefore not included in our catalogue of nature and its rules.

Question 25.

Marking Criteria	Marks
Question 25 a	
• Uses $v^2 = u^2 + 2as$ to calculate a • Uses F = ma = qE and then solves for E • Answer = 62 534 V/m	**2**
Answer given correctly, but no working shown OR Answer not given in correct units (N/c or V/m)	**1**
Question 25 b	
• Uses $l_v = l_0\sqrt{1 - \frac{v^2}{c^2}}$ • Correctly assigns l_0 = 1500 m, $v^2 = (0.999\ c)^2$ • Answer l_v = 67 m	**2**
As above but with one error OR Answer given w/out unit	**1**

Question 26.

Marking Criteria	Marks
Question 26 a	
The dashed line represents the axis of rotation of the coil	**1**

Marking Criteria	Marks
Question 26 b	
• Generator P will produce AC • Because P has a pair of slip rings, the purpose of which • …is to allow the brushes to remain in contact throughout the full 360° of rotation without any inversion of polarity	**3**
As above but without explaining what the slip rings do	**2**
Only identifies generator P as the AC	**1**

Question 27.

Marking Criteria	Marks
Question 27 a	
Accurate description of variation of torque given	**2**
General description of reduction in torque given	**1**

At the beginning, torque is at a maximum (as $\tau \alpha \cos\Theta$), but as rotation commences, the torque will decrease to zero by 90^0, by $\cos\Theta$, as $\cos 90^0 = 0$ and $\cos 0 = 1$.

Marking Criteria	Marks
Question 27 b	
• Similarity – both are aspects of the coil • Difference – force given by $BIl\sin\theta$, torque by $nBIA\cos\theta$ • Difference - Force θ is constrained to 90° and 270°, torque θ goes through 360° • Difference force is a push or pull whereas torque is twisting force three of the above = 3 marks	**3**
• Two of the above	**2**
• One of the above	**1**

DC power supplies need to be connected through a split-ring commutator using brushes usually made from graphite so the current is reversed each half-turn. AC power is connected to motors using two slip rings. Again brushes are used to make the connection between the wires and the slip rings.

Question 28.

Marking Criteria	Marks
Question 28 a	
Two appropriate methods are identified, each increases the rate of change of flux	**2**
One appropriate method identified	**1**

To increase the rate of change of flux through the saucepan base:

- Increase the frequency of the AC power supply to the electromagnetic coils,
- Increase the voltage of the power supply to the electromagnetic coils.

Marking Criteria	Marks
Question 28 b	
Full explanation given clearly	**2**
Partial explanation or identification of source of heat provided only	**1**

The induced eddy currents in the saucepan base cause heating of the base of the saucepan which is in contact with the food, so that the food is heated directly and therefore less heat is lost than in a conventional cooktop. In a conventional cooktop, some of the heat from the cooktop escapes without going into the saucepan, reducing its efficiency.

Question 29.

Marking Criteria	Marks
• Scientific argument defined (merit is technical) • Economic argument defined (merit is financial) • Basic research is defined as curiosity driven research aimed at explaining nature • Student response shows **deep understanding** of the topic/question • Two arguments are outlined, one being correctly scientific and the other being correctly economic • Each argument is supported by 2 detailed examples. • The scientific argument relies on demonstration of a working solution to a problem (e.g. Tesla‟s Niagra Falls project as proof-of-concept for the production of AC electricity) • The economic argument relies on demonstration of the money that can be generated as a result of this activity (the size of the US economy grew as a result of providing electrical energy to businesses).	**5-6**

As above, except • 3 of 4 examples only given in full detail OR 4 examples with brief descriptions OR • *Scientific, economic arguments* or *basic research* not defined but are used correctly OR • Response shows that the student has a **thorough understanding** of the topic	**3-4**
As above, except • Max of 2 of 4 examples only given in full detail OR • 3 (in total) examples with brief descriptions OR • 2 detailed examples, but relationships between them are only briefly described OR Response shows that the student has a only a **basic understanding** of the topic	**1-2**
Response shows that the student has **misunderstood** the topic/question	**0**

e.g. Modelled response

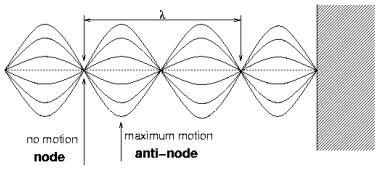
Basic research is research that is often described as being "curiosity driven" and is designed merely to discover how nature works. A scientific argument is one made in terms of the technical merits of a proposition, whereas an economic argument is one made in terms of any financial merit.

Scientifically, the main reason for supporting basic research lies in the power acquired by humanity over its environment at every step in the journey of discovery. Development for humans has been driven by technologies such as smelting metals and grinding glass. The competitive nature of human society has seen a long history of technological advantage exploited by early adopters. By the 19th century many technologies were becoming limited by the materials of which they were made, e.g. wood or stone. In the 20th century new materials called semiconductors have allowed the development of revolutionary technology such as computers, which has changed how humans everywhere exchange information. This has in turn increased the rate at which human discovery has progressed, for example the speed with which the human genome can now be sequenced (hours) is a miniscule fraction of the time it took to do for the first time (years).

Economically, heading off into the unknown seems financially risky, as one cannot show a measureable return on invested funds over timescales that are financially relevant. Indeed the link between scientific discovery and development of profitable business opportunities is often impossible to draw directly from discovery to product. It is clear that investigations into the electrical conductivities of materials at various temperatures has yielded

two new classes of materials: semi-conductors (which only conduct above some minimum temperature) and superconductors (which when cooled sufficiently will conduct with zero electrical resistance). So far many, many people have made a lot of money out of computer technology, which is based on semiconductor physics. It would be financially historically ignorant to withhold funds from basic research.

Question 30.

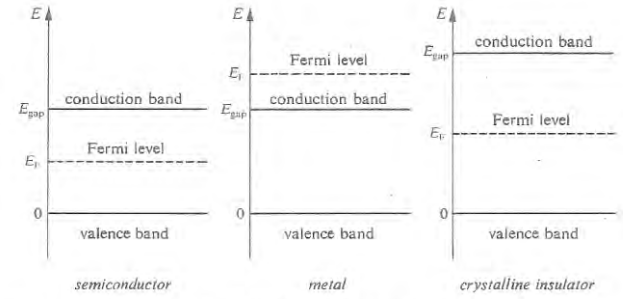
Marking Criteria	Marks
Mentions need for cavity of length $\frac{n\lambda}{2}$, where *n* can be 1, 2, 3 etc Mentions wave of wavelength λ, Which is reflecting from one end of the cavity to the other Describes nodes and antinodes Includes a labelled drawing like: 	**3**
Missing any two of the above	**2**
Has only a basic drawing that is correct	**1**

Question 31.

Marking Criteria	Marks
• Hertz varied the cavity length. Knowing he would have a standing wave he measured what λ was. • He then used the frequency that he was generating to calculate the speed via $v = f \times \lambda$	**2**
Mentions Hetrz measuring λ but not how the measurement was made, and then explains that he then used the frequency that he was generating to calculate the speed via $v = f \times \lambda$	**1**

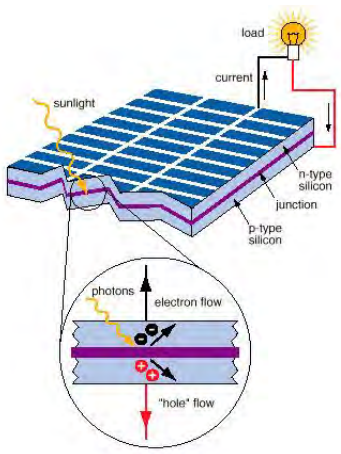
Question 32.

Marking Criteria	Marks
• Electron energy bands are clearly explained as being the *range of allowed energy values* than electrons in a real solid material can possess.	**5-6**

• Those bands are further discriminated into *valence band* (where electrons are within the neighbourhood of their parent atom) and *conduction band* (where electrons are delocalised from their parent atoms and are available for electrical current). • Has diagram similar to  FIGURE 4.9 Location of Fermi level in various materials. • Explains clearly that in the case of a semiconductor the Fermi level lies just below the conduction bands and that a temperature increase will cause the promotion of electrons from the valence band into the conduction band, effectively switching on the material as a conductor. • Explains clearly that in the case of a metal, the Fermi level lies above the conduction band already and so there are electrons always available to participate in current. • Explains clearly that in the case of an insulator the Fermi level lies well below the conduction band and that the energy gap is too large for electrons to be promoted by heating or other stimulus and hence current does not flow in this type of material.	
• As above but no (3) or poor (4) explanation of what the bands are OR • Explains bands well and supplies labelled diagram but does not explain each material in turn. OR • As above, no diagram (4)	**3-4**
• Diagram only, fully labelled OR • Partially labelled diagram and partial explanations of the conductivities.	**2**
• ONE sensible, accurate, relevant statement OR • Diagram has 3 materials, which have valence and conduction bands, but there may be errors in the locations of these bands.	**1**

Question 33.

Question 33 (a)	
Marking Criteria	**Marks**
• Correctly explains that the energy of a photon incident on a metal will be equal to the sum of the work function of the metal and the kinetic energy of a liberated conduction electron. The work function is a property of the metal related to the energy required to free the electron from its position in the lattice. • $E = hf = \phi + KE$ is given as the relationship between the variables, each of which is correctly identified •	**3**
• Above equation given and variables correctly identified • One electron per photon means that photocurrent is intensity dependant, and not frequency dependant.	**2**
• Correct equation only, not all variables identified	**1**

Question 33 (b)	
Marking Criteria	**Marks**
• One technology that is based in the photoelectric effect is correctly identified • Diagram is correct (shows all the parts in the right place) • Diagram is labelled, 2D, pencil, ruled lines etc • Explanation is clear, concise and correct in all detail. e.g. photovoltaic solar cells exploit this effect. Diagram looks like:  How it works – when light strikes the junction between the two semiconductors a potential difference is created as electrons are promoted into the conduction band, leaving behind positive „holes". With a potential difference current will flow that	**3**

can be used to do work.	
• As above with one omission	**2**
• As above with two omissions	**1**

Question 34.

Marking Criteria	**Marks**
(1) Research into electrical conductivity as a function of temperature discovered that there are conductors (electric current will flow), insulators (current will not flow), semi-conductors (current flows only above some minimum temperature) and superconductors (resistance ceases below a maximum temperature). (2) Semiconductors enabled the development of computers since conductivity can be switched on and off, providing a means of encoding binary data, and computer logic. (3) Superconductors allow the production of intense magnetic fields which can be used in conjunction with electro magnets to produce magnetic levitation.	**3**
Statements (2) & (3) only or similar	**2**
Statement similar to (1) only	**1**

Section II Option: Medical Physics Questions [25 Marks]

Question 35 (a)	
Marking Criteria	**Marks**
(i) Ultrasound defined as above 20 kHz	**1**
(ii) Since a piezoelectric crystal will change shape when a voltage is applied, an oscillating voltage of frequency *f* will cause a compression wave in the surrounding tissue of the same frequency.	**2**
only Describes how a piezo changes shape with applied potential difference	**1**

Question 35 (b)	
Marking Criteria	**Marks**
(i) $z = \rho \times v = 1560 \times 1025 = 1.60 \times 10^6$ kg m^{-2} s^{-1} must have units	**1**
(ii) $\frac{I_r}{I_0} = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2} = 0.33$ 33% of the incident beam intensity will be reflected from that boundary, which would mean that imaging on the other side of the bone will be difficult.	**3**
Correct calculation, showing working + statement only that imaging on other side is difficult (no linking)	**2**
Correct calculation, showing working ONLY	**1**
(iii) Doppler effect correctly described as measured or detected shift in frequency of sound due to relative motion between source and detector. this can be used to determine the speed with which a reflecting surface is moving, e.g. blood cells in an artery. To do this we exploit the fact that if the motion of the cells causes a change in the frequency of the reflected sound, then the superposition of those sounds will produce beats and the beat frequency is proportional to the velocity of the blood.	**2**
Doppler effect described as the change in frequency or pitch of sound produced a sound source moves relative to a detector. (No mention of using beats)	**1**

Question 35 (c)	
Marking Criteria	**Marks**
(i) $I_0 = I_R + I_T$ must have correct variables must have correct math symbols	**2**
Students writes an expression that is true but specific rather than general e.g. tries to write for the blood/bone interface	**1**
(ii) Scattering is described as a diffusing or attenuation of signal intensity due to wave collisions with isolated particles or barriers. The various lumpy bits in the body just uselessly bounce part of the US away. The effect of reflection at boundaries as waves pass through successive tissues they will be losing intensity since after every boundary what is transmitted is now incident on the next boundary, where some reflection will also occur. This is true also on the way back out of the body to the detector. When the US signal is used continuously the scattering effects produce too much noise and a clear measurement cannot be made. Using a pulse allows for a wave packet to be used that can be later identified when it gets returned to the detector.	**4**
Connects the pulse concept to the problem of attenuation (loss) explicitly as a solution to that problem. Describes Briefly that successive boundaries all reduce signal intensity AND that this is in both directions. Describes briefly that the already weak signal gets further degraded by bouncing off random hard bits.	**3**
Connects the pulse concept to the problem of attenuation (loss). Attributes loss to scattering or reflection without defining *scattering*.	**2**
ONLY Identifies a pulse as a short group of 3-4 cycles of a wave	**1**

Question 35 (d)	
Marking Criteria	**Marks**
• Coherent light refers to light waves that are all in phase with each other. • Coherent light is used in endoscopy to provide a means of obtaining an image that has all parts of the image in their correct positions • Incoherent light is used to illuminate the target area, as coherency is not needed for this purpose.	**3**

• Missing one of the above points	**2**
• Missing two of the above points	**1**

Question 35 (e)	
Marking Criteria	**Marks**
Relaxation refers to the precessing nuclei moving back to their original energy state. Relaxation time is the time this process takes. Relaxation time is tissue-type dependant, t1 wieghting (fat & large moelcules are bright, water is dark); t2 weighting (water and diseased tissue is bright, tendon, muscle, liver is dark). Proton density (urine, cerebrospinal fluid are bright) ∴ using different relaxation times can be used to provide contrast.	**3**
Relaxation time =time for protons to "relax" after aligning with magnetic field Different tissues = different relaxation times and get contrast from this	**2**
Relaxation time is defined correctly ONLY	**1**

Question 35 (f)	
Marking Criteria	**Marks**
(i) Its functional information in these images	**1**
(ii) Yes, you can tell by counting the squares to the centre of the circle, which is 7 up from the 70-75 column in both images.	**2**
Yes. You can tell because both circles have the same features in the image around them.	**1**
(iii) We can conclude that Susan Polger uses the same part of her brain for both playing chess and facial recognition. (or similar)	**1**