Newington College

2014 Year 12
TRIAL HSC Examination
PHYSICS

General Instructions

- Reading Time: 5 minutes
- Working time: 3 hours
- Board approved calculators may be used
- Write using black or blue pen
- Draw diagrams using a sharp pencil and ruler
- A Data and Formula Sheet is provided.
- Write your Student Number at the top of each page.

Total marks – 100

Section I

80 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 – 60 marks

- Attempt Questions 21-35
- Allow about 1 hour and 50 minutes for this part

Section II

20 marks

- Candidates are to answer ONE elective question. **Answer in the spaces provided.**
  Allow about 35 minutes for this section

Section I

80 marks

Part A – 20 marks

Attempt Questions 1-20

Allow about 35 minutes for this part

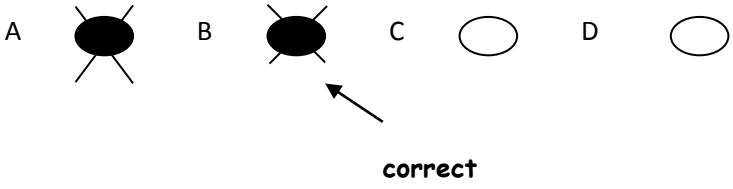
Use the multiple-choice answer sheet.

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

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

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

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.



Part A: **Multiple Choice** (Questions 1 to 20)

---

1. A satellite orbits the Moon with an orbital radius of 10,000 km.

Compared to the same satellite with an identical orbital radius orbiting Earth, the satellite orbiting the Moon will:

(A) be moving faster.

(B) have the same centripetal force acting on it.

(C) have greater kinetic energy.

(D) have a longer orbital period.

2. In school laboratory observations, cathode ray particles would be most deflected by:

(A) the cathode material.

(B) strength of the perpendicular magnetic field they pass through.

(C) potential difference between the electrodes.

(D) the gravitational field they are in.

3. Which statement is correct?

(A) The Moon exerts a smaller gravitational force on the Earth than the gravitational force exerted by the Earth on the Moon.

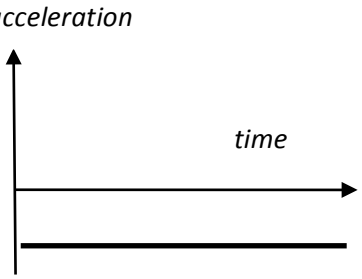
(B) The Moon's gravitational field has a greater magnitude than Earth's due to the lack of an atmosphere on the Moon.

(C) The Moon and the Earth exert the same gravitational force on each other.

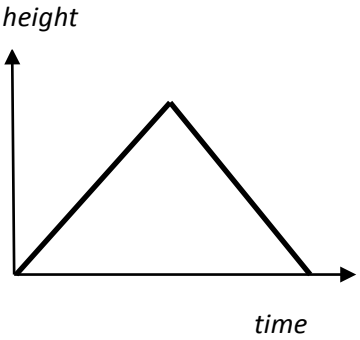
(D) Satellites orbit the Moon with a greater speed than they orbit the Earth.

4. Which graph most closely represents the motion of a bullet fired vertically upwards that then falls back to the height from which it was fired?

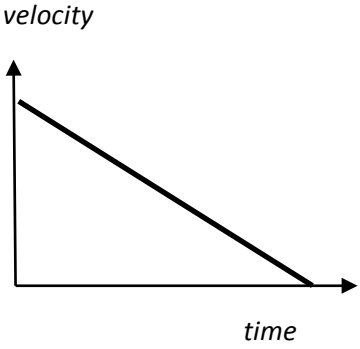
(A)



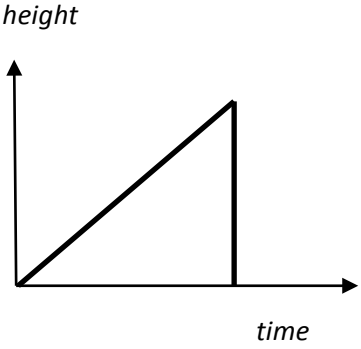
(B)



(C)



(D)



5. A 50 m long spacecraft is observed for 60 seconds as it approaches, travelling at close to the speed of light relative to the observer. A clock on board the spacecraft can be seen.

During this time, it is possible for the observer to note that:

(A) the length of the spacecraft appears to be less than 50 m and the clock on the spacecraft shows 75 s has passed.

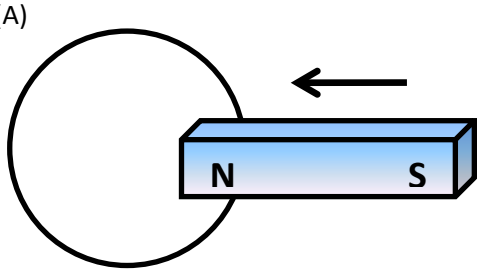
(B) the length of the spacecraft appears greater than 50 m and the masses of the astronauts have increased.

(C) the spacecraft appears longer than 50 m and its mass has increased.

(D) the length of the spacecraft appears to be less than 50 m and the clock on the spacecraft shows less than 60 seconds has passed.

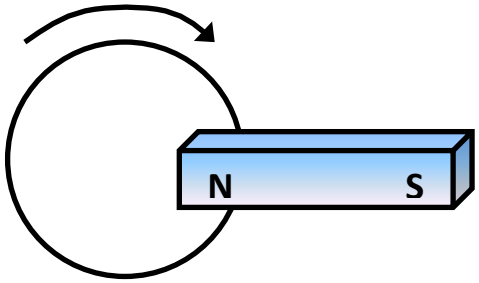
6. Which procedure shown below would NOT induce a current in the loop?

(A)



The magnet is moved towards the loop

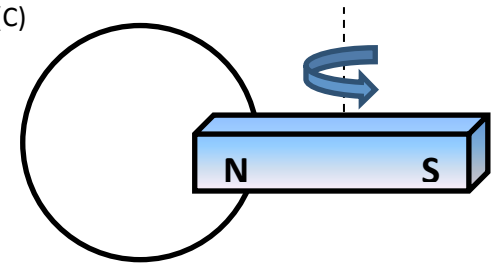
(B)



The loop rotates as shown.

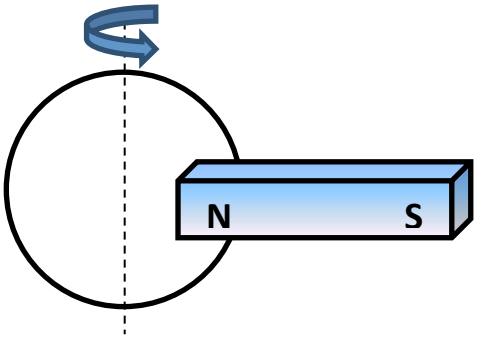
The magnet remains stationary

(C)



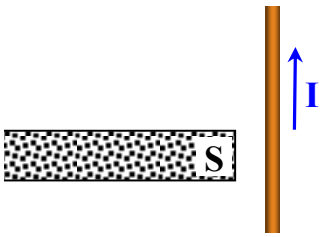
The magnet is rotated near the loop

(D)



The loop is rotated near the stationary magnet.

7.



The south pole of a bar magnet is brought close to the western side of a wire carrying DC current due north, as shown in the diagram.

What is the direction of the force on the wire?

(A) to the left

(B) to the right

(C) out of the plane of the page

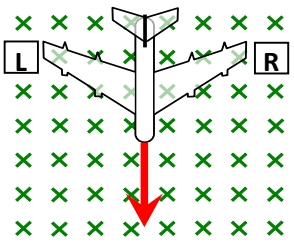
(D) into the plane of the page

8. A transformer is wired into a 240 V mains supply. It has 500 turns on its primary coil and 100 turns on its secondary coil.

Which alternative could be true?

	Type of transformer	Secondary voltage
(A)	step up	48 V
(B)	step down	1200 V
(C)	step up	1200 V
(D)	step down	48 V

9.



An aircraft is flying due south at cruising speed above a point where Earth's magnetic field is directed vertically downwards.

An emf is induced between the tips of the plane's wings.

To which of the wingtips, L or R, do electrons move, and which wingtip becomes positively charged?

(A) Electrons move towards wingtip R, so it becomes positively charged

(B) Electrons move towards wingtip L, so it becomes positively charged

(C) Electrons move towards wingtip R, so wingtip L becomes positively charged

(D) Electrons move towards wingtip L, so wingtip R becomes positively charged.

10. An effective way to protect overhead power lines from lightning strikes is to:

(A) Hang an earth wire just above the power lines.

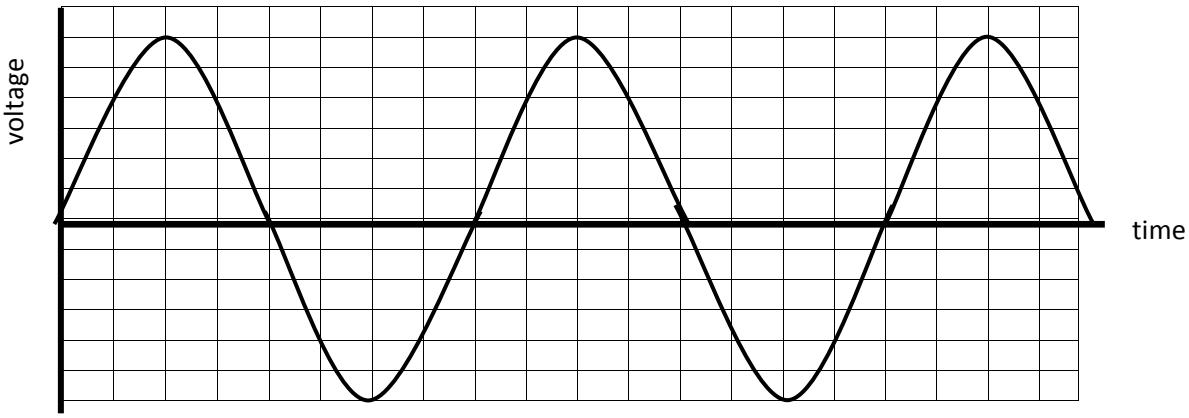
(B) Reduce the voltage in the power lines.

(C) Use ceramic insulating discs between the wire and the supporting metal pole

(D) Hang the power lines closer to each other.

11. A hand-turned electric generator has its outputs connected to a CRO.

The CRO screen appears below:



Which set of statements apply to this generator?

	AC or DC output	Slip rings or split ring commutator
(A)	AC	Split ring commutator
(B)	DC	Split ring commutator
(C)	AC	slip rings
(D)	DC	slip rings

12.

The Michelson-Morley experiment was a most significant feature in the abandonment of the theory that light needed a medium, called the aether, to propagate through space.

Despite the experiment having been carried out many times in different localities and at different times of the day and year, it almost always produced a null result.

Which of the following alternatives best describes what is meant by a null result?

(A) The dependent variable does not change when the independent variable changes

(B) The dependent variable changes in a non-linear way relative to the independent variable

(C) The dependent variable changes in a non-consistent way as the independent variable is changed

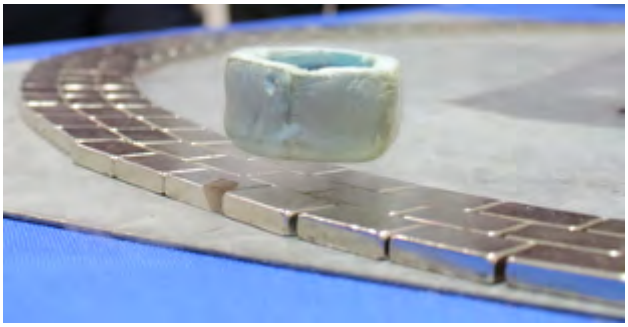
(D) The dependent variable changes in a way contrary to what the experiment had predicted as the independent variable is changed.

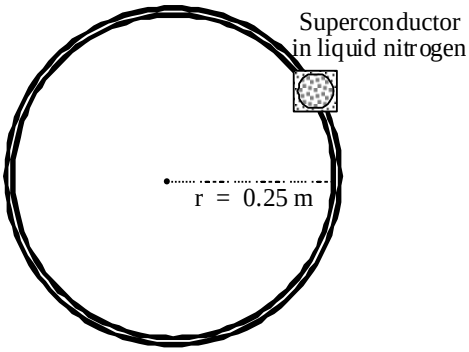
13. An investigation similar to Thomson's experiment to determine the charge to mass ratio of electrons was performed. In the place of electrons, however, this investigation used single negative fluoride ions, F^-. These ions have a mass 3.5×10^4 times greater than the mass of one electron and the same charge as one electron.

To make the fluoride ions curve with the **same radius** as electrons when entering the perpendicular magnetic field, which changes would be required?

	speed of F^- ions compared to electrons	**strength of perpendicular magnetic field compared to when electrons are used**
(A)	3.5×10^4 faster	half
(B)	3.5×10^4 slower	same
(C)	$\sqrt{3.5\times10^4}$ faster	double
(D)	$\sqrt{3.5\times10^4}$ slower	same

14.





Track made of a ring of powerful magnets

The photograph above shows a superconductor (in a liquid air bath inside a polystyrene box) undergoing uniform circular motion when pushed over a circular track made of magnets.

In this example the superconductor is found to complete 3 revolutions in 8.0 seconds. The combined mass of the superconductor, the container and the liquid air is 0.16 kg.

Which of the following gives the nearest correct values of the orbital speed of the superconductor package, and the centripetal force acting on it?

	Orbital speed	*Centripetal force*
(A)	0.59 m s^{-1}	0.22 N
(B)	0.59 m s^{-1}	11 N
(C)	4.2 m s^{-1}	0.7 N
(D)	4.2 m s^{-1}	11 N

15. Germanium was used in early transistors because:

(A) it was easier to obtain in a sufficiently pure form.

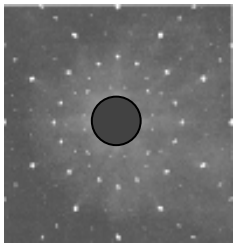
(B) it was cheaper to manufacture.

(C) its electrical properties are better than alternative substances.

(D) it was discovered earlier than other alternatives.

16. The diagram below shows the interference pattern caused when a stream of X-rays are scattered from the surface of sodium chloride.

Which of the following physicists would have found patterns like this one in the experiments they were carrying out?



(A) Bardeen, Cooper and Schrieffer in experiments to explain superconductivity

(B) Wilhelm Hertz in his experiments to find the velocity of electromagnetic rays

(C) William and Lawrence Bragg in their experiments to determine crystal shapes

(D) Thomson in his experiments with cathode-rays to find the *q/m* ratio of electrons

17. What frequency does a photon of light have if it has the same energy as an electron's kinetic energy when moving with a velocity 0.1c ?

(A) 4.1×10^{-16} Hz

(B) 6.2×10^{17} Hz

(C) 4.5×10^{40} Hz

(D) 2.4×10^{-17} Hz

18. The weight of a 75 kg person decreases to exactly half of its old value when the person moves from the Earth's surface to a different position.

This different position could be:

(A) on the surface of an Earth-sized planet but with one-quarter Earth's mass.

(B) twice as far from the centre of the Earth.

(C) on the surface of a planet with twice Earth's radius and twice its mass.

(D) nowhere, as the person's weight will not change.

19. An 80 kg dare-devil stuntperson jumps from a helium-filled balloon at an altitude of 20 km.

Sometime later, when at an altitude of 10 km, the stuntperson is measured to be falling at 250 ms^{-1} through the atmosphere.

Assume g = 9.8 ms^{-2}

The amount of heat and sound energy produced by the friction while the stuntperson falls through this 10 km distance is closest to:

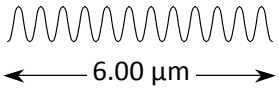
(A) 2500 kJ

(B) 4560 kJ

(C) 5350 kJ

(D) 7850 kJ

20. The diagram below represents a photon of electromagnetic radiation that strikes a metal having a work function of 3.85×10^{-19} J.



Which of the following identifies the frequency of the photon, the energy it possesses, and whether it releases a photoelectron?

	Frequency [Hz]	*Photon energy [J]*	*Releases photoelectron?*
(A)	5.0×10^{13}	3.3×10^{-20}	yes
(B)	5.0×10^{13}	3.3×10^{-20}	no
(C)	6.0×10^{14}	4.0×10^{-19}	no
(D)	6.0×10^{14}	4.0×10^{-19}	yes

END OF PART A

PART B (Questions 21 to 35)

60 marks

ANSWER ALL QUESTIONS.

Show all working, including the appropriate formulae. Full marks may not be awarded if working is insufficient.

Question 21 (4 marks) **Marks**

An investigation was performed to distinguish between non-inertial and inertial frames of reference.

(a) Give a definition of an 'inertial frame of reference'. **1**

(b) Describe how this investigation could be performed. **2**

(c) Outline what Einstein postulated with respect to the relativity principle in inertial reference frames. **1**

Question 22. (2 marks) **Marks**

Two long insulated conductors are strung very close together between two poles.

They are carrying electricity to an appliance requiring a 15 ampere current.

(a) If the wires are 20m long and separated by 5.0mm, what is the maximum force between them? **2**

Question 23. (2 marks)

A 12 kg rock is initially located at a distance 40 000 km from the centre of Earth, which has a mass of 6.0×10^{24} kg.

Determine the gravitational potential energy of the rock at this location. **2**

Question 24. (5 marks) **Marks**

A bullet is fired horizontally with a speed of 524 ms^{-1} from a height of 22.0 m above the ground.

(a) Calculate the time of flight of the bullet. **2**

(b) Calculate the range (horizontal displacement) of the bullet. **1**

(c) At what angle from the vertical will the bullet hit the ground? **2**

Question 25 (5 marks) **Marks**

Early observations of the behaviour of cathode rays led to the discovery of their nature and to advances in models of the structure of the atom.

(a) Describe TWO of the observations made that led to the determination of the sign of the charge on cathode ray particles. **2**

(b) With the aid of a labelled diagram and appropriate mathematical expressions, explain how cathode ray particles can be passed through charged electric plates and a magnetic field without being deflected. **3**

Question 26 (3 marks) **Marks**

(a) Compare and explain the changes in conductivity of conductors and semiconductors when heat energy is provided. **2**

(b) A piece of silicon is doped with gallium. Identify what this does to the overall charge of the piece of silicon. **1**

Question 27 (5 marks)

When a magnet is placed above a cooled superconducting material it is observed to hover for as long as the material remains in its superconducting state.

(a) Describe what is occurring inside the superconducting material that makes the magnet hover above it. **2**

(b) Superconductors have been proposed for use in applications such as maglev trains.

Explain a key advantage the use of superconductors would offer in such trains and outline TWO specific problems that hinder their current use in maglev trains. **3**

Question 28 (7 marks)

The law of conservation of momentum can be used to analyse the launch of a rocket.

(a) Explain why it is ideal for the exhaust gases from a rocket's engines to be expelled at the highest velocity possible. **2**

(b) Use appropriate laws of physics to explain why a rocket's acceleration is lowest just after lift-off. **2**

(c) Calculate the acceleration of a 5.0×10^4 kg rocket just after lift-off, if its motor is expelling 50kg of exhaust at 2.0×10^4 m s^{-1} every second. **3**

Question 29 (2marks) **Marks**

In the late nineteenth century the shape of experimentally obtained black body radiation curves were unable to be explained by the prevailing theories of light.

Describe how the work of Max Planck changed our understanding of black body radiation. **2**

Question 30 (2 marks)

AC Induction motors do not have a direct electrical connection to the rotor.

Outline how an AC induction motor operates. **2**

Question 31 (2 marks)

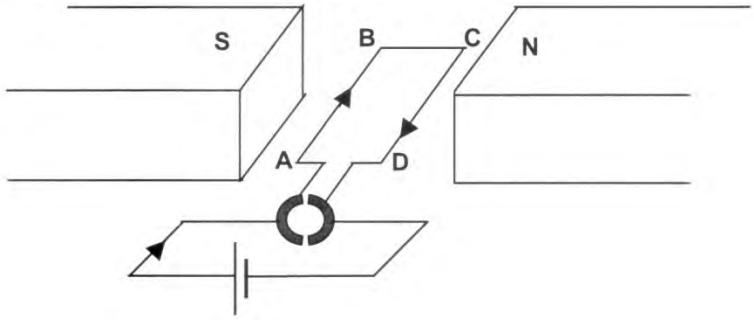
For ONE of Tsiolkovsky, Oberth, Goddard, Esnault-Pelterie, O'Neill or von Braun, describe how their work contributed directly to the development of space exploration. **2**

Question 32 (2 marks) **Marks**

The following diagram is of a simple electric motor with a single loop forming a rectangular coil.

Current in loop = 5.0 A Magnetic field strength = 1.0×10^{-2} T

AB = **CD** = 0.080 m **BC** = 0.020 m

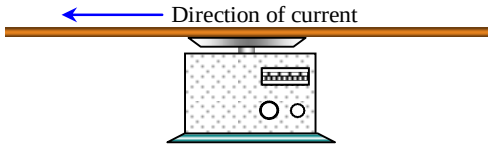


(a) Calculate the magnitude of the maximum torque on the motor. **2**

Question 33 (2 marks)

For ONE first hand investigation performed during your Physics course, outline how a risk assessment was performed. This includes the hazard that was identified and how this potential hazard was controlled. **2**

Question 34 (7 marks) **Marks**



Students have been asked to test magnetic fields. They place a 40-cm length of stiff copper wire on the top of an accurate electronic balance and connect it to the output of a variable voltage source so they can vary the DC current flowing through it. The current is directed *due north*. A horizontal uniform magnetic field is set up between two lines of powerful rare earth magnets on either side of the wire.

The readings the students obtain as the current is varied are shown in the table below. Notice that the readings on the electronic balance are in *kilograms*:

Current (A)	0.25	0.75	1.00	1.50	2.00
Reading (kg)	0.0039	0.0071	0.0090	0.0120	0.0153

(a) Use the axes provided below to design an appropriate graph of the relationship between the current through the wire and the readings on the balance, including the consequent line of best fit. **3**

This question continues on the next page ---------->

Question 34 continued: **Marks**

(b) Use the graph to determine the mass of the 40-cm length of wire. **1**

(c) **Use the graph** to find the magnitude of the external magnetic field. **3**

Question 35 (6 marks) **Marks**

Analyse the use of large scale AC generators and transformers with respect to the efficient and safe distribution of electricity and the associated environmental impacts. **6**

END OF SECTION 1

Section II

20 marks
Attempt ONE question from Questions 36-40

Allow about 35 minutes for this section

Answer the question in the space provided.
Show all relevant working in questions involving calculations.

Newington Candidates are advised to answer question 39 (From Quanta to Quarks)

Marks

Question 36 Geophysics (20 marks)

(a) (i) Using a labelled diagram, describe Earth's magnetic field. **1**

(ii) Evaluate the evidence for the belief that Earth's magnetic field has reversed polarity many times in the past **3**

(b) (i) Outline the function of a geophone. **1**

(ii) Describe the use of seismometers in gathering evidence for the Earth having a liquid outer core and a solid inner core. **3**

(c) (i) A satellite has an orbital radius of 8.00×10^3 km around a planet. The satellite's orbital period is 4.00 hours. Find the mass of the planet. **3**

(ii) What change would be observed to the satellite's orbital period if the planet's mass was somehow increased **1**

(d) (i) Describe how a first-hand investigation could be performed to analyse the variation in density of different rock types **4**

(ii) Justify the need to be able to identify the density of rock strata using remote sensing methods **4**

Question 37 **Medical Physics** (20 marks) **Marks**

(a) (i) Outline how the interaction of an electron and a positron can result in the production of gamma rays. **1**

(ii) Describe how such interactions can be used as the basis for an imaging technique that is useful in making diagnoses. **3**

(b) (i) Outline the role of total internal reflection in the use of an endoscope. **1**

(ii) Compare the roles of coherent and incoherent bundles of fibres in an endoscope. **3**

(c) (i) Identify the method used to generate ultrasound. **1**

(ii) Use the data in the table below to calculate the ratio of the intensity of the reflected signal to the intensity of the incident intensity for ultrasound passing from fat into bone. **3**

Medium	**Acoustic impedance kg m^{-2} s^{-1}**
fat	1.38×10^6
bone	5.32×10^6

(d) (i) Explain why a bone scan would be performed in addition to an X-ray scan. **2**

(ii) Compare and contrast the methods used to produce X-ray scans and bone scans. **2**

(e) Describe the roles of a strong magnetic field, relaxation of precessing nuclei and pulses of radio waves in the production of MRI scans. **4**

Question 38 **Astrophysics** (20 marks) **Marks**

(a) (i) Identify the source of energy in the core of main sequence stars. **1**

(ii) Explain why it is believed that elements heavier than iron were formed only when very massive stars went supernova. **3**

(b) (i) Identify the reason why many astronomical observatories are placed in orbit around the Earth. **1**

(ii) Describe how interferometry can increase both the resolution and the sensitivity of telescopes. **3**

(c) An eclipsing binary star pair is observed to have a period of 140 days. The two stars both have the same spectral class as our Sun, which has a mass of 2.0×10^{30} kg.

(i) Calculate the distance between these two stars. **3**

(ii) Identify how this binary pair would be identified by astronomers. **1**

(d) (i) Explain the reason why the colour index of a star is determined. **2**

(ii) Describe how an investigation could be performed that demonstrates the use of filters to find the colour index of a star. **2**

(e) Describe the technology needed to measure the spectra of stars and outline the features of such spectra that provide information on surface temperature, rotational and translational velocity, density and chemical composition of stars. **4**

Question 39 From Quanta to Quarks (20 marks)

Marks

(a) Describe the key features of the Rutherford model of the atom and explain what was problematic about its treatment of electron orbits. **3**

(b) Calculate and then compare the longest wavelength of an emission line in the Balmer series (n_f = 2) to the longest wavelength of an emission line in the Paschen series (n_f =3) for hydrogen. **3**

Question 39 continues on the next page ---------->

Question 39 continued: **Marks**

(c) The production of the hydrogen spectra was significant to the development of the model of the atom.

(i) Explain its importance to Bohr's development of his model of the atom. **2**

(ii) Describe ONE characteristic of the hydrogen spectra that could not be explained using Bohr's model. **1**

(d) Outline the contributions of Pauli **OR** Heisenberg to the development of atomic theory. **2**

Name of Scientist chosen: _____

Question 39 continues on the next page---------->

Question 39 continued:

(e) Outline how a Wilson Cloud Chamber or similar detection device enables the paths of radiation particles to be made visible. **2**

(f) (i) Write a nuclear equation for the beta (minus) decay of ***Pb- 214*** **2**

(ii) When the energies of the decay particles produced in beta decay were first studied scientists noticed a problem. Identify this problem and describe how it was solved. **2**

(g) (i) Calculate the binding energy for a helium-4 nucleus. State your answer in joules.
(The mass of He-4 is 6.64832×10^{-27} kg) **2**

(ii) Convert your answer in part (i) to MeV **1**

End of question 39

Question 40 **The Age of Silicon** (20 marks) **Marks**

(a) (i) describe the function of a LED. **2**

(ii) Describe the structure of LEDs in terms of p-type and n-type semiconductors. **3**

(b) (i) Identify the primary factor that has allowed computing power to increase as it has over the past few decades. **1**

(ii) Describe the limitations that are beginning to come into effect on the continued increase in computing power. **4**

(c) Potential dividers play useful roles in many electronic circuits.

(i) Draw a circuit diagram showing a potential divider with an input voltage of 240V and an output voltage of 60V. **2**

(ii) Describe an application where a voltage divider would be used. **2**

(d) (i) Outline the role of a summing amplifier in electronic circuits and identify an appropriate application. **3**

(ii) Describe the procedure used during a first-hand investigation to observe the function of a summing amplifier with two different sources. **3**

END OF EXAMINATION

Newington College

2014 PHYSICS TRIAL EXAMINATION

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 ◯

DATA SHEET

Charge on electron, q_e	-1.602×10^{-19} C
Mass of electron, m_e	9.109×10^{-31} kg
Mass of neutron, m_n	1.675×10^{-27} kg
Mass of proton, m_p	1.673×10^{-27} kg
Speed of sound in air	340 m s^{-1}
Earth's gravitational acceleration, g	9.8 m s^{-2}
Speed of light, c	3.00×10^8 m s^{-1}
Magnetic force constant, $\left(k \equiv \frac{\mu_0}{2\pi}\right)$	2.0×10^{-7} N A^{-2}
Universal gravitational constant, G	6.67×10^{-11} N m^2 kg^{-2}
Mass of Earth	6.0×10^{24} kg
Planck constant, h	6.626×10^{-34} J s
Rydberg constant, R (hydrogen)	1.097×10^7 m^{-1}
Atomic mass unit, u	1.661×10^{-27} kg 931.5 MeV/c^2
1 eV	1.602×10^{-19} J
Density of water, ρ	1.00×10^3 kg m^{-3}
Specific heat capacity of water	4.18×10^3 J kg^{-1} K^{-1}

FORMULAE SHEET

$$v = f\lambda$$

$$I \propto \frac{1}{d^2}$$

$$\frac{v_1}{v_2} = \frac{\sin i}{\sin r}$$

$$E = \frac{F}{q}$$

$$R = \frac{V}{I}$$

$$P = VI$$

$$\text{Energy} = VIt$$

$$v_{\text{av}} = \frac{\Delta r}{\Delta t}$$

$$a_{\text{av}} = \frac{\Delta v}{\Delta t} \quad \text{therefore} \quad a_{\text{av}} = \frac{v - u}{t}$$

$$\Sigma F = ma$$

$$F = \frac{mv^2}{r}$$

$$E_k = \frac{1}{2}mv^2$$

$$W = Fs$$

$$p = mv$$

$$\text{Impulse} = Ft$$

$$E_p = -G\frac{m_1 m_2}{r}$$

$$F = mg$$

$$v_x^2 = u_x^2$$

$$v = u + at$$

$$v_y^2 = u_y^2 + 2a_y\Delta y$$

$$\Delta x = u_x t$$

$$\Delta y = u_y t + \frac{1}{2}a_y t^2$$

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

$$F = \frac{Gm_1 m_2}{d^2}$$

$$E = mc^2$$

$$l_v = l_0\sqrt{1 - \frac{v^2}{c^2}}$$

$$t_v = \frac{t_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$m_v = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

FORMULAE SHEET

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

$$F = BIl\sin\theta$$

$$\tau = Fd$$

$$\tau = nBIA\cos\theta$$

$$\frac{V_p}{V_s} = \frac{n_p}{n_s}$$

$$d = \frac{1}{p}$$

$$M = m - 5\log\left(\frac{d}{10}\right)$$

$$\frac{I_A}{I_B} = 100^{(m_B - m_A)/5}$$

$$m_1 + m_2 = \frac{4\pi^2 r^3}{GT^2}$$

$$F = qvB\sin\theta$$

$$E = \frac{V}{d}$$

$$E = hf$$

$$c = f\lambda$$

$$\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$\lambda = \frac{h}{mv}$$

$$Z = \rho v$$

$$\frac{I_r}{I_0} = \frac{\left[Z_2 - Z_1\right]^2}{\left[Z_2 + Z_1\right]^2}$$

$$A_0 = \frac{V_{\text{out}}}{V_{\text{in}}}$$

$$\frac{V_{\text{out}}}{V_{\text{in}}} = -\frac{R_{\text{f}}}{R_{\text{i}}}$$

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number
Atomic Weight
79 Au 197.0 Gold
Symbol of element
Name of element

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.41 Zinc	31 Ga 69.72 Gallium	32 Ge 72.64 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc [97.91] Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanoids	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.8 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po [209.0] Polonium	85 At [210.0] Astatine	86 Rn [222.0] Radon
87 Fr [223] Francium	88 Ra [226] Radium	89–103 Actinoids	104 Rf [261] Rutherfordium	105 Db [262] Dubnium	106 Sg [266] Seaborgium	107 Bh [264] Bohrium	108 Hs [277] Hassium	109 Mt [268] Meitnerium	110 Ds [271] Darmstadtium	111 Rg [272] Roentgenium							

Lanthanoids

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [145] Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.0 Ytterbium	71 Lu 175.0 Lutetium

Actinoids

89 Ac [227] Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np [237] Neptunium	94 Pu [244] Plutonium	95 Am [243] Americium	96 Cm [247] Curium	97 Bk [247] Berkelium	98 Cf [251] Californium	99 Es [252] Einsteinium	100 Fm [257] Fermium	101 Md [258] Mendelevium	102 No [259] Nobelium	103 Lr [262] Lawrencium

For elements that have no stable or long-lived nuclides, the mass number of the nuclide with the longest confirmed half-life is listed between square brackets.
The International Union of Pure and Applied Chemistry Periodic Table of the Elements (October 2005 version) is the principal source of data. Some data may have been modified.

Newington College

2014 Year 12
TRIAL HSC Examination
PHYSICS - SOLUTIONS

General Instructions

- Reading Time: 5 minutes
- Working time: 3 hours
- Board approved calculators may be used
- Write using black or blue pen
- Draw diagrams using a sharp pencil and ruler
- A Data and Formula Sheet is provided.
- Write your Student Number at the top of each page.

Total marks – 100

Section I

80 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 – 60 marks

- Attempt Questions 21-……
- Allow about 1 hour and 50 minutes for this part

Section II

20 marks

- Candidates are to answer ONE elective question. Answer in the spaces provided.

Allow about 35 minutes for this section

Section I

80 marks

Part A – 20 marks

Attempt Questions 1-20

Allow about 35 minutes for this part

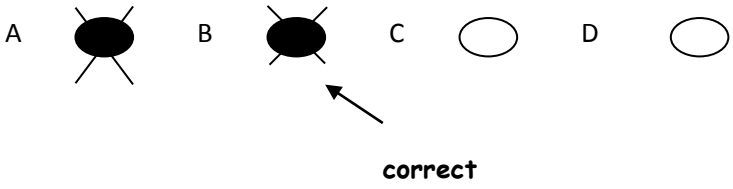
Use the multiple-choice answer sheet.

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

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

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

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.



Part A: **Multiple Choice** (Questions 1 to 20)

---

1. A satellite orbits the Moon with an orbital radius of 10,000 km.

Compared to the same satellite with an identical orbital radius orbiting Earth, the satellite orbiting the Moon will:

(A) be moving faster.

(B) have the same centripetal force acting on it.

(C) have greater kinetic energy.

(D) have a longer orbital period.

2. In school laboratory observations, cathode ray particles would be most deflected by:

(A) the cathode material.

(B) strength of the perpendicular magnetic field they pass through.

(C) potential difference between the electrodes.

(D) the gravitational field they are in.

3. Which statement is correct?

(A) The Moon exerts a smaller gravitational force on the Earth than the gravitational force exerted by the Earth on the Moon.

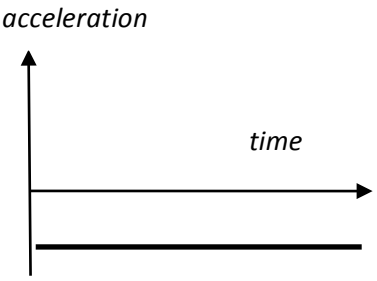
(B) The Moon's gravitational field has greater magnitude than Earth's due to the lack of an atmosphere on the Moon.

(C) The Moon and the Earth exert the same gravitational force on each other.

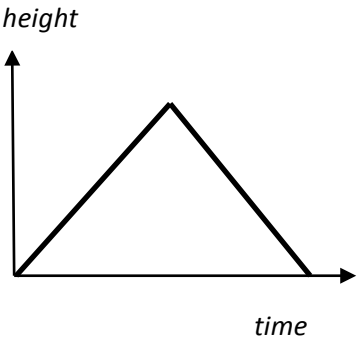
(D) Satellites orbit the Moon with a greater speed than they orbit the Earth.

4. Which graph most closely represents the motion of a bullet fired vertically upwards that then falls back to the height from which it was fired?

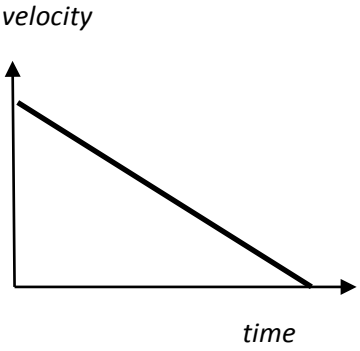
(A)



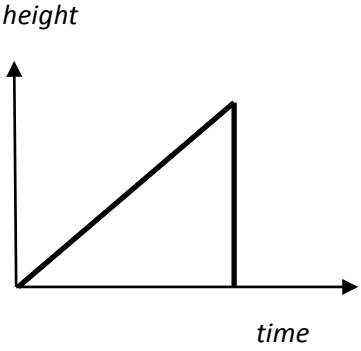
(B)



(C)



(D)



5. A 50 m long spacecraft is observed for 60 seconds as it approaches, travelling at close to the speed of light relative to the observer. A clock on board the spacecraft can be seen.

During this time, it is possible for the observer to note that:

(A) the length of the spacecraft appears to be less than 50 m and the clock on the spacecraft shows 75 s has passed.

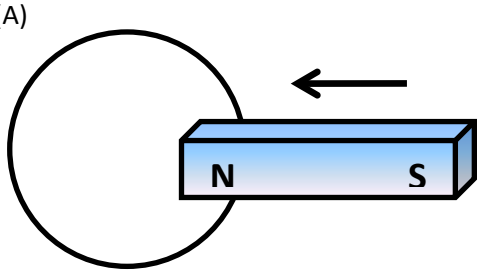
(B) the length of the spacecraft appears greater than 50 m and the masses of the astronauts have increased.

(C) the spacecraft appears longer than 50 m and its mass has increased.

(D) the length of the spacecraft appears to be less than 50 m and the clock on the spacecraft shows less than 60 seconds has passed.

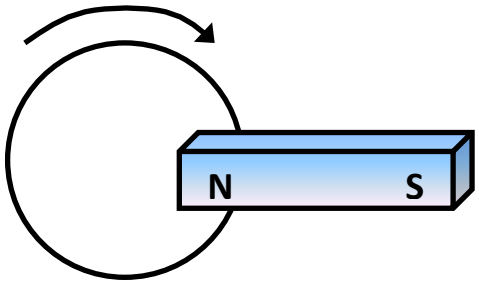
6. Which procedure shown below would NOT induce a current in the loop?

(A)



The magnet is moved towards the loop

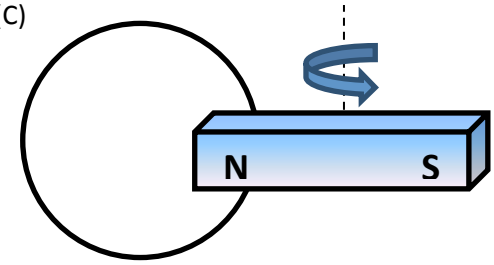
(B)



The loop rotates as shown.

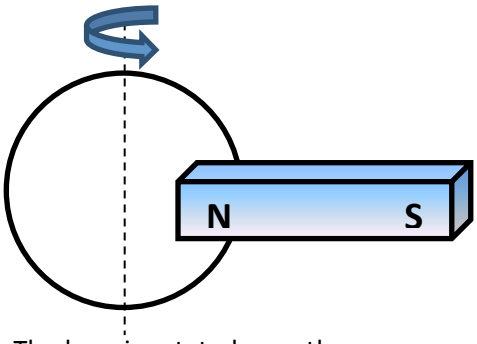
The magnet remains stationary

(C)



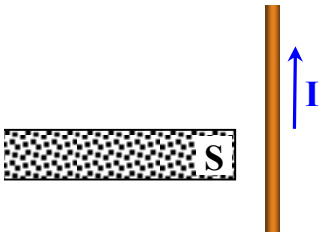
The magnet is rotated near the loop

(D)



The loop is rotated near the stationary magnet.

7.



The south pole of a bar magnet is brought close to the western side of a wire carrying DC current due north, as shown in the diagram.

What is the direction of the force on the wire?

(A) to the left

(B) to the right

(C) out of the plane of the page

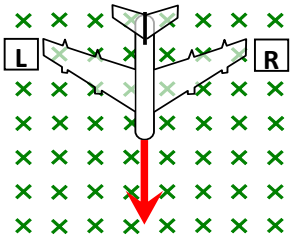
(D) into the plane of the page

8. A transformer is wired into a 240 V mains supply. It has 500 turns on its primary coil and 100 turns on its secondary coil.

Which alternative could be true?

	Type of transformer	Secondary voltage
(A)	step up	48 V
(B)	step down	1200 V
(C)	step up	1200 V
(D)	step down	48 V

9.



An aircraft is flying due south at cruising speed above a point where Earth's magnetic field is directed vertically downwards.

An emf is induced between the tips of the plane's wings.

To which of the wingtips, L or R, do electrons move, and which wingtip becomes positively charged?

(A) Electrons move towards wingtip R, so it becomes positively charged

(B) Electrons move towards wingtip L, so it becomes positively charged

(C) Electrons move towards wingtip R, so wingtip L becomes positively charged

(D) Electrons move towards wingtip L, so wingtip R becomes positively charged.

10. An effective way to protect overhead power lines from lightning strikes is to:

(A) Hang an earth wire just above the power lines.

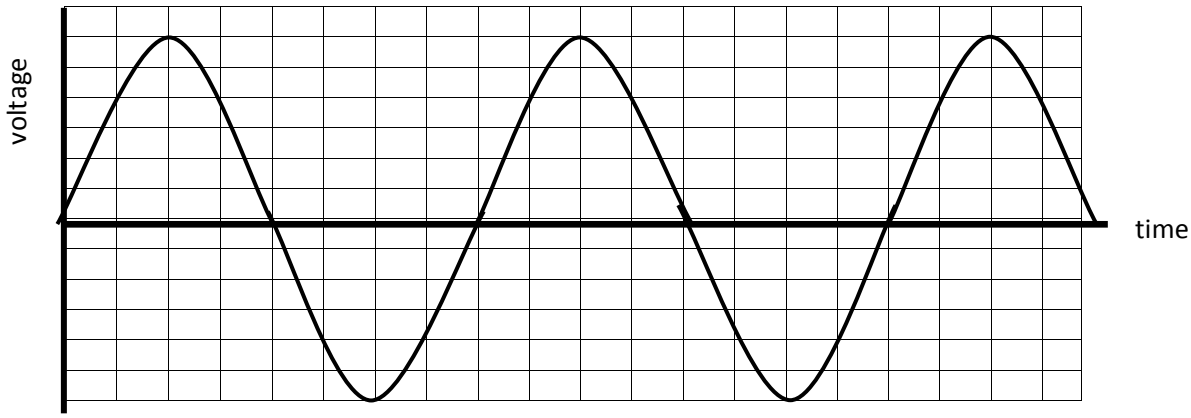
(B) Reduce the voltage in the power lines.

(C) Use ceramic insulating discs between the wire and the supporting metal pole

(D) Hang the power lines closer to each other.

11. A hand-turned electric generator has its outputs connected to a CRO.

The CRO screen appears below:



Which set of statements apply to this generator?

	AC or DC output	**Slip rings or split ring commutator**
(A)	AC	Split ring commutator
(B)	DC	Split ring commutator
(C)	AC	slip rings
(D)	DC	slip rings

12.

The Michelson-Morley experiment was a most significant feature in the abandonment of the theory that light needed a medium, called the aether, to propagate through space.

Despite the experiment having been carried out many times in different localities and at different times of the day and year, it almost always produced a null result.

Which of the following alternatives best describes what is meant by a null result?

(A) The dependent variable does not change when the independent variable changes

(B) The dependent variable changes in a non-linear way relative to the independent variable

(C) The dependent variable changes in a non-consistent way as the independent variable is changed

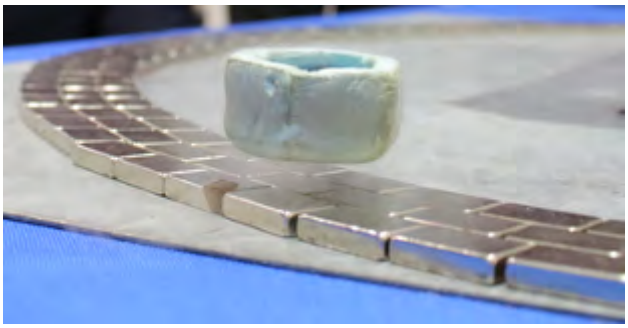
(D) The dependent variable changes in a way contrary to what the experiment had predicted as the independent variable is changed.

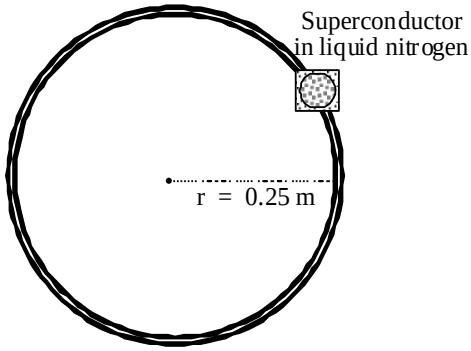
13. An investigation similar to Thomson's experiment to determine the charge to mass ratio of electrons was performed. In the place of electrons, however, this investigation used single negative fluoride ions, F^-. These ions have a mass 3.5×10^4 times greater than the mass of one electron and the same charge as one electron.

To make the fluoride ions curve with the **same radius** as electrons when entering the perpendicular magnetic field, which changes would be required?

	speed of F^- ions compared to electrons	**strength of perpendicular magnetic field compared to when electrons are used**
(A)	3.5×10^4 faster	half
(B)	3.5×10^4 slower	same
(C)	$\sqrt{3.5\times10^4}$ faster	double
(D)	$\sqrt{3.5\times10^4}$ slower	same

14.





Track made of a ring of powerful magnets

The photograph above shows a superconductor (in a liquid air bath inside a polystyrene box) undergoing uniform circular motion when pushed over a circular track made of magnets.

In this example the superconductor is found to complete 3 revolutions in 8.0 seconds. The combined mass of the superconductor, the container and the liquid air is 0.16 kg.

Which of the following gives the nearest correct values of the orbital speed of the superconductor package, and the centripetal force acting on it?

	Orbital speed	*Centripetal force*
(A)	0.59 m s^{-1}	0.22 N
(B)	0.59 m s^{-1}	11 N
(C)	4.2 m s^{-1}	0.7 N
(D)	4.2 m s^{-1}	11 N

15. Germanium was used in early transistors because:

(A) it was easier to obtain in a sufficiently pure form.

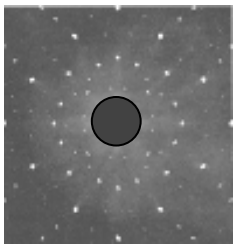
(B) it was cheaper to manufacture.

(C) its electrical properties are better than alternative substances.

(D) it was discovered earlier than other alternatives.

16. The diagram below shows the interference pattern caused when a stream of X-rays are scattered from the surface of sodium chloride.

Which of the following physicists would have found patterns like this one in the experiments they were carrying out?



(A) Bardeen, Cooper and Schrieffer in experiments to explain superconductivity

(B) Wilhelm Hertz in his experiments to find the velocity of electromagnetic rays

(C) William and Lawrence Bragg in their experiments to determine crystal shapes

(D) Thomson in his experiments with cathode-rays to find the *q/m* ratio of electrons

17. What frequency does a photon of light have if it has the same energy as an electron's kinetic energy when moving with a velocity 0.1c ?

(A) 4.1×10^{-16} Hz

(B) 6.2×10^{17} Hz

(C) 4.5×10^{40} Hz

(D) 2.4×10^{-17} Hz

18. The weight of a 75 kg person decreases to exactly half of its old value when the person moves from the Earth's surface to a different position.

This different position could be:

(A) on the surface of an Earth-sized planet but with one-quarter Earth's mass.

(B) twice as far from the centre of the Earth.

(C) on the surface of a planet with twice Earth's radius and twice its mass.

(D) nowhere, as the person's weight will not change.

19. An 80 kg dare-devil stuntperson jumps from a helium-filled balloon at an altitude of 20 km.

Assume $g = 9.8\ ms^{-2}$

When at an altitude of 10 km, the stuntperson is falling at $250\ ms^{-1}$ through the atmosphere. The amount of heat and sound energy produced by the friction while the stuntperson falls through this 10 km distance is closest to:

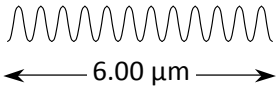
(A) 2500 kJ

(B) 4560 kJ

(C) 5350 kJ

(D) 7850 kJ

20. The diagram below represents a photon of electromagnetic radiation that strikes a metal having a work function of = 3.85×10^{-19} J.



Which of the following identifies the frequency of the photon, the energy it possesses, and whether it releases a photoelectron?

	Frequency [Hz]	*Photon energy [J]*	*Releases photoelectron?*
(A)	5.0×10^{13}	3.3×10^{-20}	yes
(B)	5.0×10^{13}	3.3×10^{-20}	no
(C)	6.0×10^{14}	4.0×10^{-19}	no
(D)	6.0×10^{14}	4.0×10^{-19}	yes

END OF PART A

PART B (Questions 21 to …..)

60 marks

ANSWER ALL QUESTIONS.

Show all working, including the appropriate formulae. Full marks may not be awarded if working is insufficient.

Question 21 (6 marks) **Marks**

An investigation was performed to distinguish between non-inertial and inertial frames of reference.

(a) Give a definition of an 'inertial frame of reference'. **1**

Marking Criteria	Marks
• **Complete definition supplied, including explanation of motion observed within. Must refer to non-acceleration (ie rest of constant velocity)**	**1**

Eg: A frame of reference which is not accelerating and in which all motion can be explained using only recognised physics laws.

(b) Describe how this investigation could be performed. **3**

Marking Criteria	Marks
• **An investigation that includes both types of FoRs is described** • **Must be a specific set of instructions that could be followed.**	**2**
• **A simple investigation linked to either type of FoR** • **OR: instructions not specifically linked to inertial and non-inertial** • **OR: vague method outlined, not a specific set of apparatus described**	**1**

Eg: Use a plumb bob (mass at end of string). Suspend it from internal car mirror. At rest or moving at constant velocity (inertial FoR) the bob hangs vertically down. If the car accelerates (such as turns a corner) the bob will swing away from the vertical, thus demonstrating a non-inertial FoR.

(c) Outline what Einstein postulated with respect to the relativity principle in inertial reference frames. **1**

It is always obeyed (even for light) **OWTTE** **(1)**

The question is NOT just asking you to restate or re-phrase the relativity principle (which of course pre-dates Einstein by several centuries). Instead you are being asked to show an understanding of how Einstein extended the principle to include light, therefore ALL laws of physics obeyed in an intertial FoR (Therefore, there is no special or 'privileged' FoR)

His statements regarding the constancy of light are not directly relevant for this question.

Question 22. (2 marks) **Marks**

Two long insulated conductors are strung very close together between two poles.

They are carrying electricity to an appliance requiring a 15 ampere current.

(a) If the wires are 20m long and separated by 5.0mm, what is the maximum force between them? **2**

Marking Criteria	***Marks***
Answer calculated	***2***
Answer calculated with error made in units or one other error	***1***

$$F = k\frac{I_1 I_2}{d} l$$
$$= 2\times10^{-7}\frac{15\times15}{5.0\times10^{-3}}\times20$$
$$= 0.18\ \text{N}$$

Question 23. (2 marks)

A 12-kg rock is initially located at a distance 40 000 km from the centre of Earth, which has a mass of 6.0×10^{24} kg.

Determine the gravitational potential energy of the rock at this location. **2**

Criteria	**Mark**
• Correct substitution into a correct formula, yielding a correct answer • OR one error made with respect to units	2
• Correct substitution into a correct formula	1

$$E_P = -G\frac{m_1 m_2}{r} \quad \therefore E_P = -\frac{6.67\times10^{-11}\times6.0\times10^{24}\times12}{40\,000\times10^{3}} = -1.2\times10^{8}\ \text{J}$$

Question 24. (5 marks) **Marks**

A bullet is fired horizontally with a speed of 524 ms^{-1} from a height of 22.0 m above the ground.

(a) Calculate the time of flight of the bullet. **2**

Criteria	Marks
Correct value of 2.12 s found	2
One error with calculation – but overall physics is sound. (however, incorrect use of horizontal velocity in an equation dealing with vertical acceleration will not receive any marks)	1

$S = u\,t + \frac{1}{2}\,a\,t^2$.

$22.0 = 0 + \frac{1}{2} \times 9.8 \times t^2$

$t = 2.12$ s

(b) Calculate the range (horizontal displacement) of the bullet. **1**

One mark awarded for correct answer accompanied by valid working.

$S_x = v_x\,t$

***$S_x = 524 \times 2.12 = 1110$ m** *error carried forward (ecf) if incorrect time determined in part (a).*

(c) At what angle from the vertical will the bullet hit the ground? **2**

Marking criteria	Marks
Final vertical velocity found Horizontal and vertical velocities added as vectors to find correct angle	2
final vertical velocity found	1

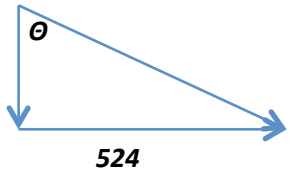
Find final vertical velocity and then add this as a vector to the constant horizontal velocity.

Then use trigonometry to find angle.

ecf if incorrect time (part a) and hence incorrect range (part b)

Final vertical velocity: $v_v = u + a\,t$

$V_v = 0 + (9.8 \times 2.12) = 20.776 = 20.8\ ms^{-1}$



$\tan \Theta = 524 / 20.8 = 25.19\ldots$

$\Theta = 87.8^0$

(Also accepted angle from horizontal, $\Theta \approx 2.27$)

Question 25 (5 marks) **Marks**

Early observations of the behaviour of cathode rays led to the discovery of their nature and to advances in models of the structure of the atom.

(a) Describe TWO of the observations made that led to the determination of the sign of the charge on cathode ray particles. **2**

Marking Criteria	Marks
• **Two observations described completely**	**2**
• **Two observations described incompletely** **OR** • **One observation described completely**	**1**

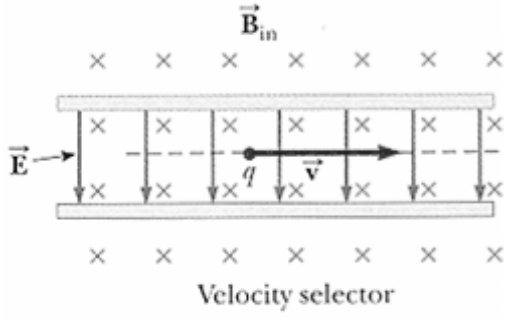
Eg: ***(any TWO of these:***

- ***they travelled from the negative electrode and were attracted to the positive electrode***
- ***they were deflected towards a positively charged plate***
- ***they were deflected in a magnetic field in the same direction as negative particles***
- ***paddle wheel moved from cathode towards anode, implying the particles are moving away from the cathode (negative electrode) and so behaving as a negative charge.***

NB. It is insufficient to state only that cathode ray particles were deflected by electric field "in the direction that a negative charge would be deflected", though this allowance was made for deflection due to magnetic field.

25(b) With the aid of a labelled diagram and appropriate mathematical expressions, explain how cathode ray particles can be passed through charged electric plates and a magnetic field without being deflected. **3**

Marking Criteria	*Marks*
• *correct explanation provided* • *diagram is correct, labelled and clear* • *forces from both fields are equal and opposite (and this must be clearly shown in the diagram that in fact the forces will cancel out)* • *explanation is logically presented*	*3*
• *explanation includes crossed fields, and appropriate maths/formulae used.* • *diagram provided shows this (but directions may not be clear or correct)* *OR* *Good diagrams and maths, but mis-use/confusion of terminology such as words like 'force' and 'field'.*	*2*
• *diagram shows crossed fields OR crossed fields implied in response* *OR* • *recognition that electric force must be cancelled by magnetic force (not 'field') (either in words or symbols)*	*1*



magnitude of F_E = magnitude of F_B

With a magnetic field crossed perpendicular to an electric field, as shown, the forces on an electron $F_E = qE$ and $F_B = qvB$ are equal and opposite and thus cancel each other so the electron moves through undeflected.

****If student mixed-up labels for charged plates, no penalty (provided they had perpendicular arrangement of electric field and magnetic field.***

REMEMBER: The right-hand palm rule gives the force experienced by a POSITIVE charge moving through a magnetic field; the force on an electron will therefore by opposite.

Question 26 (3 marks) **Marks**

(a) Compare and explain the changes in conductivity of conductors and semiconductors when heat energy is provided. **2**

Marking Criteria (and sample answer)	*Marks*
• ***Conductors' ability to conduct goes down (or resistance goes up)as the electrons undergo more collisions with the vibrating lattice (or lose energy in more collisions)*** • ***Semiconductors conductivity goes up (or resistance goes down)as more electrons gain energy to cross the energy gap into the conduction band***	***2***
• ***Changes in either semiconductors or conductors explained*** • ***OR*** • ***Correct identification of conductivity changes but insufficient explanation***	***1***

(b) A piece of silicon is doped with gallium. Identify what this does to the overall charge of the piece of silicon. **1**

The material will remain neutral; addition of neutral atoms will not affect the overall charge.

Doping does NOT make the material either more positive or more negative.

Question 27 (5 marks) **Marks**

When a magnet is placed above a cooled superconducting material it is observed to hover for as long as the material remains in its superconducting state.

(a) Describe what is occurring inside the superconducting material that makes the magnet hover above it. **2**

Marking Criteria	*Marks*
• *Response describes the Meissner Effect in detail*	*2*
• *A relevant aspect of the cause of the magnet hovering is provided*	*1*

The Meissner Effect occurs when eddy currents flow in the superconducting material which produce a magnetic field that exactly cancels the externally sourced magnetic field. This prevents a magnetic field from entering the superconducting material and gives rise to the repulsion of the magnet above it, making it hover.

(b) Superconductors have been proposed for use in applications such as maglev trains.

Explain a key advantage the use of superconductors would offer in such trains and outline TWO specific problems that hinder their current use in maglev trains. **3**

NB. The marking criteria was relaxed for this question because 99% of candidates misinterpreted the question as only asking about advantages for maglev trains in general. The question was, in fact, asking about the advantage of using superconductors in maglev trains (as opposed to, say, electromagnets or permanent magnets).

Marking criteria	Marks
TWO problems explained well AND a key advantage explained(eg: magnetic fields can be large as currents can be large) or no friction between train and track due to levitation and therefore reduced energy losses.	3
Two of the points below made	2
One of the following identified: • Large currents can flow in the superconductor, therefore large magnetic fields can be produced • Need for expensive cooling systems • Chemically unstable in the environment • Brittle and hard to make into wires	1

Sample answer:

The superconductor on the underside of the train can produce a huge magnetic field (and hence obtain levitation) due to their ability to carry large currents. (Students may also discuss that because large fields are made b/c of the large currents, therefore heavy iron cores are not needed to make the field).

The superconductors however are currently expensive to operate due to the need for cooling systems to get and maintain the temperature below the critical temperature.

Additionally, it is difficult to make the materials chemically or physically stable in the external environment as they tend to be brittle ceramics (which is also why they are hard to make into wires).

Question 28 (7 marks) The law of conservation of momentum can be used to analyse the launch of a rocket.

(a) Explain why it is ideal for the exhaust gases from a rocket's engines to be expelled at the highest velocity possible. **2**

Marking Criteria	*Marks*
• ***High Velocity related to high momentum change*** • ***Momentum change (of expelled gases) in one direction is matched by the subsequent change in momentum (hence velocity) of the rocket in the other direction.*** • ***note: use of appropriate formulae regarding conservation of momentum may be used to help a candidate's answer.***	***2***
• ***Partially complete explanation***	***1***

As F x t = I

= ΔP

= mΔv

The faster the exhaust gases are expelled, the larger the value of Δp. By the conservation of momentum, the ΔP of the exhaust gases is equal but in the opposite direction to the ΔP of the rocket if no external forces are acting.

(b) Use appropriate laws of physics to explain why a rocket's acceleration is lowest just after lift-off

Marking Criteria	*Marks*
Correct reason explained AND appropriate reference made to a specific law *such as newton's second law, F = m a)	
Incomplete explanation containing at least one relevant and correct statement. ***(fundamentally flawed responses will not be awarded mark)***	***1***

The upward thrust force of the engine on the rocket must overcome the weight of the rocket at launch and the excess becomes the net force, F_{net} = ma. As the mass of the rocket is greatest when hardly any fuel has been combusted, a is smallest just after lift-off.

Part (c) is on the next page ---------->

(c) Calculate the acceleration of a 5.0 x 10^4 kg rocket just after lift-off, if its motor is expelling 50kg of exhaust at 2.0 x 10^4 m s^{-1} every second. **3**

Marking Criteria	*Marks*
• ***Correct answer***	***3***
• ***Appropriate equations used to find force and acceleration*** • ***Correct value of thrust calculated*** • ***OR :*** • ***acceleration calculated using a value of thrust (but weight force of rocket has not been taken into account)***	***2***
• ***Appropriate equations used OR thrust correctly calculated***	***1***

F_{net} = thrust (up) – weight (down) ***Therefore, as*** ***a = F/m***

= ΔP/t – 5.0 x 10^4 x 9.8 ***= 5.1 x 10^5/5.0 x 10^4***

= (50 x 2.0 x 10^4)/1 – 4.9 x 10^5 ***= 10 m s^{-2} (up)***

= 1 x 10^6 – 4.9 x 10^5

= 5.1 x 10^5 N (up)

Question 29 (2 marks) **Marks**

Marking criteria (and sample answer)	**Marks**
Planck stated that energy is exchanged in discrete packets, rather than as a continuous wave. **Formulated *E = hf* to describe the energy of each packet**	**2**
Partially complete answer	**1**

NOTE: must have some notion of quantised energy for first mark. Second mark derived from supporting information such as equation with terms defined/how related, continuous wave/classical development, how BB curves explained or experimental 'fit'.

Question 30 (2 marks)

AC Induction motors do not have a direct electrical connection to the rotor.

Outline how an AC induction motor operates. **3**

Marking Criteria	*Marks*
• ***All important points regarding operation of induction motor outlined*** • ***Response is in a sequential, logical order***	***2***
• ***A relevant feature of an AC induction motor is identified*** • ***OR*** • ***significant misconceptions included among any correct and relevant statements***	***1***

A <u>rotating magnetic field,</u> synchronous with the supply AC, must be generated around the rotor. The rotor must have electrical conducting bars, such as in a "squirrel cage", "mouse wheel" etc that, when exposed to the <u>changing magnetic field, have a current induced in them.</u> (1 mark)

This induced current then generates its own magnetic field that opposes the external rotating field so that a torque is exerted on the entire rotor (or the induced magnetic field causes the rotor to 'chase' after the rotating external magnetic field). (1 mark)

NOTE: must have <u>changing</u> magnetic field or flux.

NOTE: HSC would require some specific detail such as squirrel cage to outline function.

Question 31 (2 marks)

For ONE of Tsiolkovsky, Oberth, Goddard, Esnault-Pelterie, O'Neill or von Braun, describe **how** their work contributed directly to the development of space exploration. **2**

Marking Criteria	*Marks*
• ***Information regarding selected scientist is relevant and relates to space exploration***	***2***
• ***Some information on selected scientist***	***1***

e.g. Goddard: launched the first liquid fuel rocket in 1926; he also patented the idea of a 2 or 3 stage rocket using solid fuel. Goddard's inventions were used in early space exploration – liquid fuel rockets with 3 stages were used for the Apollo missions.

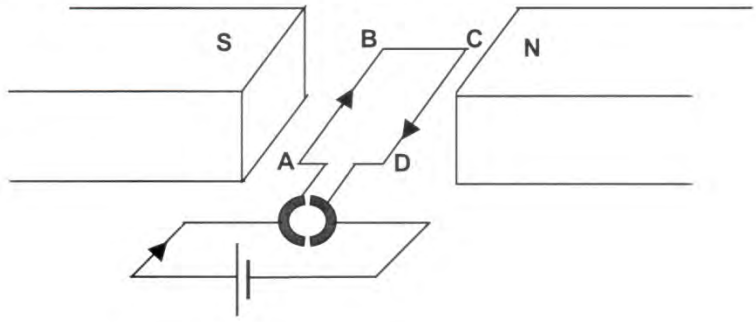
NOTE: At least one development or contribution required AND a reasonable link to current space exploration (this should be more explicit than what candidates presented).

Question 32 (2 marks)

The following diagram is of a simple electric motor with a single loop forming a rectangular coil.

Current in loop = 5.0 A Magnetic field strength = 1.0×10^{-2} T

AB = **CD** = 0.080 m **BC** = 0.020 m



(a) State the magnitude and direction of the maximum torque on the motor.

Marking Criteria	**Marks**
Correct answer *with units (Nm……NOT Nm^{-1})*	**2**
Correct answer but wrong units or no units	**1**

T = nBIA cos Θ

T = 1 x 0.01 x 5 x 0.08 x 0.02 = 8×10^{-5} Nm (CLOCKWISE)….direction not required for full marks.

Question 33 (3 marks)

For ONE first hand investigation (FHI) performed during your Physics course, outline how a risk assessment was performed. This includes the hazards that were identified and how these potential hazards were controlled. **3**

Marking Criteria	*Marks*
• ***A relevant hazard associated with an appropriate FHI is identified with an appropriate control***	***2***
• ***A laboratory hazard and related control identified***	***1***

e.g. Observations using cathode ray tubes:

Risk/Hazard: high voltages; Control: operate under teacher supervision, turn off mains power when handling apparatus, stand well back.

Risk/hazard: production of X-rays when operating equipment; Control: use for minimum time possible, stand back 3m when operating.

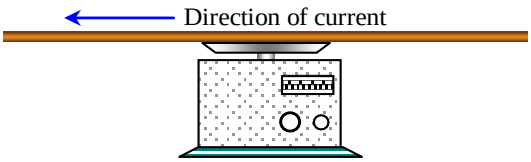
NOTE: Does not need to be a mandatory FHI.

Only [1] mark awarded for vague (non-specific) methods of control or weak "hazards" identified.

NOT accepted – weak arguments for goggles for projectile motion investigations

NOT accepted – electric shock/electrocution for motor effect investigation

Question 34 (8 marks) **Marks**



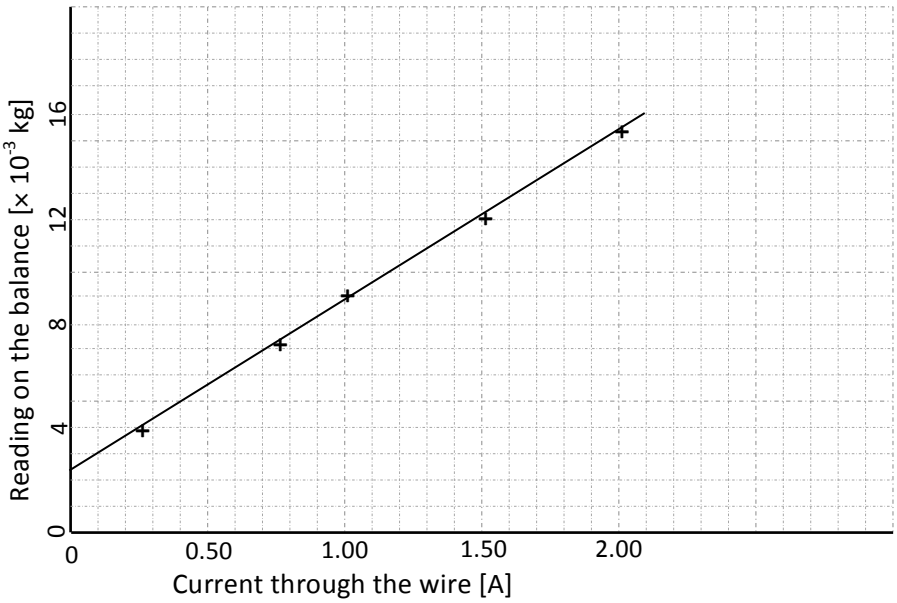
Students have been asked to test magnetic fields. They place a 40-cm length of stiff copper wire on the top of an accurate electronic balance and connect it to the output of a variable voltage source so they can vary the DC current flowing through it. The current is directed *due north*. A horizontal uniform magnetic field is set up between two lines of powerful rare earth magnets on either side of the wire.

The readings the students obtain as the current is varied are shown in the table below. Notice that the readings on the electronic balance are in *kilograms*:

Current (A)	0.25	0.75	1.00	1.50	2.00
Reading (kg)	0.0039	0.0071	0.0090	0.0120	0.0153

(a) Use the axes provided below to design an appropriate graph of the relationship between the current through the wire and the readings on the balance, including the consequent line of best fit. **4**

Sample answer



Criteria	*Marks*
• ***A correct label and units for both axes, and*** • ***Correct and uniform scaling for both axes with correct orientation, and*** • ***Marking in all five points correctly (within 0.5 of a unit either direction), and*** • ***Drawing a neat, straight, appropriate line of best fit***	***3***
Successfully completing three of the required outcomes	***2***
Successfully completing two of the required outcomes	***1***

(b) Use the graph to determine the mass of the 40-cm length of wire. **1**

The wire's mass is 2.5 × 10^{-3} kg; I = 0 (no magnetic force) when the graph line is at that point.

(c) **Use the graph** to find the magnitude of the external magnetic field. **3**

Criteria	*Marks*
• *Determination of the slope of the graph as F/I, and attempting to find it* • *Conversion of the weight force into newtons* • *Successfully finding B(but e.c.t considered in final answer)*	*3*
• *One of the above required outcomes is missing*	*2*
• *One of the above outcomes is present*	*1*

Max [1] mark awarded for attempted calculation with addition of forces (including x9.81) to find B (without gradient)

Max [2] marks awarded for attempted calculation to determine B with straight substitution of a point. Must have x9.81.

Sample answer

The slope of the line of best fit is found as: $\dfrac{\Delta m}{\Delta I} = \dfrac{15.3\times10^{-3} - 2.5\times10^{-3}}{2.00 - 0} = 6.4\times10^{-3}\ \text{kg A}^{-1}$

This represents the rate of change of the apparent mass of the wire as the current varies, but since the scale is measured in kg it must be converted to newtons, i.e.

$$\frac{\Delta F_B}{\Delta I} = 6.4\times9.8\times10^{-3} = 6.272\times10^{-2}\ \text{N A}^{-1}$$

Since

$$F_B = BI\ell \quad \therefore \frac{\Delta F_B}{\Delta I} = B\ell \quad \therefore\ 6.272\times10^{-2} = 0.40\times B \quad \therefore\ B = 0.1568[=0.16]\ \text{T}$$

Question 35 (6 marks) **Marks**

Analyse the use of large scale AC generators and transformers with respect to the efficient and safe distribution of electricity and the associated environmental impacts. **6**

Marking Criteria	*Marks*
A comprehensive understanding of the relevant science principles: (Need the following FOUR points to be made in the answer) ***1. AC generators allow use with transformers as their changing magnetic fields allow voltages to be induced in the secondary coil of a transformer. (a six mark answer MUST include this point about why AC rather than DC generators are used)*** ***2. The voltages then stepped up for efficient transmission, as the key is to minimize currents flowing, as power loss is proportional to the square of the current.*** ***Step down transformers lower the voltage (increase current) when closer to households, so low and safe voltages are delivered to homes.*** ***3 & 4: Need one significant positive AND one significant negative impact on environment to be made.*** ***The environmental advantages are that power stations can be built a long way from cities (thus reducing city pollution from emissions, including acid rain issues) as we now have an efficient transmission network.*** ***On the negative side, the ease of transmission has allowed widespread electrification of society, meaning (such as in NSW) much fossil fuel is used to generate the electricity and the carbon emissions contribute to global warming/climate change*** ***For 6 marks the answer is logically constructed with relevant physics incorporated and clearly explained.***	***5-6***
Environmental advantage/disadvantage outlined with respect to large scale electricity generation. ***AND*** ***Two or three science points identified as to why transformers used, but lack of depth in the response (eg: not saying why we want to have low currents, or why AC generators are used over DC with respect to transformers)***	***3-4***
TWO of the points below made	***2***
ONE of the following points made: • *AC generators allow use of transformers* • *Step up transformers used for long distance transmission so as to minimize power loss* • *Step down transformers closer to the end-user to allow for safe voltages in the home* • *A relevant point made in favour of environmental issues involving AC generation/transmission* • *A relevant point made against environmental issues involving AC generation/transmission*	***1***

NOTE:

Only few "6" mark answers across candidates. More practise of extended responses needed across the cohort – specifically breaking down the question to address each component.

No "assessment" needed for this question.

Common misconception – resistance in transmission wires is quite constant (at constant temperature) and intrinsic to the actual wire.

Many candidates omitted the fundamental physics of the question – transformers CAN be used with AC, not DC due to changing magnetic field/flux from primary coil, inducing emf, thus current in secondary.

Candidates should support/strengthen their power loss argument (low current, high voltage) with the appropriate equation.

Many candidates did not sufficiently consider the environmental impacts.

END OF SECTION 1

Section II

20 marks
Attempt ONE question from Questions 36-40

Allow about 35 minutes for this section

Answer the question in the space provided.
Show all relevant working in questions involving calculations.

Question 39 From Quanta to Quarks (20 marks)

Marks

(a) Describe the key features of the Rutherford model of the atom and explain what was problematic about its treatment of electron orbits. **3**

Marking criteria	***Marks***
Small dense positive nucleus, containing most of the atom's mass ***Electrons orbit at some distance from the atom/atom is mainly empty space*** ***Electrons are undergoing acceleration as they do their circular motion. Accelerated charges should emit (continuous) EMR and thus spiral into the atom. This does not happen***	***3***
Two of the above	***2***
One of the above	***1***

NOTE: cannot just say 'electrons are in orbit', as this is actually told to you in the question!

Also, avoid saying terms like 'protons' and 'neutrons' as these were not terms used when this model of the atom was put forward 9The term proton first appears in the scientific literature in About 1920).

(b) Calculate and then compare the longest wavelength of an emission line in the Balmer series (n_f = 2) to the longest wavelength of an emission line in the Paschen series (n_f =3) for hydrogen. **3**

Marking Criteria	*Marks*
• ***correct wavelengths calculated and a valid comparison made based on this information***	***3***
• ***Both wavelength correctly calculated*** • ***OR*** • ***correct substitution into both equations (using correct values for n_i) and valid comparison made of incorrect wavelengths (ie, a mathematical error was made)***	***2***
• ***One wavelength correctly calculated*** • ***OR*** • ***Correct substitution into both equations*** • ***OR*** • ***Incorrect values for n_i chosen, but then a correct wavelength found***	***1***

Sample answer:

Balmer series: n_f = 2 and n_i = 3 for longest wavelength (lowest energy):

$$\frac{1}{\lambda} = R\left(\frac{1}{n^2{}_f} - \frac{1}{n^2{}_i}\right)$$
$$= 1.097\times10^{7}\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$$
$$= 1.52\times10^{6}$$
$$\lambda = 6.56\times10^{-7} \text{ or } 656 \text{ nm}$$

Paschen series: n_f = 3 and n_i = 4 for longest wavelength (lowest energy):

$$\frac{1}{\lambda} = R\left(\frac{1}{n^2{}_f} - \frac{1}{n^2{}_i}\right)$$
$$= 1.097\times10^{7}\left(\frac{1}{3^2} - \frac{1}{4^2}\right)$$
$$= 5.33\times10^{5}$$
$$\lambda = 1.88\times10^{-6} \text{ or } 1880 \text{ nm}$$

The longest wavelength in the Paschen series is well into the infra-red whereas the Balmer series' longest wavelength is around the colour of red visible light, and is clearly a much shorter value.

Common errors: Not choosing correct values for n_i , which meant that candidates could only score 1 mark maximum (assuming they did everything else correct).

Question 39 continued: **Marks**

(c) The production of the hydrogen spectra was significant to the development of the model of the atom.

(i) Explain its importance to Bohr's development of his model of the atom. **3**

Criteria	*Marks*
• ***Describes briefly the spectrum produced by excited hydrogen atoms – a few specific lines at very specific frequencies*** • ***Outlines clearly how Bohr related these unique spectral lines to his theory of electrons in set stable orbits , with specific wavelengths/frequencies emitted when electron moves down from a higher to a lower level.***	***3***
• ***One correct and relevant physics statement made.*** • ***Or first and/or second of Bohr's postulates stated***	***1***

Sample answer:

Bohr stated that electrons can exist in stable stationary states and not emit emr (1st postulate)

However, when an electron moves from a higher to a lower state there is an energy change in the form of a photon of specific frequency emr being emitted.

The observed specific wavelengths/frequency of the emitted light from excited hydrogen atoms matched the predicted energy changes with Bohr's energy level jumps.

Note: Many candidates scored one mark fairly easily, but did not quite make the explicit and clear link with the specifics of the hydrogen spectral lines.

(ii) Describe ONE characteristic of the hydrogen spectra that could not be explained using Bohr's model. **1**

Criteria	*Marks*
• ***Any ONE of below:*** • ***Describes that each band when viewed closely was not a solid line of emitted light or a narrow range of frequencies emitted from the atom but were in fact made up of a number of hyperfine spectral lines.*** • ***Describes that some spectral lines in the hydrogen spectra were brighter than others*** • ***The Zeeman effect, where spectral lines split when the hydrogen was under the influence of a magnetic field***	***1***

Notes: Marked generously, but many candidates were loose in their use of terminology. Be very very careful to avoid misleading statements.

(d) Outline the contributions of Pauli OR Heisenberg to the development of atomic theory. **2**

Marking Criteria	Marks
• Two contributions described	**2**
• One contribution described • OR • Two contributions identified (but not described in sufficient detai)	**1**

Sample answer:

Eg: Heisenberg:

The uncertainty principle stated that that location and momentum (velocity) of particles (such as the electron) cannot both be known to the same high precision. Nature is inherently uncertain.

He also developed a purely mathematic model of the atom using 'matrix mathematics; which dispensed with concrete visual representations of the atom.

NOTE: The question needs more than just 'identify' or 'state'

(e) Outline how a Wilson Cloud Chamber or similar detection device enables the paths of radiation particles to be made visible. **2**

Marking Criteria	*Marks*
• ***Operational principles of a Wilson Cloud chamber or other suitable device outlined in appropriate detail***	***2***
• ***One aspect of a suitable detection device identified***	***1***

Sample answer:

Using dry ice, a vapour of ethanol or other liquid is cooled in an enclosed chamber. When a radioactive source is placed into the chamber the ionising particles cause a trail of condensed vapour behind it, making the path of the particle visible.

(f) (i) Write a nuclear equation for the beta minus decay of *Pb- 214* **2**

$$^{214}_{82}Pb \rightarrow ^{214}_{83}Bi + ^{0}_{-1}e + ^{0}_{0}\overline{\nu}_e$$

(***Award one mark if an error is made, but the general format of the equation is still <u>substantially correct</u>)***

(ii) When the energies produced in beta decay were first studied scientists noticed a problem. Identify this problem and describe how it was solved. **2**

As The beta particles were being emitted emitted with a range of energies, it appeared that the laws of conservation of mass/energy were not being obeyed. (1 mark)

Pauli suggested that an, as yet undiscovered particle, called the neutrino was also emitted during beat decay, and that this <u>neutrino carried off the excess energy</u>. (1 mark)

(g) (i) ***1 mark = finding mass defect***

1 mark = correct use of $E = mc^2$, with a mass defect value being substituted.

(i) $\text{LHS} = 6.64832 \times 10^{-27}\ \text{kg}$

$\text{RHS} = 2 \times p + 2 \times n$

$= 2(1.673 \times 10^{-27}) + 2(1.675 \times 10^{-27})$

$= 6.696 \times 10^{-27}\ \text{kg}$

$\text{mass defect} = \text{RHS} - \text{LHS}$

$= 6.696 \times 10^{-27} + 6.64832 \times 10^{-27}$

$= 4.768 \times 10^{-29}$

$E = mc^2$

$= 4.768 \times 10^{-29}(3 \times 10^8)^2$

$= 4.2912 \times 10^{-12}\ \text{J}$

(ii) ***1 MeV = 1.6 x 10^{-13} J***

Therefore 4.2912 x 10^{-12} J = 26.82 MeV (1 mark)

<u>NOTE: 1 MeV is 10^{-13} Joules, NOT 10^{-19} joules.</u>

End of question 39

Newington College

2014 PHYSICS TRIAL EXAMINATION

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 ◯