2012

Newington College

TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
- Draw diagrams using pencil
- Approved calculators may be used
- Write your student number in the space provided

Total marks – 100

Section I (Core)

85 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 – 65 marks
- Attempt Questions 21-37
- Allow about 1 hour and 50 minutes for this part

Section II (Elective)
15 marks
- **Candidates are to answer Question 41: <u>From Quanta to Quarks</u>**
- Allow about 25 minutes for this section

Section I
75 marks

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

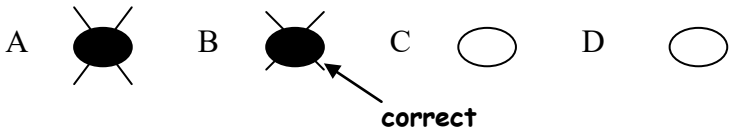
Use the multiple-choice answer sheet.

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

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1. A satellite in circular orbit around Earth has a period of 90 minutes. The satellite is then joined by a space craft having the same mass.

After the space craft docks with the satellite, the period of the orbit will be:

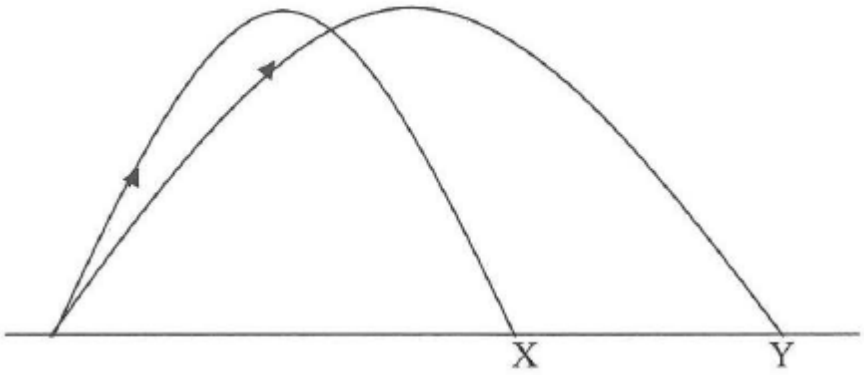
(A) 45 minutes

(B) 90 minutes

(C) 180 minutes

(D) 360 minutes

2. The diagram below shows the paths of two projectiles, X and Y, which rise to the same height.



Which of the following is identical for both projectiles X and Y?

(A) Initial horizontal velocities.

(B) Initial vertical velocities

(C) Initial velocities

(D) Horizontal displacements.

3. In a parallel universe where the universal gravitational constant G was greater than in our own universe, the effect on satellites, assuming that they exist in the same orbits, would be that they:

(A) have faster orbital speeds.

(B) have greater mass.

(C) have slower orbital speeds.

(D) have less mass.

4. On what experimental evidence was the proposal in 1800s of the existence of the *aether* based?

(A) All known waves except light waves were matter waves

(B) Light was an electromagnetic wave

(C) The aether was needed to transmit light through space

(D) They had no evidence for the existence of aether.

5. An amount of work, **W**, is expended when a space craft is launched from rest, from the Earth. The space craft achieves an orbit with kinetic energy **K**.

The change in the space craft's gravitational potential energy, **P**, is given by:

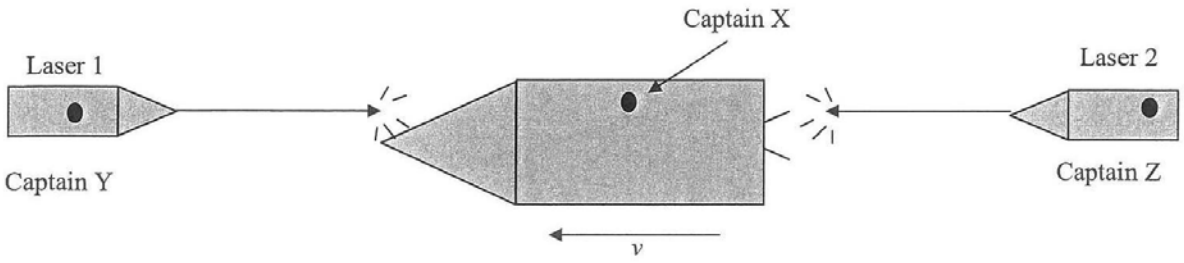
(A) $\mathbf{P} = \mathbf{W} - \mathbf{K}$

(B) $\mathbf{P} = \mathbf{W} + \mathbf{K}$

(C) $\mathbf{P} = \mathbf{K} - \mathbf{W}$

(D) $\mathbf{P} = -(\mathbf{K} + \mathbf{W})$

6. Two laser cannons are equidistant from spaceship '**X**'. Lasers are fired from each spacecraft (**Y** and **Z**) simultaneously at spaceship '**X**' as it flies at a speed of 0.5 c.



Which statement about this event is correct?

(A) Light from laser 1 reaches Captain **X** before light from laser 2.

(B) Light from laser 1 and laser 2 reach Captain **X** at the same time.

(C) Light from laser 2 will not reach the spaceship.

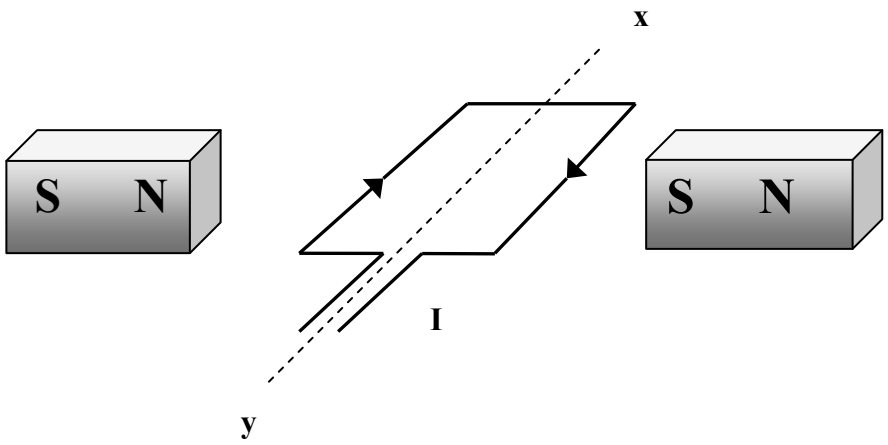
(D) Light from laser 2 reaches Captain **X** before light from laser 1.

7. A rocket car moves on a straight horizontal track. Half of the initial mass of the rocket car is fuel propellant. During the run, the fuel propellant is consumed at a constant rate and the products of the combustion of the fuel are ejected at a constant velocity.

Which of the following best describes the force propelling the rocket car, and the magnitude of the acceleration of the rocket car while the combustion products of the propellant fuel are being ejected?

	Force	*Acceleration*
(A)	constant	constant
(B)	increasing	constant
(C)	constant	increasing
(D)	increasing	increasing

8. A rectangular loop of wire as shown has a current **I** flowing through it. The loop extends past the magnets in the direction **x**.



The torque on this loop could be increased the most by:

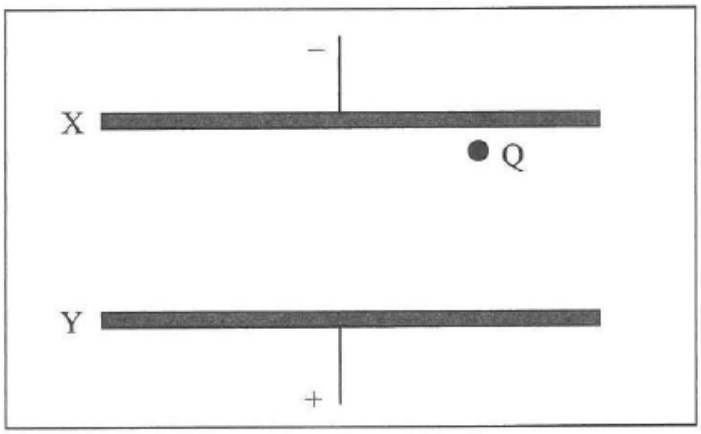
(A) extending the length of the loop in the direction x-y as shown.

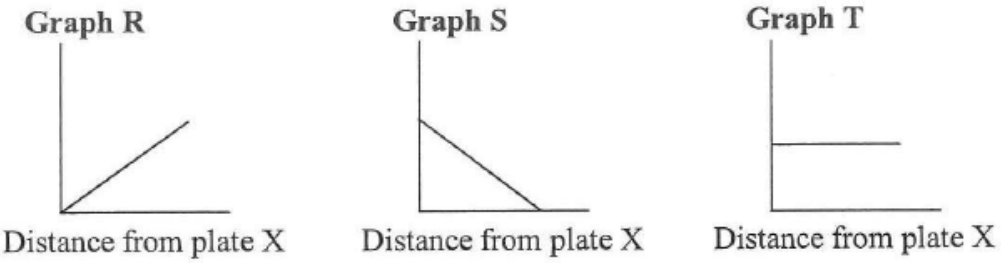
(B) extending the width of the loop towards the magnets.

(C) decreasing the thickness of the wire in the loop.

(D) reversing the direction of the current in the loop.

9. A potential difference is applied across two parallel plates, as shown below.
A negative charge is placed between the plates at point *Q* and released. Three graphs are also shown.





Which option best identifies the graphs which show the *electric field strength*, between X and Y, the *electric potential difference*, between X and Y, and the *velocity* of the negative charge?

	Electric field strength	**Potential Difference**	**Velocity of charge**
A	**Graph T**	**Graph S**	**Graph T**
B	**Graph T**	**Graph R**	**Graph R**
C	**Graph R**	**Graph T**	**Graph S**
D	**Graph S**	**Graph R**	**Graph R**

10. The production and long-distance transmission of electricity in large electric generators is predominately AC in most parts of the world.

This is because large AC electricity is:

(A) able to be used with transformers

(B) less dangerous than DC.

(C) more easily used with superconductors

(D) transmitted faster than DC.

11. A key advantage of an AC induction motor compared to a DC motor is that:

(A) Induction motors have no moving parts

(B) Induction motors have no brushes to wear out

(C) Induction motors do not need a magnetic field

(D) Induction motors do not need a coil

12. Which statement best describes a reliable investigation?

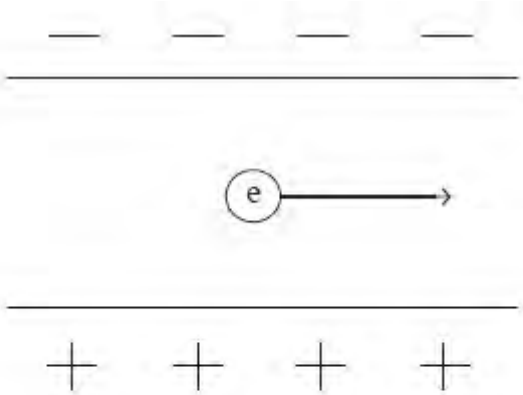
(A) The method allows for a fair test.

(B) The method allows the results to be repeatable.

(C) The method allows for the results to be accurate.

(D) The hypothesis will be supported.

13. An electron is travelling down a cathode ray tube at a speed of 3 x 10^7 m/s.
It passes between two metal plates 10 cm apart, as shown in the diagram.



There is a potential difference of 12 V between the plates.
There is a potential difference of 12 V between the plates.
The size and direction of the force on the electron is
The size and direction of the force on the electron is:

(A) 1.9×10^{-19} N up.
(A) 1.9 x 10^{-17} N up.
(B) 1.9 x 10^{-17} N down.
(C) 1.9 x 10^{-19} N down.
(D) 1.9 x 10^{-19} N down.

14. The concept of a "fair test" when applied to the Scientific Method is best reflected by having:

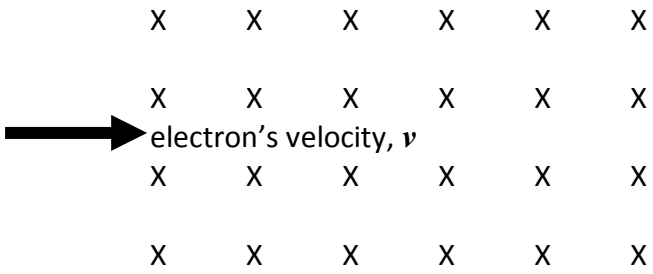
(A) a hypothesis which is supported by the results of the investigation.

(B) only one variable being changed in the investigation.

(C) a conclusion which addresses the aim of the investigation.

(D) a method which is clearly stated in point form.

15. An electron moving at a speed ***v*** enters a uniform magnetic field perpendicular to the field, as shown. Its path while in the magnetic field is circular with a radius of 30.0 cm.



A research student then sets up two parallel charged plates separated by a distance **d**, with a voltage of **V** between them. Where the charged plates overlap with the magnetic field, the electron's path changes from circular to straight.

What is the relationship between the values of the electric field between the parallel plates **E**, the magnetic field **B**, and the speed of the electron, ***v***?

(A) $v = E / B$

(B) $v = BE$

(C) $B = vE$

(D) $v^2 B = E$

16. If the value of Planck's constant, *h*, was higher than it is, the effect on a photo-electric effect experiment would be:

(A) the threshold frequency, f_o would be lower for all metals.

(B) the energy of incident photons would be less.

(C) the threshold frequency would be greater for all metals.

(D) the photoelectric current would be greater.

17. Hertz's measurement of the speed of radio waves was not performed by directly measuring their speed. The property of radio waves Hertz actually measured to find their speed was:

(A) frequency

(B) amplitude

(C) period

(D) wavelength

18. In order to calculate the strength of a uniform magnetic field, the path taken by a beam of ions fired into the magnetic field was observed. Which combination of properties of the beam of ions would it be necessary to know in order to do this successfully?

(A) mass, velocity, charge, radius of path

(B) element, charge, radius of path

(C) velocity, mass, radius of path

(D) velocity, radius of path, type of element

19. A mains transformer, working on 240 V, has 400 turns on the primary coil. The secondary output is 12 V.

How many turns are required on the secondary coil?

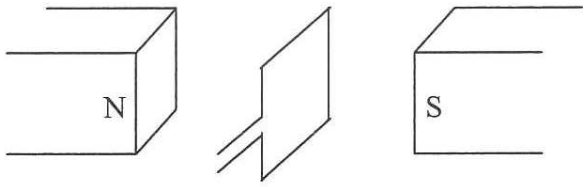
(A) 10

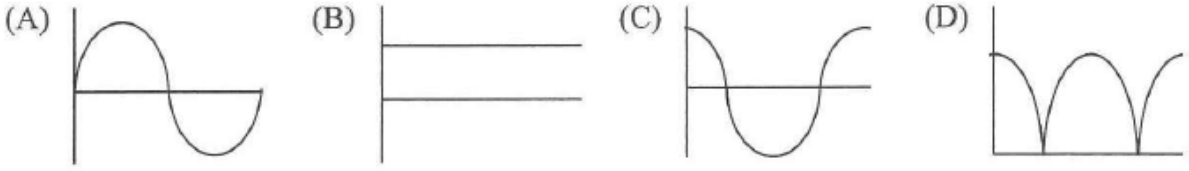
(B) 20

(C) 400

(D) 8 000

20. A coil is rotated in the space between two magnets, as shown below.
Which of the *emf* against *time* graphs below best shows the *emf* produced as the coil rotates 360^0 from this initial position?





Part B – 65 marks
Attempt Questions 21-37
Allow about 1 hour and 40 minutes for this part.

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

Question 21 (5 marks) **Marks**

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

(a) Calculate the distance that the rock will move horizontally before hitting the ground. **2**

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(b) Find the final vertical velocity and then the overall velocity of the rock just before it hits the ground. **3**

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Question 22 (2 marks) **Marks**

There are several reasons why the value of gravitational acceleration varies at different places on the Earth's surface.

Describe how the orbit of geostationary satellites would need to change if the Earth rotated faster. **2**

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Question 23 (3 marks)

At some time in the future an experiment is performed to test Einstein's predictions about time dilation. Two synchronised clocks (A and B) are obtained. Clock *A* is taken on board a spacecraft on a journey into deep space. A time of 15 years was measured by this clock.
Upon return to earth, it is observed that clock *B* (which remained on Earth) has recorded 25 years.

How fast would the spaceship be travelling on the journey undertaken by clock *A*? **3**

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Question 24 (5 marks) **Marks**

The Mars Reconnaissance Orbiter (MRO) is a NASA probe currently orbiting Mars at an altitude of 300 km above the surface. Among other things, the MRO is used to transmit data from the rovers on the surface back to Earth.

The following table contains data about Mars and the MRO.

Mass of Mars	6.42×10^{23} kg
Radius of Mars	3 400 km
Mass of MRO	1 030 kg

(a) By using Kepler's Law of Periods, calculate the period of the MRO's orbit around Mars. **2**

(b) Calculate the centripetal force on the MRO due to Mars, and state its direction. **3**

Question 25 (3 marks)

Marks

When it operated, the Space Shuttle was able to attain a low-Earth orbit at an altitude of several hundred kilometres. However, it was not considered as "escaped" from Earth's gravitational field. **3**

Describe the conditions necessary for a spacecraft to escape Earth's gravitational field in terms of the energy required using appropriate equations and symbols.

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Question 26 (3 marks)

Electric motors are designed to rotate continuously, however, a galvanometer which operates using the motor effect only turns through a limited angle.

Outline the operation of a galvanometer as an application of the motor effect. **3**

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Marks

Question 27 (3 marks)

(a) With the aid of a labelled diagram, explain how electric currents and heat can be induced in the base of a saucepan when placed on an induction cooktop. **3**

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Question 28 (2 marks)

Define the term *step-up transformer* and with appropriate mathematical expressions show how it obeys the law of conservation of energy. **2**

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Question 29 (4 marks) **Marks**

Analyse Edison's and Westinghouse's electricity supply solutions for cities. **4**

Question 30 (4 marks) **Marks**

A student conducted an investigation by observing the nature of cathode rays.

(a) Describe TWO observations which would lead the student to the conclusion that cathode rays are negatively charged particles. For each observation explain why it is consistent with that conclusion. **4**

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Marks

Question 31 (7 marks)

(a) Identify what was wrong with classical physics theory that led to Planck's hypothesis that radiation emitted by a black body was quantised. **2**

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(b) Identify how Planck's hypothesis regarding the nature of black body radiation differed from the explanation offered by classical physics. **1**

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(c) A student is investigating the photoelectric effect using a photocell with a cobalt cathode whose work function is 4×10^{-19} J, and three LEDs (light emitting diode) of wavelength 450 nm, 550 nm and 650 nm, to illuminate the photocell.
By the use of supporting calculations, explain which, if any, of the LEDs will cause a current in the circuit. **4**

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Question 32 (4 marks) **Marks**

Describe the ***two*** methods of doping a semiconductor material that can change the material's electrical properties. **4**
Labelled diagrams may be used as part of your answer.

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Question 33 (2 marks) **Marks**

Outline ONE advantage and ONE limitation of current superconductor technology. **2**

(i) Advantage

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(ii) Disadvantage

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Question 34 (2 marks) **2**

A small electric motor in a drill was turning at its normal fast rate. The drill was then used to create a hole in a nearby wall, causing it to slow down. A burning smell was then observed to be coming from the motor.
Use your understanding of back emf to explain this observation.

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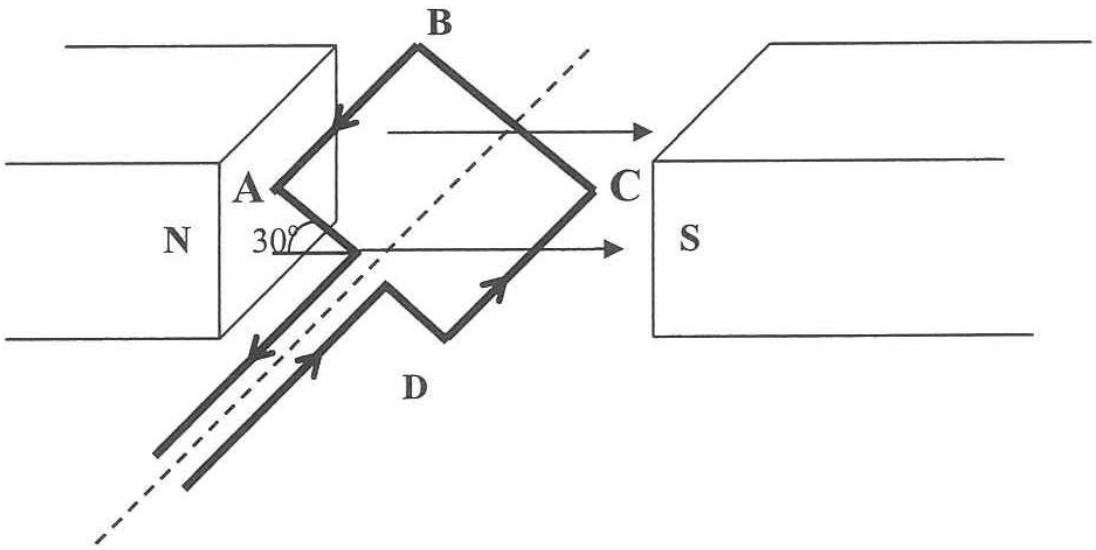
Question 35 (5 marks) **Marks**

A rectangular coil, with 250 turns, is between the poles of two bar magnets.
Its plane makes an angle of 30^0 with the direction of the magnetic field. The side AB measures 15 cm and the side BC measures 10 cm. The magnetic field strength between the poles of the magnets is 5.0 mT and the current through the coil is 25 mA.



(a) Calculate the *magnitude* and *direction* of the force on side AB when the coil is in the position shown. **3**

(b) The angle between the coil and magnetic field is 30^0. However, this will not result in a maximum torque value. Use the appropriate formulae to explain for what angle maximum torque will be achieved. **2**

Question 36 (6 marks) **Marks**

The equation for the force between two parallel currents is given by the equation

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

To investigate this relationship, a student measured the force between two parallel wires carrying electric currents as the distance between the wires was changed.
The measurements are in the table below.

F = Force (N)	*d = distance (m)*	$\frac{I}{d}$
10×10^{-6}	0.010	
5×10^{-6}	0.020	
3.3×10^{-6}	0.030	
2.5×10^{-6}	0.040	
2.0×10^{-6}	0.050	

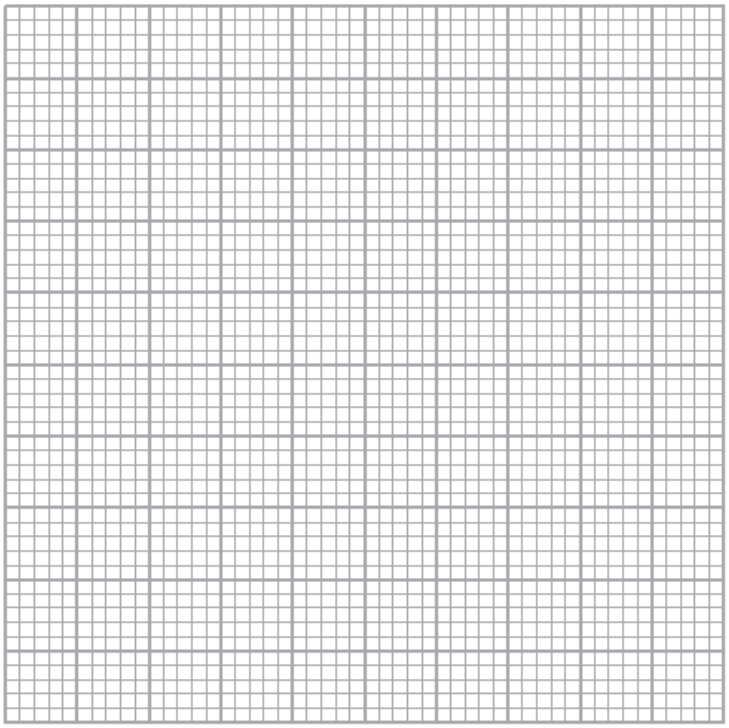
Other measurements:
The two currents were each equal to 1.0 A, and the length of the wire was 50 cm.

(a) Calculate values for I / d, and write then in the table above. **1**

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

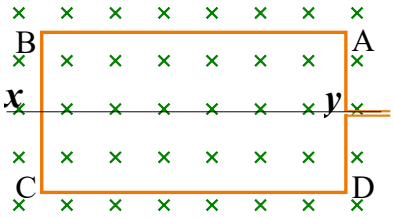
Question 36 continued: **Marks**

(b) Plot a graph of F against $1/d$ on the grid below. **3**



(c) Use the gradient from the graph to calculate an experimental value for k, the constant in the equation. **2**

Question 37 (5 marks) **Marks**



The length of the single loop ABCD is 0.75 m and its breadth is 0.40 m. Initially ABCD lies perpendicular to a uniform magnetic field that has a flux density of 0.25 T.

(a) Find the change in the magnetic flux penetrating loop ABCD, including units, when it rotates 90° around the axis ***xy***, such that AB comes up out of the page. **2**

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(b) If the loop is rotating at 50 Hz, how long does it take to turn through 90°? **1**

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(c) Faraday's Law is $emf = - n \Delta\Phi / \Delta t$

Determine the magnitude of the *emf* generated in ABC as it is turned through 90^0. **1**

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(d) On the diagram draw the direction of the induced current that would flow in the loop. **1**

END OF PART B

Section II

15 marks

Attempt Question 41 *only*.

Allow about 25 minutes for this section

Answer the question in a writing booklet.
Show all relevant working in questions involving calculations.

		Page
Question 38	Geophysics……	22
Question 39	Medical Physics……	23
Question 40	Astrophysics……..	24
Question 41	From Quanta to Quarks…….	25
Question 42	The Age of Silicon……	26

Marks

Question 38 Geophysics (15 marks)

(a) (i) Identify two uses of remote sensing of radiation in mineral exploration. **2**

(ii) Explain why remote sensing is often the preferred method over other methods when mineral exploration is undertaken. **2**

(b) The value of the gravitational acceleration on the surface of a newly discovered planet is 13.4 m s^{-2}. The diameter of the planet is 5.89 x 10^3 km.

Calculate the mass of this planet. **4**

(c) (i) Describe an investigation which models the way in which the inclination of Earth's magnetic field varies with latitude. **4**

Include a diagram to illustrate your answer.

(ii) Assess the validity of the model referred to in part (i). **3**

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Marks

Question 39 Medical Physics (15 marks)

(a) (i) Compare the two types of beta emission that may occur when a radioactive isotope decays. **2**

(ii) Explain what happens to positrons when they are emitted within a human. **2**

(b) By selecting two suitable materials from the table provided, show how the reflected ultrasound signal has a low intensity compared to the incident signal intensity when the acoustic impedance of the two materials is similar. **3**

Material	**Acoustic impedance ($x10^6$ kg m^{-2} s^{-1})**
fat	1.38
tissue	1.63
blood	1.61
muscle	1.70
bone	5.6

(c) (i) Compare and contrast images produced by an endoscope with images produced by an X-ray. **3**

(ii) Describe the advantages of using an endoscope to obtain images of internal body organs. **2**

(d) Describe how the composition of the nuclei and the strength of the applied external magnetic field determine the frequency of precesssing of the nuclei. **3**

Marks

Question 40 Astrophysics (15 marks)

(a) (i) Describe the difference between intrinsic and extrinsic variable stars, giving examples of each. **2**

(ii) Identify the type of variable star that can have its light used to photometrically measure its distance and outline how this is done. **2**

(b) A pair of binary stars, "alpha" and "beta" have visual magnitudes of +12.5 and +15.7 respectively.

(i) How much is "alpha" brighter than "beta"? **2**

(ii) Explain why it is not possible to tell if "alpha" is closer than "beta" using this information alone. **2**

(c) (i) Describe a suitable method used for an investigation that would demonstrate why it is desirable to have a telescope with a large diameter objective lens or mirror. **3**

Use a diagram to illustrate your answer.

(ii) Outline how the validity of such an investigation could be ensured. **2**

(d) Outline the limitations of ground-based trigonometric parallax measurements. **2**

Question 41 From Quanta to Quarks (15 marks) **Marks**

(a) The Rutherford model of the atom introduced the concept of a dense, positively charged nucleus, which is a concept we still use today.
However, it was less successful with explaining the behaviour of electrons.
Describe an important limitation that the Rutherford model had in relation to electron behaviour. **2**

(b) (i) Describe an investigation in which the visible components of the hydrogen spectrum are observed.

A labelled diagram should be used to illustrate your answer. **2**

(b) (ii) Describe an important step you would take in the experiment to ensure that your results were valid. **1**

Question 41 continues on the next page ---------->

Question 41 continued

(c) The visible wavelengths of the electromagnetic spectrum have a range from 400 nm to 700 nm.

Calculate the minimum speed that an electron would need to achieve so that its wavelength lies within the range of wavelengths of visible light. **2**

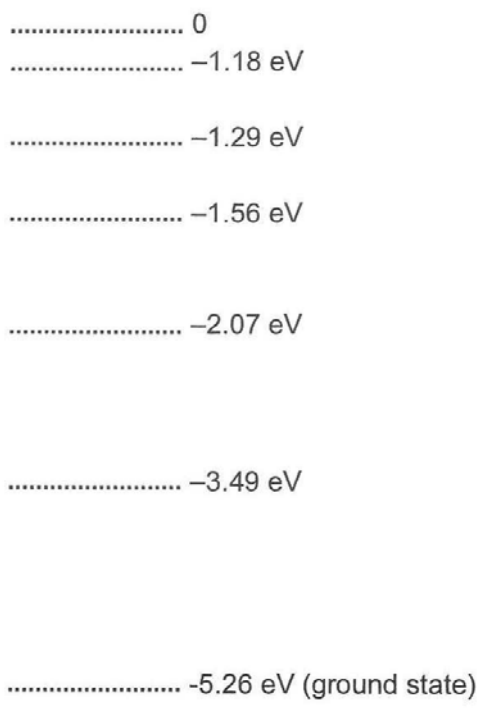
(d) (i) Identify a key limitation in the Bohr model of the atom that de Broglie's wave-particle duality was able to address. **1**

(ii) Describe how an application of de Broglie's work helped address the issue identified in (i). **2**

Question 41 continues on the next page ---------->

Question 41 continued **Marks**

(e) The diagram below shows the energy levels in an atom.



Calculate the frequency of the radiation emitted when an electron falls from the 5th to the third energy level. **3**
Note: 1 eV = 1.6 x 10^{-19} J

(f) The element Thorium-232 undergoes alpha decay. **2**
Write a nuclear equation for this event.

END OF QUESTION 41

Marks

Question 42 The Age of Silicon (15 marks)

(a) (i) Identify ***one*** digital system and ***one*** analog system in devices. **2**

(ii) Compare and contrast the two systems identified above by outlining how each system operates. **2**

(b) Explain, using an example, how AND, OR and inverter gates can be used in combination with each other to make half or full adders. **3**

(c) (i) Describe an investigation which can be performed to show how a summing amplifier operates by adding voltages from two separate sources. **4**

(ii) Outline how validity of the results of this investigation were ensured. **2**

(d) Explain the need for a relay when switching large currents **2**

Newington College

2012 PHYSICS TRIAL EXAMINATION

MULTIPLE-CHOICE ANSWER SHEET

Question	**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

$$v = f\lambda$$

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

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

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

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

$$P = VI$$

$$\text{Energy} = VIt$$

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

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

$$\Sigma F = ma$$

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

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

$$W = Fs$$

$$p = mv$$

$$\text{Impulse} = Ft$$

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

$$F = mg$$

$$v_x^{\,2} = u_x^{\,2}$$

$$v = u + at$$

$$v_y^{\,2} = u_y^{\,2} + 2a_y\Delta y$$

$$\Delta x = u_x t$$

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

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

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

$$E = mc^2$$

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

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

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

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 / Symbol of element / Atomic Weight / Name of element — e.g. 79 Au 197.0 Gold

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 Trial Physics Examination 2012

Marking Criteria

Part A: Multiple Choice

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

21. (**a)**

Marking Criteria	Marks
• Correct answer	**2**
• One appropriate calculation towards answer is calculated OR • Answer provided contains an arithmetical error	**1**

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

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

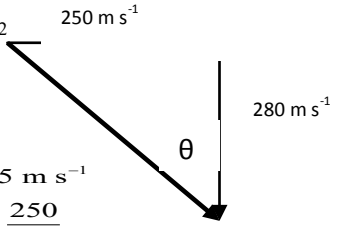
$$\Delta x = u_x t$$
$$= 250 \times \text{t}$$
$$= 7142.5 \text{ m}$$
$$= 7.14 \times 10^3 \text{ m}$$

(b)

Marking Criteria	Marks
• Correct velocity given, including a valid direction	**3**
• Calculations performed with an arithmetic error OR • Correct overall velocity given without angle	**2**
• Final vertical velocity calculated	**1**

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

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



$$v_y = 375 \text{ m s}^{-1}$$
$$\tan \Theta = \frac{250}{280}$$
$$\theta = 42^o \text{ from vertical (or } 48^0 \text{ from horizontal)}$$

22.

Marking Criteria	Marks
• Both changes described	**2**
• One change described or both changes (period and radius) identified	**1**

To achieve a shorter period (travel faster) to keep up with Earth's rotation, the orbital radius of geostationary satellites would be reduced.

23.

Criteria	Marks
Calculates correct answer	3
One mathematical error in finding 'v', but does make correct decisions re t_0 *and* t_v	2
Incorrect substitution, but subsequent calculation correct OR t_0 and t_v correctly identified	1

Use time dilation formula, where t_v = 25 years, and t_0 = 15 years.

V = 0.8 c (2.4 x 10^8m/s)

Many candidates had issues with either substituting correctly or manipulating the equation.

24. (a)

Gives the correct answer 2

Answer involves one error in working. . . 1

(a) Radius of orbit $= 3700 \text{ km} = 3.7 \times 10^6 \text{ m}$

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

$$\frac{(3.7 \times 10^6)^3}{T^3} = \frac{6.67 \times 10^{-11} \times 6.42 \times 10^{23}}{4\pi^2}$$

From whence we derive $T = 6833.6$ s

(b)

- Gives correct answer 3

- Error in working (especially wrong mass or radius used) or left out direction 2

- Makes two errors in working 1

(b) Using $C = 2 \bullet r = 2 \bullet (3.7 \times 10^6) = 2.32 \times 10^7$ m (the distance travelled by the MRO). Now, to determine the velocity, use this figure and the answer from part (a):

$$v = \frac{d}{t} = \frac{2.32 \times 10^7}{6833.6} = 3395 \text{ m s}^{-1}$$

Now find the centripetal force using

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

$$= \frac{1030 \times 3395^2}{3.7 \times 10^6} = 3209 \text{ N}$$

Note there are Alternative approaches: (see next page)

24 (b) continued

Alternative approach #1:

$$v = \sqrt{\frac{GM}{r}}$$

V = 3401.96 m/s

Then use $F_c = m v^2 / r$

F = 3221.8 N

Alternative approach #2

Equate gravitational force with centripetal force

$$F_C = F_G$$

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

This will give F = 3221.7 N

25.

Marking Criteria	Marks
• sound understanding of relevant factors and relationships evident • appropriate energy formulae referred to • Logical presentation	**3**
• basic understanding of the relevant factors and relationships evident, • some appropriate formulae identified	**2**
• Some understanding of a relevant concept evident (such as quoting the escape velocity formula)	**1**

Sample answer: For a spacecraft to escape Earth's gravitational field it must either: possess sufficient kinetic energy, $E_K = 1/2mv^2$*, so that it can gain gravitational potential energy,* $E_P = -Gm_1m_2/r$ *of at least zero ; or be able to propel itself with sufficient fuel so that it can "climb up" to a potential energy of zero. For a projectile at launch,* E_K *equal to or greater than* Gm_1m_2/r.

Alternative approach:
Discuss the factors involved in achieving escape velocity as outlined in the escape velocity formula. BUT...candidates still need to discuss energy factors, as this is explicitly asked for in the question.

26.

Marking Criteria	Marks
• A thorough outline is provided that describes the relevant aspects	**3**
• A basic outline of a galvanometer is provided	**2**
• One appropriate aspect provided	**1**

Sample answer:
A current flows through coils within a radial magnetic field.
The coils are free to rotate but have a spring attached which exerts a progressively stronger restoring force when they turn.
A needle is attached to the coil structure.
The greater the current, the more the coils try to rotate against the spring, and the needle swings against a background scale to indicate the current flowing through the circuit.

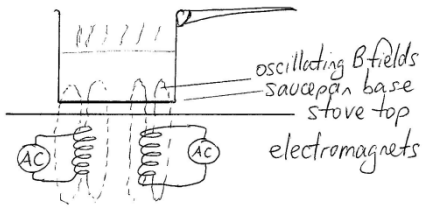
The radial field is important as it means that a linear scale can be used on the galvanometer as the torque is independent of the position of the coil. (ie: the coils experience a constant torque due to the radial magnetic field)

27. (a)

Marking Criteria	Marks
• Thorough explanation is provided with either a diagram or a clear description	**3**
• A description of some of the aspects of the operation of induction cooktops provided	**2**
• A limited description of induction cooktop principles is provided	**1**

Sample Answer:
Solenoids beneath the cooktop act as sources of changing magnetic fields as they are connected to the AC mains supply. This then generates a changing magnetic flux through the base of the saucepan above, which in turn induces eddy currents in the saucepan base. The eddy currents generate heat (ohmic heating...resistance of the iron) in the saucepan base itself. The food, in contact with the saucepan, is then heated directly.

Candidates could describe hysteresis as source of heat....



28.

Marking Criteria	Marks
• Step up transformer defined • The conservation of energy is related to transformers using $P\ in = P\ out = IV_{in} = IV_{out}$, and link to increased voltage in secondary is accompanied by a reduction in current	**2**
• One of the above done	**1**

Sample answer:
Step-up transformers increase the voltage output (in the secondary coil) (1 mark)

For any transformer, the power in is given by $P_{in}=V_pI_p$ and the power output given by $P_{out}=V_sI_s$.
So in an ideal transformer has $P_{in}=P_{out}$ therefore with no lost energy. It follows then that $V_pI_p=V_sI_s$ for ideal transformers. i.e. In step-up transformers, the voltage increases while the current is decreased.

29.

Marking Criteria	Marks
• Transformers use AC only • AC better for larger transmission distance due to energy/power considerations • Edison's DC model of local generators (eg: every suburb) • One other relevant issue: such as pollution issues, comparing motors	**4**
• The supply solutions are compared, including distance/transmission issues and the ability for AC to allow transformers (energy efficiency considerations) • Some differences are outlined	**3**
• Several aspects of either supply solution are outlined OR • An aspect of both supply solutions is outlined	**2**
• An aspect of either supply solution is identified	**1**

Sample answer: Edison proposed a DC distribution system whereby small power stations would be necessary throughout the city, delivering 110 volts to homes, factories and shops. Westinghouse was able to propose an AC system with power stations remotely located, as transformers could be used to step up the voltage from the power station so long distance transmission could be achieved efficiently, which Edison's system could not do. AC was believed to more dangerous, so Westinghouse proposed a 110 V final voltage to match Edison's DC. The advantages of Westinghouse's system allowed Niagara Falls and other remote power sources such as coal fired power stations to be built on large scales and produce electricity much more cheaply, efficiently and with less pollution in densely populated areas.

30.

Marking Criteria	Marks
• The relevant observations are described clearly and for each, an explanation that shows it supports a negative particle model is provided	**4**
• Relevant observations are described with some links made to the negative particle model (but students did not address *both* particle *and* charge) • Three marks awarded if observations were relevant to charge nature, but no statement made about charges needing mass.	**3**
• Several appropriate observations of cathode rays are provided	**2**
• An observation of cathode rays is provided	**1**

Sample answers:
Maltese cross casts a shadow → travel in straight lines like particles should
Deflected by an electric field → in a direction consistent with negative charge → if charged must be particles
Deflected by a magnetic field → consistent with being negatively charged particles
Can push a paddle wheel → have mass (demonstrate momentum) → evidence of particles

NOTE: Magnets are NOT described with words like 'positive' or 'negative'

31. (a)

Marking Criteria	Marks
• A clear explanation is provided	**2**
• A problem with classical theory is identified/inconsistent with observations	**1**

Sample answer:

Classical physics predicted that as the temperature of the black body emitter increased, the energy radiated would increase enormously until infinite amounts would be given off – which violated the law of conservation of energy, and must therefore be incorrect as it was not consistent with observations.
Many candidates did not mention the temperature increase of the black body

(b)

Marking Criteria	Marks
• Planck's hypothesis is identified	**1**

Sample answer:
Planck hypothesised that the radiation emitted by black bodies is quantised – i.e. given off as discrete packets of energy (quanta) as opposed to classical theory which stated that the energy is given of continuously with a wave nature.

Question 31 (c)

(c)

$E = hf = \frac{hc}{\lambda}$, so $\lambda = \frac{hc}{E}$ $= \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{4 \times 10^{-19}}$ $= 4.95 \times 10^{-7}$ m So LEDs with wavelength shorter than this will produce a photocurrent, that is, only the 450 nm LED will produce a protocurrent.	9.4.2 H7, H10 • Correct formulas for energy and wavelength; correct substitutions of values into calculation; correct value for minimum wavelength and correct conclusion about which LEDs will produce a photocurrent 4
	• Correct formulas for energy and wavelength; correct substitutions of values into calculation; correct value for minimum wavelength; but incorrect conclusion about which LEDs will produce a photocurrent 3
	• Correct formulas for energy and wavelength; correct substitutions of values into calculation; but incorrect value for minimum wavelength. 2
	• Correct formulas for energy and wavelength 1

Marker's notes:

1. There are several methods of determining that only the 450 nm diode will work, in addition to the one shown above. EG: finding the energies of each of the diodes (4.4, 3/6 and 3.1 x 10^{-19} J)

2. While a correct conclusion about which wavelength will cause a photocurrent must be stated, further justification was not required, although the questions did ask for an 'explanation' (ie, cause and effect).

32.

Marking Criteria	Marks
• Two methods of doping described thoroughly • A four mark answer will have no ambiguity	**3-4**
• Two methods of doping identified OR • One method described clearly	**2**
• One method of doping identified	**1**

Sample Answer:
n-type doping: a group V element is introduced into the silicon lattice in small numbers. One electron from each of these group V atoms has no place to bond and acts as a charge carrier; (2 marks)
p-type doping: a group III element is introduced into the silicon lattice so that there is an electron "hole" or vacancy which other electrons may jump into, thus movement of the hole acts as a charge carrier. (2 marks)

33.

Criteria	Marks
Advantage AND limitation outlined	2
Advantage OR limitation outlined	1

Sample answer: there are no energy losses when superconductors carry large currents, so their implementation will prevent energy wastage.

However, it is difficult and costly to maintain them at the required very low temperatures.

Possible issues to consider: fragility, the lack of being malleable/ductile

34.

Criteria	Marks
Relevant and correct physics described, lack of back emf linked to excess current (and thus heat) being produced	2
Partially correct explanation (such as lack of back emf once motor slowed down)	1

Sample answer: As the motor coil in the saw rotates, it cuts magnetic field lines (or undergoes a change in flux) and an induced emf is created in the coil. The direction of this 'back' emf (Lenz's Law) opposes supply emf, and so the net voltage across the coil decreases, ensuring a low current in the motor windings.

When the drill slowed down, there was much reduced back emf, and so the net emf was higher and so was the resulting current. This caused the wires in the motor to overheat and burn out (hence the burning smell).

Note: A majority of candidates did not score the two marks on offer in this question. The key point about emf being reduced when the motor slowed down was missed by many students.

Furthermore, candidates are reminded to use terminology carefully. Too many students were using terms such as 'emf' or 'current' or 'resistance' incorrectly. For example, current and emf are NOT the same thing.

35. (a)

Criteria	Marks
Calculates correct answer with direction	3
Calculates correct answer but direction is absent or wrong OR One error in calculation AND correct direction given	2
Correct formula selected and data substituted (However, two or more subsequent errors made)	1

$F = n\ B\ I\ L = 250 \times 5 \times 10^{-3} \times 25 \times 10^{-3} \times 0.15 = 4.7 \times 10^{-6}$ N upwards

NOTES: this question was asking about the force on side AB....not for the torque on the coil.

Candidates need to be familiar with prefixes such as 'milli'.

The side AB is at 90 degrees to the magnetic field, not 30 degrees. Therefore, there is no

sin Θ factor.

There are 250 turns on the coil.

(b)

Criteria	Marks
Full and correct explanation	2
Correct and relevant formula quoted and partially explained	1

$T = n\ B\ I\ A \cos\vartheta$

If $\vartheta = 0$ (ie coil lies parallel to plane of magnetic field), then $\cos\vartheta = 1$, and this will give a maximum value for torque.

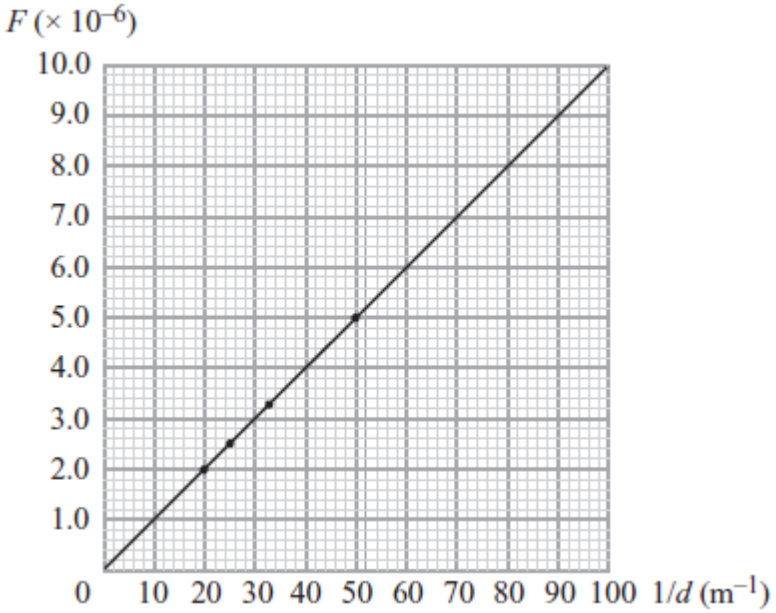
NOTE:

Need to <u>explicitly</u> <u>explain</u> the reason for zero degrees.

36. (a) Correct values in table = 1 mark

F = force (N)	d = distance (m)	$\frac{1}{d}$
10×10^{-6}	0.010	100
5×10^{-6}	0.020	50
3.3×10^{-6}	0.030	33.3
2.5×10^{-6}	0.040	25
2.0×10^{-6}	0.050	20

(b)



- Axes labelled, points correctly plotted, straight line of best fit drawn 3

- Two of above 2

- One of the above 1

NOTE: labelled axes must include correct units (many candidates did not do this or put wrong units for the horizontal axis)

36 (c) is on next page ------->

36. (c)

• Gives correct value for gradient and correct answer 2
• Gives incorrect answer but correct substitution in correct equation 1

Sample answer:

Gradient from graph = 10^{-7}N, $m = \frac{\text{rise}}{\text{run}}$

Using $\frac{F}{l} = k\frac{I_1 I_2}{d}$ the gradient is given by the kI_1I_2l.

$10^{-7} = k \times 1 \times 1 \times 0.5$

$k = 2 \times 10^{-7}$

K = 2 x 10^{-7} NA^{-2}

NOTE: MUST make explicit reference to the gradient (the question requires this, and is testing your ability to correctly take gradients from graphs)

Also note that gradients have units. Candidates who did not include appropriate units (or wrong units) can consider themselves lucky not to have been penalized)

37. (a)

Criteria	Marks
• Correct application of $\Phi = B.A$ (initial and final flux values) • Correct determination of the difference between Φ_f and Φ_i • Correct units included somewhere in answer (Wb)	2
• Correct determination of either Φ_f or ***OR*** Values found for the flux while coil is horizontal and when it is vertical, but student confuses these values or makes some other subsequent error	1

Sample answer

The formula for magnetic flux may be written $\Phi = B.A$

Initially the flux through loop ABCD is $\Phi_i = 0.25 \times (0.75 \times 0.40) = 0.075$ Wb

After being rotated through 90° it becomes *0 Wb.*

$\Delta\Phi$ = final flux – initial flux = 0 - 0.075

$\therefore \Delta\Phi = -7.5 \times 10^{-2}$ Wb, [*Direction not required*]

Q37 (b) is on next page ----->

37. (b)

Criteria	Mark
• Correct reasoning leading to an answer	1

Sample answer

90° is one-quarter of a rotation. Hence T = ¼ × 1/50 seconds = 0.005 s

37. (c)

Criteria	Mark
• Correct substitution into the formula leading to an answer	1

$$\text{emf} = n.\frac{\mathrm{d}\Phi}{\mathrm{d}t} = 1 \times \frac{7.5\times10^{-2}}{0.005} = 15 \text{ V}$$

(d) The induced current (in the coil) will be CLOCKWISE. (This is an application of Lenz's Law)

Many candidates had a poor understanding of magnetic flux. They (wrongly) thought it was the same as magnetic field strength.

41 Quanta to quarks

(a)

Criteria	Marks
An important limitation identified and explained in some detail	2
An important limitation identified, but poor or missing detail	1

Sample answer: The orbiting electrons were NOT observed to give off a continuous spectrum (1), and furthermore, as accelerated charges they should spiral into the nucleus thus collapsing the atom. This was not observed to happen.

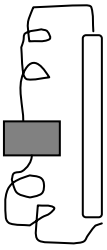
(other acceptable answers possible...such as describing the inability to explain discrete line spectra etc)

BUT: this question was asking about 'electron behaviour' NOT the composition of the nucleus. Therefore candidates discussing nucleus issues were not answering the question.

(b)

Marking Criteria	Marks
• An appropriate investigation is outlined accompanied by a labelled diagram	**2**
• One important aspect of an appropriate investigation is provided	**1**

A hydrogen discharge tube is connected to an induction coil. The emitted light is observed through a spectroscope from a safe distance to avoid exposure to X-rays generated by the apparatus and to avoid receiving a shock from the high voltage. The wavelengths of the emission lines are noted using the spectroscope's scale.



spectroscope

Induction coil and spectral tube

Many candidates were confusing experiments. A common mistake was to get confused with cathode ray tubes, alpha particles, diffraction experiments.

(ii)

Marking Criteria	Marks
Nature of validity of investigation described with a specific example	**1**

Sample answer: Background light minimised so that only the H_2 spectrum is observed and not fluorescent lights etc

NOTE: Many candidates confused reliability with validity. Repeating the experiment (multiple trials, taking averages etc) is all about improving reliability. Improving reliability is a good thing, but it is not the same as validity. For example, if the spectroscope was detecting light from other nearby sources, then no matter how many times you did the experiment, it still would not be valid.

Also remember to LABEL diagrams. Artistic skill is not so important, but if you label everything, then you leave no doubt as to what you are drawing.

41 continued

(c)

Marking Criteria	Marks
• Correct minimum speed calculated	**2**
• An appropriate equation selected and data substituted • 700 nm correctly selected but subsequent mathematical error OR 400 nm wrongly selected, but subsequent calculation was correct	**1**

$$\text{As } \lambda \text{ decreases with momentum, need } \lambda = 700 \text{ nm}$$

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

$$v = \frac{h}{\lambda m}$$

$$= \frac{6.626 \times 10^{-34}}{700 \times 10^{-9} \times 9.1 \times 10^{-31}}$$

$$= 1040 \text{ m s}^{-1}$$

$$= 1.04 \text{ km s}^{-1}$$

(d)

(i) Bohr was unable to explain *why* electrons could exist in their stationary (or 'allowed')states without emitting EMR (1 mark)

OR: Bohr was unable to give a full reason *why* angular momentum was quantised

NOTE: This question was not about problems with the Bohr model in general. It was specifically asking you to consider the issues that could be directly addressed by de Broglie's wave-particle idea.

Also note that the abbreviation for electromagnetic radiation is EMR NOT 'EMF'.

This question is continued on the next page .-------->

41 (d) continued

(ii)

Criteria	Marks
Full explanation of de Broglie linked to Bohr	2
Partial explanation (eg: standing waves described)	1

Sample answer;

Bohr stated the electrons existed in stable stationary states, without giving off electromagnetic radiation. We can use the de Broglie electron wavelength to explain why this is possible. The circumference of electron orbits were integral multiples of the de Broglie electron wavelength.

For example, the first orbit circumference = 1 x electron wavelength

The second orbit = 2 x electron wavelength etc

Therefore, while in the stationary state the electron would then be able to form a standing wave, and would not lose energy (as no destructive interference would occur while a standing wave).

41. Continued.

(e)

Criteria	**Marks**
Calculates correct answer with unit	3
One error (such as not correctly converting *eV into joules*) OR wrong two energy levels chosen for calculation (but everything else in answer, including units, is correct)	2
Two errors, but candidates *does* attempt to use $E = h f$ relationship OR: calculates energy difference between the two levels. OR: Uses Rydberg equation (with '3' and '5' substituted into the equation for energy levels) to find a frequency.	1

Sample answer:

$\Delta E = 0.78\ e\ V = 0.78 \times 1.6 \times 10^{-19} = 1.25 \times 10^{-19}$ *J (1 mark)*

$E = h f$, $f = E / h = 1.25 \times 10^{-19} / 6.626 \times 10^{-34}$ (1 mark)

$= 1.9 \times 10^{14}$ Hz

NOTE: the Rydberg-Balmer equation is NOT valid. This equation is only valid for Hydrogen.

The data in this question is NOT for the hydrogen atom.

(f) Correct decay equation including mass and atomic number information and correct symbols = 2 marks

One minor error = one mark

$$_{90}Th^{232} \text{-------} > {}_{88}Ra^{228} + {}_{2}He^{4}$$

NOTE: some confusion between atomic mass and atomic number. Also, some candidates wrongly thought that alpha particles were a 'reactant' rather than being emitted!