Name: ________________
Class: ________________

20
22

TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Physics

Weighting: 30%

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
- Draw diagrams using pencil
- NESA approved calculators may be used
- A data sheet, formulae sheet and Periodic Table are provided at the back of this paper
- For questions in Section II, show all relevant working in questions involving calculations
- Write your name at the top of pages 13 and 35

Total Marks: 100

Section I – 20 marks (pages 2-11)

- Attempt Questions 1-20
- Allow about 35 minutes for this section

Section II – 80 marks (pages 13-29)

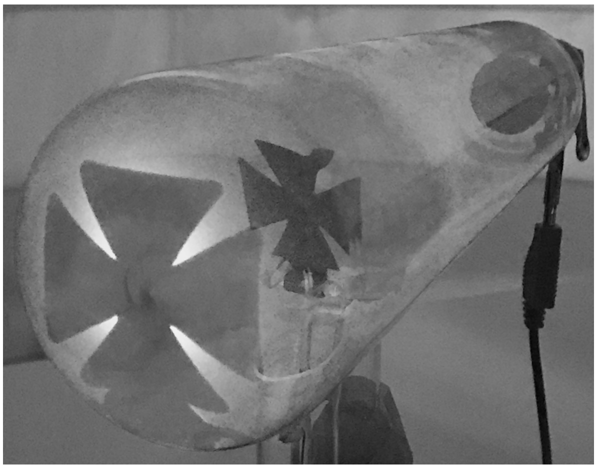
- Attempt Questions 21 - 35
- Allow about 2 hours and 25 minutes for this section

Section I

20 marks
Attempt all questions 1 – 20
Allow about 35 minutes for this section

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

1. The picture below shows a cathode ray tube.



Which property of cathode rays does the cathode ray tube demonstrate?

A. Cathode rays have momentum.

B. Cathode rays travel in straight lines.

C. Cathode rays are deflected by an electric field.

D. Cathode rays are deflected by a magnetic field.

2. Who developed the theory that unified electricity and magnetism?

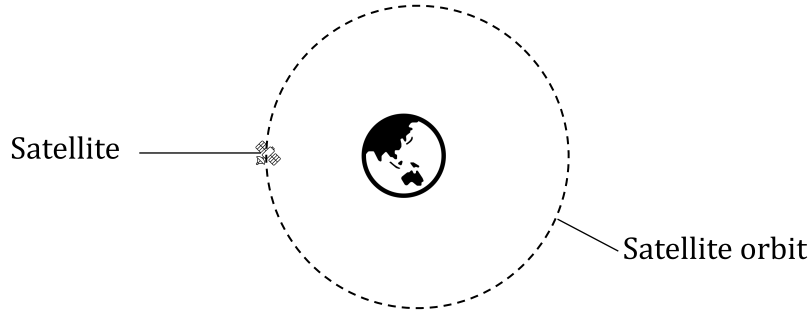
A. Einstein

B. Huygens

C. Maxwell

D. Newton

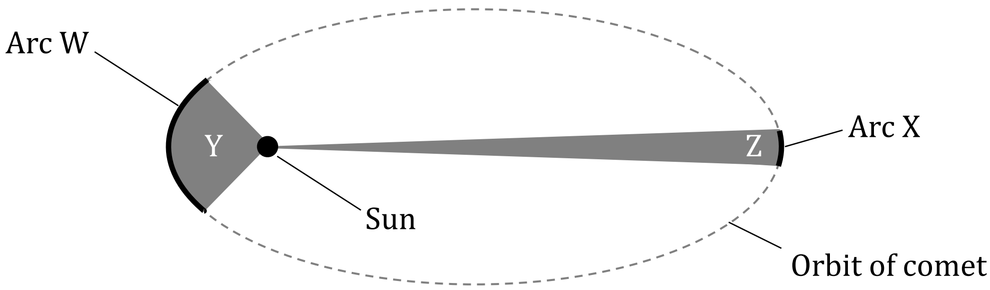
3. The diagram below shows a satellite orbiting the Earth in uniform circular motion.



Which row in the table correctly shows the direction of the satellite's orbital velocity and the centripetal acceleration when the satellite is in the position shown?

	Orbital Velocity	Acceleration
A.	→	→
B.	→	↓
C.	↓	→
D.	↓	↓

4. The diagram below shows the orbit of a comet around the Sun.



The areas of the two shaded sectors, Y and Z are equal. Therefore, the comet takes the same amount of time to travel along arcs W and X.

Which law describes this relationship?

A. Kepler's First Law

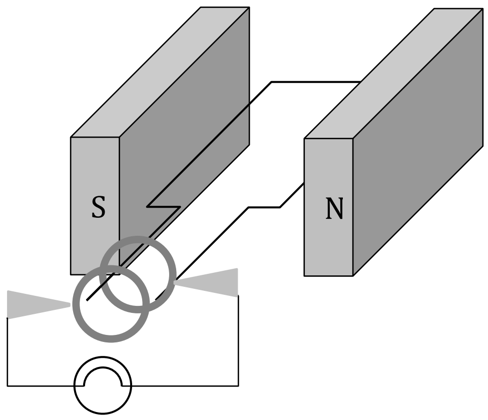
B. Kepler's Second Law

C. Kepler's Third Law

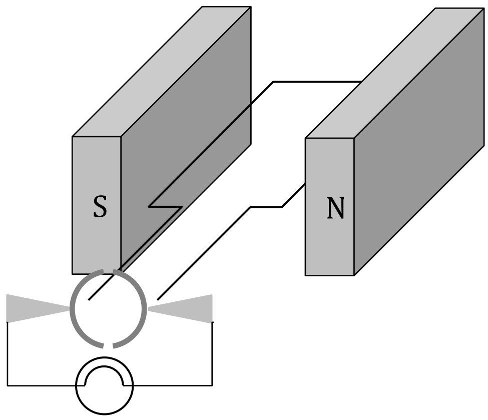
D. Newton's Law of Universal Gravitation

5. Which of the diagrams below shows a DC motor?

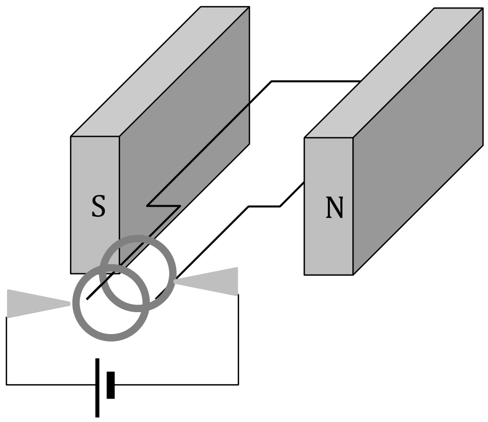
A.



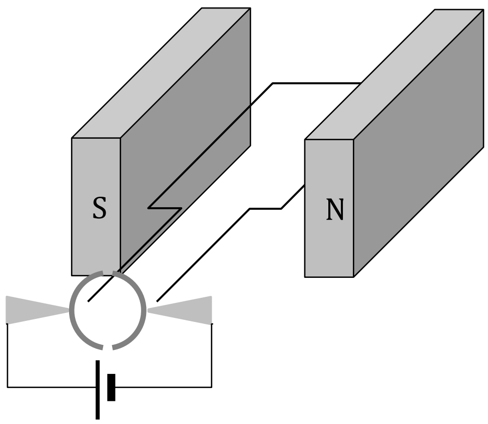
B.



C.



D.



6. The corpuscular model of light was proposed in the 17th Century. It claimed that light was made up of particles.

Which observation below can NOT be explained using the corpuscular model of light?

A. Light can travel through a vacuum

B. Light reflects predictably off a surface

C. Light travels slower in water than it does in air

D. Light bends when it enters a new medium at an angle

7. The table below compares the mass and radius of four planets.

Planet	Mass (kg)	Radius (m)
Planet W	M	R
Planet X	M	2R
Planet Y	2M	R
Planet Z	2M	2R

Which planet has the greatest gravitational field strength (g) at its surface?

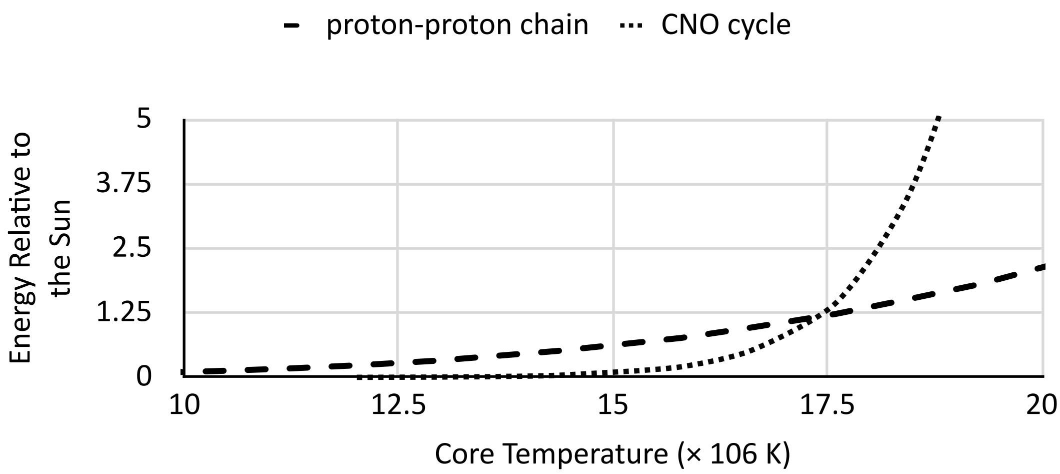
A. Planet W

B. Planet X

C. Planet Y

D. Planet Z

8. The graph below shows the energy emitted by main sequence stars as a result of the proton-proton chain and the CNO cycle.



At what temperature does the CNO cycle produce more energy than the proton-proton chain?

A. 12×10^6 K

B. 14×10^6 K

C. 16×10^6 K

D. 18×10^6 K

9. In some transformers the secondary coil is wound on top of the primary coil.

This improves the efficiency of the transformer by

A. decreasing the back EMF.

B. reducing incomplete flux linkage.

C. producing smaller eddy currents.

D. decreasing resistive heat production.

10. A 2.5 cm long wire carries a current of 3.6 A. It experiences a force of 27 mN when perpendicular to a magnetic field.

What is the magnitude of the magnetic field?

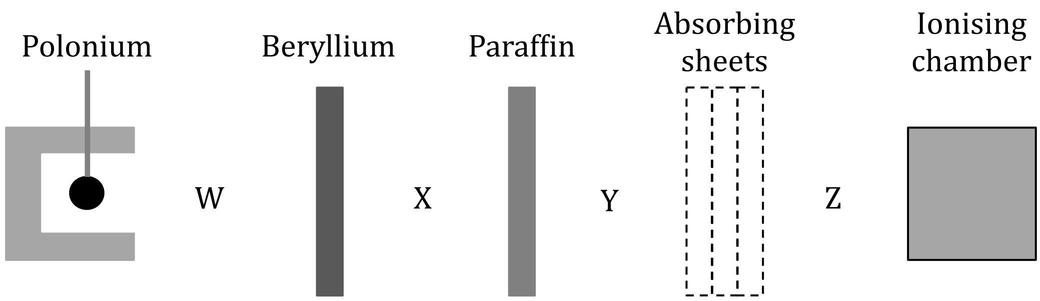
A. 0.003 T

B. 0.3 T

C. 3 T

D. 300 T

11. The diagram below represents the apparatus Chadwick used to discover the neutron.



In which position would you be most likely to find neutrons?

A. W

B. X

C. Y

D. Z

12. The cosmic microwave background has a temperature of 2.7 K.

What is the energy of a photon emitted at the peak wavelength by a blackbody at this temperature?

A. 1.9×10^{-22} J

B. 2.3×10^{-23} J

C. 7.4×10^{-26} J

D. 6.2×10^{-31} J

13. Which of the following experimental observations can be explained by the photoelectric effect?

A. The electrical resistance of selenium decreases when light shines on it.

B. Light is emitted when an electron decelerates as it travels near a nucleus.

C. Light is emitted when an electron in an atom moves to a lower energy level.

D. A current-carrying wire produces light at a wavelength dependent on its temperature.

14. A projectile is launched over flat ground. 6.1 seconds later, it lands 244 metres from where it was launched.

What is the magnitude of the initial velocity of the projectile?

A. 30 ms^{-1}

B. 40 ms^{-1}

C. 50 ms^{-1}

D. 60 ms^{-1}

15. The table below shows the absolute magnitude and surface temperature of four stars.

Star	Absolute Magnitude	Surface Temperature (K)
119 Tauri	-5.2	3 800
GD 61	+15	17 000
LP 944-20	+20	2 700
Zeta Puppis	-6.2	40 000

Which of the stars is a white dwarf?

A. 119 Tauri

B. GD 61

C. LP 944-20

D. Zeta Puppis

16. A charged oil drop was suspended in an electric field of 4.9×10^{4} NC^{-1} directed down.

What is the charge on the oil drop if it has a mass of 1.2×10^{-14} kg?

A. -2.4×10^{-18} C

B. -2.4×10^{-19} C

C. 2.4×10^{-19} C

D. 2.4×10^{-18} C

17. The table below shows the amount of energy required to remove an electron from different energy levels of a hydrogen atom.

Energy Level	Energy required to remove electron from atom (eV)
1	13.6
2	3.40
3	1.51
4	0.85
5	0.54

A hydrogen atom absorbs a photon with a frequency of 2.34×10^{14} Hz.

Which electron transition does the absorption of this photon cause?

A. $2 \rightarrow 4$

B. $3 \rightarrow 5$

C. $4 \rightarrow 2$

D. $5 \rightarrow 3$

18. A rocket travels past the Earth at a constant velocity close to the speed of light.

Which statement correctly describes observations made from the rocket and from the Earth?

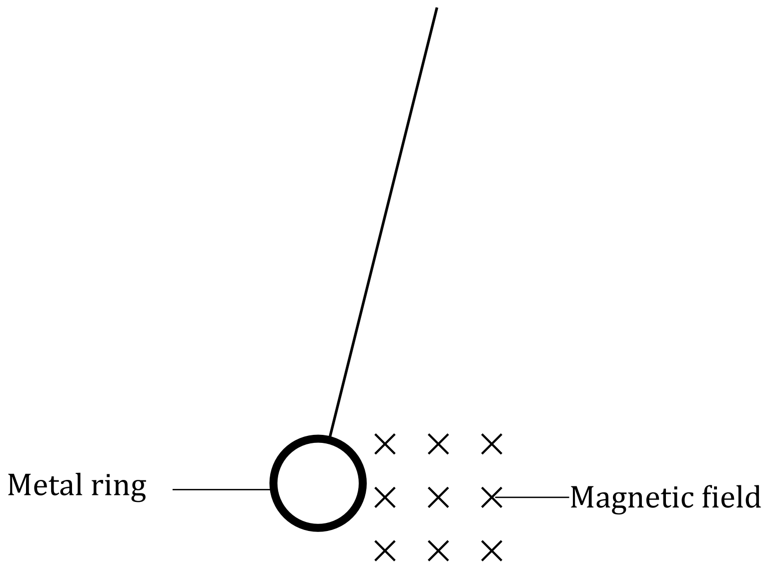
A. An observer on the rocket will measure light travelling faster than an observer on the Earth.

B. An observer on the rocket will measure the length of rocket as being shorter than an observer on the Earth.

C. An observer on the rocket and an observer on the Earth will agree that time is passing slower on the rocket than on the Earth.

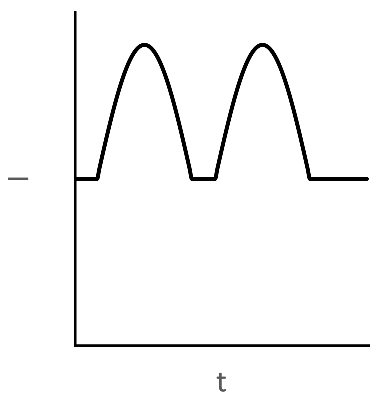
D. An observer on the rocket and an observer on the Earth will agree that an object on the rocket travels at a constant velocity if no net force acts on it.

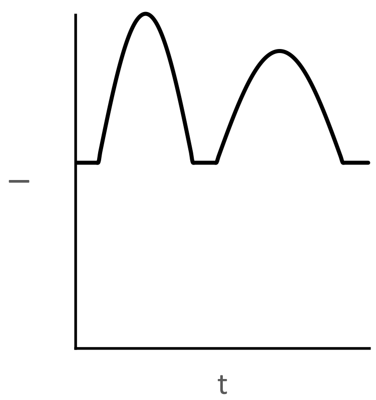
19. A metal ring is suspended from a string. The metal ring is pulled to the side and released so it swings through a magnetic field, as shown below.



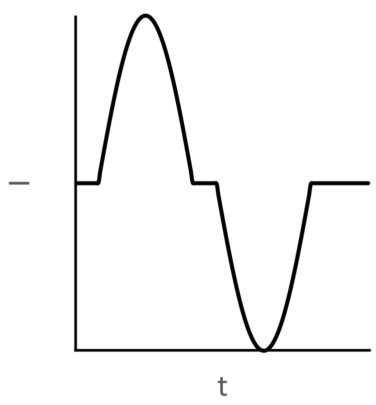
Which graph below shows the current in the ring as it moves into and out of the magnetic field?

A.





B.
C.



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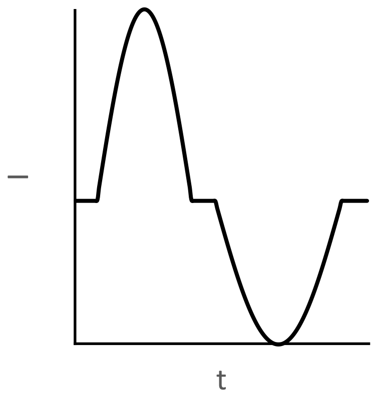
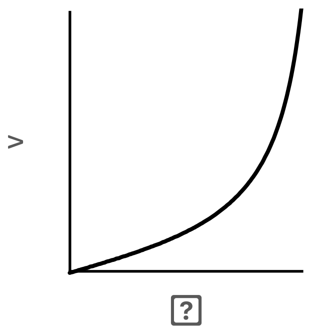


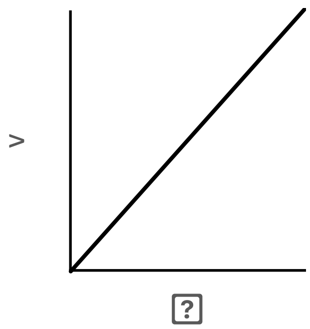
20. A car executes uniform circular motion as it moves around a circular bend on a banked track.

As the car travels around the circular bend, the driver does not need to turn the steering wheel to stay on the track.

Ignoring friction, which graph below shows the relationship between the angle of banking (θ) and the car's velocity (v).

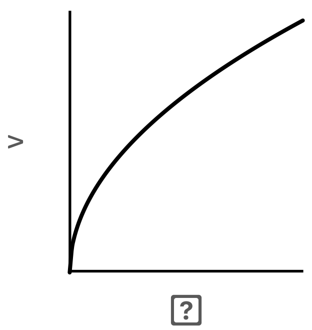
A.

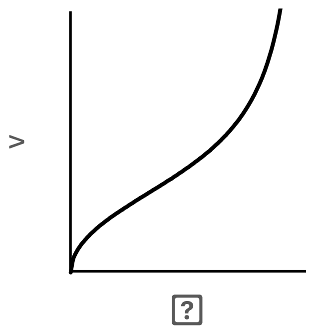




B.

C.





D.

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Physics
Section II
Answer Booklet

Name: ________________

Class: ________________

80 marks
Attempt all questions 21 – 35
Allow about 2 hours and 25 minutes for this section

Instructions

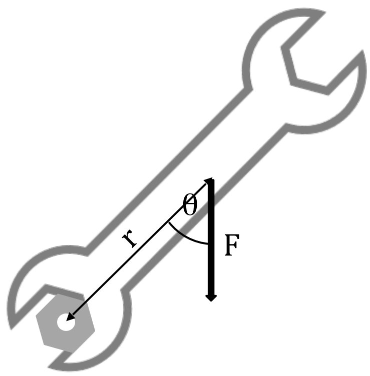
- Write your name at the top of this page.
- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in the questions involving calculations.

Please turn over

21. (2 marks)

A force is applied to a spanner. **2**

The diagram below shows the displacement (r) between the force (F) and the fulcrum. The angle between the force and the displacement is shown as θ.



Outline TWO changes that would increase the torque applied to the spanner.

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22. (2 marks)

During your physics course you conducted a practical investigation to validate the modelling of projectile motion. **2**

Describe how you managed an identified risk as you conducted the practical investigation.

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23. (3 marks)

A 1300 kg car moves around a circular bend with a radius of 13 m at 36 km/h. **3**

What is the magnitude of the centripetal force on the car?

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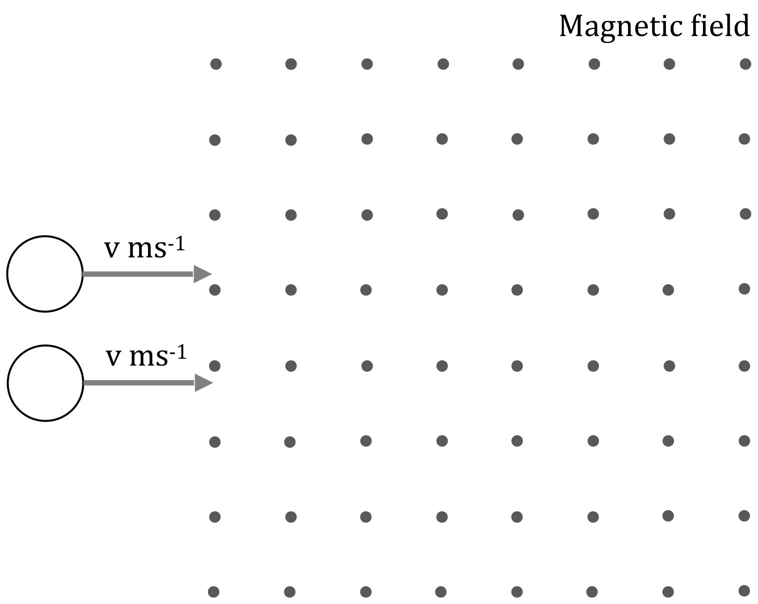
24. (3 marks)

An electron () and a positron () are travelling at the same velocity. **3**

Both particles enter a uniform magnetic field, as shown below.

Sketch the path of the electron and the positron through the uniform magnetic field.



25. (7 marks)

In an experiment to investigate the photoelectric effect, light is shone on an iron target.

The work function of iron is 4.5 eV.

a) Calculate the threshold frequency for iron. **3**

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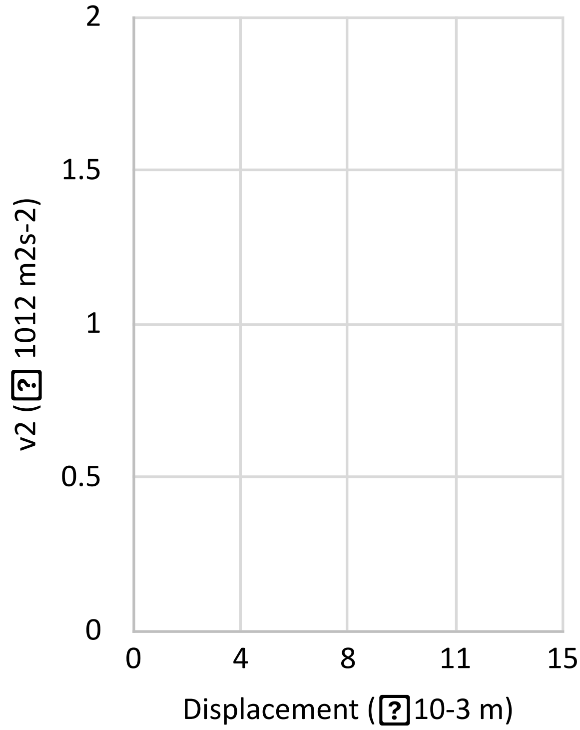
Question 25 continues on page 17

b) The frequency of light shone on the iron target is increased above the threshold frequency. A photoelectron is emitted and moves through an evacuated glass tube. A voltage is applied to decrease the kinetic energy of the photoelectron. **4**

The table below shows the square of the photoelectron's velocity (v^2) as it moves through the evacuated glass tube.

Displacement ($\times 10^{-3}$ m)	3	6	9	12	15
v^2 ($\times 10^{12}$ m^2s^{-2})	1.3	0.97	0.66	0.36	0.05

Plot the data on the axes below and hence determine the initial velocity (u) of the photoelectron.



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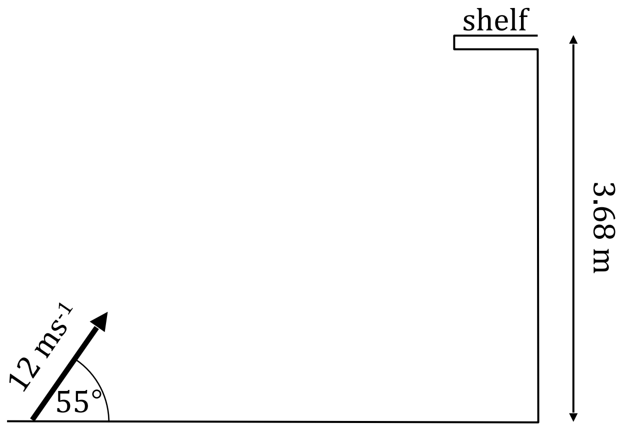
End of Question 25

26. (4 marks)

A box is thrown onto a shelf, as shown below. **4**



The box is thrown with an initial velocity of 12 ms^{-1} 55° above the horizontal.
The shelf is 3.68 m above the point where the box was thrown from.

Calculate the time it takes for the box to land on the shelf.

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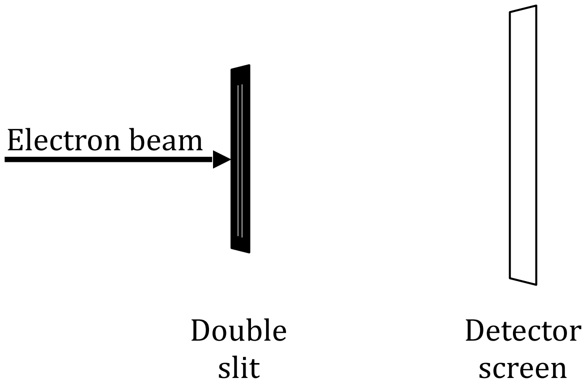
27. (4 marks)

An electron passed through two slits separated by 5×10^{-4} m, as shown below.



After passing through the slits, an interference pattern was detected on a screen 2.5 m away.

The maxima of the interference pattern were separated by 1.2×10^{-6} m.

a) Show that the de Broglie wavelength of the electrons is 2.4×10^{-10} m. **2**

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b) Calculate the velocity of the electrons. **2**

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28. (4 marks)

Explain why the force between two parallel current-carrying wires is proportional to the product of the two currents. **4**

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29. (6 marks)

a) A 10 m long train carriage travels past a station at 0.8c. **2**

Calculate the length of the train carriage in the station's inertial frame of reference.

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b) Using labelled diagrams and text, describe how experimental evidence supports Einstein's prediction of length contraction. **4**

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30. (9 marks)

A spacecraft is in a circular orbit around the Earth.

To stay in the circular orbit, the spacecraft needs to travel at the orbital velocity (v_{orb}).

To escape the Earth's gravitational field, the spacecraft needs to increase its speed to the escape velocity (v_{esc}).

a) Show that $v_{\text{esc}} = \sqrt{2}v_{\text{orb}}$. **3**

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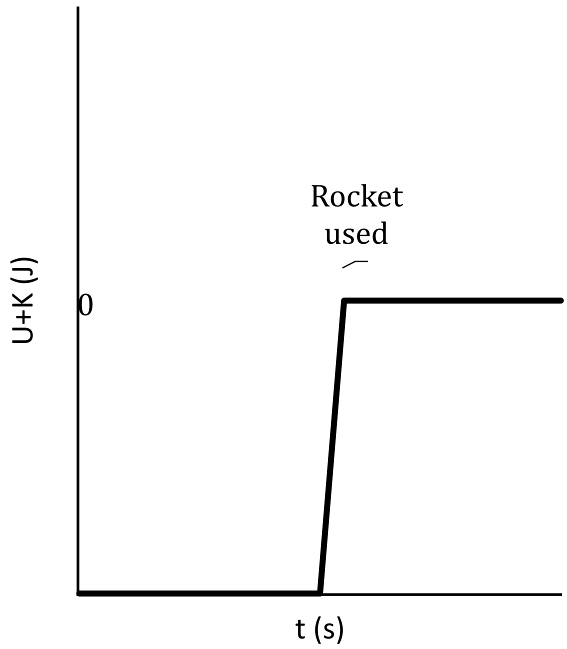
Question 30 continues on page 23

b) The spacecraft's rocket is used to take it out of the circular orbit. **6**

The graph below shows how the total mechanical energy (U+K) of the spacecraft changes over time (t). The time that the spacecraft's rocket is used is indicated on the graph.



Account for the shape of graph.

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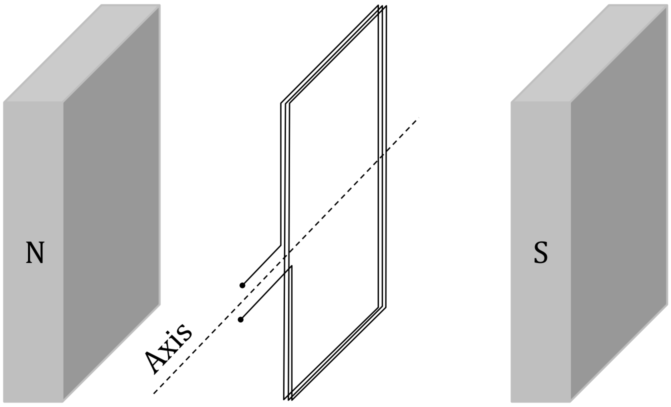
End of Question 30

31. (5 marks)

A coil of 1100 turns is in a magnetic field as shown below. The coil is aligned so that the area vector is parallel to the magnetic field.



The coil has an area of 1.2×10^{-2} m^2. It is in a magnetic field of 0.25 T.

a) Show that the magnetic flux through the coil is 3×10^{-3} Wb. **2**

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b) The coil rotates 180° in 0.01 s. **3**

Calculate the emf induced across the coil.

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32. (9 marks)

a) Explain how Thomson used an understanding of forces to determine the charge-to-mass ratio of the electron. **4**

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b) How does Rutherford's atomic model account for the results of Thomson's charge-to-mass experiment and the Geiger-Marsden experiment? **5**

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33. (6 marks)

What is the role of evidence in the development of theories in physics? **6**

In your answer refer to the discovery of the expansion of the Universe by Hubble and ONE other discovery.

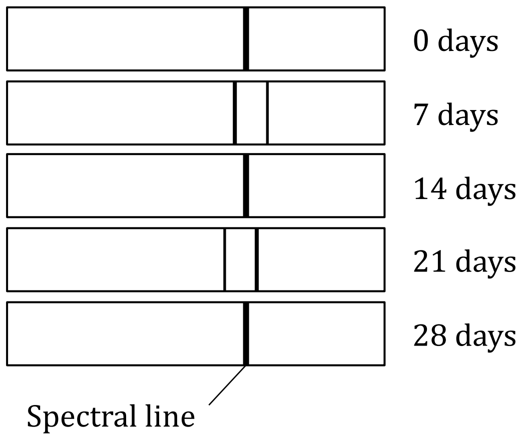
34. (7 marks)

Explain how energy is conserved in the operation of a DC motor. **7**

35. (9 marks)

A binary star system consists of two stars in orbital motion around each other. **9**

The spectrum of a spectroscopic binary star system changes over time. Changes to a spectral line from a spectroscopic binary star system are shown below.



Explain changes to the spectrum over time. In your answer, include information about the periodic nature and the magnitude of the changes.

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Question 35 is continued on page 29

End of paper

Section II extra writing space

If you use this space, clearly indicate which question you are answering.

2022 TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Physics

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	$3.00 \times 10^{8} \text{ m s}^{-1}$
Electric permittivity constant, ε_0	$8.854 \times 10^{-12} \text{ A}^2 \text{ s}^4 \text{ kg}^{-1} \text{ m}^{-3}$
Magnetic permeability constant, μ_0	$4\pi \times 10^{-7} \text{ N A}^{-2}$
Universal gravitational constant, G	$6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
Mass of Earth, M_E	6.0×10^{24} kg
Radius of Earth, r_E	6.371×10^{6} m
Planck constant, h	6.626×10^{-34} J s
Rydberg constant, R (hydrogen)	$1.097 \times 10^{7} \text{ m}^{-1}$
Atomic mass unit, u	1.661×10^{-27} kg $931.5 \text{ MeV}/c^2$
1 eV	1.602×10^{-19} J
Density of water, ρ	$1.00 \times 10^{3} \text{ kg m}^{-3}$
Specific heat capacity of water	$4.18 \times 10^{3} \text{ J kg}^{-1} \text{ K}^{-1}$
Wien's displacement constant, b	2.898×10^{-3} m K

FORMULAE SHEET

Motion, forces and gravity

$$s = ut + \frac{1}{2}at^2$$

$$v = u + at$$

$$v^2 = u^2 + 2as$$

$$\vec{F}_{\text{net}} = m\vec{a}$$

$$\Delta U = mg\Delta h$$

$$W = F_{||}s = Fs\cos\theta$$

$$P = \frac{\Delta E}{\Delta t}$$

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

$$\sum \frac{1}{2}mv^2_{\text{before}} = \sum \frac{1}{2}mv^2_{\text{after}}$$

$$P = F_{||}v = Fv\cos\theta$$

$$\sum m\vec{v}_{\text{before}} = \sum m\vec{v}_{\text{after}}$$

$$\Delta\vec{p} = \vec{F}_{\text{net}}\Delta t$$

$$a_{\text{c}} = \frac{v^2}{r}$$

$$\omega = \frac{\Delta\theta}{t}$$

$$F_{\text{c}} = \frac{mv^2}{r}$$

$$\tau = r_{\perp}F = rF\sin\theta$$

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

$$v = \frac{2\pi r}{T}$$

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

$$U = -\frac{GMm}{r}$$

Waves and thermodynamics

$$v = f\lambda$$

$$f_{\text{beat}} = \left| f_2 - f_1 \right|$$

$$f = \frac{1}{T}$$

$$f' = f\,\frac{(v_{\text{wave}} + v_{\text{observer}})}{(v_{\text{wave}} - v_{\text{source}})}$$

$$d\sin\theta = m\lambda$$

$$n_1\sin\theta_1 = n_2\sin\theta_2$$

$$n_{\text{x}} = \frac{c}{v_{\text{x}}}$$

$$\sin\theta_{\text{c}} = \frac{n_2}{n_1}$$

$$I = I_{\text{max}}\cos^2\theta$$

$$I_1 r_1^2 = I_2 r_2^2$$

$$Q = mc\Delta T$$

$$\frac{Q}{t} = \frac{kA\Delta T}{d}$$

FORMULAE SHEET (Continued)

Electricity and magnetism

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

$$V = \frac{\Delta U}{q}$$

$$W = qV$$

$$W = qEd$$

$$B = \frac{\mu_0 I}{2\pi r}$$

$$B = \frac{\mu_0 NI}{L}$$

$$\Phi = B_{\parallel}A = BA\cos\theta$$

$$\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$$

$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

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

$$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$$

$$I = \frac{q}{t}$$

$$V = IR$$

$$P = VI$$

$$F = qv_{\perp}B = qvB\sin\theta$$

$$F = lI_{\perp}B = lIB\sin\theta$$

$$\frac{F}{l} = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{r}$$

$$\tau = nIA_{\perp}B = nIAB\sin\theta$$

$$V_p I_p = V_s I_s$$

Quantum, special relativity and nuclear

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

$$K_{max} = hf - \phi$$

$$\lambda_{max} = \frac{b}{T}$$

$$E = mc^2$$

$$E = hf$$

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

$$t = \frac{t_0}{\sqrt{\left(1 - \frac{v^2}{c^2}\right)}}$$

$$l = l_0\sqrt{\left(1 - \frac{v^2}{c^2}\right)}$$

$$p_v = \frac{m_0 v}{\sqrt{\left(1 - \frac{v^2}{c^2}\right)}}$$

$$N_t = N_0 e^{-\lambda t}$$

$$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$$

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number	79
Symbol	Au
Standard Atomic Weight	197.0
Name	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 65.38 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 87.61 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.96 Molybdenum	43 Tc 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 183.9 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 Polonium	85 At Astatine	86 Rn Radon
87 Fr Francium	88 Ra Radium	89–103 Actinoids	104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Ds Darmstadtium	111 Rg Roentgenium	112 Cn Copernicium	113 Nh Nihonium	114 Fl Flerovium	115 Mc Moscovium	116 Lv Livermorium	117 Ts Tennessine	118 Og Oganesson

Lanthanoids

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm 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 173.1 Ytterbium	71 Lu 175.0 Lutetium

Actinoids

89 Ac Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium

Standard atomic weights are abridged to four significant figures.

Elements with no reported values in the table have no stable nuclides.

Information on elements with atomic numbers 113 and above is sourced from the International Union of Pure and Applied Chemistry Periodic Table of the Elements (November 2016 version).

The International Union of Pure and Applied Chemistry Periodic Table of the Elements (February 2010 version) is the principal source of all other data. Some data may have been modified.

Name: ________________

Class: ________________

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

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

A○ B● C○ D○

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

A● ~~B●~~ C○ D○

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

~~A●~~ ~~B●~~ C○ D○

Correct

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) ○

Marking Guidelines

Section I

Multiple Choice Answer Key

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

Section II

Question 21

Criteria	Marks
• Outlines TWO changes that would increase the torque	2

• Provides some relevant information	1

Sample answer:

Increasing the magnitude of the force. Increasing the displacement.

Answers could include:

Increasing θ towards 90°

Notes:

Question 22

Criteria	Marks
• Describe how an identified risk was managed	2
• Provides some relevant information	1

Sample answer:

All members of the group wore safety goggles to reduce the risk of an eye injury.

Answers could include:

Keeping people out of the path of the projectile

Notes:

Question 23

Criteria	Marks
• Correctly calculates force with correct unit	3
• Provides some relevant steps	2
• Provides some relevant information	1

Sample answer:

$$v = 36\ \text{kmh}^{-1} = \frac{36000}{3600}\ \text{ms}^{-1} = 10\ \text{ms}^{-1}$$

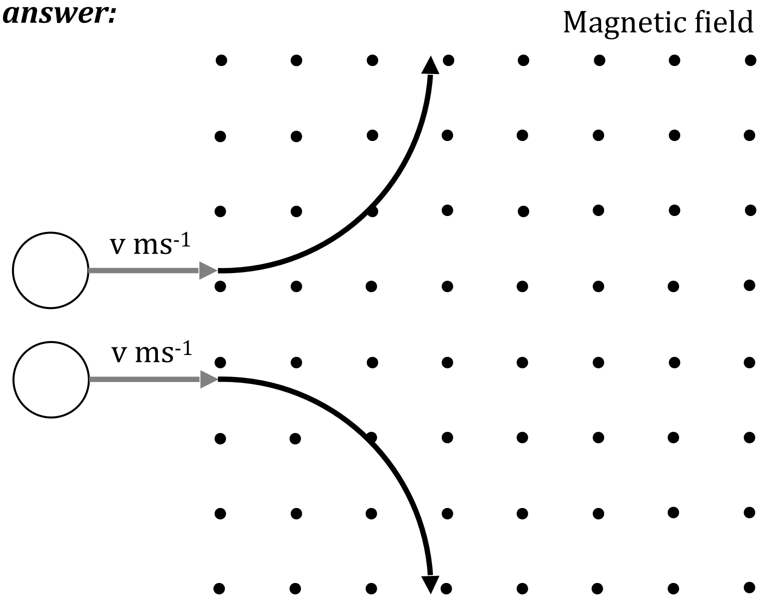
$$F_C = \frac{mv^2}{r} = \frac{1300 \times 10^2}{13} = 1.0 \times 10^4\ \text{N}$$

Notes:

Question 24

Criteria	Marks
• Sketches path of the electron and positron	3
• Sketches path of the electron or positron	2
• Identifies a feature of a particle’s path	1

Sample answer:



Notes:

Question 25a

Criteria	Marks
• Correctly calculates the threshold frequency	3
• Provides some relevant steps	2
• Provides some relevant information	1

Sample answer:

$$\phi = 4.5 \text{ eV} = 4.5 \times 1.6 \times 10^{-19} = 7.2 \times 10^{-19} \text{ J}$$

For threshold frequency (f_0):

$$\phi = hf_0 \therefore f_0 = \frac{\phi}{h} = \frac{7.2 \times 10^{-19}}{6.626 \times 10^{-34}} = 1.1 \times 10^{15} \text{ Hz}$$

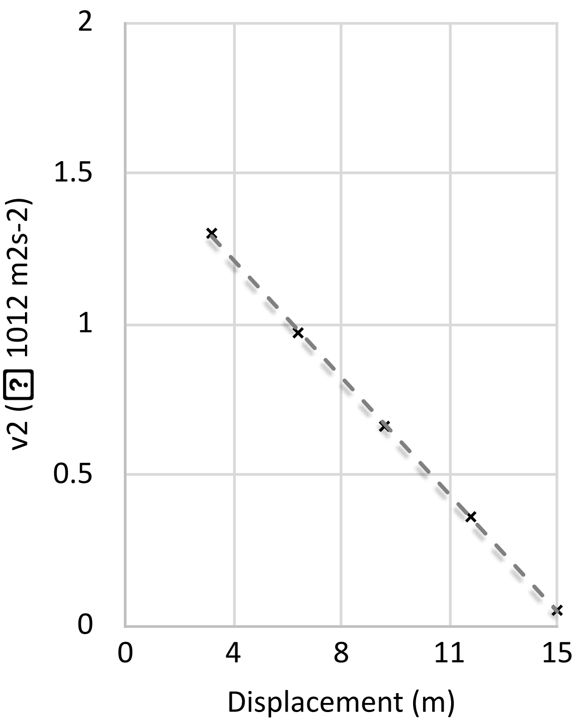
Notes:

Question 25b

Criteria	Marks
• Determines u using the line of best fit	4
• Determines u^2 using the line of best fit	3

• Plots the values on the graph • Draws a line of best fit to determine u^2	2
• Correctly plots some points OR • Correctly draws a line of best fit	1

Sample answer:



At 0 m, $v^2 = 1.6 \times 10^{12}$ m^2s^{-2}. Therefore, $u = 1.3 \times 10^6$ ms^{-1}

Notes:

Question 26

Criteria	Marks
• Correctly identifies the time that the box lands on the shelf	4
• Correctly identifies a time that the box is level with the shelf	3
• Provides some relevant steps	2
• Provides some relevant information	1

Sample answer:

$$u_v = u\sin\theta = 12\ \sin 55 = 9.8\ \text{ms}^{-1}$$

$$s = ut + \frac{1}{2}at^2\ \therefore 3.68 = 9.8t + \frac{1}{2} \times (-9.8)t^2 \therefore\ -4.9t^2 + 9.8t - 3.68 = 0$$

$$t = \frac{-9.8 \pm \sqrt{9.8^2 - 4 \times (-4.9) \times -3.68}}{-9.8} = \frac{-9.8 \pm 4.9}{-9.8} = 0.5 \text{ms}^{-1} \text{ or } 1.5 \text{ ms}^{-1}$$

∴ the box lands on the shelf 1.5 s after it is thrown.

Notes:

Question 27a

Criteria	Marks
• Provides working to calculate the wavelength	2
• Provides some relevant information	1

Sample answer:

$$m\lambda = d \sin\theta$$

$m = 1$ and $\sin\theta \approx \tan\theta = \frac{x}{L}$

$$\lambda = \frac{dx}{L} = \frac{5 \times 10^{-4} \times 1.2 \times 10^{-6}}{2.5} = 2.4 \times 10^{-10} \text{ m}$$

Notes:

Question 27b

Criteria	Marks
• Correctly calculates the velocity of the electrons	2
• Provides some relevant information	1

Sample answer:

$$\lambda = \frac{h}{mv} \therefore v = \frac{h}{m\lambda} = \frac{6.626 \times 10^{-34}}{9.1 \times 10^{-31} \times 2.4 \times 10^{-10}} = 3.0 \times 10^{6} \text{ ms}^{-1}$$

Notes:

Question 28

Criteria	Marks
• Explains why the force is proportional to the product of the currents	4
• Relates the force between the wires to the Motor Effect or Newton's Third Law	3
• Describes the force between two current-carrying wires	2
• Provides some relevant information	1

Sample answer:

Each wire is in the magnetic field that surrounds the other. The force on each wire due to this magnetic field is given by $F = lIB$ where I is the current through the wire within the magnetic field. By Newton's Third Law, because each wire exerts a force on the other, the force on each wire must be equal. As the force on one wire is proportional to current through it and the two forces are equal, the force between the wires must be proportional to the product of the currents.

Answers could include:

Derivation of Ampere's Law

Question 29a

Criteria	Marks
• Correctly calculates the length of the carriage	2
• Provides some relevant information	1

Sample answer:

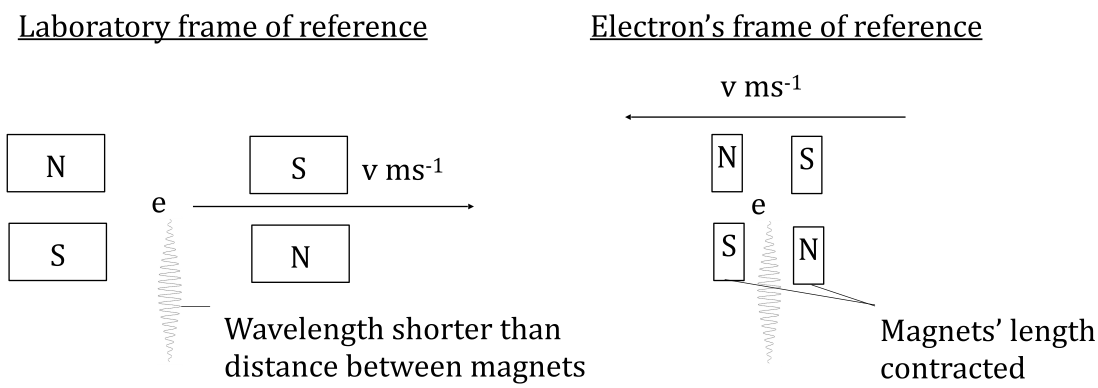
$$l = l_0\sqrt{1 - \frac{v^2}{c^2}} = 10\sqrt{1 - \frac{(0.8c)^2}{c^2}} = 10 \times 0.6 = 6 \text{ m}$$

Notes:

Question 29b

Criteria	Marks
• Provides diagrams with text describing length contraction in a relevant experiment	4
• Provides a diagram with text describing a relevant experiment	3
• Outlines a relevant experiment OR • Provides a relevant diagram	2
• Provides some relevant information	1

Sample answer:



Electrons will emit electromagnetic radiation as they move between regularly spaced magnets. The wavelength of the electromagnetic radiation is equal to the separation of the magnets.

When electrons in a particle accelerator are accelerated to close to the speed of light, the magnets are closer together in the electron's inertial frame of reference. The electromagnetic radiation detected in the laboratory frame of reference has a wavelength equal to the distance between the magnets in the electron's frame of reference.

Answers could include:

Observations of cosmic-origin muons at the Earth's surface

Notes:

Question 30a

Criteria	Marks
• Correctly derives the relationship	3
• Shows some correct steps or reasoning	2
• Provides some relevant information	1

Sample answer:

$$v_{\text{orb}} = \sqrt{\frac{GM}{r}}$$

$$v_{esc} = \sqrt{\frac{2GM}{r}} = \sqrt{2}\sqrt{\frac{GM}{r}} = \sqrt{2}v_{\text{orb}}$$

Notes:

Question 30b

Criteria	Marks
• Provides reasons for the shape of the graph before, during and after the rocket is used	6
• Relates the shape of the graph to the motion of the spacecraft • Provides reasons for the shape of sections of the graph	5
• Provides reasons for the shape of sections of the graph	4
• Relates sections of the graph to the motion of the spacecraft OR • Provides a reason for the shape of a section of the graph	3
• Relates a section of the graph to the motion of the spacecraft	2
• Provides some relevant information	1

Sample answer:

Before the rocket is used the spacecraft is in a circular orbit. Because it is in uniform circular motion, no work is done so its total mechanical energy is constant.

When the rocket is used, the spacecraft's kinetic energy is increased so the total mechanical energy is increased. The rocket accelerates the spacecraft beyond the escape velocity so the total mechanical energy of the spacecraft increases to a positive value.

When the rocket is turned off the total mechanical energy is constant as kinetic energy is converted to gravitational potential energy as it moves away from the Earth.

Notes:

Question 31a

Criteria	Marks
• Provides working to show the magnetic flux	2
• Provides some relevant information	1

Sample answer:

$$\Phi = B_{||}A = 0.25 \times 1.2 \times 10^{-2} = 3 \times 10^{-3}\ \text{Wb}$$

Notes:

Question 31b

Criteria	Marks
• Provides correct working for calculating the emf	3
• Provides some working for calculating the emf	2
• Provides some relevant information	1

Sample answer:

$$\Delta\Phi = \left(-3 \times 10^{-3}\right) - 3 \times 10^{-3} = -6 \times 10^{-3}\ \text{Wb}$$

$$\varepsilon = -N\frac{\Delta\Phi}{\Delta t} = -1100 \times \frac{-6 \times 10^{-3}}{0.01} = 660\ \text{V}$$

Notes:

Question 32a

Criteria	Marks
• Shows the role of a single force and forces in equilibrium in Thomson's experiment	4

• Shows the role of a single force or forces in equilibrium in Thomson's experiment OR • Derives equation to calculate the charge-to-mass ratio of the electron	3
• Outlines a feature of Thomson's experiment OR • Identifies features of Thomson's experiment	2
• Provides some relevant information	1

Sample answer:

Thomson passed electrons through perpendicular electric fields and magnetic fields. He adjusted the strength of the fields until the electrons passed through undeflected. This meant that the net force on the electrons were zero. Therefore $qE = qvB \therefore v = \frac{E}{B}$.

He then turned the electric field off and measured the radius. As the magnetic field provided the centripetal force, $qvB = \frac{mv^2}{r} \therefore \frac{q}{m} = \frac{v}{Br}$.

Question 32b

Criteria	Marks
• Relates feature(s) of Rutherford's atomic model to the results of each experiment	5
• Relates feature(s) of Rutherford's atomic model to the results of one experiment • Provides information about the results of the other experiment	4
• Relates feature(s) of Rutherford's atomic model to the results of one experiment OR • Provides information about Rutherford's atomic model and both experiments	3
• Provides information about Rutherford's atomic model and a related experiment	2
• Provides some relevant information	1

Sample answer:

In the Geiger-Marsden experiment, most alpha particles were not deflected as they travelled through the gold foil, but some were deflected at angles greater than 90°. To account for this, most of the volume of Rutherford's atom was empty space, with most of the mass of the atom being found in the dense, positive nucleus.

Thomson's experiment showed that the atom contained negative subatomic particles. In Rutherford's model, these electrons were in orbit around the nucleus.

Question 33

Criteria	Marks
• Relates evidence to the development of theories • Refers to the discovery of the expansion of the Universe • Refers to another relevant discovery	6
• Describes features of the development of theories • Refers to a relevant discovery	4-5
• Outlines a theory and a relevant discovery	3
• Outlines a theory or a relevant discovery OR • Identifies theories and/or relevant discoveries	2
• Provides some relevant information	1

Sample answer:

In physics, evidence is used to test theories. Experimental evidence enables physicists to assess theories, determining which ones to discard and which ones to develop further.

The development of quantum physics provides an example of physicists discarding a theory that could not explain experimental evidence and replacing it with one that could. Von Lenard showed that the kinetic energy of photoelectrons was independent of the light intensity. Because the wave model of light predicted kinetic energy would depend on light intensity, the model was ultimately replaced by quantum physics.

Experiments also provide evidence that support theories. Einstein's theory of general relativity predicts that the Universe is expanding. Hubble provided experimental evidence for this. To do this he used measurements of the redshift of galaxies to determine their velocity relative to the Earth. In this example, the evidence supported the theory and enabled its further refinement.

Answers could include:

- Classical wave model of light
- Special relativity
- The existence and properties of the electron
- Nuclear model of the atom
- Matter waves

- The internal structure of protons and neutrons
- The existence of subatomic particles other than protons, neutrons and electrons

Notes:

Question 34

Criteria	Marks
• Shows how energy is transformed in a DC motor • Relates back emf to work done by the motor	7
• Relates motor effect to energy transformation in the operation of a DC motor • Describes role of back emf OR • Relates back emf to energy transformation • Describes role of motor effect	5-6
• Describes role of motor effect and back emf in the operation of a DC motor	4
• Describes role of motor effect or back emf in the operation of a DC motor	2-3
• Provides some relevant information	1

Sample answer:

In a DC motor, a current flows through a coil inside a magnetic field. By the motor effect, each side of the coil experiences a force in the opposite direction. Therefore, there is a torque in the coil and electrical energy is transformed to rotational kinetic energy.

As the coil turns inside the magnetic field, a back emf is induced. This reduces the current flowing through the coil and the electrical energy used in the motor. When the motor does work, the spinning coil slows down, decreasing the back emf and increasing the current through the coil. The electrical energy used by the motor increases to account for the extra work that the motor does.

Notes:

Question 35

Criteria	Marks
• Relates the period, magnitude and direction of frequency changes to the orbital motion of a star	9
• Relates TWO changes to the spectrum to the orbital motion of a star	7-8

• Relates a change to the spectrum to a property of a star • Describes a second change to the spectrum and a related feature of the star	5-6
• Relates a change to the spectrum to a property of a star	4
• Describes a change to the spectrum and a related feature of the star	3
• Describes changes to the spectrum	2
• Provides some relevant information	1

Sample answer:

The two stars are in a gravitational orbit around each other. This means that the period of orbit is determined by the orbital radius. The spectral line changes over a 28-day period so the period of rotation of the stars is 28 days.

The observed frequency of light from a star depends on the star's velocity relative to the observer. The two stars keep emitting light of different frequencies because they travel in opposite directions while they orbit each other. Light from the approaching star is blueshifted and light from the receding star is redshifted. Half an orbit later, each star is travelling in the opposite direction so the frequency shift of each star is towards the other end of the spectrum.

The magnitude of the shift is determined by the magnitude of the star's translational velocity. If the star is travelling faster, the spectral line will shift further. On the spectra at 7 days the left spectral line has shifted further than the right spectral line whereas it has reversed after 21 days. Therefore, one of the stars is travelling faster than the other.

Notes:

Judging (short answer to be added)

Band	Range
1	0
2	0
3	1-4
4	5-10
5	11-16
6	17-20

Mapping Grid

Section I

Question	Marks	Content	Syllabus Outcomes
1	1	Mod 8 Structure of the Atom	PH12-15
2	1	Mod 7 Electromagnetic Spectrum	PH12-14
3	1	Mod 5 Circular Motion	PH12-12
4	1	Mod 5 Motion in Gravitational Fields	PH12-12
5	1	Mod 6 Applications of the Motor Effect	Ph12-13
6	1	Mod 7 Light: Wave Model	PH12-14
7	1	Mod 5 Motion in Gravitational Fields	PH12-12, PH11/12-6
8	1	Mod 8 Origin of the Elements	PH12-15, PH11/12-5
9	1	Mod 6 Electromagnetic Induction	PH12-13
10	1	Mod 6 The Motor Effect	PH12-13, PH11/12-4
11	1	Mod 8 Structure of the Atom	PH12-15, PH11/12-6
12	1	Mod7 Light: Quantum Model	PH12-14, PH11/12-6
13	1	Mod 7 Light: Quantum Model	PH12-14
14	1	Mod 5 Projectile Motion	PH12-12, PH11/12-6
15	1	Mod 8 Origin of the Elements	PH12-15
16	1	Mod 6 Charged Particles, Conductors and Electric and Magnetic Fields	PH12-13, PH11/12-6
17	1	Mod 8 Quantum Mechanical Nature of the Atom	PH12-15, PH11/12/6
18	1	Mod 7 Light and Special Relativity	PH12-14
19	1	Mod 6 Electromagnetic Induction	PH12-13, PH11/12-6
20	1	Mod 5 Circular Motion	PH12-12, PH11/12-6

Section II

Question	Marks	Content	Syllabus Outcomes
21	2	Mod 5 Circular Motion	PH12-12,
22	2	Mod 5 Projectile Motion	PH12-12,
23	3	Mod 5 Circular Motion	PH12-12, PH11/12-6, PH11/12-7
24	3	Mod 8 Deep Inside the Atom	PH12-15,
25a	3	Mod 7 Light: Quantum Model	PH12-14,
25b	4	Mod 6 Charged Particles, Conductors and Electric and Magnetic Fields	PH12-13, PH11/12-5, PH11/12-6
26	4	Mod 5 Projectile Motion	PH12-12,
27a	2	Mod 7 Light: Wave Model	PH12-14,
27b	2	Mod 8 Quantum Mechanical Nature of the Atom	PH12-15, PH11/12-6
28	4	Mod 6 The Motor Effect	PH12-13
29a	2	Mod 7 Light and Special Relativity	PH12-14,
29b	4	Mod 7 Light and Special Relativity	PH12-14,
30a	3	Mod 5 Motion in Gravitational Fields	PH12-12,
30b	6	Mod 5 Motion in Gravitational Fields	PH12-12,
31a	2	Mod 6 Electromagnetic Induction	PH12-13,
31b	3	Mod 6 Electromagnetic Induction	PH12-13,
32a	4	Mod 8 Structure of the Atom	PH12-15,
32b	5	Mod 8 Structure of the Atom	PH12-15,
33	6	Mod 8 Origin of the Elements	PH12-15,
34	7	Mod 6 Applications of the Motor Effect	PH12-13
35	9	Mod 5 Motion in Gravitational Fields Mod 7 Electromagnetic Spectrum	PH12-12, PH12-14, PH11/12-4