2021

HIGHER
SCHOOL
CERTIFICATE
TRIAL EXAMINATION

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black 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 Student ID at the bottom of this page and at the top of page 10

Total marks: 100

Section I — 20 marks (pages 2-9)

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

Section II — 80 marks (pages 10-26)

- Attempt Questions 21–36
- Allow about 2 hours and 25 minutes for this section

STUDENT ID: _____

Section I

20 marks
Attempt Questions 1–20
Allow about 35 minutes for this section.

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

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1 Three balls are rolled off a bench top with different speeds. They fall off the bench and hit the floor.

Which of the following statements is most correct?

A. The slowest ball will land on the floor last

B. All three balls will land with the same range

C. All three balls will land on the floor at the same time

D. The fastest ball will land on the floor with the highest acceleration

2 Two weather satellites, WS-1 and WS-2 are placed in the same orbit around Earth. WS-1 has a mass four times the mass of WS-2.

What is the ratio of WS-1's orbital speed to WS-2's orbital speed?

A. 1:1

B. 1:4

C. 4:1

D. 16:1

3 Four particles are fired horizontally from left to right into a magnetic field which is directed into the page.

Radiations	*Deflection*	*Path of Trajectory*
R1	Down	Curved
R2	Up	Curved
R3	Up	Straight
R4	Down	Straight

Which set of results would most likely represent an electron's path?

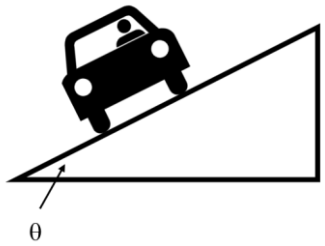
A. R1

B. R2

C. R3

D. R4

4 A safety track is designed with a banked road which is angled as shown below.



Safe driving is achieved with a radius of 100 m and a top speed of 20 ms^{-1}.

What is the most accurate angle required to achieve safe driving?

A. 15°

B. 22°

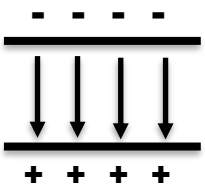
C. 33°

D. 40°

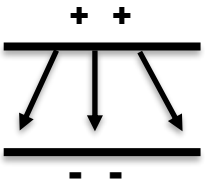
5 Uniform electric fields can be created using parallel plates.

Which diagram represents a uniform field with the correct plate set up?

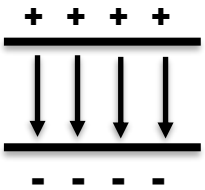
A.



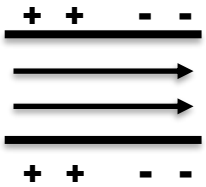
B.



C.



D.



6 Which statement best summarises De Broglie's ideas about the atom?

A. Electrons are best thought of as waves.

B. Electrons exist in distinct electron "clouds".

C. Electrons are best thought about in terms of mathematical probability.

D. Electrons are best thought of as electromagnetic waves which creates spectra.

7 Isotopes of uranium can undergo decay to emit different types of radiations.

Which reaction correctly shows the decay of uranium with the emission of gamma radiation?

A. $^{235}_{92}\text{U} \rightarrow \gamma + ^{235}_{92}\text{U}$

B. $^{235}_{92}\text{U} \rightarrow \gamma + ^{238}_{92}\text{U}$

C. $^{235}_{92}\text{U} \rightarrow \gamma + ^{231}_{90}\text{Th}$

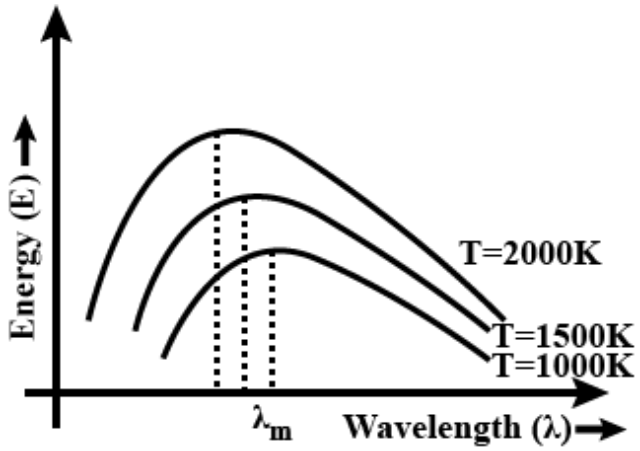
D. $^{235}_{92}\text{U} \rightarrow \gamma + ^{235}_{93}\text{Np}$

8 A relativistic spacecraft reaches a speed of 0.8 c as it leaves Earth to travel across the galaxy.

Which observations most correctly compares the two frames of reference?

	Space craft at rest on Earth	*Spacecraft travelling at relativistic speed*
A.	Contracted length	Normal length
B.	Dilated mass	Normal mass
C.	Speed = 0.8 c	Speed = 0.8 c
D.	Normal time	Dilated time

9 The following curve is created when an experiment is performed.



What does this experiment relate to?

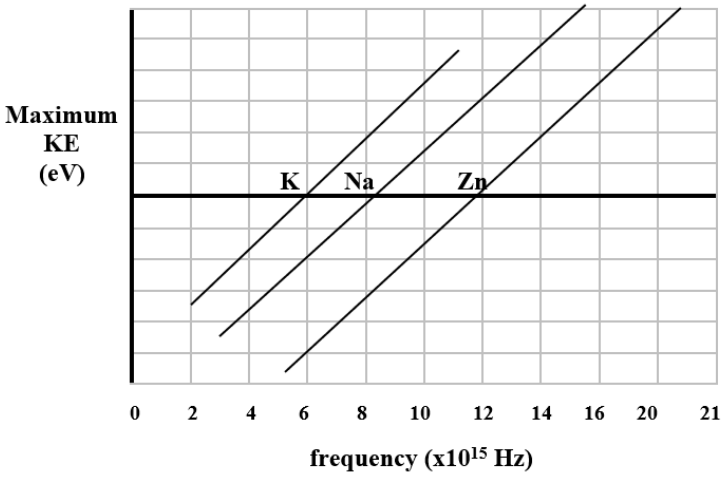
A. Malus's Law and polarisation

B. Schrodinger and cloud orbitals

C. Planck and blackbody radiation

D. Einstein and the photoelectric effect

10 The graph shows three metals K, Na and Zn. It displays results which support Einstein's theories relating to the photoelectric effect.



Which statement is most correct when describing these results?

A. The work function for zinc is 12 x10^{15} Hz.

B. The slope of each of these graphs equals Planck's constant.

C. Potassium creates photocurrent at the frequency 6 x10^{15} Hz.

D. Potassium ejects electrons at higher energies in comparison to sodium.

11 Which nuclear equation accurately shows the beta decay of Lithium 3?

A. $^{8}_{3}\text{Li} \rightarrow {}^{8}_{4}\text{B} + {}^{0}_{-1}\text{e}$

B. $^{7}_{3}\text{Li} \rightarrow {}^{3}_{1}\text{H} + {}^{4}_{2}\text{He}$

C. $^{7}_{3}\text{Li} \rightarrow {}^{7}_{2}\text{He} + {}^{0}_{1}\text{e}$

D. $^{8}_{3}\text{Li} \rightarrow {}^{8}_{4}\text{Be} + {}^{0}_{-1}\text{e}$

12 The Millikan oil drop experiment was credited with determining what idea?

A. The charge of an electron

B. The charge to mass ratio of an electron

C. Electrons orbiting far from the nucleus

D. The shell orbits of electrons in hydrogen

13 A student sketched this result to display the position of the various coloured lines observed while using a spectroscope pointed at a light source.

What light source best corresponds to this result?

A. Light from a vacuum tube

B. Light from a gas discharge tube

C. Light from an incandescent light globe

D. Light viewed through a potassium permanganate solution

14 The half-life of Cobalt 60 is 5.3 years.

Approximately what percentage of Cobalt-60 will remain in a sample after 16 years?

A. 0%

B. 6%

C. 12.5%

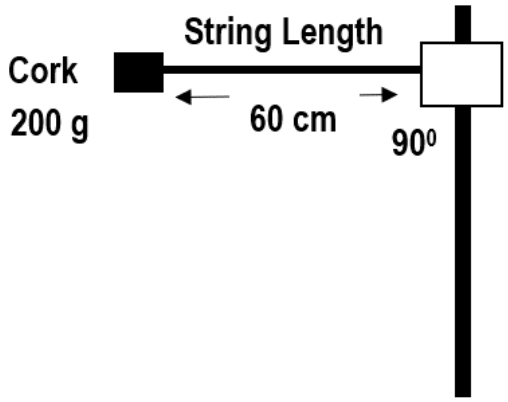
D. 25%

15 The motor effect relates proportionally to which of the following variables.

A.	εmf	Current
B.	Area	Voltage
C.	Current	Cos θ
D.	Length	Magnetic field strength

16 Uniform circular motion can be achieved when a cork is spun in a circle tied to a string as shown below. This requires some skill to keep this motion going for any long period of time.

The experiment is performed with a 60 cm string and a 200 g cork which is spun at 5 Hz.



What is the centripetal force on the cork closest to?

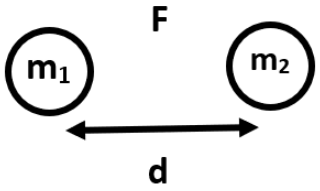
A. 62 N

B. 120 N

C. 240 N

D. 320 N

17 The following diagram was created to describe Newton's Universal Law of Gravitation as observed between planets, m_1 and m_2.



If each mass is doubled and the distance between them is doubled, what will the size of the force be closest to?

A. ¼F

B. F

C. 2F

D. 4F

18 The table below records data about two moons, Teros and Phiron, which orbit the planet Xenos.

Moon	*Radius of orbit* (metres)	*Orbital period* (seconds)
Teros	12×10^3	31×10^4
Phiron	4×10^7	T

The orbital period of Phiron, T can be best calculated using which formula?

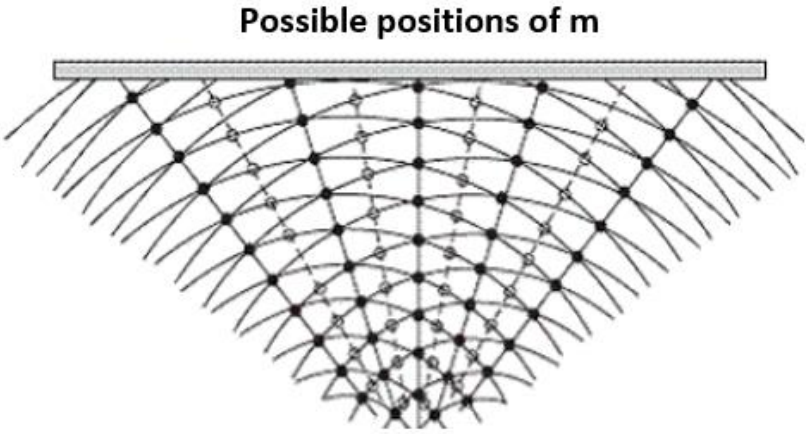
A. $T^2 = \dfrac{(4 \times 10^7)^2}{(12 \times 10^{3)})^3 \times (31 \times 10^4)^3}$

B. $T^2 = \dfrac{(12 \times 10^3)^2}{(4 \times 10^{7)})^3 \times (31 \times 10^4)^3}$

C. $T^2 = \dfrac{(12 \times 10^3)^2 \times (4x\ 10^7)^3}{(31 \times 10^{4)})^3}$

D. $T^2 = \dfrac{(31 \times 10^4)^2 \times (4x\ 10^7)^3}{(12 \times 10^{3)})^3}$

19 Young's experiment creates two sources of waves which are of the same frequency superimposing to create an interference pattern as shown below,



The constructive interference pattern can be determined using the equation $d \sin \theta = m\lambda$.

Which group gives the best positions for *m* for this calculation?

A. 0, 1, 2, 3

B. 0, 0.5, 1, 1.5

C. 0, 1, 1.5, 2.5

D. 0, 1, -1, 2, -2

20 Thompson's experiment to determine the electron's charge to mass ratio combined which two relationships?

A. Electric force and the motor effect

B. Magnetic flux and the motor effect

C. Centripetal force and magnetic force

D. Gravitational force and magnetic force

Student ID: _____

2021

HIGHER SCHOOL CERTIFICATE
TRIAL EXAMINATION

Physics

Section II
Answer Booklet

80 marks
Attempt Questions 21–36
Allow about 2 hour 25 minutes for this part

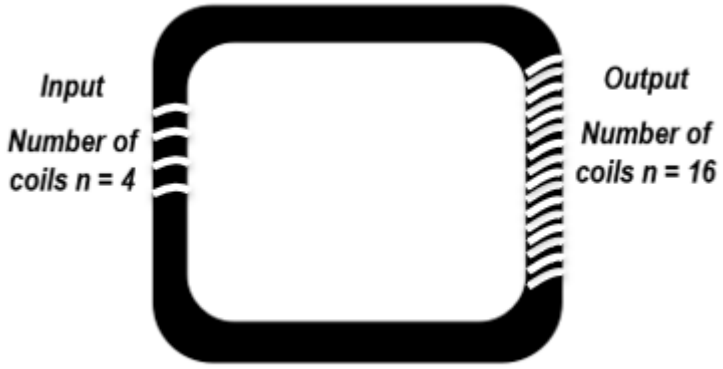
Instructions

- Write your Student ID 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 questions involving calculations.
- Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.

Please turn over

Question 21 (5 marks)

The output coil of a transformer has four times as many coils as the input. The diagram below models this transformer.



(a) Use physic principles to explain how this transformer works. **3**

(b) Calculate the amount of output current if the input current was 15 A. **2**

Question 22 (4 marks)

DC motors are designed to change electrical energy into kinetic energy.

(a) A DC motor is created from one loop of wire measuring 5 cm x 6 cm carrying 8 A of current. It is placed within a magnetic field of 0.2 T which causes the motor to spin. **2**

Draw a diagram of this motor.

(b) Describe how back emf is induced to ensure that the motor does not continue to spin faster. **2**

Question 23 (6 marks)

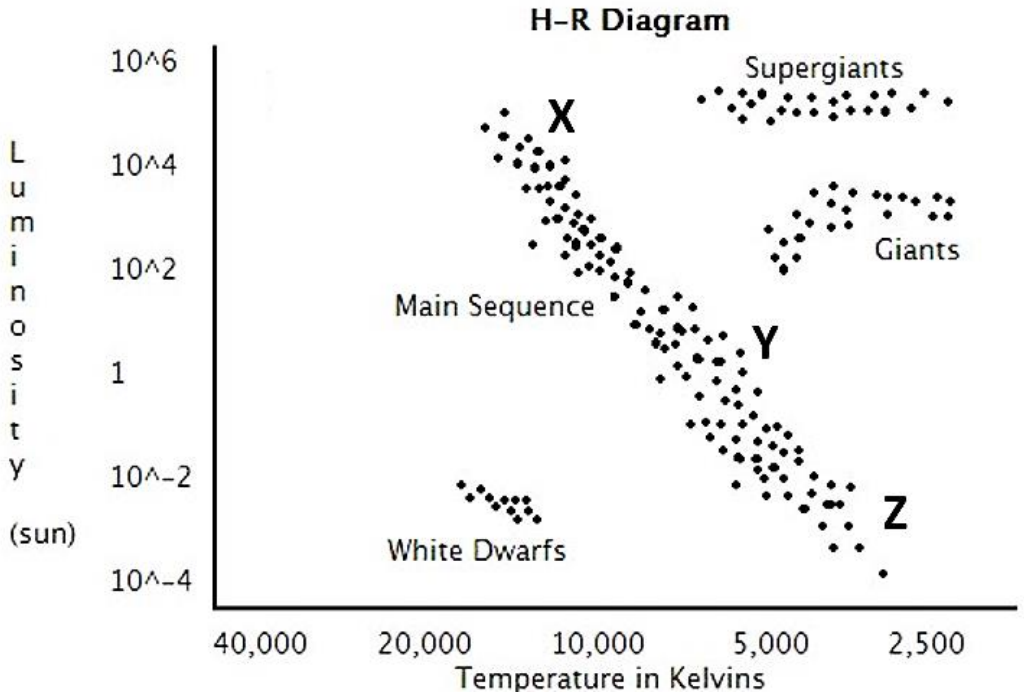
In nuclear physics, atoms can be investigated by calculating their mass defect and binding energies.

(a) Explain how mass defect and binding energy relate to atoms. **3**

(b) Calculate the binding energy for the Carbon 12 atom. **3**

Question 24 (4 marks)

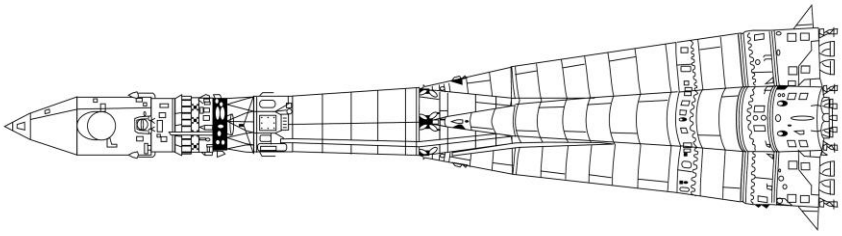
Stars on the main sequence are often compared on a Hertzsprung Russell diagram.



Describe FOUR differences between stars located at position X compared to those located at position Z. **4**

Question 25 (5 marks)

The rocket in the diagram has a rest length of 456 metres.

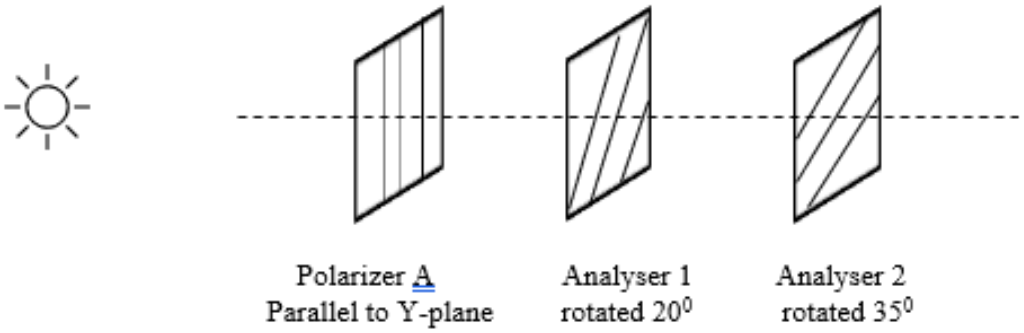


(a) Calculate the apparent length as measured by an observer who is travelling at 0.95 c past the stationary rocket. **2**

(b) Explain, using Einstein's thought experiments, why the length changes for the observer. **3**

Question 26 (4 marks)

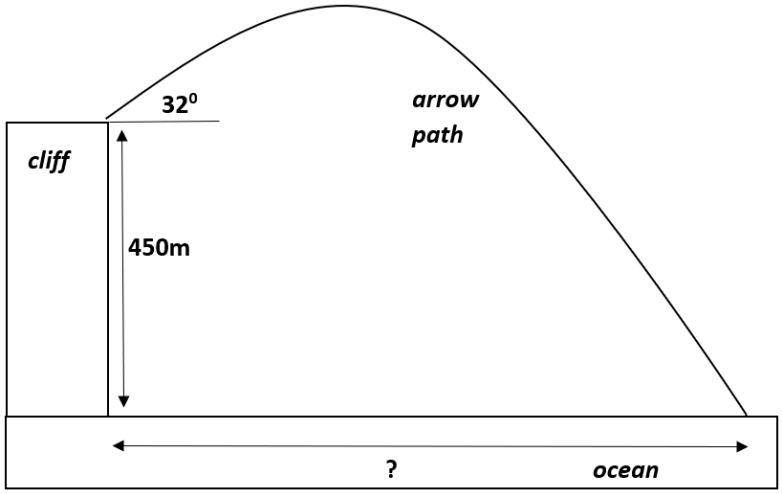
A student performed a polarisation experiment which followed the positions of Polariser A, Analyser 1 at 20˚ and Analyser 2 at 35˚.



Use your physics knowledge to explain what happens to the light as it passes through Polariser A then Analyser 1 and finally Analyser 2. **4**

Question 27 (6 marks)

An arrow was fired, with a velocity of 25 m/s at an angle of 32˚ from a 450 metre cliff, into the ocean. A student shot a video on his mobile phone to analyse this experiment in a laboratory. A sketch was made from the video as shown below.

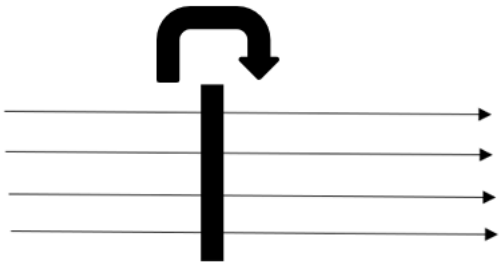


(a) Calculate the total time of the flight. **4**

(b) Calculate the final range of the arrow as it enters the ocean. **2**

Question 28 (5 marks)

The emf of an AC generator changes as the coil rotates clockwise starting in the position shown. This position is 0˚ to the magnetic field. The coil turns to a position of 360˚ to the magnetic field.

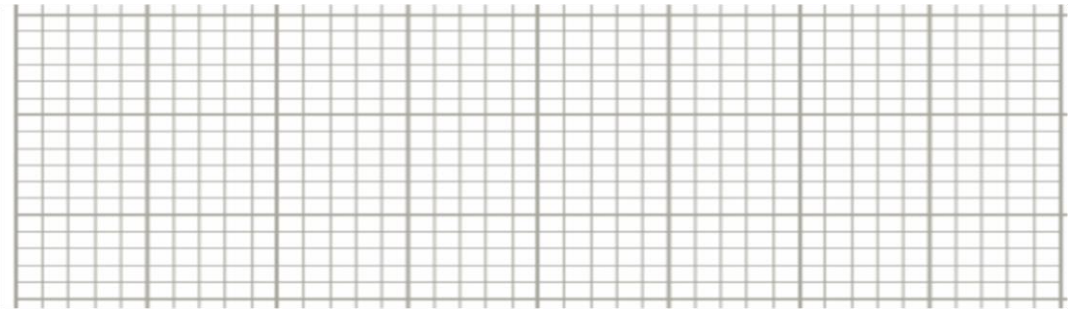


The student tabulates some results below.

Angle of the coil (θ)	emf
0˚	0
90˚	max
180˚	0
270˚	max
360˚	0

(a) Identify the most important component of an AC generator and explain its function. **2**

(b) Graph the curve created by the emf of this generator as it spins TWO revolutions. **3**



Question 29 (6 marks)

A satellite is placed in a polar orbit around Earth, which is 980 kilometres from the surface.

(a) Calculate the velocity the satellite must achieve to sustain this orbit. **2**

(b) Use the data below to calculate the escape velocity required for the rocket to leave a Mars orbit of 10 km. **2**

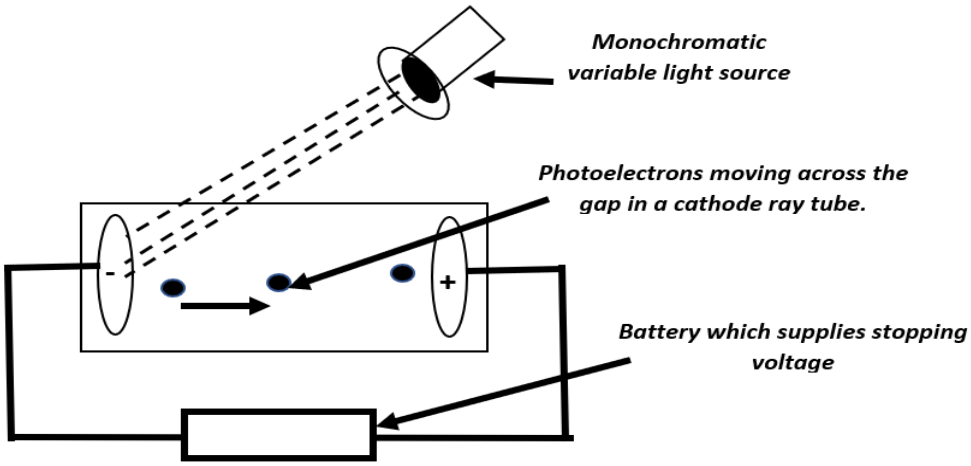
Object	*Radius* (km)	*Mass* (kg)
Mars	3390	6.4×10^{23}
Rocket	-	2502
Sun	696340	2×10^{30}

(c) A spacecraft with a mass of 1500 kg was placed in another orbit around the Earth. **2**

Calculate the gravitational potential energy required to maintain an orbit of 800 km.

Question 30 (7 marks)

The following experiment was performed to observe and verify that photons created the photoelectrons that move across the gas in the cathode ray tube.



(a) Describe TWO observations that were made in this experiment which contradicted the Wave Theory of Light. **3**

(b) Explain how the concepts that relate to the production of a photocurrent resolved the TWO limitations of wave theory. **4**

Question 31 (7 marks)

The Geiger-Marsden experiment was pivotal to physics as it provided information that changed the model of the atom. However, there were still some notable limitations to the new model. **7**

Analyse the usefulness of The Geiger-Marsden experiment in changing the model of the atom.

Question 32 (6 marks)

Several forces are involved when negotiating bends in roads.

(a) A car travels on ice around a banked curve that has a radius of 20 m and a slope of 15˚. **3**

What speed must it travel to successfully navigate the curve?

(b) In normal conditions the maximum speed around the bend is about twice that when it is icy. **3**

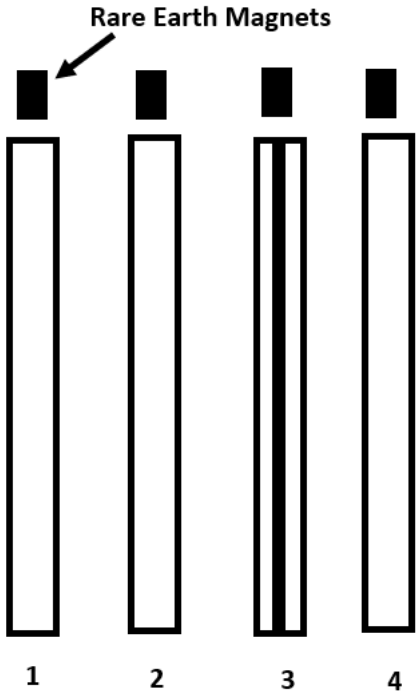
With the use of a vector diagram explain this variation in speed.

Question 33 (5 marks)

Rare earth magnets are often dropped into different types of long tubes to investigate how magnets affect different materials. **5**

An experiment was undertaken with different tubes as set out below, and the drop times recorded.

Tube	*Specifications*	*Drop time* (s)
1	2 m aluminium	7.2
2	2 m copper	11.4
3	2 m copper with slot	9.6
4	2 m plastic	3.2



Using your knowledge of electromagnetic induction principles, explain the differences in drop times.

Question 33 continues on page 24

Question 33 (continued)

End of Question 33

Question 34 (2 marks)

Draw a magnetic field which can be used to identify beta decay when it is present with alpha and gamma radiations. **2**

Question 35 (4 marks)

Young's double slit experiment is performed in a laboratory to calculate the wavelength of a laser. **4**

The distance between the double slit is 300 μm and the length between the laser and the screen is 4.3 metres. It also created 8 mm difference between m = 0 and m = 1 on a white screen.

Draw a detailed diagram and then calculate the wavelength of the laser.

Question 36 (4 marks)

A student designed a DC motor which was connected to a load. The student decided to place the spanner as the load. The student then developed a hypothesis which stated, "The DC motor will turn the spanner". **4**

The student sketched Diagram 1 and Diagram 2 and recorded some measurements as below, to determine if the spanner could be turned 32˚ with a DC electric motor.

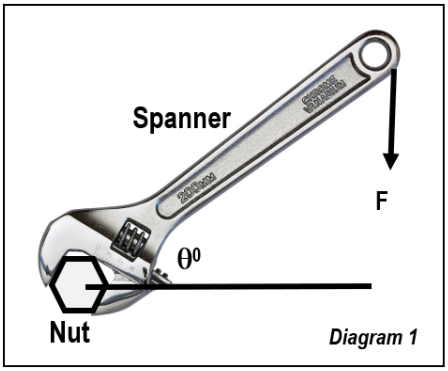


Diagram 1

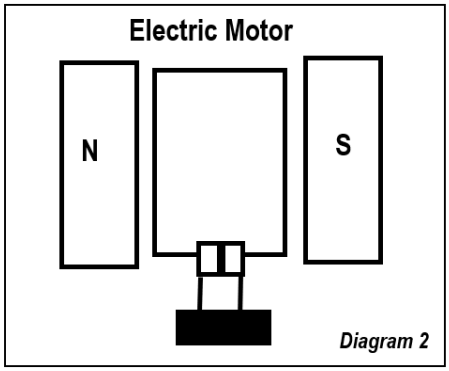


Diagram 2

Measurements	
Current = 2.5A Force on spanner = 14N Number of loops in the coil = 2	Length of spanner = 8 cm Magnetic field strength = 3T Area of coil (A): 240 mm x 300 mm θ of turn = 32°

Verify the student's hypothesis with calculations and determine any difference.

Section II extra writing space

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

2021 HSC Trial
Physics Marking Guidelines

Section I

Multiple-choice Answer Key

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

Section II

Question 21 (5 marks)

(a)

Criteria	Marks
• Explains how the transformer works	3
• Outlines how the transformer works	2
• Provides some relevant information	1

Sample answer:

The transformer works by inducing an alternating current in the secondary coil, this is done by supply an alternating current in the primary coil which causes a flux change in the primary coil which is then transferred to the secondary coil through flux linkage an iron core. The amount of induced current is proportional to this relationship $V_p/V_s= n_p/n_s =I_s/I_p$

(b)

Criteria	Marks
• Correctly calculates: $4/16=I_s/15$ $I_s =4/16 \times 15$ $I_s = 3.74$ A	2
• Correctly states the specific relationship $N_p/N_s = I_s/I_p$	1

Sample answer:

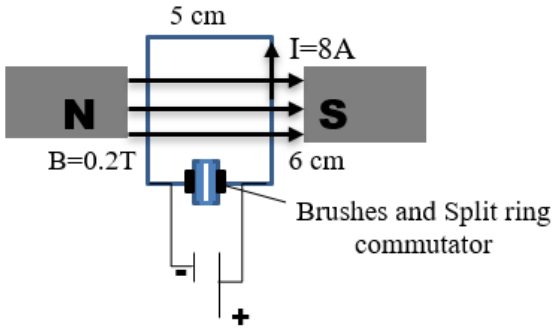
$N_p/N_s = I_s/I_p$
$4/16 = Is/15$
$I_s =4/16 \times 15$
$I_s = 3.74$ A

Question 22 (4 marks)

(a)

Criteria	Marks
• Draws a correct diagram clearly showing the features: – Brushes and split ring commutator (1 mark) – Loop with power source – Magnets/magnetic field	2
• Provides some relevant information	1

Sample answer:



(b)

Criteria	Marks
• Describes how back emf is induced	2
• Provides some relevant information	1

Sample answer:

Back emf is induced in a motor as soon as it starts to spin. The change in magnetic flux produced by the spin induces a back emf which then counteracts the speeding up of the motor. This back emf is best described with Lenz's law and ensures the conservation of energy.

Question 23 (6 marks)

(a)

Criteria	Marks
• Explains how the mass defect and the binding energy relate atoms	3
• Describes some relevant information about mass defect AND binding energy	2
• Provides some relevant information	1

Sample answer:

The mass defect of a nucleus is the difference between the total mass of a nucleus and the sum of the masses of all its nucleons. The binding energy of a nucleus is equal to the amount of energy released in forming the nucleus, or the mass defect multiplied by the speed of light squared ($E = mc^2$).

(b)

Criteria	Marks
• Correctly calculates the binding energy with working and units	3
• Correctly calculates the mass deficit with working	2
• Correctly calculates the mass of the nucleus or the mass of the particles	1

Sample answer:

Mass Defect = Mass of the Nucleus – Mass of the Particles
Mass of Nucleus = mass of carbon atom – mass of electrons
Mass of carbon atom = 12 x 1.66054x10-^{27} kg = 1.99265x10^{-26} kg
Mass of Nucleus = 1.99265x10^{-26} kg – 6 x 9.11 x10^{-31} kg
Mass of Nucleus = 1.99210x10^{-26}
Mass of Particles = 6 (1.6726x10^{-27}) + 6(1.67493x10^{-27}) = 2.00853x10^{-26} kg
Mass Defect = 1.99210 x10^{-26} - 2.00853x10^{-26} = -1.643x10^{-28} kg
Binding energy = mc^2 = -1.643x10^{-28} x (3 x 10^8)^2 = <u>1.479 x 10^{-11}J</u>

Question 24 (4 marks)

Criteria	Marks
• Describes FOUR differences for stars in both positions	4
• Describes THREE differences for stars in both positions	3
• Describes TWO differences for stars in both positions	2
• Provides some relevant information	1

Sample answer:

Stars located in Position X are typically bluer, larger stars, which have a hotter surface temperature, and higher luminosity with more of its energy being produced through the CNO cycle which dominates over the Proton-Proton chain reaction. The stars are typically given the spectral class O, B, A and have shorter lifespan. However, stars located in Position Z are typically redder, smaller stars, which have a cooler surface temperature, and lower luminosity with more of its energy being produced through the Proton-Proton chain reaction which dominates the CNO cycle. The stars are typically given the spectral class K and M and have longer lifespan.

Question 25 (5 marks)

(a)

Criteria	Marks
• Correctly calculates answer with correct unit	2
• Provides some relevant information	1

Sample answer:

$L_v = L_O \sqrt{1-0.95c^2/c^2}$

$L_v = 456 \sqrt{1-0.95}$

$L_v = 102$ m

(b)

Criteria	Marks
• Explains, using Einstein's thought experiments, why the length changes for the observer	3
• Describes why the length changes for the observer	2
• Provides some relevant information	1

Sample answer:

Einstein predicted from his postulates that the laws of relativity must hold for all experiments and that the speed of light is the absolute reference point for all investigations. This means that the speed of light must be invariant for all observers. For this to be true the length of the spacecraft which moves with a speed of 0.95c will be different as measured by the astronaut and an outside observer. The journey predicts that the length will contract a significant amount as measured by the observer while the proper length is measured by the astronaut. The length of the spacecraft must contract for the observer for the speed of light to remain invariant for both the observer and the astronaut. As the spacecraft approaches the speed of light the length will become increasingly shorter.

Question 26 (4 marks)

(a)

Criteria	Marks
• Explains comprehensively what happens to the light as it passes through Polariser A, then Analyser 1, and finally Analyser 2	4
• Describes what happens to the light as it passes through Polariser A, then Analyser 1, and finally Analyser 2	3
• Outlines what happens to the light as it passes through Polariser A, then Analyser 1, and finally Analyser 2	2
• Provides some relevant information	1

Sample answer:

Light has multiple planes of vibration called unpolarised light. When the light passes through Polariser A only the vertical plane of light will be allowed to pass while the other planes are completely blocked. The light that passes through Polariser A will have ½ of its original intensity and will have its horizontal component completely blocked as it passes through the polariser. $I = I_0/2$ As the polarised light passes through Analyser 1, some of the light will be blocked further but some of the light will be allowed through but the intensity of light passing through Analyser 1 will be significantly lowered as per Malus' Law: $I_0/2 = \text{Cos}^2 20$. As the light passes through Analyser 2 more of the polarised light will be blocked and an even smaller amount of the original light will be allowed to through as its intensity is further lowered: $I_0/2 = \text{Cos}^2 35$ To achieve zero intensity the analyser must be placed at right angles or at 90^0 to the polarised light this will ensure that all the components of the light are blocked, and the polarised light will be completely blocked by the analyser.

Question 27 (6 marks)

(a)

Criteria	Marks
• Correctly calculates total time	4
• Makes significant progress to answer	3
• Makes progress to answer	2
• Provides some relevant information	1

Sample answer:

$v_y = u_y + at_1$ *(for time to max height)*

$t_1 = 0 - 25\sin 32/9.8$

$\underline{t_1 = 1.35 \text{ s}}$

$s_y = u_y t + ½ at^2$ *(distance for max height)*

$s_y = 25\sin 32\ (1.35) + ½ -9.8\ (1.35)^2$

$s_y = 17.88 – 8.9$

$\underline{s_y = 8.9\text{m}}$

$s_{yt} = ut + ½ at_2^2$ *(s_{yt} is distance from max height – ground; and t_2 is time to fall to ground from max height)*

$450 + 8.9 = 0 + ½\ 9.8\ t_2^2$

$t_2^2 = 458.9 \times 2/9.8$

$\underline{t_2 = 9.67 \text{ s}}$ and t total = $t_1 + t_2$ so $\underline{\text{t total} = 11 \text{ s}}$

(b)

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

Sample answer:

$\Delta_x = u_x t$

$\Delta_x = 25\cos 32 \times 11$

$\Delta_x = \underline{233 \text{ m}}$

Question 28 (5 marks)

(a)

Criteria	Marks
• Describes the function of the slip rings	2
• Provides some relevant information	1

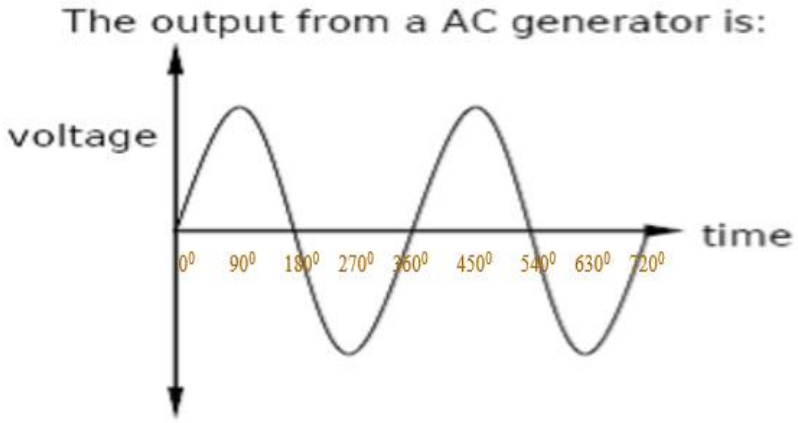
Sample answer:

The most important component of the AC generator is the slip rings. They provide electrical contacts while allowing the rotation of the armature, this in turn allows an alternating current to flow through the generator thus generating the AC output emf/voltage).

(b)

Criteria	Marks
• Provides a correct graph with 0^0 as Zero emf and 90^0 as a max emf and displays two turns as shown	3
• Plots a graph which shows the wave form as below	2
• Provides some relevant information	1

Sample answer:



Question 29 (6 marks)

(a)

Criteria	Marks
• Correctly calculates answer with correct unit	2
• Provides some relevant information	1

Sample answer:

$v = \sqrt{GM/r}$

$v = \sqrt{(6.67 \times 10^{-11})(6 \times 10^{24})/(6.371 \times 10^{6} + 980 \times 10^{3})}$

$\underline{v = 7378\ ms^{-1}}$

(b)

Criteria	Marks
• Correctly calculates the answer	2
• Provides some relevant information	1

Sample answer:

$V = \sqrt{2GM/r}$

$V = \sqrt{2(6.67 \times 10^{-11})(6.4 \times 10^{23})/3390 \times 10^{3}}$

$v = 5.018\ ms^{-1}$

(c)

Criteria	Marks
• Correctly calculates the answer with correct unit	2
• Provides some relevant information	1

Sample answer:

$U = -GMm/r$

$U = -(6.67 \times 10^{-11})(6 \times 10^{24})(1500)/(6.371 \times 10^{6}) + (800 \times 10^{3})$

$U = -8.37 \times 10^{10}\ J$

Question 30 (7 marks)

(a)

Criteria	Marks
• Fully describes two relevant observations	3
• Outlines two relevant observations	2
• Outlines one relevant observation	1

Sample answer:
The first observation which contradicted the wave model was that increasing the intensity of light did not increase the photocurrent in all situations, as would have been expected. The second observation was that a when a continuous supply of energy was placed on the surface of the cathode it did not eventually produce the emission of a photocurrent – a definite threshold frequency was required for the photocurrent to start. These observations were not predicted by the wave model but supported the particle model.

(b)

Criteria	Marks
• Describes the TWO limitations of wave theory • Describes how the production of photons relates to the quanisation of light • Clearly links the quanisation of light to resolving the two limitations of wave theory	4
• Identifies the TWO limitations of the wave model • Links TWO particle model observations in some way to their resolution	3-2
• Identifies the two limitations of the wave model OR links ONE particle model observations in some way to a resolution	1

Sample answer:
Wave model stated that increasing the intensity of light did not always result in increasing current flow as expected, the particle model resolved this limitation.

Einstein explained that it was not more intensity, but more energy that was needed to release a photocurrent. He extended Planck's idea of quanta and proposed the idea of photons of light which were themselves quantised. The energy of each photon would be derived using the formula E =hf. Only photons of light at the correct frequency would have the needed energy for electrons to be released.

Wave model: if a continuous supply of energy was placed on the surface of the cathode photocurrent was not eventually be emitted as expected

Einstein's particle model explained that excess light was not light with more energy but more photons with the same amount of energy and that at a specific energy of light or frequency was needed for an electron to breakaway and create a photocurrent. This specific energy required was called the work function W: $KE = hf-W$ or $hf = W + \frac{1}{2} mv^2$

As light increased in frequency photocurrent increased. All these observations and ideas verified the proposal that particles "photons" were creating the photoelectric effect.

Question 31 (7 marks)

Criteria	Marks
• Provides a comprehensive analysis of the experiment • Describes Rutherford's Model explaining improvements made to previous atomic models that relate to this experiment • Describes limitations of Rutherford's model	6-7
• Provides a description of the experiment with some analysis • Outlines some improvements made to previous atomic models that relate to this experiment • Identifies the limitations of Rutherford's model	4-5
• Identifies some improvements made to previous atomic models that relate to this experiment • Identifies a limitation of Rutherford's model	2-3
• Provides some relevant information	1

Sample answer:

The Geiger-Marsden (Rutherford) experiment investigating the scattering of alpha particles made as alpha particles were directed to gold foil. The position of the scattering was small flashes of light and was detected using a microscope. The scattering pattern created could not be explained by the Thompson model of the atom. Thomson had suggested that charge was evenly distributed in the atom, but the scatter pattern suggested that a positive charge was concentrated in a small mass greater than the mass of the alpha particles. The positive charge instead of being located throughout the atom was now thought to be in the centre of the atom.

Rutherford proposed the idea that the atom had a positively charge nucleus in the centre of the atom. Most of the particles passed the gold without deflection this suggest that most of the atom was free space. Some of the alpha particles were deflected by the gold sheet at exceedingly small angles which supports the idea that the positive charge of the atom is not uniformly distributed but more likely to be concentrated in a very small volume in the nucleus of the atom. Very few alpha particles were deflected back which indicates that volume of the positively charged particles in the atom is exceedingly small compared to the total volume of the atom.

While the Geiger-Marsden (Rutherford) experimental results advanced the model from a plum pudding type arrangement to an atom that was mostly empty space with a small, dense, positive nucleus surrounded by electrons, it did not give any specific information about the stability of electrons around the nucleus. Rutherford could not explain this stability of the atom, he suggests that electrons would rotate in orbit This theory had limitation as electrons moving in orbits should emit radiation. This energy should reduce the orbit speed and eventually cause the electron to collapse into the nucleus. The Rutherford model did not explain the arrangement of the electrons the atom which made his theory incomplete. It also made no explanation of spectral lines created by atoms which are heated.

Question 32 (6 marks)

(a)

Criteria	Marks
• Provides correct answer	3
• Makes substantial progress to answer	2
• Provides some relevant information	1

Sample answer:

$v_{max} = \sqrt{rg\sin\theta/\cos\theta}$

$= \sqrt{20 \times 9.8 \times \sin 15/\cos 15}$

$= 7.24\ ms^{-1}$

OR

$mg = N \cos 15$

$mv^2/r = N \sin 15$

$N \sin 15 / N \cos 15 = mv^2r/mg$

$\tan 15 = v^2/gr$

$v^2 = \tan 15 \times gr$

$v^2 = (\tan 15)(9.8)(20)$

$v^2 = 52.5$

$v = 7.25\ ms^{-1}$

(b)

Criteria	Marks
• Explains variation in speed • Supports answer with a correct diagram	3
• Describes variation with a supporting diagram OR • Explains answer without a diagram	2
• Provides some relevant information	1

Sample answer:

When the road is icy there is no friction between the road and the tyres, but in dry conditions the friction between the road and the tyres comes into play. As can be seen in the diagram the friction force acts to keep the car on the road as it acts in a direction to oppose the car's inertia. This force is added to the equation used in part (a): $mv^2/r = N \sin 15 + \mu N$
Thus, it increases the bend's max velocity.

Question 33 (5 marks)

Criteria	Marks
• Explains the concept of electromagnetic induction and the production of eddy currents in tubes • Uses Lenz's Law to relate this em induction to the braking effects on the magnet as it passes through the tubes • Relates the structure and/or composition of the tubes to the variations in drop times	5
• Describes the concept of electromagnetic induction producing eddy currents in tubes • Relates Lenz's Law to the braking effects on the magnet • Relates the structure and/or composition of the tubes to the variations in drop times	4-3
• Relates the structure and/or composition of TWO tubes to the variations in drop times	2
• Some relevant information	1

Sample answer:

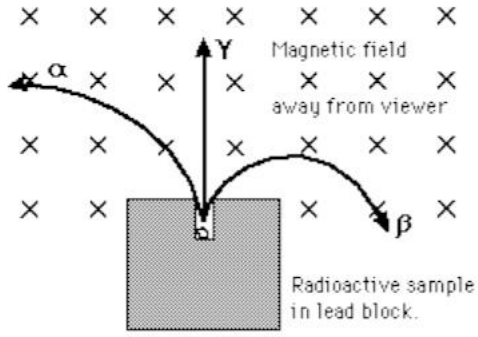
A changing magnetic field will induce a current to flow in a conductor. As the magnet falls it produces a changing flux that will induce currents to flow in the metal tubes. This current, using Lenz's Law will be in a direction that will oppose the direction of the changing flux. This results in an opposing force that slows the magnet's fall. The better the conductor the bigger the current induced and the greater the opposing force.

This means that in non-conductors such as tube 4 the magnet will not experience an opposing force and will freefall, so it will have the fastest time. The slower times for the copper tubes means they are better conductors than the aluminium tube, therefore producing the greatest opposition to the magnet. The slit down copper tube 3 would weaken the eddy currents thus weakening the opposing force, therefore it has a faster time than the copper without the slit.

Question 34 (2 marks)

Criteria	Marks
• Provides correct nuclear reaction	2
• Provides some relevant information	1

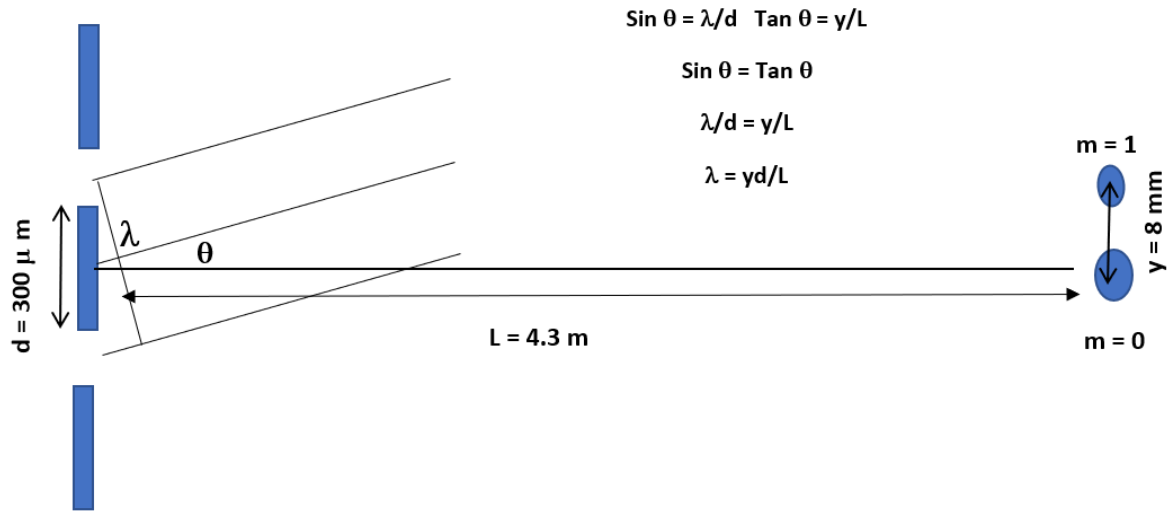
Sample answer:



Question 35 (4 marks)

Criteria	Marks
• Provides a detailed, correct diagram • Provides correct calculation with working	4
• Provides a correct diagram • Provides correct calculation	3
• Provides a generalised diagram or a diagram with multiple errors • Provides calculation, may have an error	2
• Provides some relevant information	1

Sample answer:



$\lambda = yd/L$
$\lambda = 8 \times 10^{-3} \times 3 \times 10^{-4} / 4.3$
$\lambda = 5.58 \times 10^{-7}$ m
$\lambda = 558$ nm

Question 36 (4 marks)

Criteria	Marks
• Identifies the principle • Correctly calculates the torque for both the spanner and the motor • Identifies the difference • States that the motor will not rotate the spanner	4
• Calculates the torque for both the spanner and the motor • Identifies the difference • States that the motor will not rotate the spanner	3
• Makes progress towards answer	2
• Provides some relevant information	1

Sample answer:
The torque on the DC motor must be equal or greater than the torque required to turn the spanner.

Torque required to turn spanner.
τ = Fd sin θ $\tau =$ (14 x 0.08) Sin 32 = 0.59Nm

Torque achieved by DC Motor.
τ = nBIA Sin θ τ = (2) (3) (2.5) (0.24) (0.3) sin 32 τ = 0.57Nm

The hypothesis is not supported as the torque required to turn the spanner is not achieved by the motor it will not move. The difference between the torque of the spanner and the torque of the motor is 002Nm.

2021 HSC Trial Physics Mapping Grid

Question	Marks	Content	Syllabus outcomes
Section I			
1	1	5.1.1	PH12-12, PH12-3
2	1	5,3,2	PH12-12, PH12-6
3	1	6.1.4	PH12-13, PH12-4
4	1	5.2.2	PH12-12, PH12-6
5	1	6.1.2	PH12-13, PH12-3
6	1	8.3.4	PH12-15, PH12-4
7	1	8.4.4	PH12-15, PH12-4
8	1	7.4.2	PH12-14, PH12-6
9	1	7.3.1	PH12-14, PH12-4
10	1	7.3.3	PH12-14, PH12-1
11	1	8.4.3	PH12-15, PH12-6
12	1	8.2.2	PH12-15, PH12-7
13	1	7.1.4	PH12-14, PH12-5
14	1	8.4.2	PH12-15, PH12-7
15	1	6.2.1	PH12-13, PH12-6
16	1	5.2,3	PH12-13, PH12-2
17	1	5.3.1	PH12-12, PH12-5
18	1	5.3.4	PH12-12, PH12-6
19	1	7.2.2	PH12-14, PH12-5
20	1	8.2.1	PH12-15, PH14-4
Section II			
21 (a)	3	6.3.4	PH12-13, PH12-7
21 (b)	2	6.3.3	PH12-13, PH12-6
22 (a)	2	6.4.1	PH12-13, PH12-5
22 (b)	2	6.4.3	PH12-13, PH12-4
23 (a)	3	8.4.6	PH12-15, PH12-7
23 (b)	3	8.4.6	PH12-15, PH12-5
24	4	8.1.6	PH12-15, PH12-4

25 (a)	2	7.4.1	PH12-14, PH12-6
25 (b)	3	7.4.2	PH12-14, PH12-5
26	4	7.2.4	PH12-14, PH12-2
27 (a)	4	5.1.2	PH12-12, PH12-6
27 (b)	2	5.1.2	PH12-12, PH12-6
28 (a)	2	6.4.2	PH12-13, PH12-4
28 (b)	3	6.4.2	PH12-13, PH12-6
29 (a)	2	5.3.2	PH12-12, PH12-6
29 (b)	2	5.3.4	PH12-12, PH12-4
29 (c)	2	5.3.5	PH12-12, PH12-6
30	7	7.3.2	PH12-14, PH12-2
31	7	8.2.2	PH12-15, PH12-3
32 (a)	3	5.2.3	PH12-12, PH12-6
32 (b)	3	5.2.3	PH12-12, PH12-6
33	5	6.4.3	PH12-13, PH12-3
34	2	8.4.1	PH12-15, PH12-7
35	4	7.2.2	PH12-14, PH12-1
36	4	6.4.1	PH12-13, PH12-4