Quality and creativity

KATOOMBA HIGH SCHOOL

2023 | 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 12

68

Total marks: ~~100~~ 99

Section I — 20 marks (pages 2–11)

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

Section II — 80 marks (pages 12–25)

- Attempt Questions 21–33
- Allow about 2 hours and 25 minutes for this section

STUDENT ID: Malachi Haskew

36326611

Malachi Haskew

$\lambda =$ E

$R =$ F

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

YEAR 12
HSC TRIAL
EXAMINATION

Physics

Multiple Choice Answer Sheet

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 ← this one is correct
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

fix

10

$$\frac{GMm}{r_1^2} = \frac{GMm}{r_2^2}$$

$$\frac{1}{r_1^2} = \frac{1}{r_2^2}$$

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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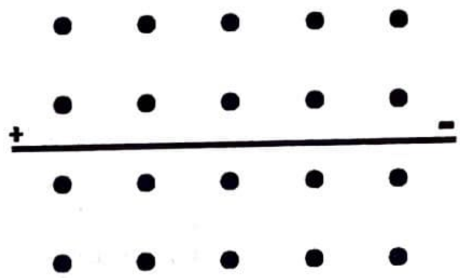
1 The diagram shows a current carrying wire in a magnetic field.



In which direction will the wire move?

A. Up the page

B. Into the page

C. Down the page

D. Out of the page

2 A device was tested in a laboratory.

A student described it as follows:

1. The device contains a stator,
2. A squirrel cage design is used,
3. Three phase wiring is part of the design, and
4. Magnetism is created by coils.

Which device would best match the description?

A. Transformer from a monitor

B. Electromagnetic braking discs

C. AC induction motor found in a fan

D. Alternator which connects to a boat engine

3 A classroom transformer was tested, and the data was recorded from the experiment.

Setting	*Voltage* (V)	*Current* (A)
A	2	0.10
B	4	0.15
C	6	0.20
D	8	0.25
E	10	0.30
F	12	0.40

20
~~26~~ 26.6
30
32

A student assesses the function of the transformer after testing it.

Which formulae best describes an accurate assessment for voltage setting D if the transformer was considered to be ideal?

~~V=IR R=~~
~~P=VI~~
$V_pI_p = V_sI_s$

A. $\frac{15}{1} = \frac{0.25}{0.08}$ 8 : 1.66

B. $\frac{30}{1} = \frac{0.25}{0.008}$ 8 : 8.33

C. $\frac{120}{8} = \frac{0.08}{0.25}$ 8 : 0.01706

D. $\frac{240}{8} = \frac{0.008}{0.25}$ 8 : 0.000853

4 Leptons are classified as fundamental particles as they do not seem to be made up of any smaller particles.

Which type of subatomic particles would be classified as leptons?

A. Protons and neutrons

B. Electrons and protons

C. Neutrons and neutrinos

D. Electrons and neutrinos

5 Which experiment made best use of the equation:

$$q = \frac{mgd}{V}\ ?$$

0

A. Geiger-Marsden experiment

B. Millikan's oil drop experiment

C. Thompson's charge to mass ratio

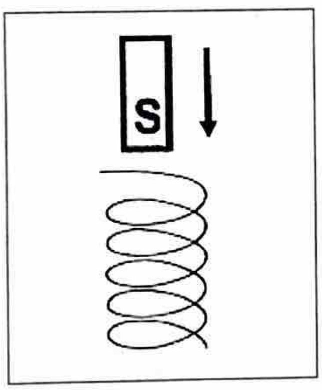
D. Determining the nature of cathode rays

6 Faraday's Law clearly describes the relationships between the amount of emf produced in a coil when a magnet is plunged into it.

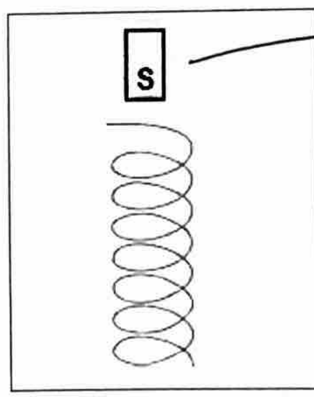
A student plunges a magnet into a coil.

Which diagram describes the situation which induces the greatest amount of emf in the coil?

A.

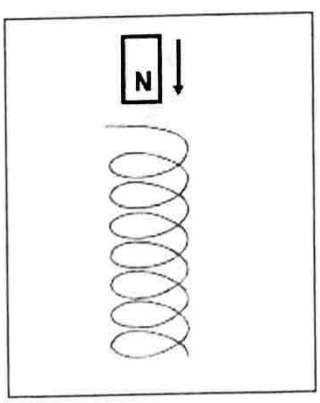


B.

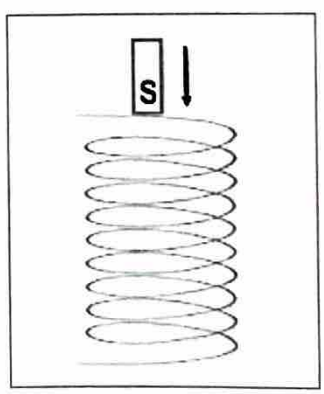


no arrow ∴ C

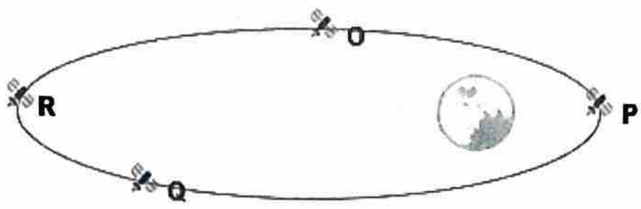
C.



D.



7 Four identical satellites are in an elliptical orbit around Earth as shown in the diagram.



Which satellite would have the greatest kinetic energy?

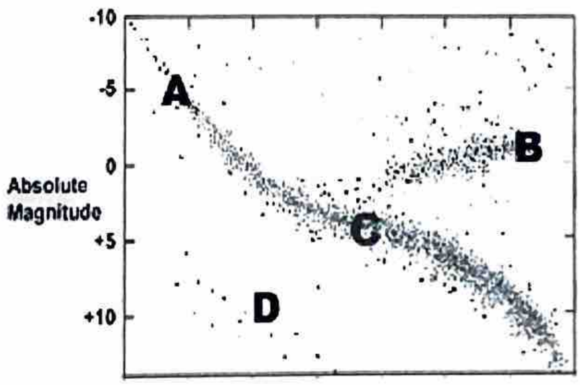
A. O

B. P

C. Q

D. R

8 The position of four stars has been plotted on a Hertzsprung-Russell (H-R) diagram.



Which star would derive the most energy from the proton-proton chain reaction?

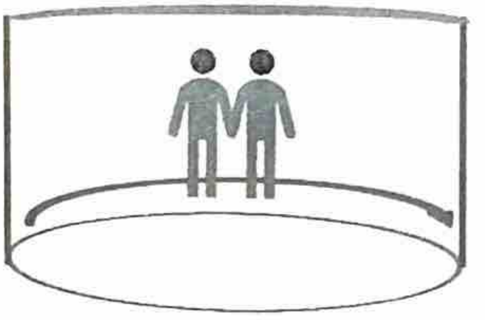
A. A

B. B

C. C

D D

9 The Rotor is a famous rotating drum ride at Luna Park.



When people enter, the drum starts to rotate. The rotation rate is slowly increased until the floor can be lowered without the people falling.

Which statement most accurately describes the net force acting on the people when the floor is removed?

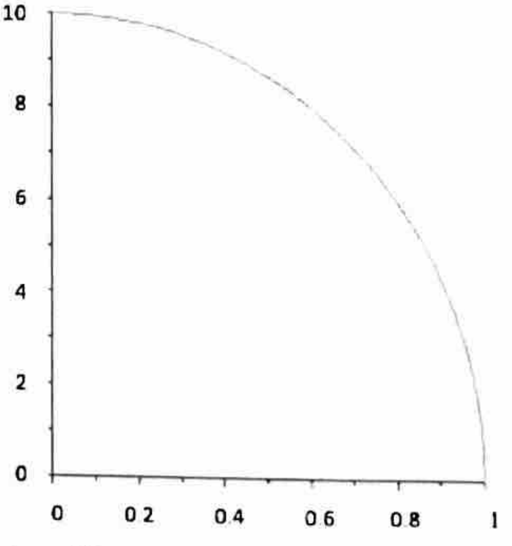
A. The magnitude of the net force is zero.

B. The magnitude of the net force is at a maximum.

C. The direction of the net force in vertically upwards.

D. The direction of the net force is perpendicular to the wall.

10 The graph below can be used to describe the effects of relativity on an object as it approaches the speed of light.



Which relativistic effect does this graph best describe?

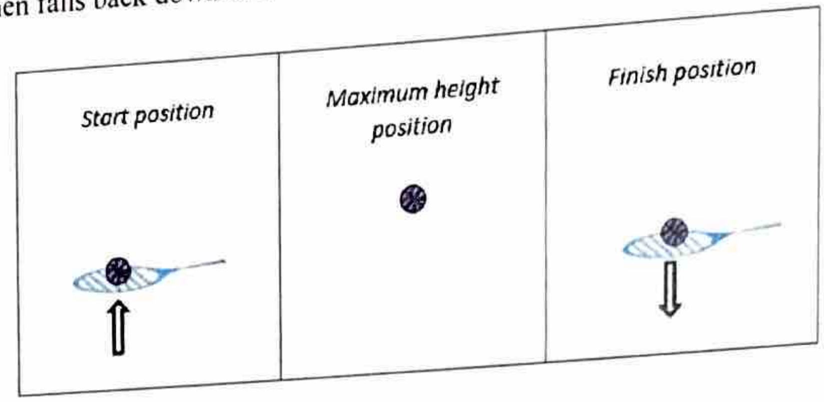
A. Time dilation

B. The twin paradox

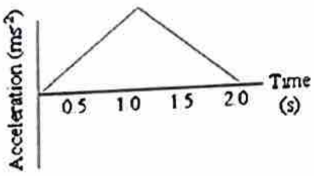
C. Length contraction

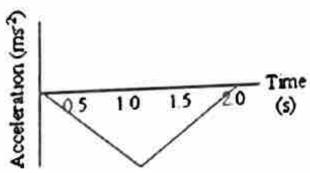
D. Relativistic momentum

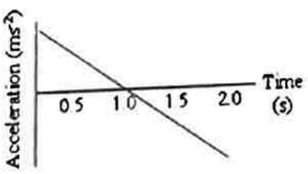
11 The diagrams below represent three positions of a tennis ball being hit vertically into the air that then falls back down onto the racket.

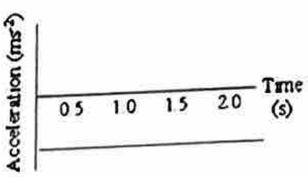


Which acceleration/time graph accurately represents the motion of the tennis ball?

A. 

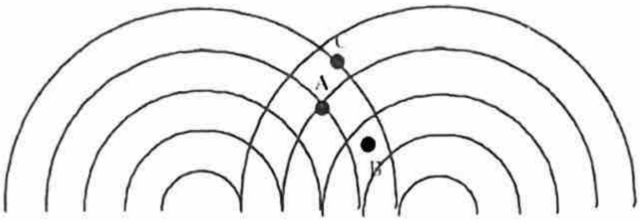
B. 

C. 

D. 

gravity is constant

12 The following wave front model represents crests as dark lines. The marks showing the outward propagation are left out for clarity.



A. A

B. B

C. C

D. None of these.

Which label correctly identifies constructive interference?

13 An electron relaxes and moves to a lower energy level.

A spectral line of 1.03×10^{-7} m would be produced when

A. moving from energy level 3 to 1.

B. moving from energy level 3 to 2.

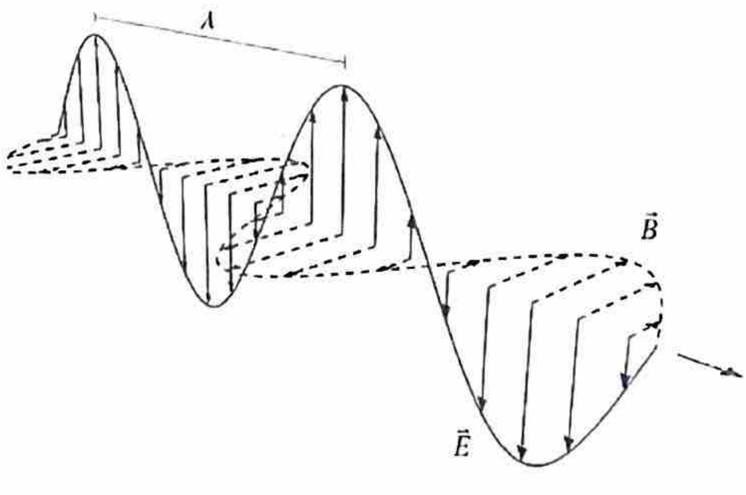
C. moving from energy level 5 to 2.

D. moving from energy level 5 to 3.

learn the names

14 Maxwell is considered a great scientist of his time as his electromagnetic model led to many discoveries.

He used his electromagnetic model to determine certain qualities of electromagnetic waves. A diagram of his model is shown.



What can Maxwell's model of waves be used to determine?

A. The speed of light

B. The speed of sound

C. Oscillation of bat sonar

D. Propagation of ocean waves

15 An arrow was released from a bow four times.

The table shows the x and y components as described.

Test flight	*Velocity* x *component* (kmh^{-1})	*Velocity* y *component* (kmh^{-1})
1	120	207
2	167	172
3	183	154
4	207	120

$0 = 207 + (-9.8)(t)$

$\therefore$ 10.6 sec × 4

$\therefore$ 8.78 sec × 4

$\therefore$ 7.86 sec × 4

$\therefore$ 6.12 sec × 4

Which test flight would have produced the greatest range?

5088m $s = ut + \frac{1}{2}at^2$

$= u(t)$

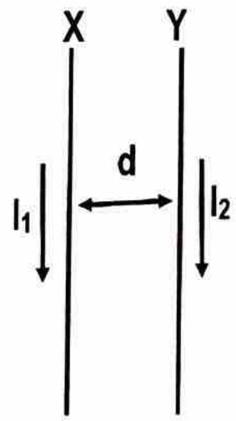
A. Test 1 ~~1272m~~ 5865m

B. Test 2 ~~1466.26m~~ 5753.5m

C. Test 3 ~~1438.38m~~ 5067m

D. Test 4

16 Two parallel wires, X and Y are placed close to each other as shown in the diagram. The force between the wires was calculated as the distance and the current was changed.



$$F = \frac{I_1 I_2}{r}$$

Which best describes changes that could be made that would result in no change to the resultant force?

	Change to the current	*Change to the distance between X and Y*
A.	Doubling the current in both wires	Doubling the distance between them
B.	Doubling the current in both wires	Quadrupling the distance between them
C.	Quadrupling the current in one wire	Doubling the distance between them
D.	Quadrupling the current in both wires	Quadrupling the distance between them

17 Four blackbodies are compared. Their peak wavelength and colours are tabulated.

Blackbody A	*Blackbody B*	*Blackbody C*	*Blackbody* D
Violet light	Red light	Yellow light	Blue light
380 nm	724 nm	580 nm	483 nm

The frequencies and temperatures of the blackbodies were calculated and recorded.

Which statement best describes the most correct comparisons of these calculations?

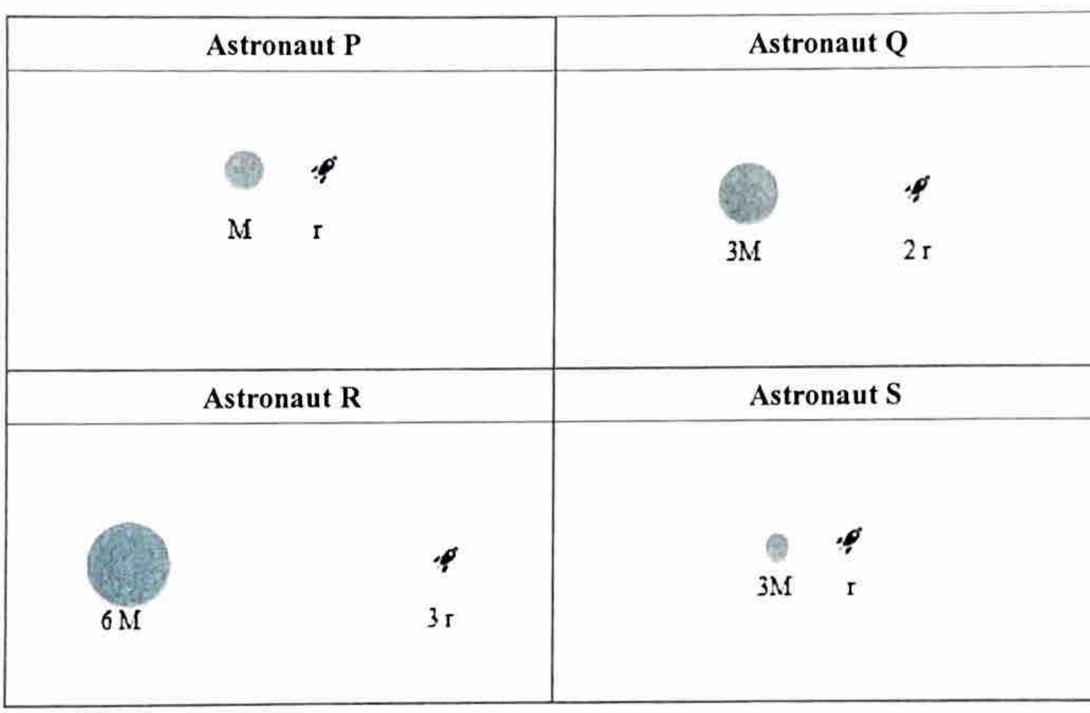
A. Blackbody A: surface temperature 7530 k and peak frequency 7.69×10^{14} Hz.

B. Blackbody B: surface temperature 3750 k and peak frequency 4.54×10^{14} Hz.

C. Blackbody C: surface temperature 4250 k and peak frequency 5.17×10^{14} Hz.

D. Blackbody D: surface temperature 5725 k and peak frequency 6.21×10^{14} Hz.

18 Four astronauts are in orbit around four different planetary bodies as shown in the diagram. The relative masses and orbital distances are included.



Which astronaut would require the greatest escape velocity to leave the orbit and return home?

A. P

B. Q

C. R

D. S

19 A radio isotope found in a rock has a decay constant of 0.0054 $years^{-1}$.

If the isotope's starting mass in the rock was 800 grams, and now there is 8 grams left, the rock's age is

A. 1.85 years.

B. 370 years.

C. 852 years.

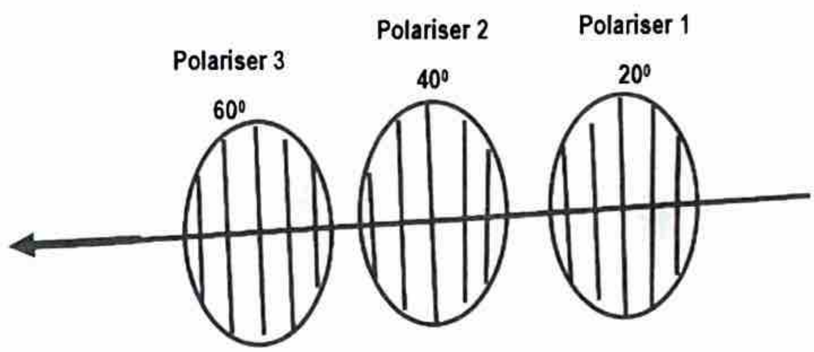
D. 1850 years.

$\lambda = \frac{\ln 2}{t}$

$P = P_0 e^{\lambda t}$

$8 = 800 e^{\lambda t}$

20 A polarising set up uses three polarisers to obtain a final intensity value for the light when it passes through Polariser 3 as shown in the diagram.



Angles are measured from the positions shown and the polarisers are all turned in the same direction.

If the initial intensity is 10 units, what will the intensity be after the light has travelled through Polariser 3?

A. 5.27

B. 6.89

C. 7.28

D. 8.83

Student ID: Maladw Haskew

2023

HIGHER SCHOOL CERTIFICATE
TRIAL EXAMINATION

Physics

Section II
Answer Booklet

80 marks
Attempt Questions 21–33
Allow about 2 hour 25 minutes for this part

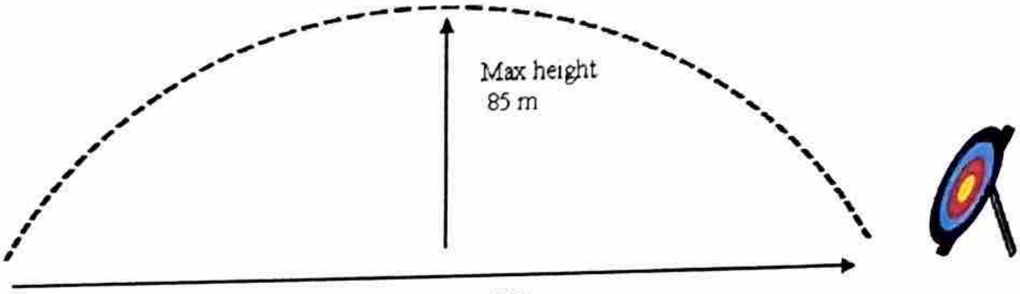
Instructions

- 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 (6 marks)

In test runs to determine where to place a large circular target, a group of archers achieved an average range of 205 m. The diagram shows the path of one arrow and the target to be used.



(a) If an arrow was airbourne for a total of 4.3 secs, calculate its initial velocity. **4**

1

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

~~$85 = 0(t) + \frac{1}{2}at^2$~~

~~$85 = 0 + \frac{1}{2}(a)(2.15)$~~

~~$a = 79.0698$~~

$v = u + at$

$0 = u + (-9.8)(4.3 \div 2)$

$0 = u + (-21.07)$

$u = 21.07$

$\therefore$ initial velocity = 21.07 m/s

need x velo & angle

(b) The archers could have achieved a greater range.

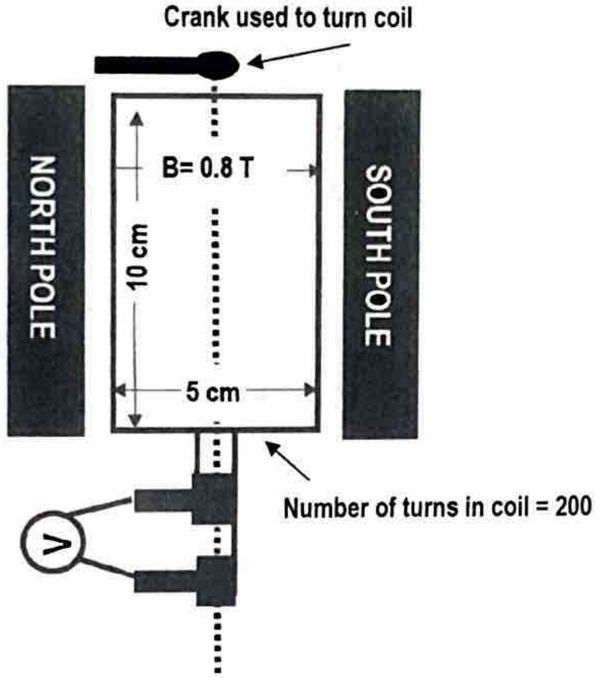
2

Identify ONE reason why they would choose not to do this and use principles of physics to justify your reason.

Archers shot at roughly 40°.
If they had aimed at 45°
then the arrow would have flown ~~father~~ further. Air resistance would prevent this optimal angle from being as effective as the lower 40° angle.

Question 22 (6 marks)

A device was constructed in a physics' laboratory and the design is shown in the diagram.



(a) Identify this device justifying your answer. **2**

AC Generator.
The ~~split ring~~ slip ring comutator identified due to the two seperate rings will cause the current induced to alternate.

1

(b) Calculate the emf created in this device if the coil was spun ¼ of revolution in 18 ms. **2**

$\varepsilon = -N \Delta($

$\varepsilon = -200 \times \frac{0.8 \times 0.1 \times 0.05}{0.018}$

$= -444.4$

1

G = D

Question 22 (continued)

(c) Explain how back emf causes this device to obey the law of conservation of energy. **2**

The back emf causes the crank ~~hangt~~ handle to take more energy to turn the greater the output energy.

1

therefore preventing more energy being produced than input.

End of Question 22

Question 23 (5 marks)

A 2000 kg satellite in an 1800 km Earth orbit loses velocity. As a result, it spirals down towards the Earth before stabilising at a new orbit of 1500 km.

(a) Calculate the change in the satellite's gravitational potential energy. **2**

$F_1 = \frac{GMm}{r_1^2}$

$\frac{GMm}{r_1^2} = \frac{GMm}{r_2^2}$

$r_1^2 = r_2^2$

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

$\frac{v^2}{r} = \frac{GM}{r^2}$

$v^2 r = GM$

$r = \frac{GM}{v^2}$

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

1800: 4.446×10^{11}

1500: 5.336×10^{11}

∴ ~~added~~ removed 8.89×10^{10} J to the potential energy

(b) Explain how the satellite would achieve the velocity needed for its new orbit. **3**

By propelling something, likely fule out of a thruster, into ints direction of velocity. The energy imparted to the propellant is removed from the satellite, causing it to drop.

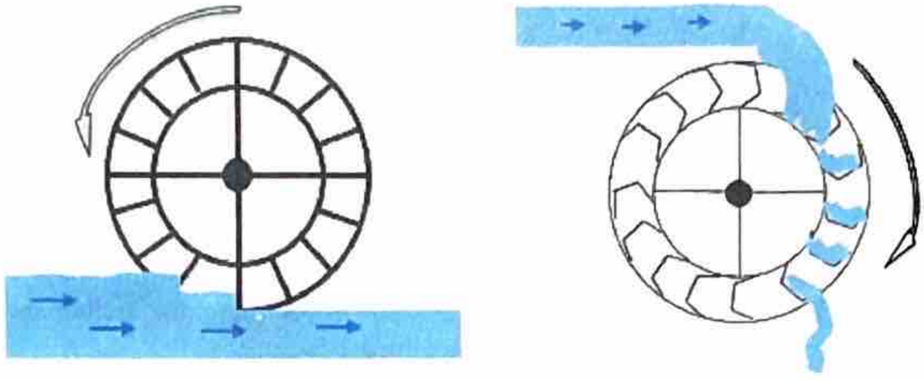
PE turned to KE to inc. vel.

Question 24 (5 marks)

A waterwheel can be used to make electricity using flowing water. The water pushes on the paddles, causing the wheel to rotate. This rotation can be used to rotate a generator to make electricity.

Two different designs are shown.

Paddle Wheel **Bucket Wheel**



Both designs have wheels available in three diameter sizes; 2 metres, 3 metres and 4 metres.

(a) Assuming water flows are identical, compare the forces acting on the two different designs of waterwheels. 2

At each of the sizes, the two wheels would have comparible ~~tou~~ torque due to the comparable radius. However the bucket design would cause the torque to be imparted longer. ∴ more torque for the bucket wheel.

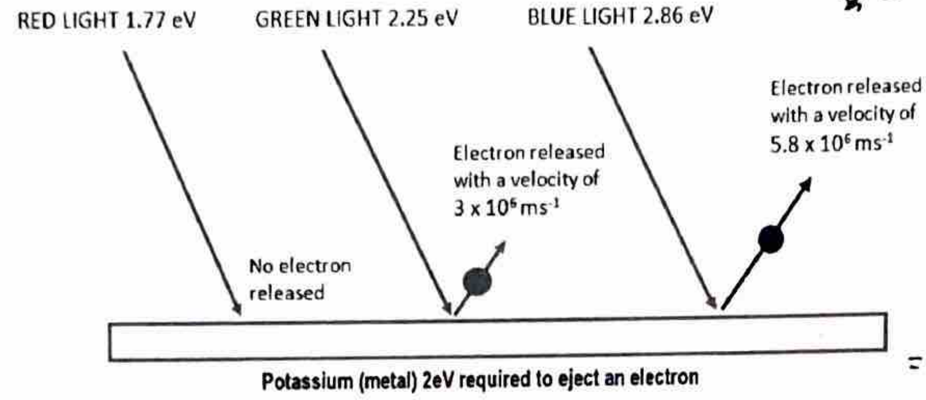
(b) A farmer wants to maximise the production of electricity on his property. 3

Justify the design **and** the size of wheel he should use to achieve this.

He should use the bucket wheel design as it would produce the most efficient generation of torque given a fixed amount of water. He should choose the 4m diameter size as it will provide the greatest mechanical advantage-

Question 25 (6 marks)

Red, green and blue light were shone on a piece of potassium metal and the results are shown in the diagram.



$c = f\lambda$

$f = \frac{c}{\lambda}$

$= 7.5 \times 10^{14}$ Hz

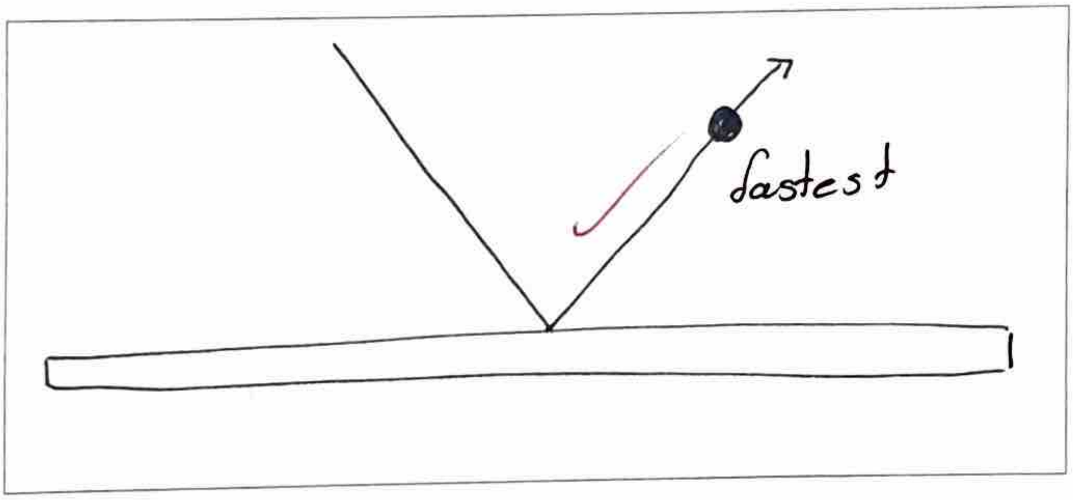
4.97×10^{-19} J

$= 3.1$ eV

$= 6.22 \times 10^5$ m/s

(a) Using the above diagram as a guide, draw a predicted result in the space below for shining 400 nm Violet light onto the potassium. On your diagram, include the velocity and energy values for any electrons which may be released. 3

2



(b) Explain how this experiment is used to support quanta and photoelectric principles. 3

0

The "all or nothing effect".
The release velocity of the electrons depends entirely on the lights fiequency with the luminocity or brightness having no effect. This means that the light must arive in quantised particles rather than a continuous stream.

Question 26 (4 marks)

A group of students learn that a pendulum is an accurate way to determine the acceleration due to gravity. The equation for the period of a pendulum is

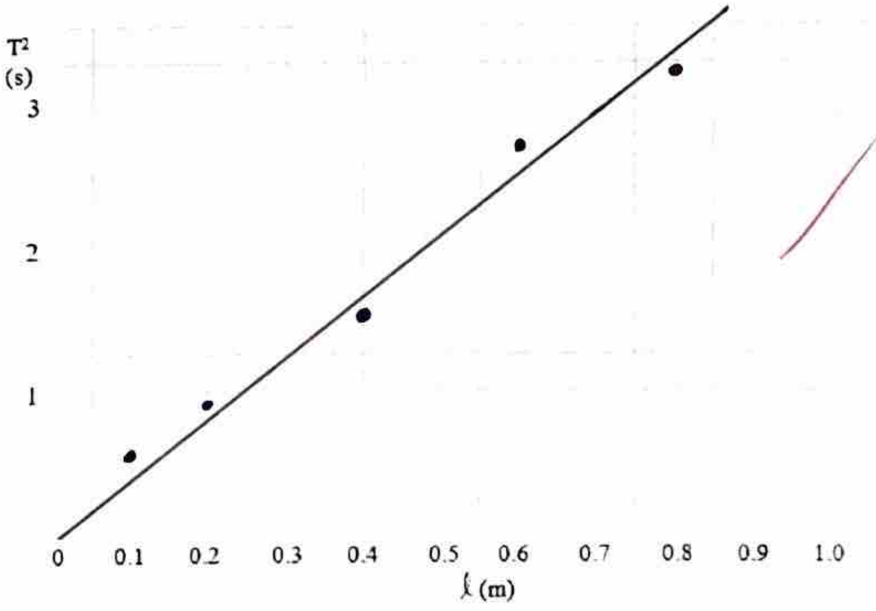
$$T = 2\pi\sqrt{\frac{l}{g}}$$

They conducted an experiment and recorded the period of oscillation for different pendulum lengths. An incomplete table of their results is shown.

Length (m)	*Time - 10 oscillations* (s)	*Period* (s)	*Period²* (s)
0.1	7.4	0.74	0.55
0.2	9.5	0.95	0.90
0.4	12.3	1.23	1.51
0.6	16.5	1.65	2.72
0.8	17.8	1.78	3.16

(a) Use the grid provided to graph their results. **1**

1



(b) Draw in a line of best fit, and use the gradient to determine the students' experimental value for g. **3**

$\frac{3.5}{0.85}$

$T = 2\pi\sqrt{\frac{l}{g}}$

$m = 4.11$

$T^2 = 4\pi^2\left(\frac{l}{g}\right)$

$4.11 = 4\pi^2\left(\frac{1}{g}\right)$

$\frac{1}{g} = 0.1$

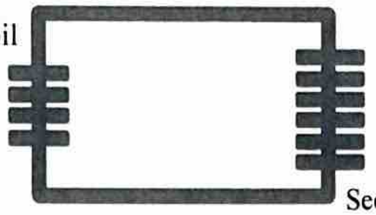
$g = 9.605\ m/s/s$

$\frac{P}{I} = Ir$

$P = I^2 r$

Question 27 (7 marks) $\frac{P}{I^2} = r$

The diagram models a transformer used to power distribution grids in Australia.



(a) Name this type of transformer and describe where it can be used in a power transmission grid. **2** (2)

Step ~~ed~~ up transformer
Increases voltage.
Used at power plant to transmit electricity with low resistance

(b) Design features are used in grid transformers to overcome issues with resistance and power loss. **5** (4)

Explain how resistance and power loss can be addressed in modern transmission grids.

By upping the voltage using a transformer, the electricity's current drops. Using the formulas $V=IR$ and $P=VI$, you can show that $R = \frac{P}{I^2}$. given that I is squared, decreasing it has a ~~ba~~ big drop in resistence without a loss in power. Lower resistance results in ~~tor~~ less wast/lost electricity such as heating the wires. This makes the transport more efficient. The process can be undone with a step down transformer at the other end. AC current is also more efficient than DC urrent. As such, generators produce AC.

also laminations, thicker wire.

Question 28 (7 marks)

Nuclear reactions can produce a range of radiations. The safety precautions used in any situation will depend on the type of radiation being produced or used.

(a) Not all nuclear reactions are classified as transmutation reactions. **3**

The production of which type/s of radiation – alpha, beta, or gamma – would be classified as transmutation reactions? Use THREE example reactions to justify your answer.

A Gamma radiation ~~is a~~ radiation reaction is clasified as a transmutation reaction. ✗

Alpha particles are released in fission reactions. ~~For exam~~

Beta particles are released in fusion reactions.

α & β

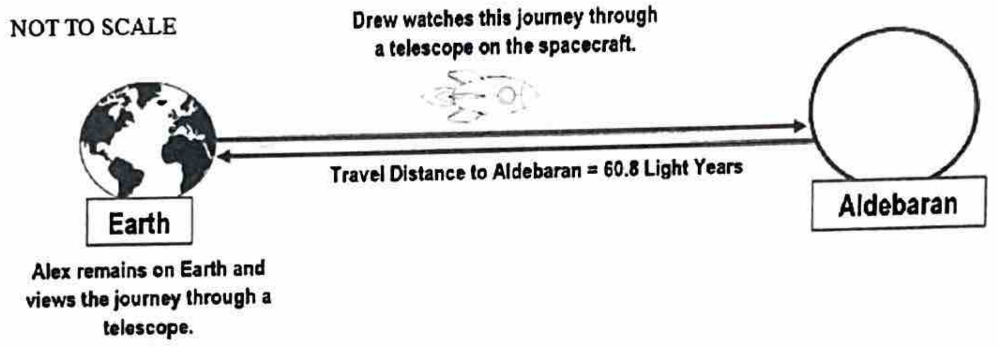
(b) Relate the properties of fission reactions and the nuclear radiation produced, to the safety precautions needed when operating fission reactors. **4**

Fission reactions work by splitting attoms. When this occurs, neutrons are released along with other types of radiation. The neutrons that ~~are~~ released can trigger other neulear fission reactions casing a chain reaction. While fission reactors utilise this to generate power, they require dense control rods to be inserted into the reactor to slow the reaction. The radiation produced also must be contained using eg. Water, Concre

Question 29 (6 marks)

Drew, an identical twin, is launched from Earth in a relativistic spacecraft travelling at 0.99c across space to the star Aldebaran which is 60.8 light years (60.8 Ly) away.

His identical twin, Alex, watches this journey from Earth, using a telescope.



Compare the age of each twin when Drew returns to Earth after his journey, then use your results to help explain how the twin paradox riddle can be resolved. **6**

5

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

time for Drew = $\frac{60.8}{0.99}$

= 61.4 years

$$\frac{61.4}{\sqrt{1 - \frac{0.99}{c}}}$$

$= 61.4$

∴ After the trip, ~~the~~ Drew will be 61.4 years younger than Alex

As such the twins who ~~wt~~ were born at the same time are different ages.

Twin Paradox

accel nullifies relativity.

Question 30 (7 marks)

We receive approximately 430 x 10^{18} joules of energy from the Sun each day. This is enough energy to power the world.

(a) Relate Einstein's equivalence of mass and energy to explain how the Sun produces this energy. **4**

3

$e = mc^2$

The suns production of energy comes at the cost of mass. The dense metals in the core of the sun are compressed by gravity to the point of nuclear fusion. This proccess produces excess radiation which is released from the sun. As such, the proccess of compressing hydrogen and helium into increasingly dense elements releases the energy that powers the world.

by converting mass defect into energy.

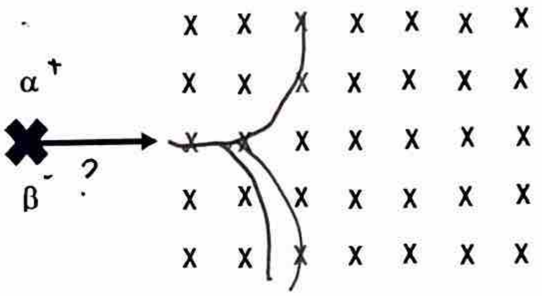
(b) Explain how the spectra of our Sun would differ to a much larger, distant star. **3**

The absorption bands would be different depending on what elements ~~a~~ are present in the ~~stan~~ star. The expansion of the universe would cause the emission spectra to be slightly redshifted due to the doplar effect.

Question 31 (8 marks)

An alpha and beta particle are fired into a magnetic field separately from the same position as shown. Their motions are analysed carefully and compared.

Both particles are fired into the magnetic field which has a strength of 6.7×10^{-4} T with the same velocity of 0.4 c.



(a) Explain any differences that occur as these particles enter the field separately. **5**

4

They both experience the exact same magnitude of forces, just in different directions. × different charge magnitude

The alpha particle will be deflected ~~down~~ up in a ~~clockwise~~ counter-clockwise curve while the beta particle will be deflected ~~up~~ down in a ~~counter~~ clockwise curve.

(b) Calculate the radius achieved by the beta particle if it stays in this magnetic field. **3**

~~$F = qvB \sin\theta$~~

~~$= 1.602 \times 10^{-19} \times 0.4c \times 6.7 \times 10^{-4}$ T~~

$F_c = \frac{mv^2}{r}$ $\quad F_c = F_B$

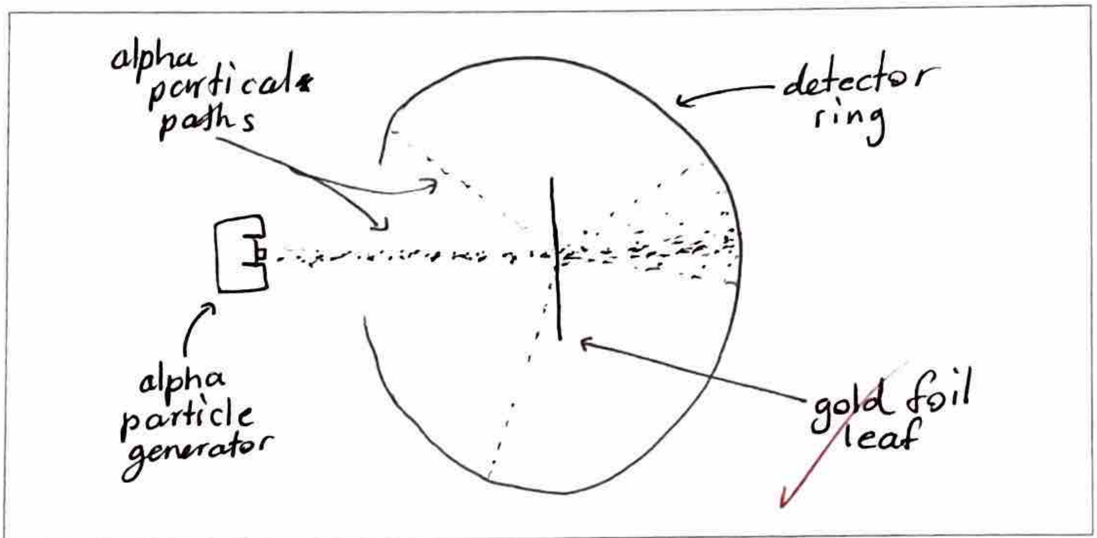
$= \therefore 1872$ m

Question 32 (6 marks)

Several scientists and many experiments have contributed to the development of the current atomic model.

Draw a model of the Geiger-Marsden experiment and explain how Rutherford's analysis of the results from this experiment advanced the atomic model. 6

6



Rutherford noticed that while the majority of the alpha particles parsed straight through the gold foil leaf with minimal diflection, some were deflected with an angle greater than anyone expected. This was identified by unexpected flashes indicating an alpha particle had hit a detector that ~~it~~ ~~was~~ it had not been expected to hit. Rutherford reasoned that the only way the ~~at~~ atom of gold could deflect the alpha particles to such an extent would be if they ~~where~~ were primarily empty space, with a hyper dense neucleaus. This observation disproved the plum pudding ~~modle~~ model in favour of the Rutherford model in which electrons orbited around a central neucleus containing the protons. ~~and neutrons.~~

undiscovered at this time.

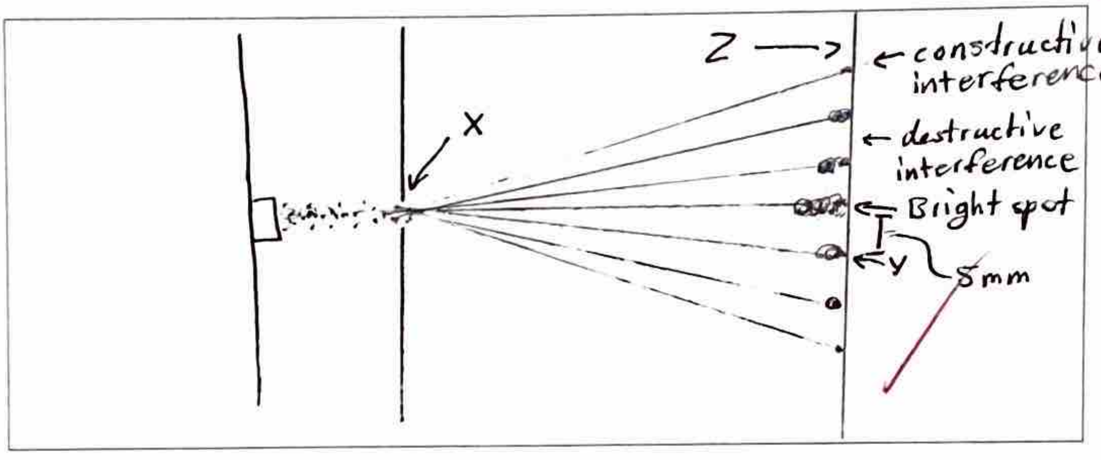
Question 33 (7 marks)

A red laser light with a wavelength of 652 nm was used in the Young's Double Slit experiment to determine the distance from the diffraction slits (*X*) to screen (*Z*).

The experiment had a slit separation of 250 μm. The distance between the bright spot and the first order value (*Y*) was measured as 5 mm.

(a) Draw a diagram of this experiment. **1**

1



(b) Calculate the distance from the diffraction slits (*X*) to the screen (*Z*). Include an explanation of how tan θ and sin θ are used to calculate *X* to *Z*. **3**

1

$d\sin\theta = m\lambda$ 250μm = 0.00025m

$\sin\theta = \frac{0.00025 \times 6.52\times10^{-7}}{0.005}$ 652 nm = 6.52×10⁻⁷

5mm = 0.005m

$\frac{\lambda}{d} = \frac{0.005}{x}$

$\theta = 1.868\times10^{-7}$

$a^2 = c^2 - b^2$

$a = \sqrt{2.5\times10^{-5}} = 0.005$

0.005 1.63×10^{-10} θ

∴ distance = 0.005m = 5mm

(c) Evaluate how the evidence for this experiment supports the principle of light possessing a wave-particle duality. **3**

2

The ~~wave~~ light experiances constructive and destructive wave ~~interp~~ interforence after it passes through the slit and is defracted.

interference is a wave property.

~~The~~ This observance to the rules of waves means that the ~~=~~ light rays sometimes behave as waves and sometimes as particles.