LMC Lachlan Macquarie College

2021 TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

HSC Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- Calculators approved by NESA may be used

Total marks:
100

Section I – 20 marks (pages x–xx)

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

Section II – 80 marks (pages xx–xx)

- Attempt Questions 21–34
- Allow about 2 hours and 25 minutes for this section

Section I

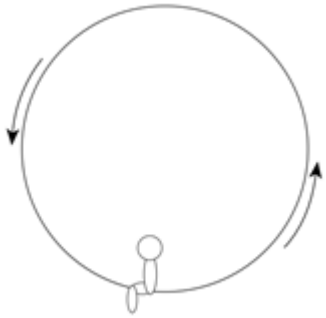
20 marks
Attempt Questions 1–20
Allow about 35 minutes for this section

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

1 The spectrum of a star is observed to have absorption bands that are wider than usual for a star of comparable temperature. What does this imply about the star?

A. It has a high density.
B. It is receding more rapidly.
C. It has a different chemical composition.
D. It has a large difference in temperature between its core and outer atmosphere.

2 A 600 N passenger travels in a circular path on a ferris wheel at Luna Park.



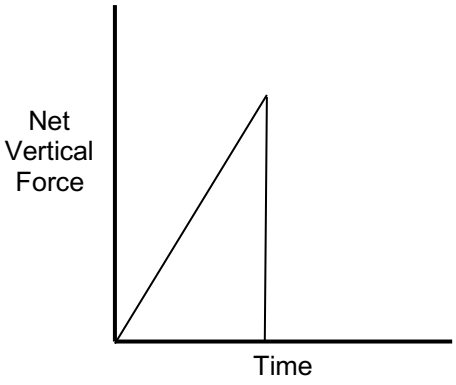
Which option best represents the forces acting on the passenger at the lowest point on the ferris wheel?

A. N = 500 N, mg = 600 N
B. N = 600 N, mg = 500 N
C. N = 600 N, mg = 600 N
D. N = 700 N, mg = 600 N

3 A clever physics student builds an electromagnetic levitation toy. When they turn on the power a small magnet slowly rises off the base and levitates a few centimeters into the air.

Which graph best shows the vertical forces on the magnet from the time the toy is started (t=0) to when it is levitating?

A.



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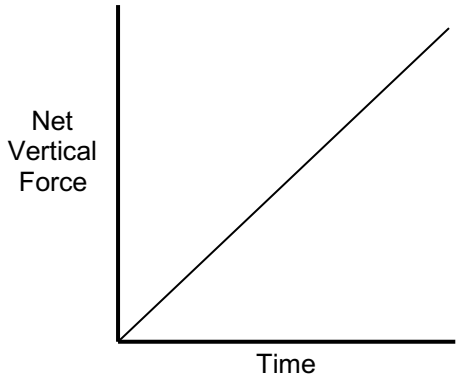

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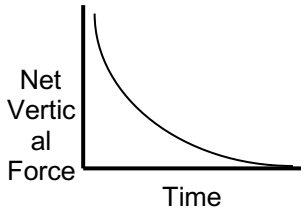
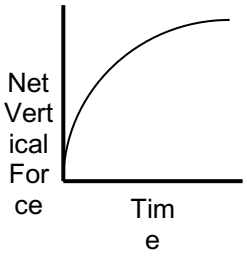


D.

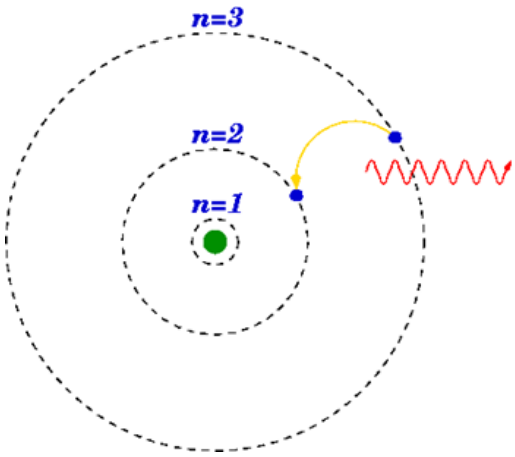


4 Theme park rides can have fail-safe braking systems consisting of conductive plates on the side of the ride which pass by extremely strong magnets on the rails. The Physics principle this system relies on is:

A. Lenz's Law
B. Malus' Law
C. Wien's Law
D. Faraday's Law

5

The image shows the transition of an electron from the 3rd to the 2nd energy level in the hydrogen atom which releases a photon.



The Rydberg equation describes the energy of the released photon.

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

What will the product of the Rydberg constant, R, and the wavelength, λ, of the released photon be?

A. $R\lambda = \frac{10}{72}$
B. $R\lambda = \frac{4}{3}$
C. $R\lambda = \frac{100}{21}$
D. $R\lambda = \frac{36}{5}$
E.

6 Dissolving ammonium chloride is an endothermic process. 53.49106 g of ammonium chloride, when dissolved, absorbs 14.4 kJ of energy. By how much does the mass change in this process?

A. 1.6×10^{-16} kg
B. -1.6×10^{-13} kg
C. 1.6×10^{-13} kg
D. -4.8×10^{-5} kg

7

The equation shows the radioactive decay of copper-64

$$\text{Cu-64} \rightarrow \text{Ni-64} + e^{+} + \nu$$

How does the Standard Model understand the transformation occurring inside the nucleus of this atom?

A. An electron becomes a positron
B. An up quark becomes a down quark
C. A down quark becomes an up quark
D. A neutron becomes a proton and an electron

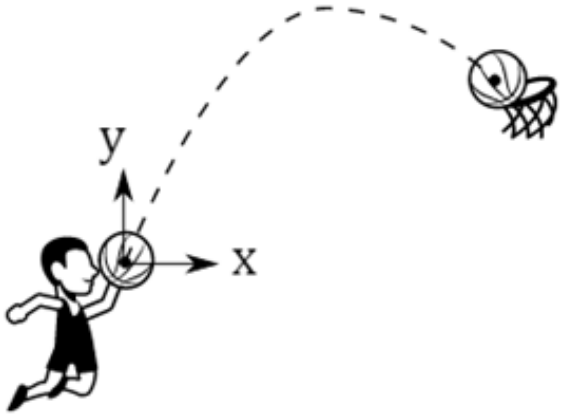
8

The gravitational force of attraction between the Sun and the asteroid Icarus travelling in an orbit of radius 1.5×10^{11} m is 6.0×10^{9} N. Given that the mass of the Sun is 2.0×10^{30} kg, what is the mass of the asteroid?

A. 1.0×10^{11} kg
B. 6.7×10^{11} kg
C. 1.0×10^{51} kg
D. 6.7×10^{51} kg

9

A student throws a basketball towards the net at an angle of 45^{0} to the horizontal with an initial velocity of 2.25 $m.s^{-1}$ from a height of 2.25 m above the ground. He is standing 3.65 m away from the mid point of the net and scores. For how long is the ball in the air before it lands in the basket?



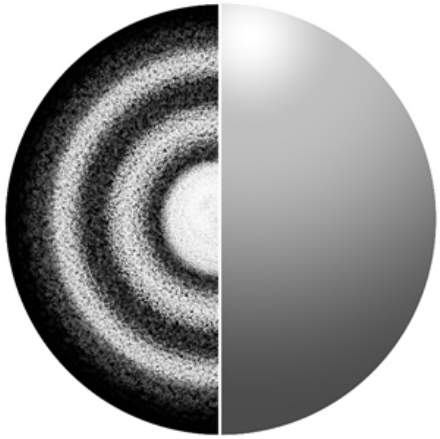
A. 0.4 s
B. 1.6 s
C. 2.3 s
D. 8.2 s

10

Which experiment uncovered properties of the atom that could not be explained by classical physics?

A. Geiger-Marsden experiment
B. Millikan's oil drop experiment
C. Chadwick's discovery of the neutron
D. Lenard's experiments on the photoelectric effect

11 The image shows a visual interpretation of Ernst Schrödinger's model of the atom



Which of the following correctly states one of Schrödinger's contributions to our model of the atom?

A. Electrons travel in quantized orbits around the nucleus
B. The electron is held in a circular orbit by electrostatic attraction
C. Electron locations could only be described as being part of a 'cloud' around the nucleus
D. The position and momentum of the electron around the atom could not both be precisely known

12 Identify a strategy to improve transformer efficiency due to resistive heat production:

A. Cooling Fins
B. Solid Iron Core
C. Grounding Wire
D. Insulated Wire Turns

13 Which of the following provided evidence to support Newton's corpuscular theory of light?

A. Light travels in straight lines.
B. Light produces interference patterns.
C. Light refracts as it enters a medium from air.
D. When light reflects, the angle of incidence equals the angle of reflection.

14 Light with a wavelength of 400 nm is incident upon a material with a work function of 3.11 eV. A potential difference is applied to just stop the ejected photoelectrons. Calculate the required stopping voltage.

A. 1.16 mV
B. 6.6 mV
C. 1.9 V
D. 6.6 V

15 The speed of light in Perspex is 2.1×10^{8} ms^{-1}. What is the wavelength of a photon with frequency 6.2×10^{14} Hz.

A. 295 nm
B. 339 nm
C. 339 μm
D. 295 μm

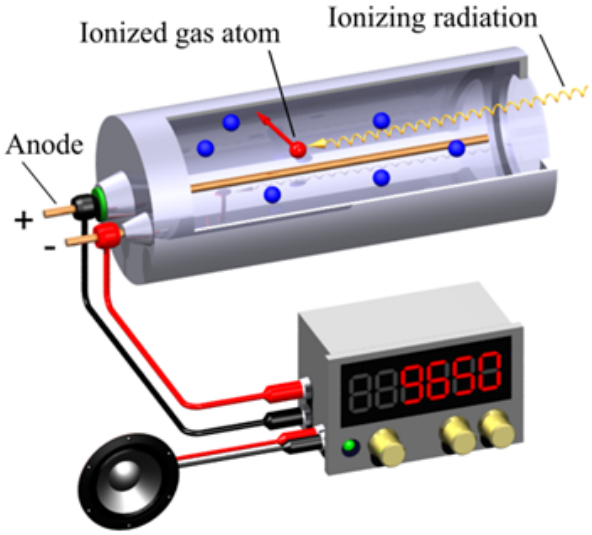
16

Which one of the following best describes the motion of a projectile close to the surface of the Earth? (assume no friction)

A. changing vertical acceleration, constant horizontal speed
B. constant vertical acceleration, changing horizontal speed
C. constant vertical acceleration, constant horizontal speed
D. changing vertical acceleration, changing horizontal speed

17

A Geiger counter is able to measure the radioactivity of a source of ionizing radiation as a count rate, A, measured in counts per second or counts per minute.



The count rate is related to the decay constant of the radioactive species, λ, by the equation

$$A=\lambda N$$

Where N is the number of radioactive particles present at a certain time.

The half-life of iodine-131 is 8.05 days. Determine the count rate per second of a sample of 10^6 undecayed I-131 atoms.

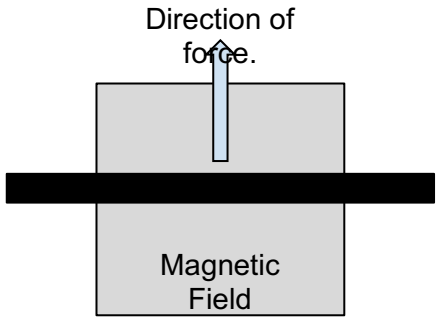
A. 1.0×10^{-6}
B. 1.0
C. 60
D. 8.6×10^5

18

A current carrying wire in a uniform magnetic field experiences a force as show in the

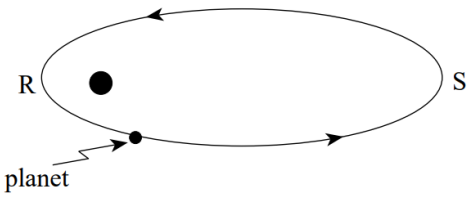
diagram:

Which pair of magnetic and electrical conditions would produce this force?



	Magnetic Field direction	**Conventional Current direction**
A.	Into page	To the left
B.	Out of page	To the left
C.	To the left	Up the page
D.	To the left	Down the page

19 A planet is in orbit as shown in the diagram below.

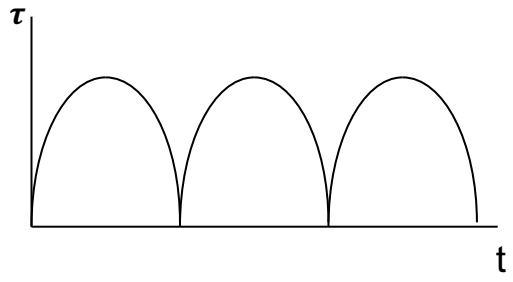


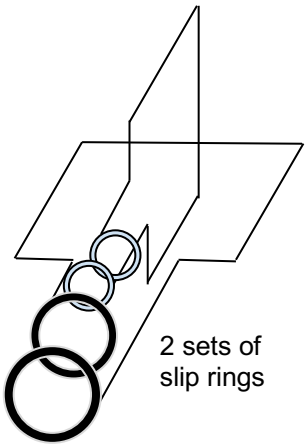
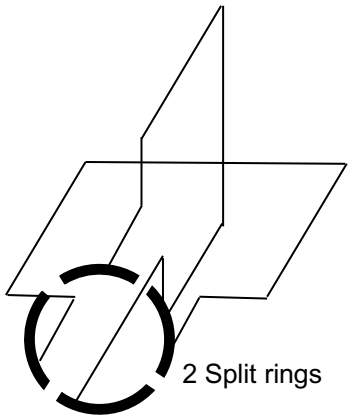
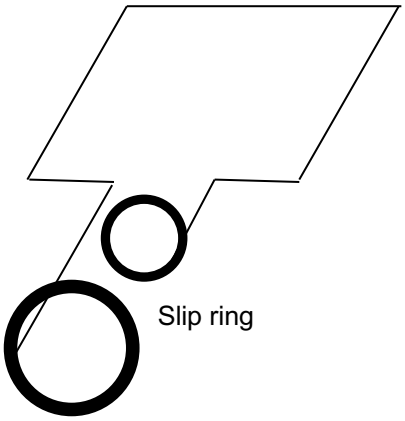
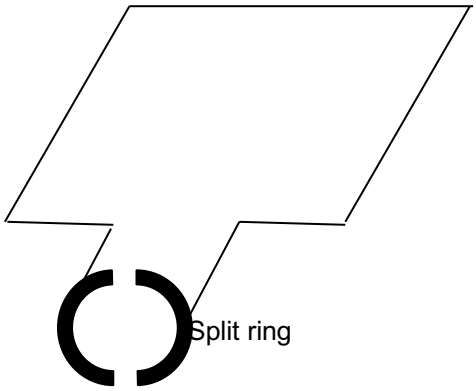
The planet's gravitational potential will:

A. be constant throughout its orbit.
B. always be equal to its kinetic energy.
C. increase as the planet goes from point R to point S.
D. decrease as the planet goes from point R to point S.

20

Which of the pictured motor coils corresponds with the τ vs t graph below?



A.		B.	
C.		D.	

2021 TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION	
Physics Section II Answer Booklet	Centre Number Student Number
80 marks **Attempt Questions 21–34** **Allow about 2 hours and 25 minutes for this section**	

Instructions

- Write your Centre Number and Student Number 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.

Please turn over

Question 21 (4 marks)

Early investigations into the nature of cathode rays used a second pair of plates halfway along a Crookes tube in an attempt to deflect the cathode ray beam.

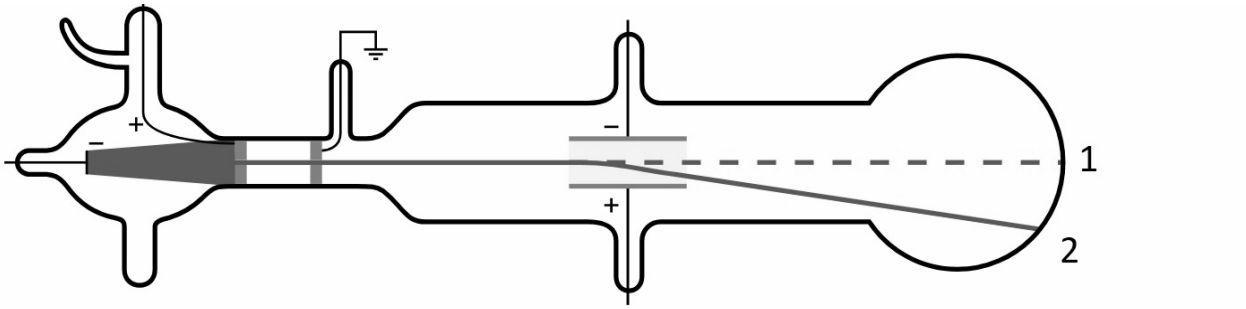


Image: commons.wikimedia.org

(a) In 1883 Hertz observed the cathode rays undeflected following the trajectory labelled 1 in the diagram. However in 1897 JJ Thomson, by evacuating the vacuum tube further than Hertz had been able to, was able to show cathode rays following the trajectory labelled 2. Explain the importance of Thomson's finding in determining the true nature of cathode rays. 2

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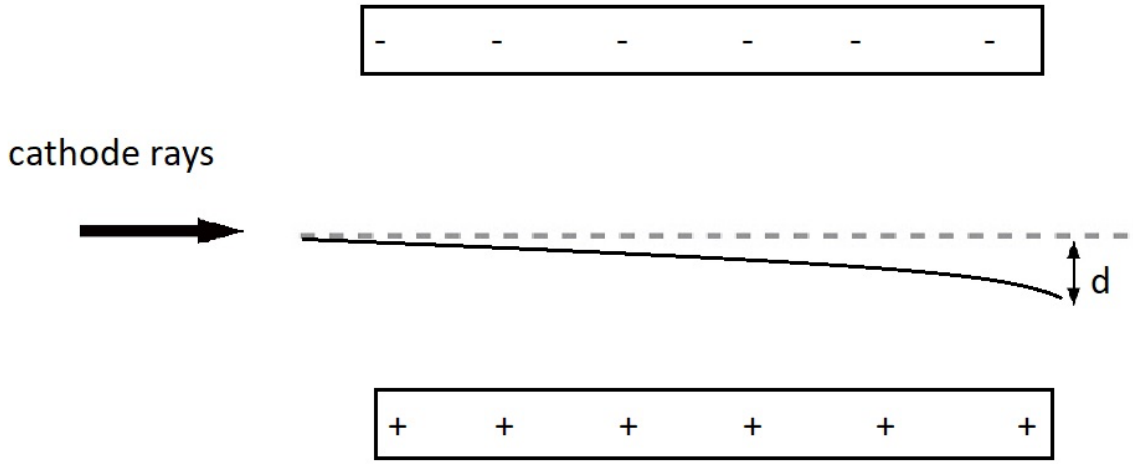
(b) The cathode rays are deflected by a distance d from their original path after travelling between the charged plates. 2



If the velocity of the electrons in the Crookes tube were doubled, and everything else kept the same, what would the new vertical deflection be?

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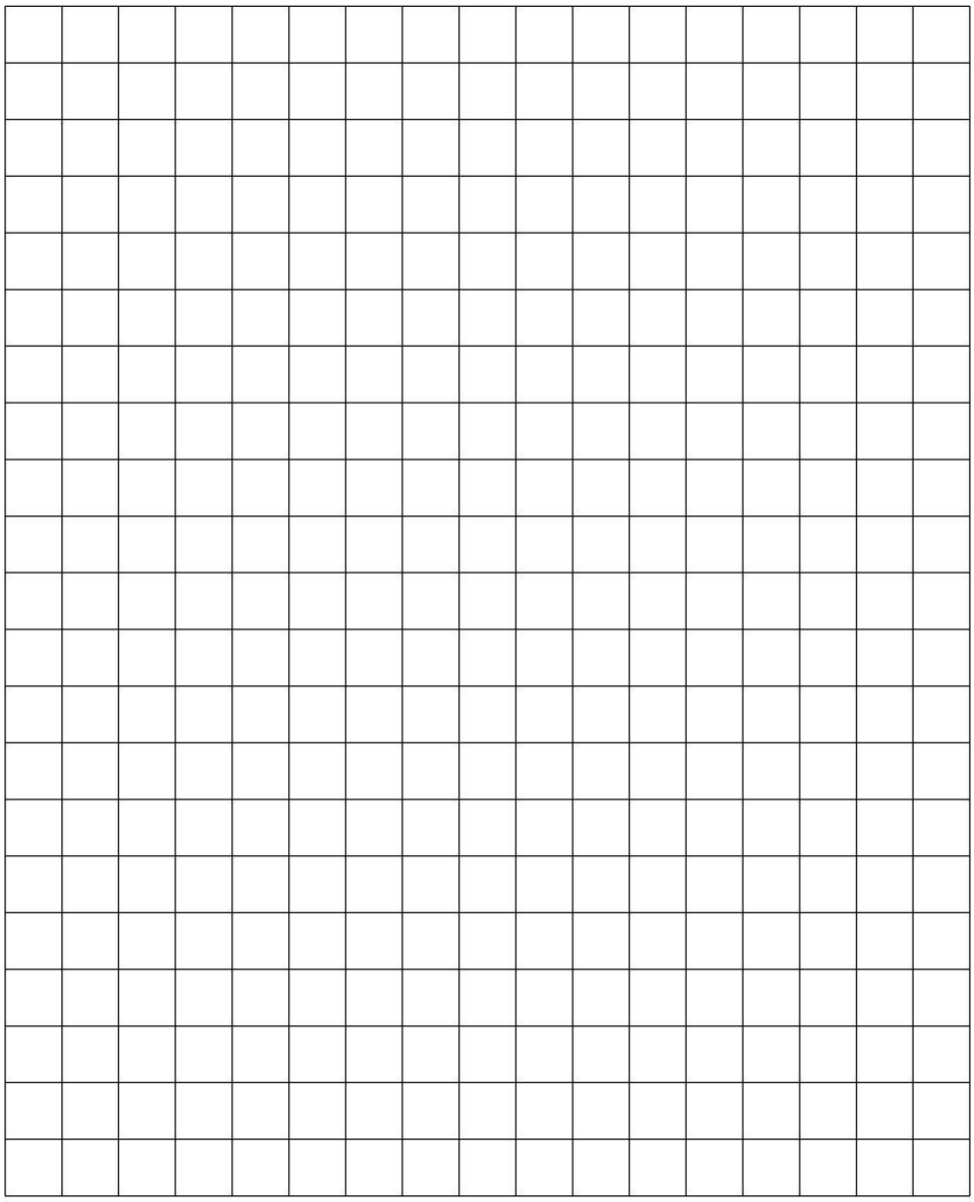
Question 22 (4 marks)

Mike the mechanic performed tests on a spanner (a tool used to tighten or loosen a bolt).

The results are provided in the following table:

Force exerted on bolt (N)	Tightening torque (Nm)
50	16
100	31
150	46
200	61
250	78

(a) Use the data to produce a graph of torque vs force on the bolt tested. 3



(b) Use your graph to estimate the length of Mike's spanner for maximum torque. 1

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Question 23 (9 marks)

Robert Millikan used a uniform electric field between two parallel plates to investigate the properties of a charge. His apparatus included an atomiser that sprayed a fine mist of oil drops into a chamber (upper chamber). Some drops drifted into a second chamber below (lower chamber) where they were exposed to a beam of x-rays, resulting in some of the drops becoming charged. An electric field, E, was applied to the lower chamber. A microscope was used to view the space between the charged plates in the lower chamber. Careful adjustment of the voltage allowed singular oil drops to be held stationary, suspended in mid-air.

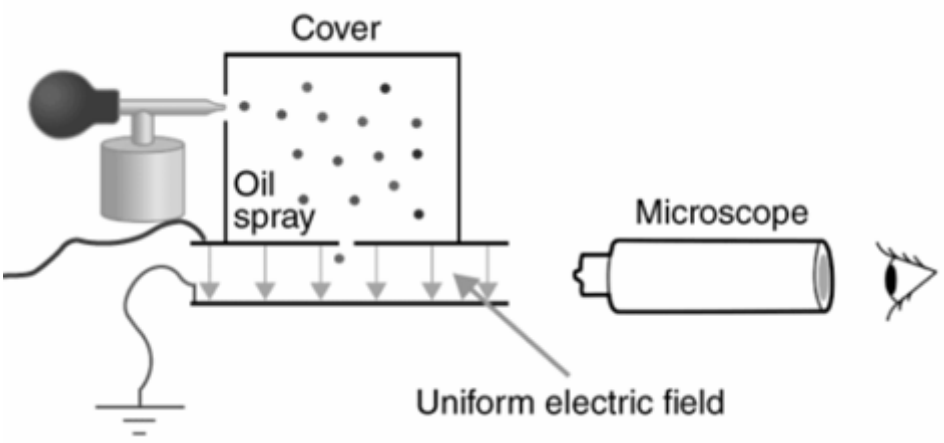

Image: commons.wikimedia.org

(a) Draw a vector diagram showing the forces acting on an oil drop when the electric field is turned on and it is suspended, mid-air, in the lower chamber. 2

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(b) The density of the oil used was 875 kg.m-3. Calculate the mass of an oil drop with radius 1.5 x 10-6 m. (Volume of a sphere: $V = \frac{4}{3}\pi r^2$ and Density: $\rho = \frac{m}{V}$). 2

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(c) When the electric field was turned off, the terminal velocity of the falling oil drop from (b) was 3.6×10^{-1} m.s^{-1}. When turned on, work was done on the oil drop to suspend it in the chamber. Using your answer from (b), calculate the applied voltage if the charge on the oil drop was -1.6×10^{-19} C. 3

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(d) How was reliability ensured in this experiment? 2

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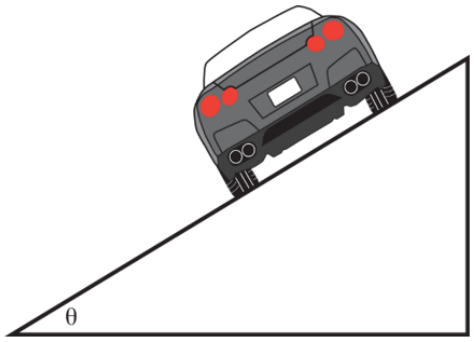
Question 24 (7 marks)

Racing car tracks use banked turns that are sloped to keep race cars tilted inwards. These banks are both safer and faster than flat roads. Very fast race cars would skid off the track if not for the banked turns.

(a) Labelled the diagram showing the forces acting on a car rounding a banked curve. 2



(b) Determine a formula for the angle at which a road should be banked so that no friction is required for a car travelling with a speed v around a curve of radius r. 3

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(c) What is the angle at which a speedway must be banked for cars travelling at 200 $km.h^{-1}$ if the radius of curvature is 200 m? 2

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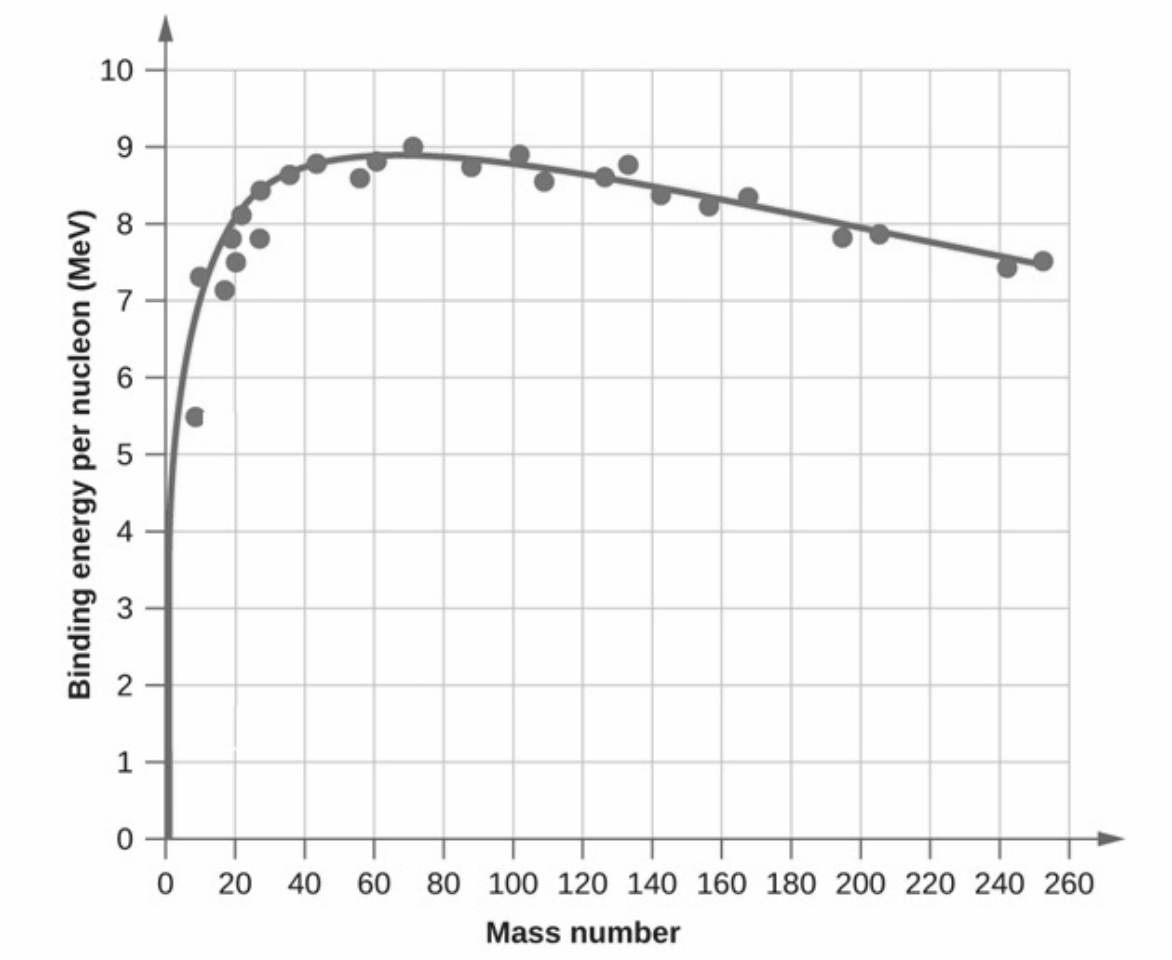
Question 25 (3 marks)

Use the graph below to show that the mass defect of an americium-241 nuclide is 1.9 u.



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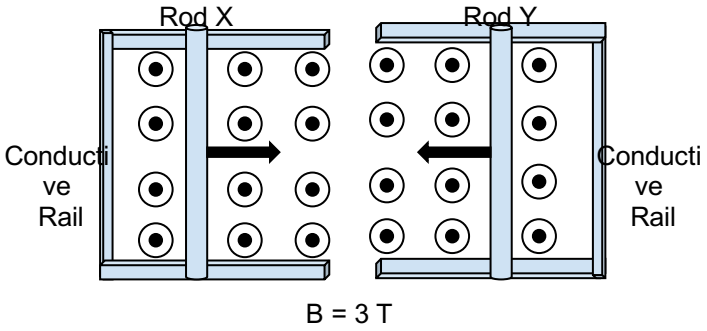
Question 26 (7 marks)

For an investigation two, 15 cm long, metal rods are rolled towards each other through a 3 Tesla uniform magnetic field. The rods each rest on separate conductive rails:



(a) Calculate the change in flux experienced by a rod if it travelled 5 cm into the field in the first second of the investigation. 2

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(b) The force rolling each rod is 0.5N. Calculate the magnitude of the current induced in each rod and the direction of this current. 3

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(c) Develop and explain a hypothesis describing the force exerted between the rods as they approach each other. 2

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Question 27 (4 marks)

Two atomic clocks are synchronised. One is left at rest on the Earth and the other is flown in a spacecraft into space at 2.4×10^8 ms^{-1}.

Quantitatively compare the distance the spacecraft has travelled according to observers on Earth and observers on the spacecraft. Account for the difference in observation. 3

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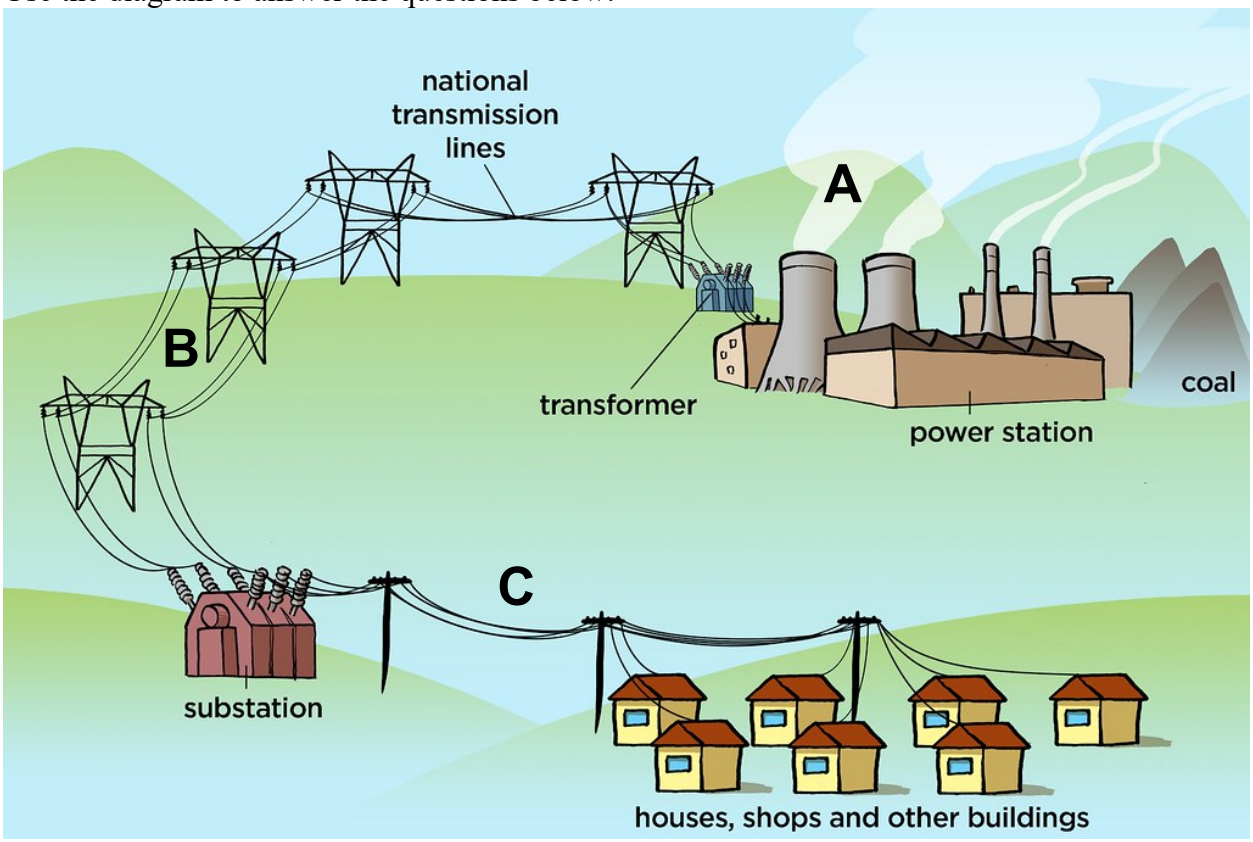
Question 28 (3 marks)

Use the diagram to answer the questions below:



"Coal Power Station and electricity distribution", by Siyavula Education, licensed under CC by 2.0

A transformer "substation", is necessary between B and C. Identify the type of transformer this "substation" represents, explain why it is necessary and qualitatively describe the arrangement of its coils. 3

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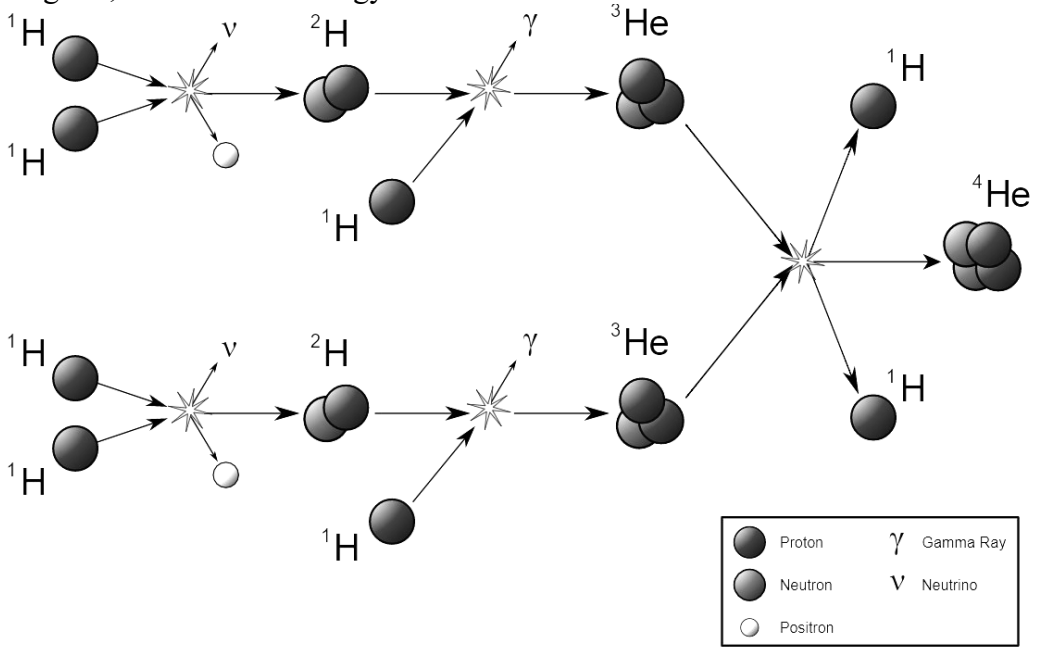
Question 29 (8 marks)

In stars a number of energy-releasing nuclear reactions can occur.

(a) Identify the process shown in this diagram which occurs in main sequence stars and outline ONE way in which energy is produced in this reaction and TWO forms, seen in the diagram, in which this energy takes after the reaction 4



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(b) Lithium undergoes the following series of nuclear reactions in some brown dwarf stars. 2

$$p + {}^{6}_{3}Li \rightarrow {}^{7}_{4}Be \quad \text{(unstable)}$$

$${}^{7}_{4}Be + e^{-} \rightarrow {}^{7}_{3}Li + \nu$$

$$p + {}^{7}_{3}Li \rightarrow {}^{8}_{4}Be \quad \text{(unstable)}$$

$${}^{8}_{4}Be \rightarrow 2\,{}^{4}_{2}He + \text{energy}$$

Particle	Mass
Proton	1.007277 u
Li-6	6.015122 u
Electron	0.000548597 u
He-4	4.002602 u

Calculate the energy released from this process.

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(c) With reference to the general trend of energy / nucleon, why is this an unusual nuclear process? 2

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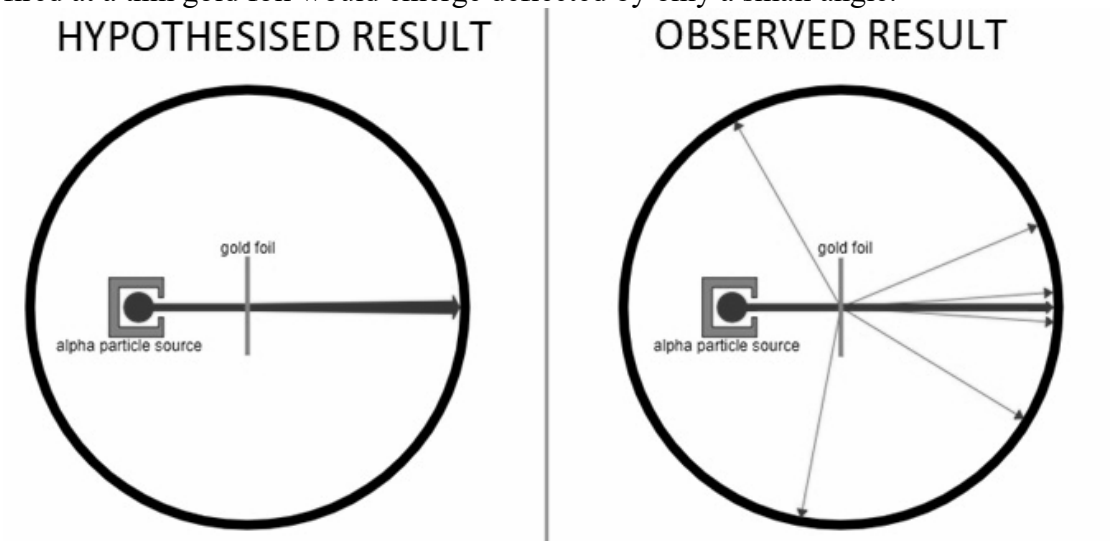
Question 30 (7 marks)

Prior to the Geiger-Marsden experiment it was reasoned by Rutherford that most α-particles fired at a thin gold foil would emerge deflected by only a small angle.



Discuss factors which can result in the modification of scientific models and in so doing explain why Rutherford's hypothesis was modified after the Geiger-Marsden experiment.

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Question 31 (6 marks)

To investigate the wave model of light, a student conducted the following procedure:

1. Measure two 1 m lengths of string and mark them at 5 cm intervals.
2. Fix the ends of the string a short distance apart, d.
3. Make a triangle of the strings such that the last dot of each string forms the apex of the triangle
4. Move the apex of the triangle to the right until the last dot of one string meets the second last dot on the other string, as shown below.
5. Measure the angle from the point midway between the fixed ends of the strings to the apex of the new triangle. Record this as θ.
6. Use the measurements you have made to calculate the distance between the fixed ends of the strings.

(a) Explain how this procedure models the diffraction pattern caused by light passing through 2 slits. 3

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(b) Use a diagram to show how the equation $d\sin\theta=m\lambda$ can be derived from this model. Explain any approximations you make. 3

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Question 32 (9 marks)

Design a reliable investigation which demonstrates the interaction between two parallel current-carrying wires. Include a diagram as well as a description of how you would obtain valid qualitative and quantitative data from the investigation.

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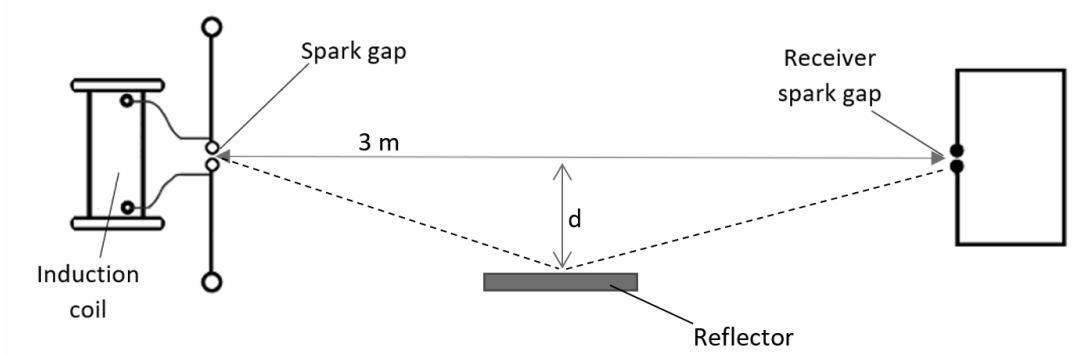
Question 33 (5 marks)

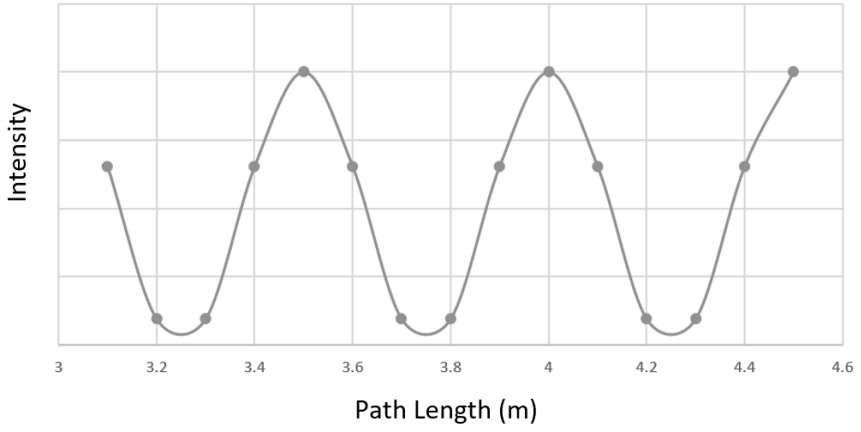
In his investigation of electromagnetic waves, Hertz set up apparatus similar to that shown below:



Sparks were generated 3 meters away at the receiver spark gap by the unknown waves produced by the sparks at the spark gap. The frequency of the sparks at the spark gap can be controlled.

A reflector was positioned midway between the spark gap and the receiver spark gap, at a variable distance, d, from the path between them. The dotted line shows the path of a reflected ray.

As d varied, the spark intensity at the receiver also varied. The length of the reflected ray's path was calculated and the spark intensity recorded. A sketch of the results are shown below.



(a) Why does the intensity of the spark vary? 2

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(b) With reference to the work of other scientists in his time, why did Hertz suspect the 3

unknown radiation was electromagnetic radiation?

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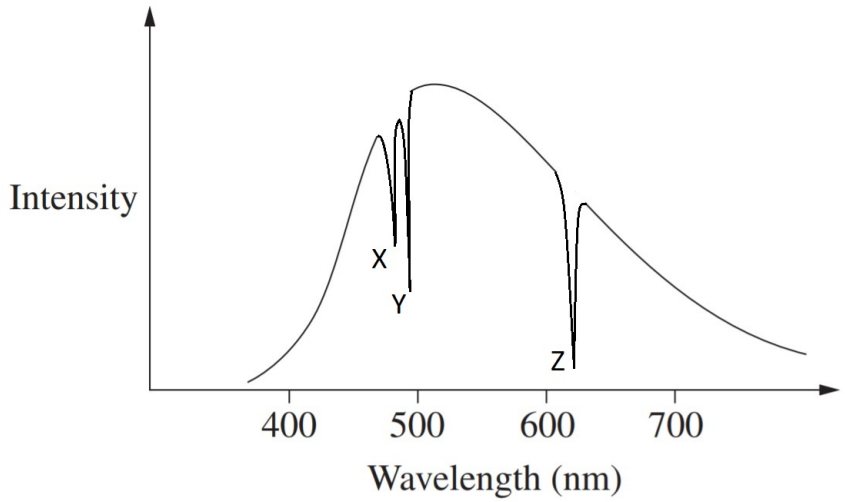
Question 34 (5 marks)

Examine the following stellar spectrum.



(a) Determine the surface temperature of this star 2

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(b) Identify the general name for the features of this spectrum labelled X, Y and Z and account for their production, in the outer layers of a star, 3

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LMC 2021 HSC Physics Trial
Marking Guidelines

Section I
Multiple-choice Answer Key

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

Section II

Question 21 (a)

Criteria	Marks
● Correctly outlines the implications of the new findings. ● Relates the new findings to the true nature of Cathode Rays as negatively charged particles.	2
● Any 1 of the above OR provides some relevant information	1

Sample answer

The importance of this finding was that it conclusively showed that cathode rays were negatively charged particles and resolved the debate once and for all over whether they were particles or radiation. Observations made by Hertz that electric fields did not appear to deflect cathode rays inside the Crookes tube seemed to suggest that cathode rays were some form of radiation.

By evacuating the vacuum tube to remove further gas JJ Thomson then showed that cathode rays were indeed deflected by an electric field. Thomson showed that the non-deflection Hertz saw was the result of charge on the plates inside the Crookes tube dissipating due to the effect of ionised gas inside the vacuum tube.

Question 21 (b)

Criteria	Marks
● Correctly describes the new path of the electron. ● Explains the impact of the changed speed.	2
● Any 1 of the above OR provides some relevant information	1

Sample answer

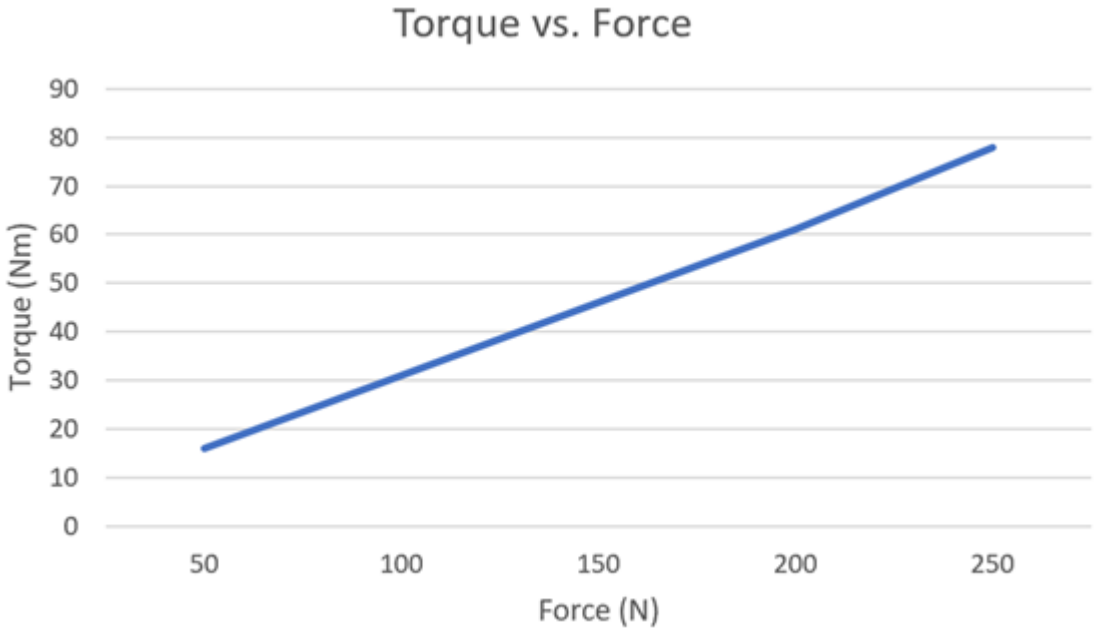
Deflection follows a parabolic path. Doubling the speed, will reduce the time the electron is in the field by half. The electron's vertical deflection is governed by $s = ut + \frac{1}{2}at^2$ therefore deflection is proportional to the inverse square of the velocity.

Deflection = d/4

Question 22 (a)

Criteria	Marks
• Correct graph including: ○ Appropriate Scale ○ Labelled Axes ○ Line of Best Fit	3
• Graph with any 2 of the above.	2
• Attempts a graph OR • provides some relevant information	1

Sample answer



Question 22 (b)

Criteria	Marks
Correctly calculates the length using the gradient from the graph	1

Sample answer

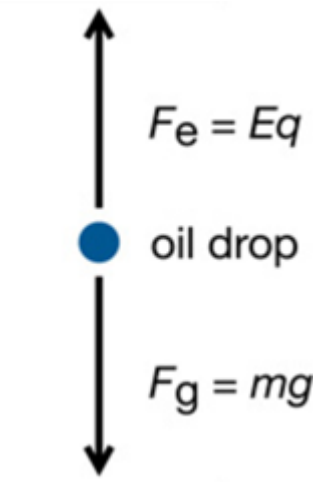
For maximum torque, assume the force was applied perpendicular to the length of the spanner.
The gradient of the line of best fit represents the length of the spanner (the distance at which the force was applied)

$$r = \frac{\Delta\tau}{\Delta F} = \frac{78 - 16}{250 - 50} = 0.31\ m\ = 31\ cm$$

Question 23 (a)

Criteria	Marks
• Vector for Electrostatic force shown and labelled. • Vector for Weight force shown and labelled.	2
• Any 1 of the above OR provides some relevant information	1

Sample answer



Question 23 (b)

Criteria	Marks
• Correctly calculates the Volume of the oil drop. • Correctly calculates the Mass of the oil drop.	2
• Any 1 of the above OR provides some relevant information	1

Sample answer

Volume of oil drop:

$$V = \frac{4}{3}\pi r^3 (1.5\ x\ 10^{-6})^3 = 1.4\ x\ 10^{-17}\ m^3$$

Mass of oil drop:

$$m = \rho V = (875)(1.4\ x\ 10^{-17}) = 1.23\ x\ 10^{-14}\ kg$$

Question 23 (c)

Criteria	Marks
● Recognises that Work done on the oil drop is equivalent to change in kinetic energy. ● Correctly calculates Work done on the oil drop. ● Correctly calculates the Voltage applied to the oil drop.	3
● Any 2 of the above	2
● Any 1 of the above OR provides some relevant information	1

Sample answer

Work must be done to change the kinetic energy:

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

Rearrange equation to calculate applied voltage:

$$V = \frac{(0.5)mv^2}{q} = \frac{(0.5)(1.23\ x\ 10^{-14})(3.6\ x\ 10^{-1})^2}{-1.6\ x\ 10^{-19}} = 5.00\ x\ 10^3\ V$$

Question 23 (d)

Criteria	Marks
● Makes a statement linking repetition to reliability. ● Makes a statement linking consistency/similarity of results to reliability.	2
● Any 1 of the above OR provides some relevant information	1

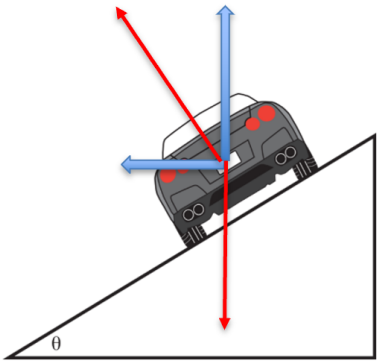
Sample answer

Millikan repeated his experiment thousands of times and compared his results to ensure they were consistent for drops of the same size.

Question 24 (a)

Criteria	Marks
• Vector for Normal force shown and labelled. • Vector for Weight force shown and labelled.	2
• Any 1 of the above. • OR unlabelled vector for both forces. • OR forces identified without vectors. • OR Provides some relevant information.	1

Sample answer



Red vector approximately North-West: Normal force

Red vector pointing down: Weight (mg)

Question 24 (b)

Criteria	Marks
● Correct formula derived and linked to centripetal force showing comprehensive sequence of steps.	3
● Steps shown in the determination of formula, including link to centripetal force and horizontal component of normal force.	2
● Provides some relevant information	1

Sample answer

The horizontal component of the normal force is equal to the centripetal force:

$$F_N sin\theta = \frac{mv^2}{r} \text{ (1)}$$

The vertical component of the normal force is equal and opposite to the gravitational force on the car:

$$F_N cos\theta - mg = 0$$

$$F_N = \frac{mg}{cos\theta} \text{ (2)}$$

Substitute (2) into (1):

$$(\frac{mg}{cos\theta})sin\theta = \frac{mv^2}{r}$$

$$tan\theta mg = \frac{mv^2}{r}$$

$$tan\theta = \frac{v^2}{rg}$$

Question 24 (c)

Criteria	Marks
● Correct banking angle calculated showing full working.	2
● Provides some relevant information	1

Sample answer

v = 200 $km.h^{-1}$

v = 55.56 $m.s^{-1}$

$$tan\theta = \frac{55.56^2}{(200)(9.8)}$$

$$tan\theta = 1.57$$

$$\theta = 58^o$$

Question 25

Criteria	Marks
● Identifies the binding energy per nucleon of Am-241 from graph. ● Calculates total binding energy of Am-241. Calculates the mass defect from the binding energy in atomic mass units	3
● Any 2 of the above.	2
● Any 1 of the above OR ● provides some relevant information	1

Sample answer

Binding energy per nucleon of Am-241 (from graph) = 7.4 MeV/nucleon
Total binding energy of Am-241 = 7.4 MeV/nucleon x 241 nucleons = 1783.4 MeV
Mass defect Am-241 = 1783.4 MeV ÷ 931.5 MeV / c2 = 1.914 amu

Question 26 (a)

Criteria	Marks
● Correctly calculates changing flux by recognising the distance travelled into the field changes the area of the loop.	2
● Provides some relevant information.	1

Sample answer

$$\Phi = BA$$
$$\Phi = B(l\Delta x)$$
$$\Phi = 3 \times (0.15 \times 0.05)$$
$$\Phi = 3 \times 0.0075$$
$$\Phi = 0.0225$$

Question 26 (b)

Criteria	Marks
● Correctly calculates the current in the rods. ● Correctly identifies the direction of the current in Rod X. ● Correctly identifies the direction of the current in Rod Y.	3
● Any 2 of the above	2
● Any 1 of the above OR ● provides some relevant information	1

Sample answer

$$F = BIlsin\theta$$
$$0.5 = 3 \times I \times 0.15 \times sin(90)$$
$$I = \frac{0.5}{0.45}$$
$$I = 1.11$$

Using Right Hand Push Rule:
Current in Rod X is Up the Page
Current in Rod Y is Down the Page

Question 26 (c)

Criteria	Marks
● Correctly calculates the current in the rods. ● Correctly identifies the direction of the current in Rod X. ● Correctly identifies the direction of the current in Rod Y.	3
● Any 2 of the above	2
● Any 1 of the above OR ● provides some relevant information	1

Sample answer

If the rods approach each other then they will experience a repulsive force. This is because the rods behave as two parallel conductors with the current in each moving in opposite directions.

Question 27

Criteria	Marks
● Correctly calculates distance reported by Earth observers. ● Correctly calculates distance reported by Spacecraft observers. ● Accounts for difference in observation with reference to special relativity.	3
● Any 2 of the above.	2
● Any 1 of the above OR ● provides some relevant information.	1

Sample answer

From earth, $d = vt = 2.4 \times 10^8 \times 54{,}000 = 1.296 \times 10^{13}$ m

On spacecraft, $d = vt = 2.4 \times 10^8 \times 32{,}400 = 7.776 \times 10^{12}$ m

The distance between the start and end points of the journey has contracted from the spacecraft's frame of reference because of its relativistic speed.

Question 28

Criteria	Marks
● Identifies the transformer as a step down transformer. ● Gives a logical explanation of why this type of transformer is necessary at this point in the distribution. ● Correctly identifies that the primary coil contains more turns than the secondary coil.	3
● Any 2 of the above	2
● Any 1 of the above OR ● provides some relevant information	1

Sample answer

The substation represents a step-down transformer. This is necessary to reduce the extremely high voltage of the transmission lines to a usable voltage and current for consumers. The primary coil in this transformer would have a greater number of turns than the secondary coil.

Question 29 (a)

Criteria	Marks
● Correctly identifies process as proton-proton chain. ● Outlines one way energy is produced in this reaction. ● Outlines two forms of energy released in the diagram.	4
● Any 3 of the above	3
● Any 2 of the above	2
● Any 1 of the above OR ● provides some relevant information	1

Sample answer

The process shown is the proton-proton chain. Energy is produced in this reaction from the conversion of mass to energy. After the reaction energy has been transformed into:

- energy in the form of gamma rays seen in diagram
- energy carried away by neutrinos seen in diagram
- the KE of the particles such as the positron or the protons represented as arrows in diagram

Question 29 (b)

Criteria	Marks
● Correctly calculates Energy	2
● Provides some relevant information	1

Sample answer

2p + Li-6 --> 2 He-4 + v

2 X 1.007277 + 6.015122 + 0.000548597 - (2 x 4.002602 + negligible) = 0.025 u

mass defect = 0.025 u

0.025 x 931.5 = 23.2875 MeV = 23.2875 x 10^{6} x 1.602 x 10^{-19} J = 3.73 x 10^{-12} J

Question 29 (c)

Criteria	Marks
• Identifies trend of nucleon energy AND • identifies that this reaction breaks that trend	2
• Any 1 of the above OR • provides some relevant information	1

Sample answer

Generally, fusion reactions release energy when the atomic number of the reactants is lower than that of the products, up to Iron. Lithium has a higher atomic number than He, so this is against the general trend.

Question 30

Criteria	Marks
• Thoroughly discusses 2 or more factors which can result in the modification of scientific models. • Outlines and justifies Thomson's hypothesis prior to the Geiger-Marsden experiment. • Discusses the results of the Geiger-Marsden experiment as evidence for a new model of the atom. • Explains the modified hypothesis after the Geiger-Marsden experiment.	7
• Discusses 2 or more factors OR thoroughly discusses 1 factor which can result in the modification of scientific models. • Outlines and justifies Thomson's hypothesis prior to the Geiger-Marsden experiment. • Discusses the results of the Geiger-Marsden experiment as evidence for a new model of the atom. • Explains the modified hypothesis after the Geiger-Marsden experiment.	6
• Discusses a factor which can result in the modification of scientific models. • Outlines and justifies Thomson's hypothesis prior to the Geiger-Marsden experiment. • Discusses the results of the Geiger-Marsden experiment as evidence for a new model of the atom. • Explains the modified hypothesis after the Geiger-Marsden experiment.	5
• Discusses a factor which can result in the modification of scientific models. • Outlines OR justifies Thomson's hypothesis prior to the Geiger-Marsden experiment. • Discusses the results of the Geiger-Marsden experiment as evidence for a new model of the atom. • Explains the modified hypothesis after the Geiger-Marsden experiment.	4
• Any 3 of the above	3
• Any 2 of the above	2
• Any 1 of the above OR provides some relevant information	1

Sample answer

A range of factors can contribute to the acceptance or rejection of scientific models, including religious, economic, technological and ethical considerations. In modern physics economic and technological factors have dominated the development of scientific models for the past 100 years.This is most recently shown by experiments such as the Large Hadron Collider which have required sound political landscapes resulting in the collaboration of over 100 countries at a cost of billions of dollars. In historical instances scientific models have been tested and revised due to factors such as newly emerged data. This is true of Thomson's plum pudding model where it was hypothesised that a diffuse electric field would exist inside the atom. As alpha particles passed through a layer of densely packed gold atoms it was expected that the alpha particles would be deflected by a small amount. This hypothesis, of the nature of the arrangement of the atom, was rejected when the observed result showed most alpha particles passing through completely undetected with smaller numbers being deflected by large angles including being deflected backwards. This data suggested that the electric field and charge on the gold atoms was concentrated in one, central, location, which Rutherford called the nucleus of the atom.

Question 31 (a)

Criteria	**Marks**
Relates four parts of the model to light diffraction and interference	3
Relates two parts of the model to light diffraction and interference	2
Provides some relevant information	1

Sample answer

The string represents light rays from two slits, which are represented by the pins, with a separation of d. The marks on the strings represent the wavelength of the light. The apex position is the first bright band (m=1) and the angle from the midpoint to the apex is theta, the diffraction angle.

Question 31 (b)

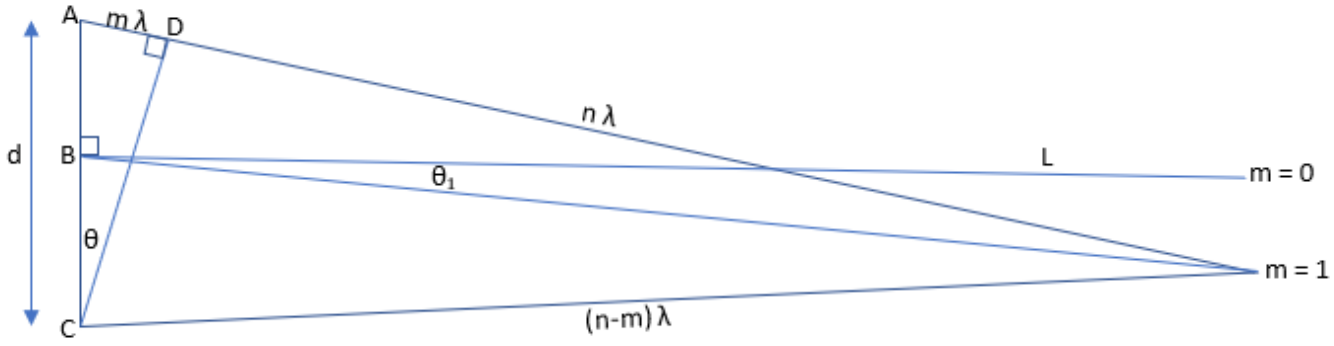
Criteria	Marks
Uses geometry to derive formula Notes approximation Draws correct diagram	3
Any 2 of the above	2
Any 1 of the above OR provides some relevant information	1

Sample answer

Approximation: the angle θ will be very close to the angle of diffraction θ_1 when the distance L from the gaps to the apex is very large compared to d.

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

$$\text{so } d\sin\theta = m\lambda$$

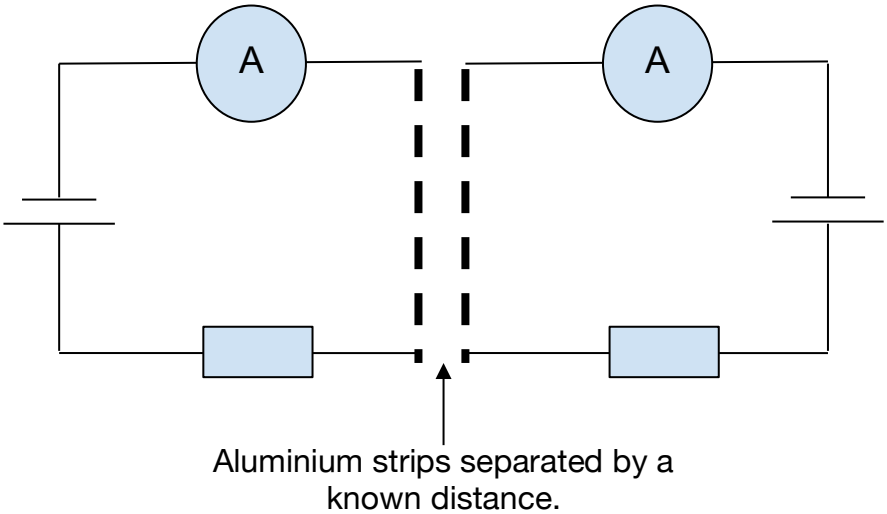


Question 32

Criteria	Marks
One mark for each of the following: ● Diagram drawn ● Diagram is labelled OR uses correct scientific symbols ● Procedure written ● Procedure is logical and could produce results demonstrating the interaction of two parallel current carrying conductors. ● Outlines how qualitative results could be collected ● Outlines how validity can be improved/ensured for qualitative data collection. ● Outlines how quantitative results could be collected. ● Outlines how validity can be improved/ensured for quantitative data collection. ● Outlines how reliability of the procedure can be assessed.	9
Any 8 of the above.	8
Any 7 of the above.	7
Any 6 of the above.	6
Any 5 of the above.	5
Any 4 of the above.	4
Any 3 of the above.	3
Any 2 of the above.	2
Any 1 of the above OR some relevant information	1

Sample answer

Set up 2 simple circuits each containing a power source, resistor, ammeter and a 20 cm long strip of aluminium foil suspended vertically as per the diagram below. Ensure that all equipment is calibrated correctly to produce valid results. Ensure the aluminium foil strips are 'slack' so that they are able to move if a force is applied to them.



Measure the distance between the Aluminium foil strips. Turning on the power supply of each circuit will cause current to run through the Aluminium strips. An observable 'bending' will occur in the strips due to the attractive or repulsive force induced by the currents. The observation of the bending can be used as qualitative data to demonstrate the interaction between two current carrying wires. To ensure the validity of this qualitative data a phone-camera with high zoom or slow motion can be used to record the event and observe it with greater precision. The type of force experienced can be changed by reversing the

current in one of the circuits so that the wires can bend towards or away from each other. Quantitative results can be obtained by varying the amount of current and measuring the deflection of the strips using a ruler or digital caliper. Graphing the change in current compared to amount of movement can be used to illustrate the proportional relationship between Force and Current. By controlling the variables such as the current, resistance and voltage of the circuit, the experiment can be repeated several times and the results compared to assess the reliability of the procedure.

Question 33 (a)

Criteria	**Marks**
Relates change in reflected path length to interference Relates interference to changes in spark intensity	2
One of the above OR provides some relevant information	1

Sample answer

As the reflected path length varies, it goes in and out of phase with the direct path. This leads to constructive interference, producing a brighter spark, and destructive interference producing a less bright spark.

Question 33 (b)

Criteria	**Marks**
Identify that Maxwell's equations were what Hertz was testing AND that EMR should be produced by an intermittent spark AND that the EMR will generate an EMF in the receiver sufficient to produce a spark.	3
Two of the above	2
Provides some relevant information	1

Sample answer

Maxwell predicted that an intermittent current (the spark) would produce an oscillating magnetic field, which would generate electromagnetic radiation that would propagate through space. The EMR could induce an EMF in the receiver, high enough to generate a spark.

Question 34 (a)

Criteria	**Marks**
Identifies the peak wavelength of the star Calculates the surface temperature of the star using Wien's Law	2
Any 1 of the above OR provides some relevant information	1

Sample answer

From the graph the peak wavelength is 520 nm

Using Wein's Law:

$$T = \frac{2.898\ x\ 10^{-3}}{5.2\ x\ 10^{-7}}$$

$$T = 5573\text{K}$$

Question 34 (b)

Criteria	**Marks**
Names features as absorption or spectral lines. Fully accounts for their production in a star's outer layer.	3
Names features as absorption or spectral lines. Partially accounts for their production in a star's outer layer	2
Any 1 of the above OR provides some relevant information	1

Sample answer

The features labelled X, Y and Z in the diagram are absorption or spectral lines.

The inner regions of a star produce a bright continuous spectrum with light of all wavelengths. As the photons fly outwards into space, particular and specific wavelengths are absorbed by different atoms (or molecules) in the cooler outer layers of the stellar atmosphere. The excited atoms then radiate photons away from themselves in a three dimensional way, and some photons are thus directed away from the way they were travelling, thus reducing the appearance of these wavelengths in the spectrum when it leaves the star and arrives at an Earth-bound observer.