
Student

NORTH SYDNEY GIRLS HIGH SCHOOL

2020

Higher School Certificate

Trial Examination

Physics

Total Marks – 100

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.
- A data sheet, formulae sheet and Periodic Table are provided on the laminated sheets.
- Write your student number at the top of this booklet AND on the multiple choice answer sheet.

Section I
20 marks (pages 3–10)
Attempt Questions 1–20
Allow about 35 minutes for this section

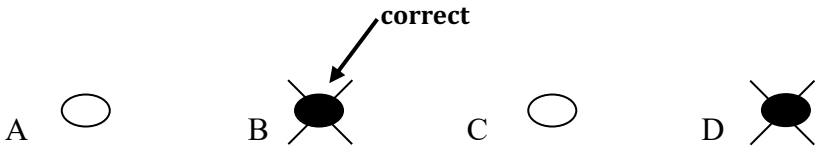
Section II
80 marks (pages 11–33)
Attempt Questions 21–37
Allow about 2 hours and 25 minutes for this section

Use the multiple-choice answer sheet.
Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

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

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

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



Section I
20 marks
Attempt Questions 1–20
Allow about 35 minutes for this section
Put your answers on the Multiple Choice answer sheet provided

1. Which of the following statements is true as you move from left to right on the electromagnetic spectrum?

A. Wavelength decreases, energy decreases
B. Wavelength increases, energy decreases
C. Wavelength decreases, energy increases
D. Wavelength increases, energy increases

2. A car experiences a force of 1.40×10^3 N from the rotation of its tyres on the road. If the tyres have a diameter of 45 cm, which of the following would be the magnitude of the clockwise torque on the tyre?

A. 31.0 Nm
B. 315 Nm
C. 630 Nm
D. 6 220 Nm

3. Which of the following scenarios would result in **no** net force from the field stated?

A. A stationary charged particle placed in a magnetic field.
B. A stationary charged particle placed in an electric field.
C. A moving charged particle placed in a magnetic field.
D. A moving charged particle placed in an electric field.

4. Which of the following rows correctly matches the headings with the orbit type?

Answer	Short Orbital Period	Large altitude	Used for mapping surface terrain
A	Geostationary Orbit	Near Earth Orbit	Near Earth Orbit
B	Near Earth Orbit	Geostationary Orbit	Geostationary Orbit

C	Geostationary Orbit	Near Earth Orbit	Geostationary Orbit
D	Near Earth Orbit	Geostationary Orbit	Near Earth Orbit

5. A current-carrying conductor experiences a force when it is placed in a uniform magnetic field. This is known as which of the following?

   A. Faraday's law.
   B. The motor effect.
   C. Lenz's law.
   D. The photoelectric effect.

6. Galileo's analysis of gravity determined which of the following?

   A. Acceleration due to gravity is $9.8ms^{-2}$, vertical velocity is independent from the horizontal velocity and distance travelled for a falling body increases at an increasing rate.
   B. Acceleration due to gravity is $9.8ms^{-2}$, vertical velocity is independent from the horizontal velocity and the more mass an object has the larger the gravitational force.
   C. The vertical velocity is independent from the horizontal velocity, the more mass an object has the larger the gravitational force and distance travelled for a falling body increases at an increasing rate.
   D. The vertical velocity is not independent from the horizontal velocity, distance travelled for a falling body increases at an increasing rate, the force between two bodies decreases according to $1/r^2$ relationship.

7. Which of the following options correctly shows the relationship between the experiment and the theory it supported?

Answer	**Model of Light**	
	Light is a particle	**Light is a wave**
A.	The Photoelectric Effect	The Photoelectric Effect
B.	Young's Double Slit Expt.	Young's Double Slit Expt.
C.	Young's Double Slit Expt.	The Photoelectric Effect
D.	The Photoelectric Effect	Young's Double Slit Expt.

8. A student attaches a tennis ball to a piece of string 1.0 m long and swings the ball vertically in a circle.
   Which of the following best describes the energy of the ball as it moves from the bottom to the top of its rotational path?

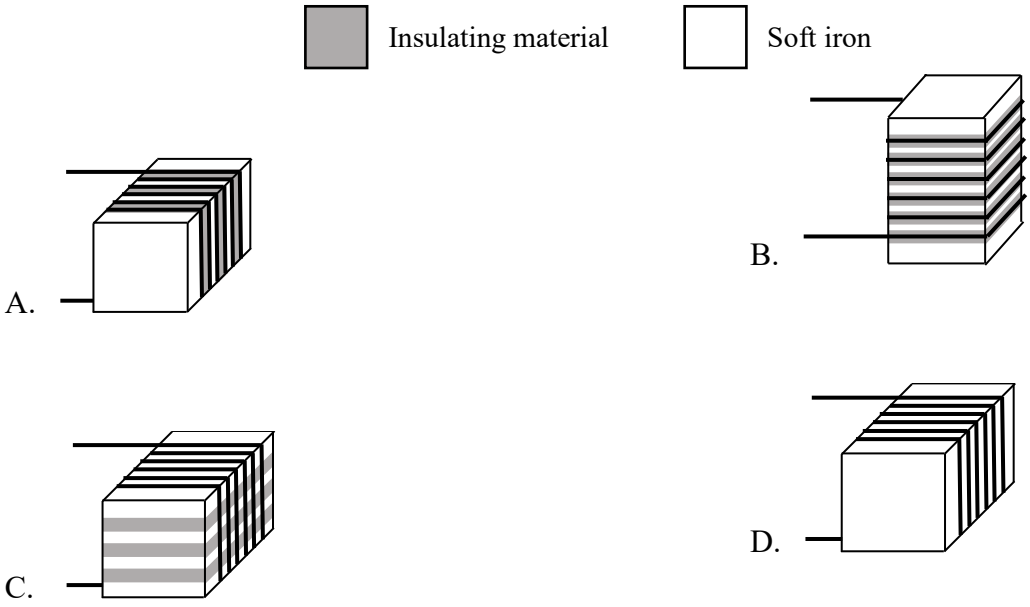
   A. Its energy changes and work is done on the ball.
   B. Its energy changes and total work is a constant.

C. Its energy remains the same and work is done on the ball.
D. Its energy remains the same and total work is a constant.

9. Two identical current-carrying conductors are placed parallel to each other. Which of the following will **not** increase the magnitude of the force by a factor of 4?

A. Doubling the current in both wires.
B. Doubling the current in one wire and halving the distance between the wires.
C. Decreasing the distance between the wires by a factor of 4.
D. Halving the current in both wires and decreasing the distance between the wires by a factor of 8.

10. Which of the following core designs would be best in minimising heating effects due to eddy currents?



11. Which of the following was NOT a contribution made by Maxwell to developing ideas in physics in the 1870's?

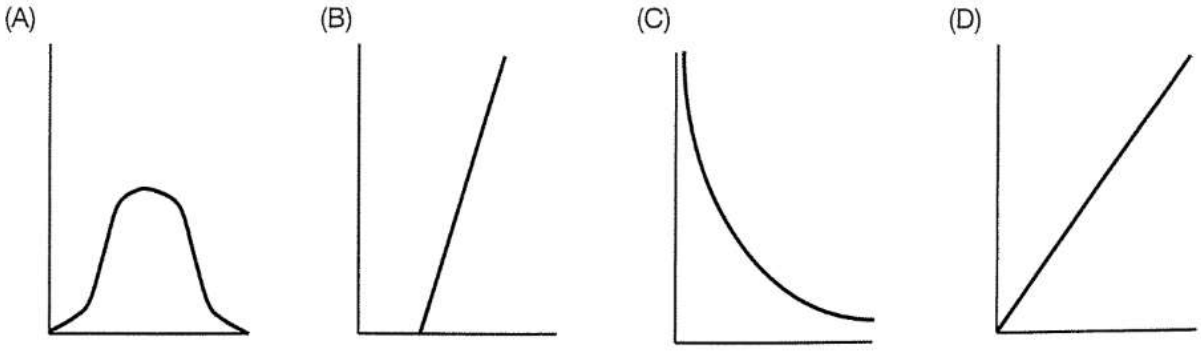
A. He was able to calculate the speed of light accurately.
B. He proposed that light was a self-propagating electromagnetic radiation.
C. He predicted an endless spectrum of electromagnetic radiation.
D. He did follow-up experiments to analyse the photoelectric effect discovered by Planck.

12. Two planets have equal acceleration due to gravity on their surface. Planet 1 has 4 times the mass of Planet 2.

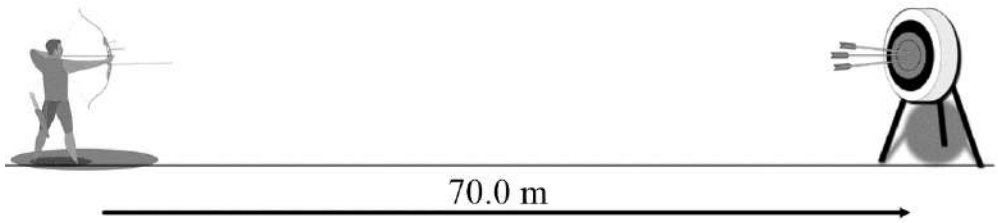
Which of the following correctly shows the relationship between the radius of Planet 1 and the radius of Planet 2?

A. $r_1 = 2r_2$
B. $r_1 = 4r_2$
C. $r_1 = 16r_2$
D. $r_1 = 64r_2$

13. Which of the following graphs shows the relationship between the energy carried by a photon (y-axis) and the wavelength of the photon (x-axis)?



14. An archer is competing in two events at the Olympics. Each event requires competitors to shoot an arrow to a bullseye (centre of the target) which is the same height off the ground as the release height of the arrow. The archer enters the 70 m and the 50 m events.



The archer shoots the first arrow horizontally over the 70.0 m under projectile motion and misses the centre of the target.

The archer fires a second arrow horizontally at an identical speed this time for the 50.0 m event.

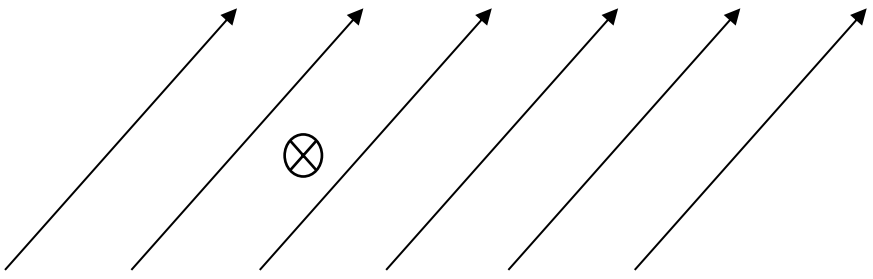
Which of the following would be the expected outcome of the two shots?

A. Both the arrows will hit the same spot on the target just below the bullseye and the time of flight will be shorter for the second arrow.
B. The first arrow will hit the target lower than the second arrow and the time of flight will be the same for both.
C. The first arrow will hit the target lower than the second arrow and the time of flight will be shorter for the second arrow.
D. The second arrow will hit the target lower than the first arrow and the time of flight will be the same for both.

15. How did Newton's particle theory of light explain refraction?

A. Stronger forces within the refracting medium changed the direction of travel of the light particles as they entered the medium.
B. Because the refracting medium was so dense compared to air, the light particles were forced to slow down.
C. The light particles scattered in the medium because the medium particles were closer together than air particles.
D. Newton's particle theory of light showed that the angle of incidence is equal to the angle of refraction.

16. A current-carrying conductor is placed in a magnetic field as shown in the diagram below. Which of the following represents the force experienced by the conductor?



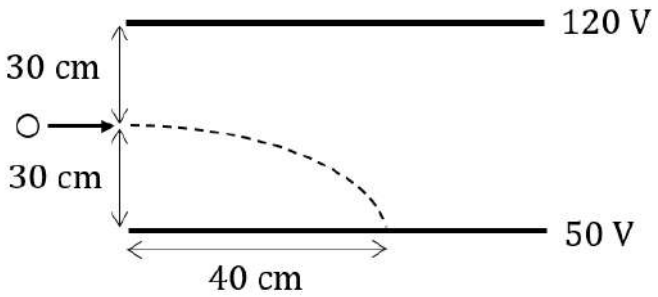
A. 

B. 

C. 

D. 

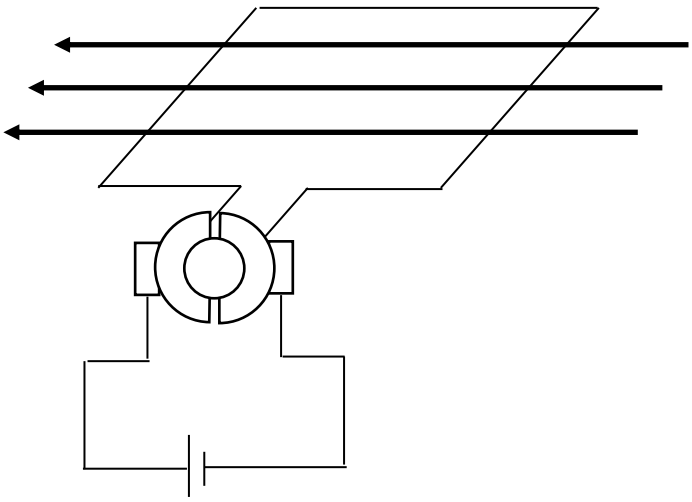
17. A particle has a charge of magnitude 2.0 x 10^{-4} C. It travels horizontally into an electric field as shown in the diagram below.



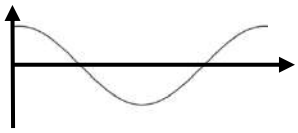
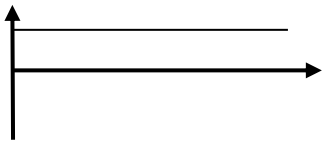
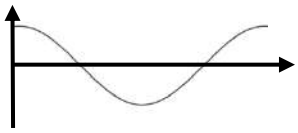
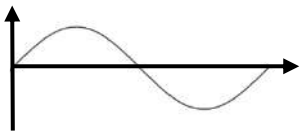
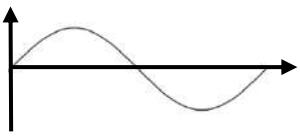
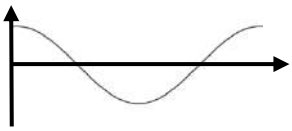
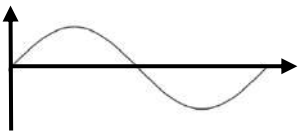
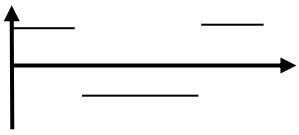
Using the motion of the charged particle, what can be concluded about the charge of the particle and the work done by the electric field?

	Charge	*Work done by the electric field*
A.	Positive	$7.0 \times 10^{-3}\ J$
B.	Positive	$1.4 \times 10^{-2}\ J$
C.	Negative	$7.0 \times 10^{-3}\ J$
D.	Negative	$1.4 \times 10^{-2}\ J$

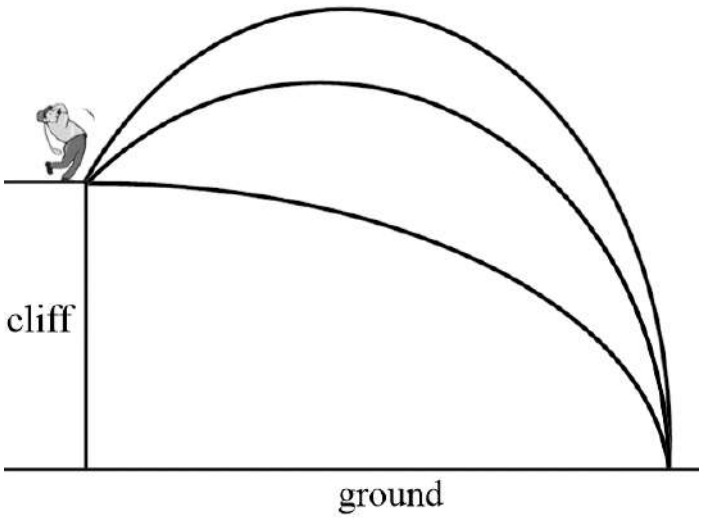
18. A DC motor has been set up as shown in the diagram below.



Which of the following represents the flux through the area $WXYZ$ and the force acting on wire WX starting from the position shown in the diagram through one revolution?

	Flux through $WXYZ$	*Force on WX*
A.		
B.		
C.		
D.		

19. A golfer hits three golf balls under projectile motion off a cliff top as drawn below.



Which of the following statements is correct about the balls being hit?

A. Each ball has the same initial velocity.
B. Each ball has the same initial horizontal velocity.
C. Each ball has the same initial vertical velocity.
D. None of the velocities are the same.

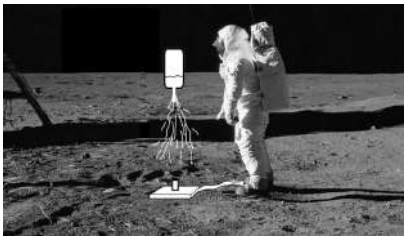
20. Starship "Alpha" travels at 0.9c past an identical starship "Beta", which is at rest. Both a cabin boy on the "Alpha" and a cook on the "Beta" measure the time required for the other ship to pass by their respective windows. Who measures the longer time?

A. The cabin boy
B. The cook
C. Both measure the same time
D. The measured times cannot be compared

Section II
80 marks
Write your answer in the space provided.

Question 21 (5 marks)

A top secret photograph was leaked from NASA showing the analysis of projectiles on the Moon. It was designed as a feasibility study to whether water propulsion systems could be used to leave the Moon's gravitational field (m_{moon} = 7.35 x 10^{22} kg, r_{moon} = 1.74 x 10^{6} m).



A typical high pressure water system can provide a constant thrust such that after 1.9 s a stationary, 120 g rocket is travelling at 22 ms^{-1}.

(a) Calculate the resultant force on the rocket assuming its mass remains at 120 g. **1**

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(b) Calculate the work done by the water rocket. **1**

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(c) Calculate how high the water rocket is at 1.9 s. **1**

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(d) Explain whether the rocket would escape the moon's gravitational field if the thrust stops at 1.9 s.

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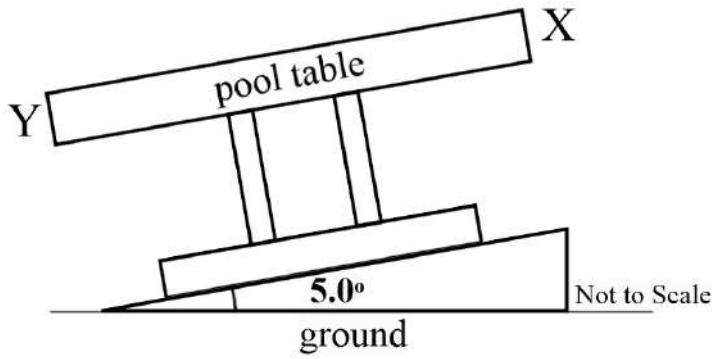
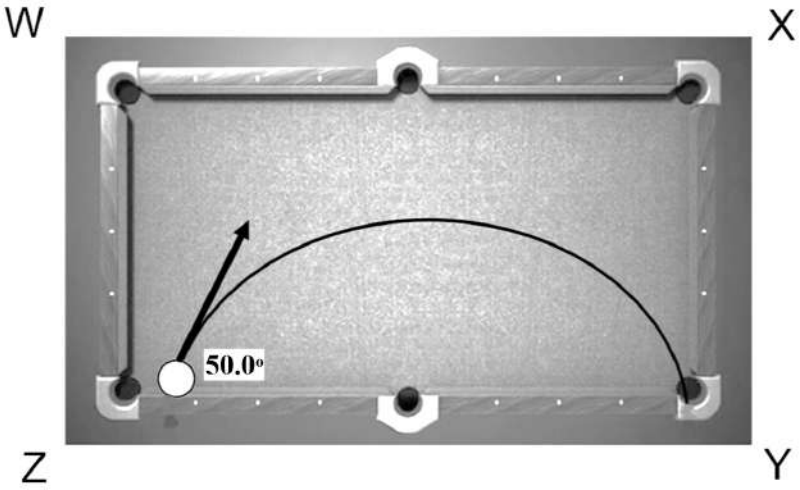
End of Question 21

Question 22 (5 marks)

Bob sets up his brand new friction free, snooker table in his house. Bob doesn't know that his floor is slightly tilted by 5.0° as shown here.



Bob places a frictionless white ball on the table and hits the ball at a velocity of 1.10 ms^{-1}, 50.0° from the long side of the table.



(a) Calculate the net acceleration on the ball. **2**

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(b) Calculate the time it takes for the ball to reach the pocket (hole). **2**

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(c) How far is the corner pocket (hole) from the position it was hit? **1**

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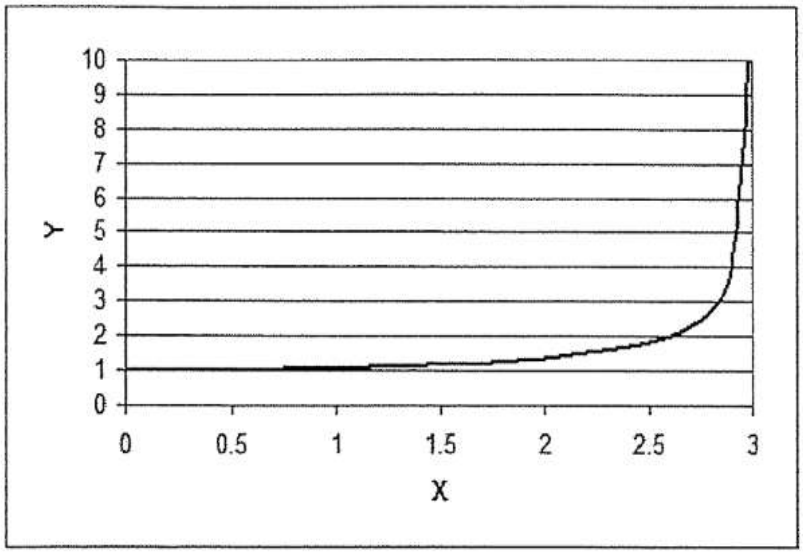
End of Question 22

Question 23 (3 marks)

The graph below shows a plot of the equation

$$Y = \frac{1}{\sqrt{1 - \frac{X^2}{3^2}}}$$



Explain the significance of the shape of the graph for our understanding of time in the special theory of relativity.

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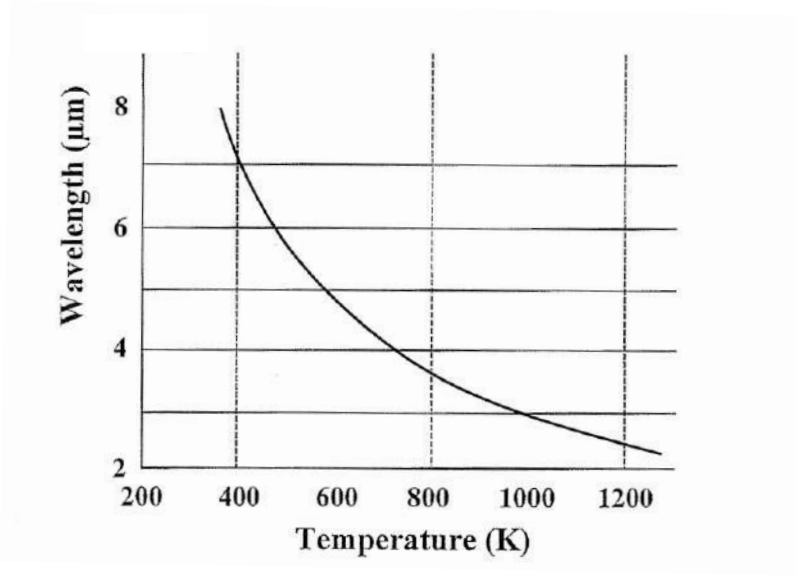
End of Question 23

Question 24 (4 marks)

The graph below shows the wavelength of the peak intensity radiation emitted by a standard black body at different surface temperatures.



Using data points from the graph, show that this graph is consistent with Wien's law. **4**

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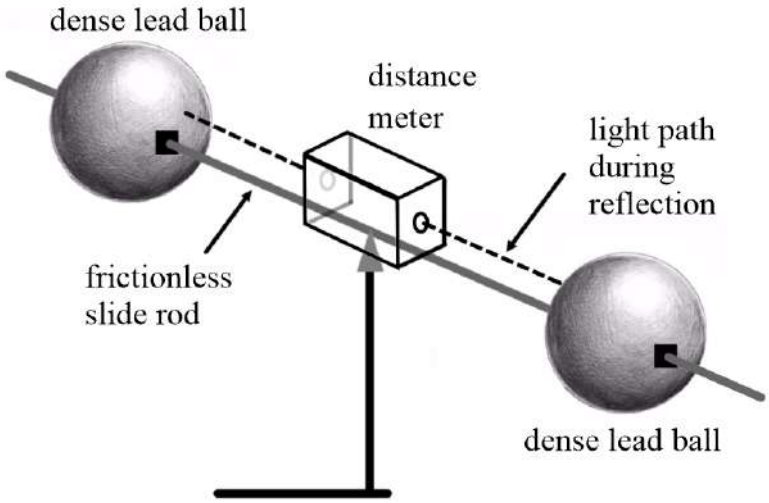
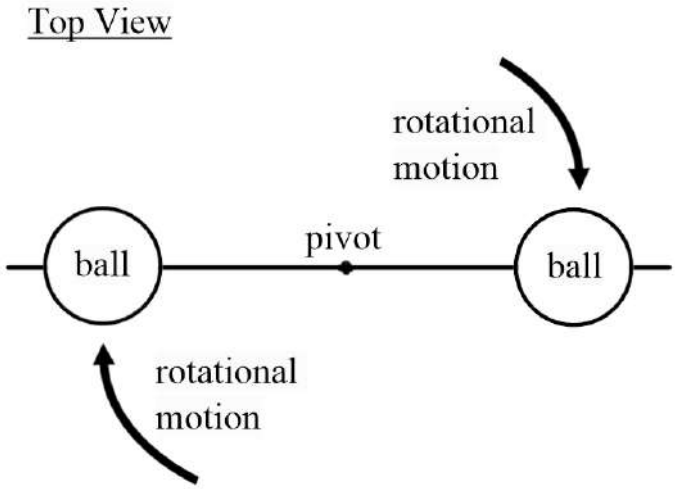
End of Question 24

Question 25 (4 marks)

Lucy was conducting a depth study in a school laboratory with the intension to validate Newton's Law of Universal Gravitation.
She set up two very dense 100kg lead balls on a frictionless slide rod such that each ball can move freely either out from the centre or into the middle. A distance meter was placed in the middle which works by reflecting light off the balls. The whole apparatus was suspended on a pivot which only allows rotation in the horizontal plane.



Lucy rotated the apparatus creating a centripetal force. The aim was to find the speed at which the centripetal force was equal to the gravitational force between the two dense lead balls.



(a) How would Lucy know when the force of gravity was equal to the centripetal force? **1**

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Question 25 continued on next page **1**

(b) Lucy found the relationship between the rotational speed and the distance of one of the balls from the fulcrum to be:

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

Show support for the relationship Lucy found by deriving this formula.

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(c) Using the equation from (b), justify why Lucy would not observe any measurable results in this experiment.

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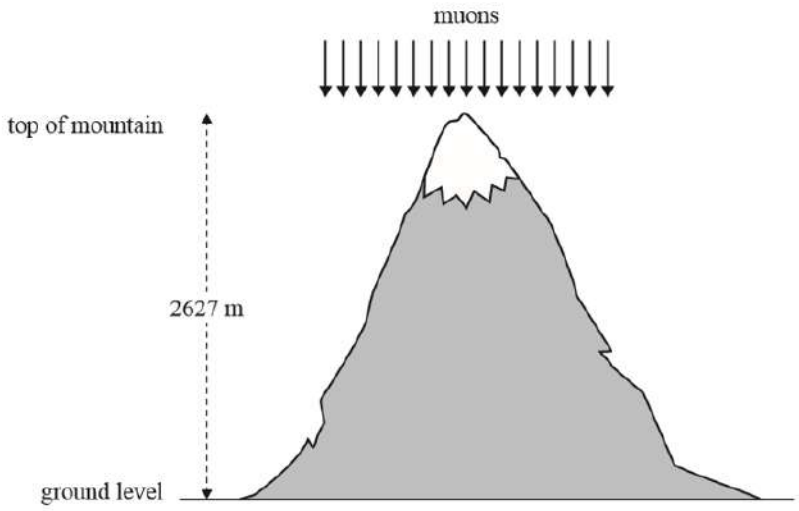
End of Question 25

Question 26 (4 marks)

Muons are elementary particles created in the upper atmosphere by cosmic rays. They are unstable and decay after 2.2μs measured in the frame of reference of the muon.
In an experiment, muons with a velocity of 0.995c were observed to pass the top of a mountain of height 2627 m and reach the ground.



a) Calculate the life time of the muons as measured by a stationary observer on the ground. **2**

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b) Explain why many more muons reached the ground than would be predicted by classical physics. **2**

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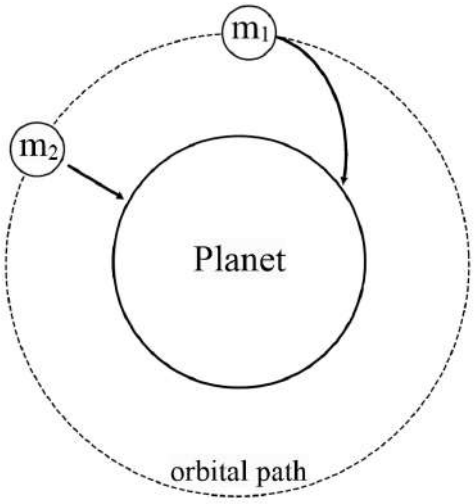
End of Question 26

Question 27 (3 marks)

Two objects of identical mass fall from space down to the surface of a planet with no atmosphere. Mass m_1 does not have enough speed to remain in orbit and follows a parabolic path down to the planet. Mass m_2 is stationary and starts to fall straight down.



Compare qualitatively the impact velocities of m_1 and m_2. Refer to energy changes in your answer. **3**

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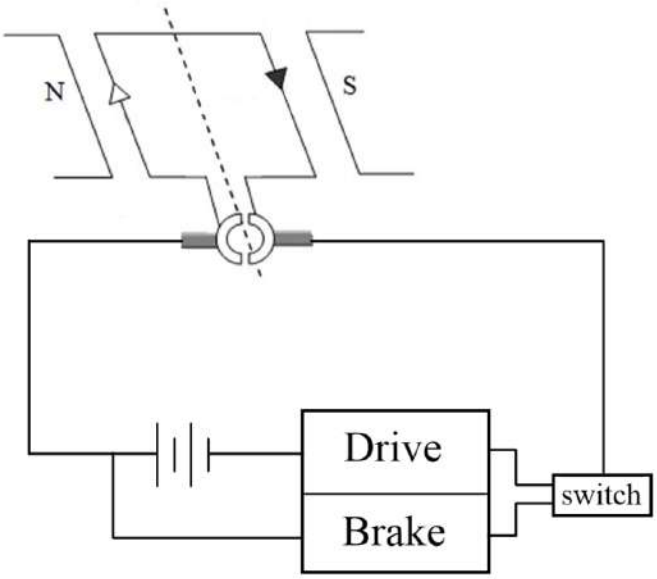
End of Question 27

Question 28 (4 marks)

Most modern electric vehicles contain a switch that converts a DC motor to a DC generator in order to change their forward motion to braking.



With reference to the Law of Conservation of Energy, explain the difference between a DC Motor and a DC generator. **4**

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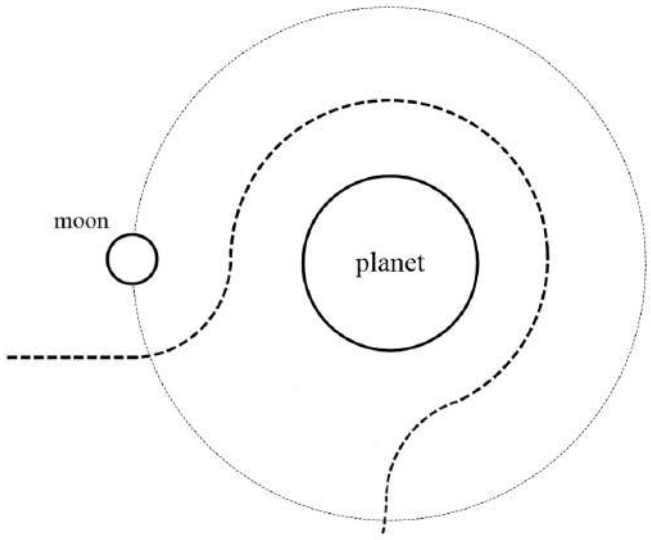
End of Question 28

Question 29 (3 marks)

A satellite is exploring a distant planet and its orbiting moon. It follows the path shown here with a dashed line and only uses its rockets to leave the planet's orbit. This picture is not to scale.



(a) Indicate, using a cross, where in the diagram the net force on the rocket is zero. **1**

(b) Describe how the model drawn above is useful in understanding satellite motion AND how the model has limitations. **2**

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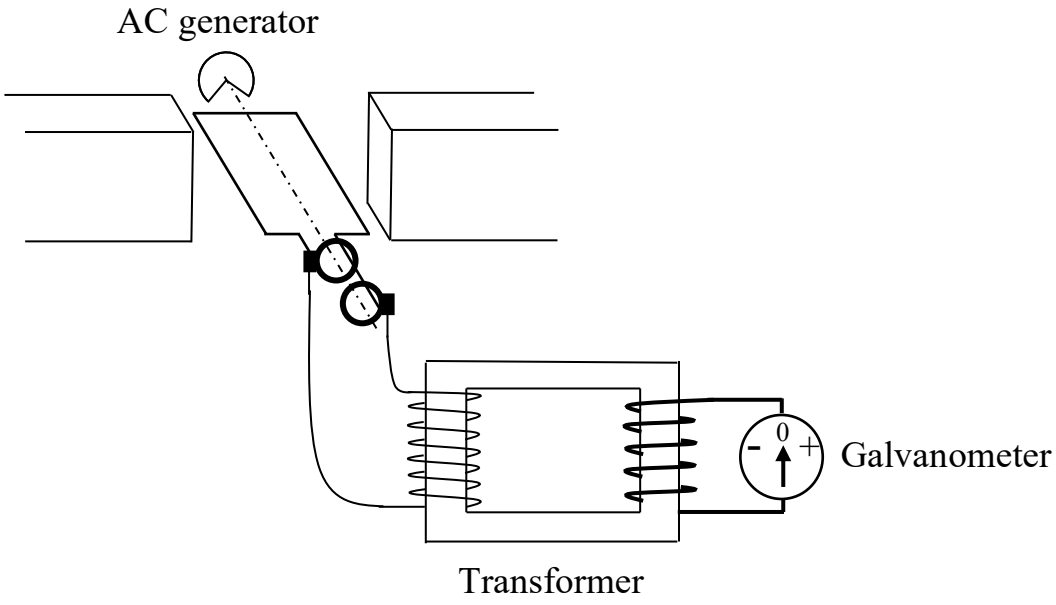
End of Question 29

Question 30 (7 marks)

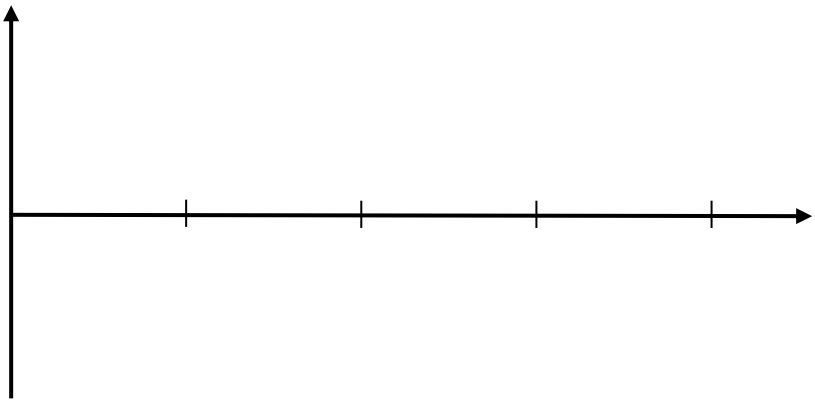
A stationary AC generator is connected to an ideal transformer as shown in the diagram below.



The table shows the data for the generator and transformer setup.

Magnetic field strength (B)	$8.50 \times 10^{-2}\ T$
Area of the coil (A)	$1.50\ m^2$
Period of rotation of the coil (T)	4.00×10^{-3} s
Resistance of the wire in the secondary coil (R)	$5.25\ \Omega$

(a) The AC generator starts from the position shown in the diagram above. Sketch a graph of the emf produced by the generator against time. **2**



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Question 30 continued on next page

(b) Identify the transformer as a step-up or step-down transformer.

3

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(c) Given that the maximum emf produced by the AC generator can be calculated by $\varepsilon_{max} = 2\pi fBA$ where f is the frequency of the rotating coil, calculate the maximum reading on the galvanometer.

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(d) The AC generator in the diagram is made into a DC generator by replacing the pair of slip rings with a split ring commutator. What would happen to the reading observed on the galvanometer?

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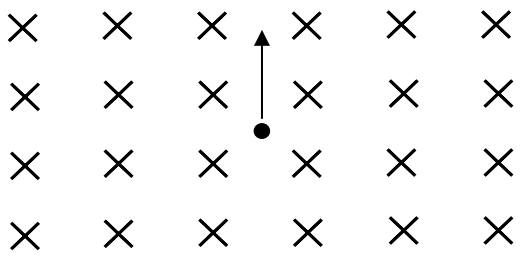
End of Question 30

Question 31 (6 marks)

A particle with mass m and charge q moves with a constant velocity v. A magnetic field of strength B is then switched on as shown in the diagram below.



(a) Show that the period of rotation T of the particle is given by $T = \frac{2\pi m}{qB}$. **2**

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(b) Calculate the period of rotation if the particle is an electron and the strength of the magnetic field is 2.0 x 10^{-4} T. **2**

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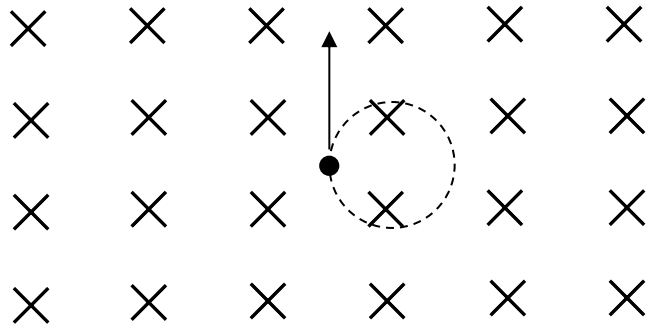
2

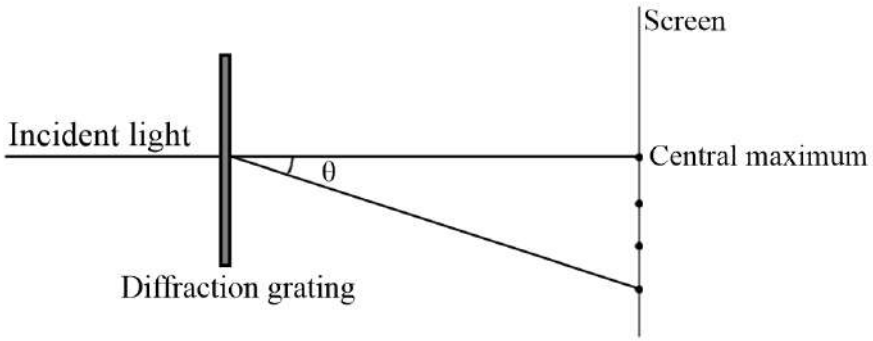
(c) The diagram below shows the path of the electron after one period, T. Draw the path of the electron for the same time T if the magnetic field strength was halved.



End of Question 31

Question 32 (5 marks)

Monochromatic light of wavelength 545 nm is shone onto a diffraction grating which has rulings of 1.2×10^3 lines per centimetre.



a) Calculate the angular deviation between the central maximum and the third-order bright spot. **2**

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b) Explain why this experiment creates regions of bright and dark spots. **3**

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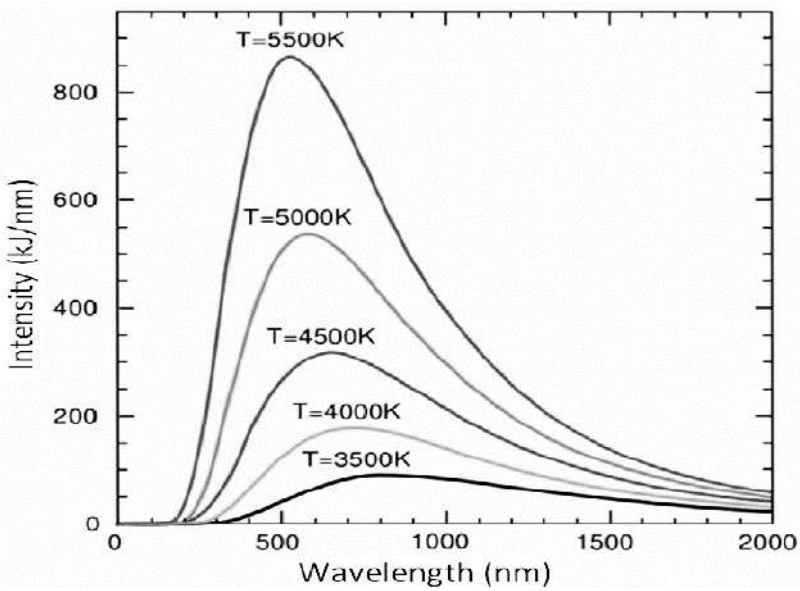
End of Question 32

Question 33 (4 marks)

Energy density versus wavelength curves are shown for blackbody radiation at various temperatures.



a) State Planck's two fundamental postulates for black-body radiation. **2**

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2

b) Explain how this was able to explain the experimental data collected at high temperatures.

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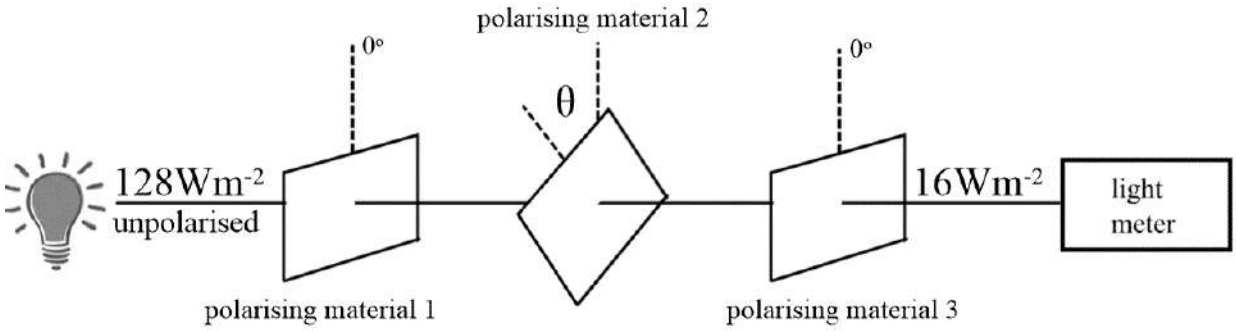
End of Question 33

Question 34 (4 marks)

Unpolarised light of intensity 128 Wm^{-2} passes through three polarising filters. The polarising axes of the first and third filters are at 0º.



If the intensity of the light passing out of the third filter is 16 Wm^{-2}, calculate the angle (θ) with which the polarising material 2 is rotated? **4**

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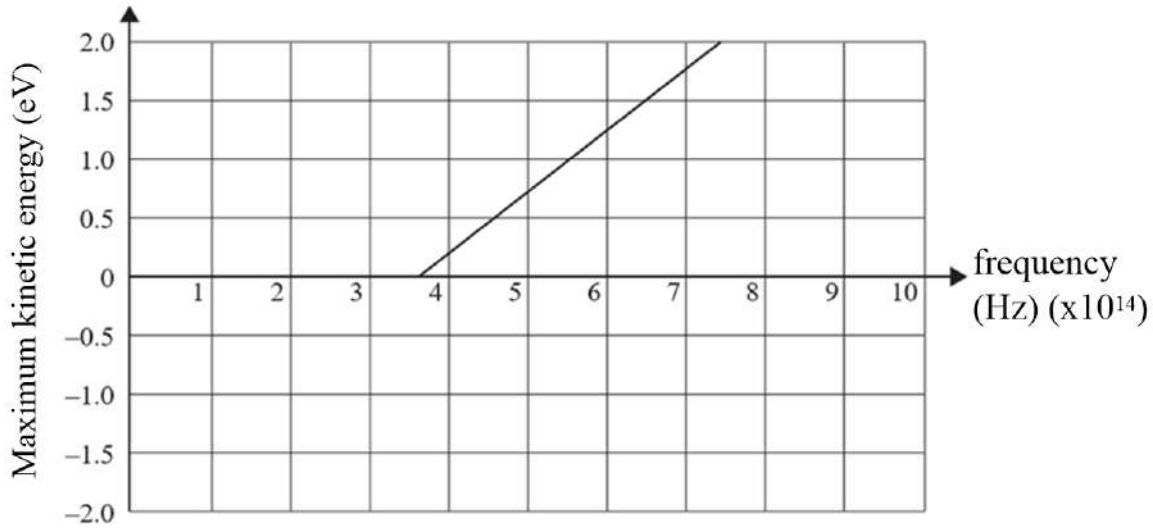
End of Question 34

Question 35 (5 marks)

Students are studying the photoelectric effect by measuring the frequency of incident light against the kinetic energy of the photoelectrons.
The graph below shows the results the students obtained for the maximum kinetic energy (K_{max}) of the emitted photoelectrons versus the frequency of the incoming light.



a) Using the data from the graph, determine the value the students would have obtained for:

i) Planck's constant, h **2**

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ii) the maximum wavelength of light that would cause the emission of photoelectrons **1**

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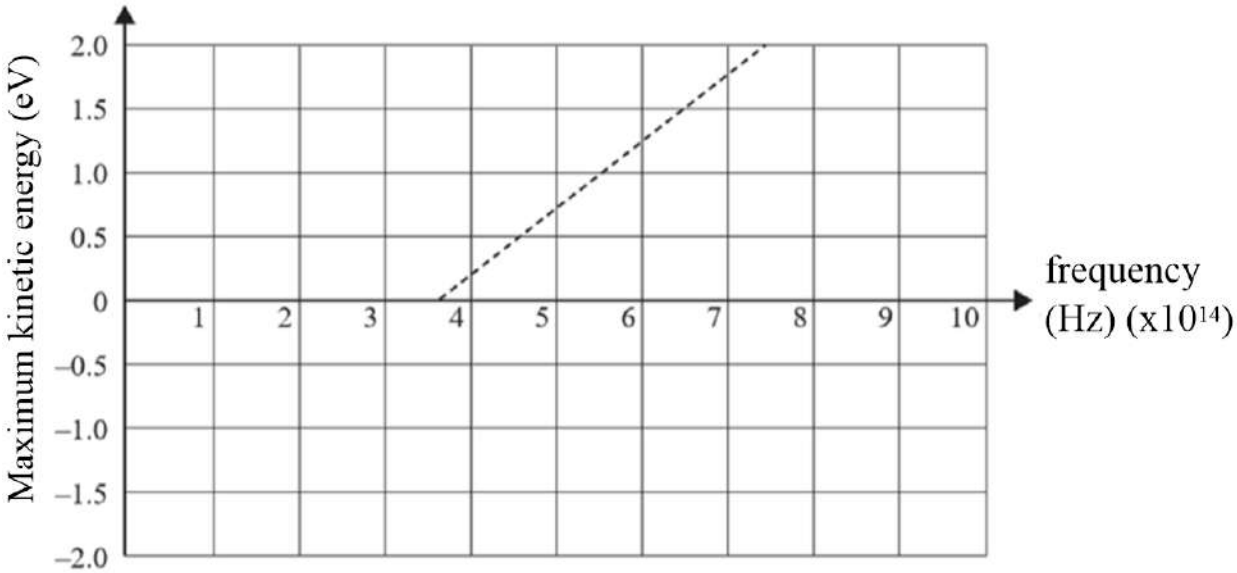
Question 35 continued on next page

b) The work function for the original metal used is $\emptyset$.

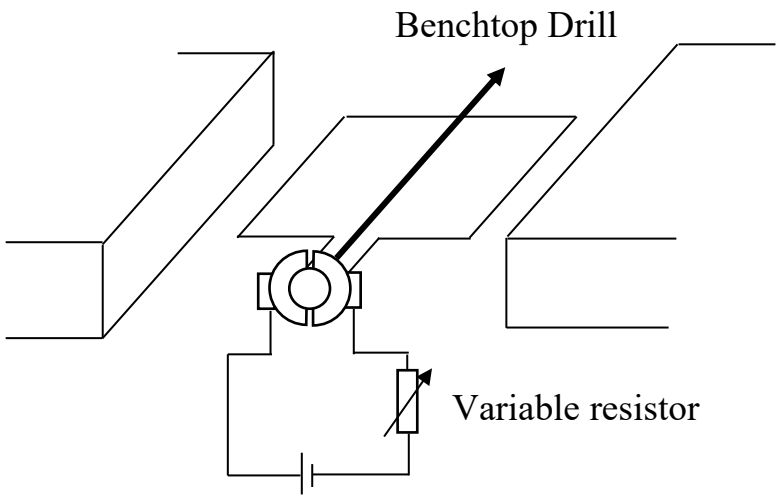
On the graph below, draw the line that would be obtained if a different metal, with a work function of $\frac{1}{2}\emptyset$, were used in the experiment. (The original graph is shown as a dashed line.) **2**



End of Question 35

Question 36 (8 marks)

A simple DC motor is used to drive a benchtop drill. The motor is connected in series with a variable resistor to protect the windings in the coil as shown in the diagram below.



The variable resistor is adjusted to have a large resistance when the motor is starting up and the resistance is slowly lowered as the motor reaches its operating speed.

Explain improvements that can be made to motors to minimise the issues with torque and back emf. **8**

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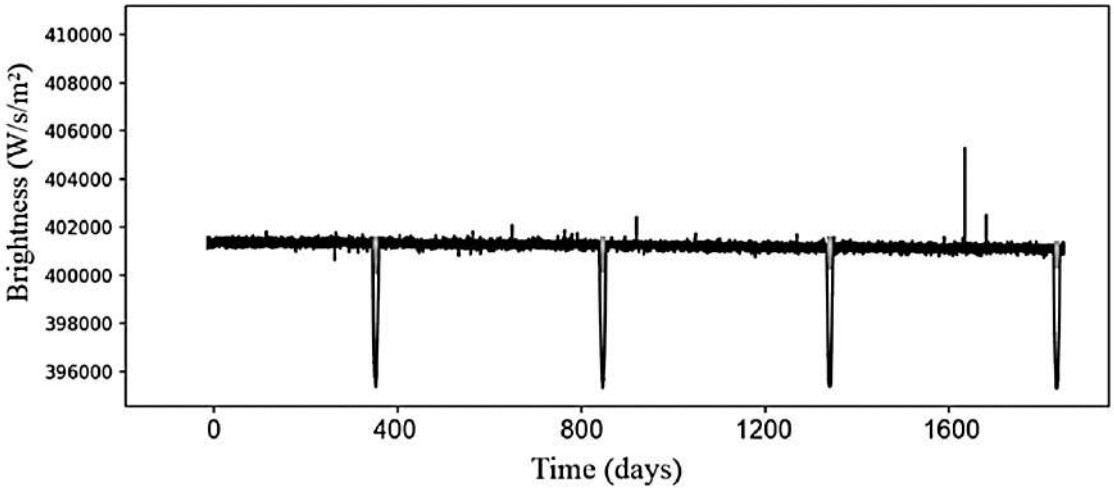
End of Question 36

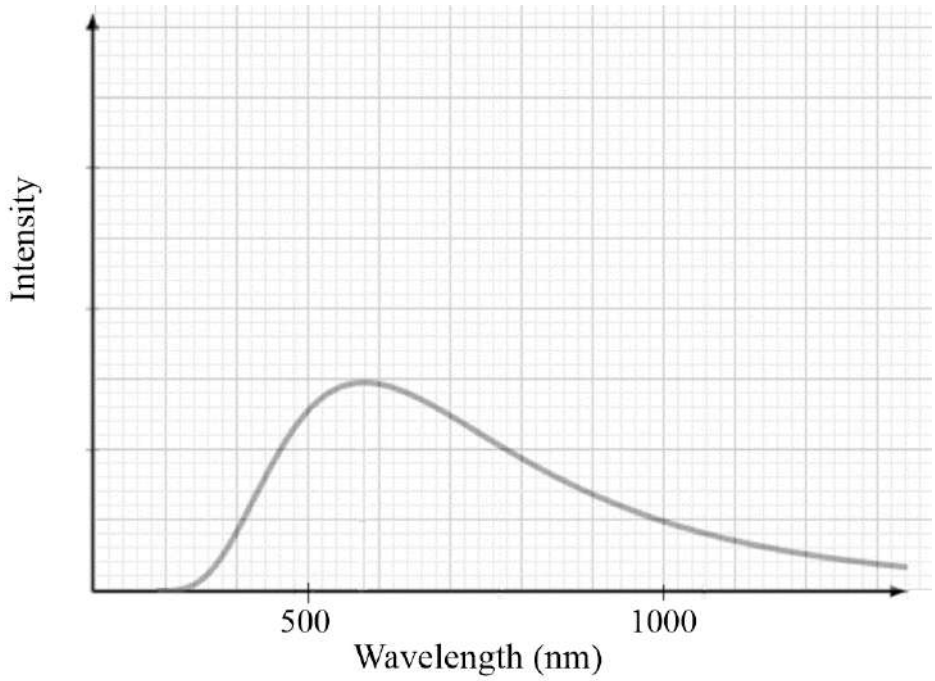
Question 37 (6 marks)

The Australian Astronomical Observatory in Coonabarabran took many pictures of a distant star P3682 over many years. They used spectral analysis and found that there was a distinct change in brightness caused by an exoplanet (planet not from our solar system) blocking the light as it orbits around P3682. Here is a graph of the data they collected (measured in Earth days).



Further spectra analysis of brightness revealed that P3682 had a mass of 7.96×10^{30} kg.

Specialised emission spectroscopy of P3682 revealed the following continuous spectra.



Question 37 continues on next page

From much discussion with other institutions of astronomy, a set of ranges were established for an exoplanet orbiting a star such as P3682, such that human life could be maintained. This table shows the values that were established.

Property	**Range to suit habitat of exoplanet**
Orbital Radius of Planet	0.5 – 2.5 Earth radii
Orbital Velocity of Planet	2 – 80 km s^{-1}
Temperature of Central Star	4000 – 6000 K

Assess if humans would be able to live on this exoplanet for habitation using the information provided here. **6**

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End of question 37

END OF EXAMINATION

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Student Number

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 ○
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 ○

Student Number

NORTH SYDNEY GIRLS HIGH SCHOOL

2020

Higher School Certificate

Trial Examination

Physics

Total Marks – 100

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.
- A data sheet, formulae sheet and Periodic Table are provided on the laminated sheets.
- Write your student number at the top of this booklet AND on the multiple choice answer sheet.

Section I
20 marks (pages 3–10)
Attempt Questions 1–20
Allow about 35 minutes for this section

Section II
80 marks (pages 11–34)
Attempt Questions 21–37
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
Put your answers on the Multiple Choice answer sheet provided

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1. Which of the following statements is true as you move from left to right on the electromagnetic spectrum?

   A. Wavelength decreases, energy decreases
   B. Wavelength increases, energy decreases
   C. Wavelength decreases, energy increases
   D. Wavelength increases, energy increases

2. A car experiences a force of 1.40×10^3 N from the rotation of its tyres on the road. If the tyres have a diameter of 45 cm, which of the following would be the magnitude of the clockwise torque on the tyre?
   A. 31.0 Nm
   B. 315 Nm
   C. 630 Nm
   D. 6 220 Nm

3. Which of the following scenarios would result in **no** net force from the field stated?
   A. A stationary charged particle placed in a magnetic field.
   B. A stationary charged particle placed in an electric field.
   C. A moving charged particle placed in a magnetic field.
   D. A moving charged particle placed in an electric field.

4. Which of the following rows correctly matches the headings with the orbit type?

Answer	Short Orbital Period	Large altitude	Used for mapping surface terrain
A	Geostationary Orbit	Near Earth Orbit	Near Earth Orbit
B	Near Earth Orbit	Geostationary Orbit	Geostationary Orbit
C	Geostationary Orbit	Near Earth Orbit	Geostationary Orbit
D	Near Earth Orbit	Geostationary Orbit	Near Earth Orbit

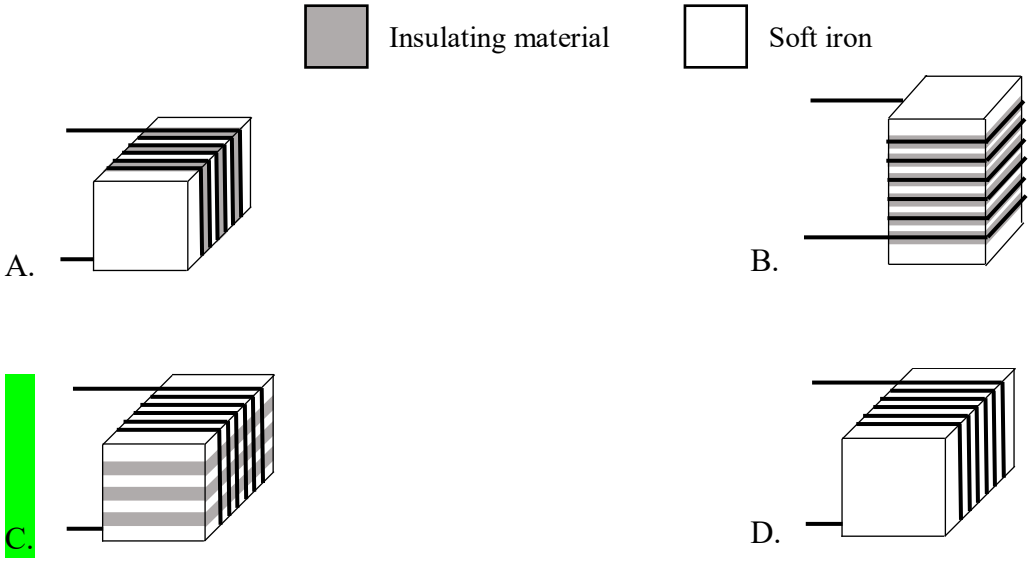
5. A current-carrying conductor experiences a force when it is placed in a uniform magnetic field. This is known as which of the following?
   A. Faraday's law.
   B. The motor effect.
   C. Lenz's law.
   D. The photoelectric effect.

6. Galileo's analysis of gravity determined which of the following?
   A. Acceleration due to gravity is $9.8ms^{-2}$, vertical velocity is independent from the horizontal velocity and distance travelled for a falling body increases at an increasing rate.
   B. Acceleration due to gravity is $9.8ms^{-2}$, vertical velocity is independent from the horizontal velocity and the more mass an object has the larger the gravitational force.
   C. The vertical velocity is independent from the horizontal velocity, the more mass an object has the larger the gravitational force and distance travelled for a falling body increases at an increasing rate.
   D. The vertical velocity is not independent from the horizontal velocity, distance travelled for a falling body increases at an increasing rate, the force between two bodies decreases according to $1/r^2$ relationship.
7. Which of the following options correctly shows the relationship between the experiment and the theory it supported?

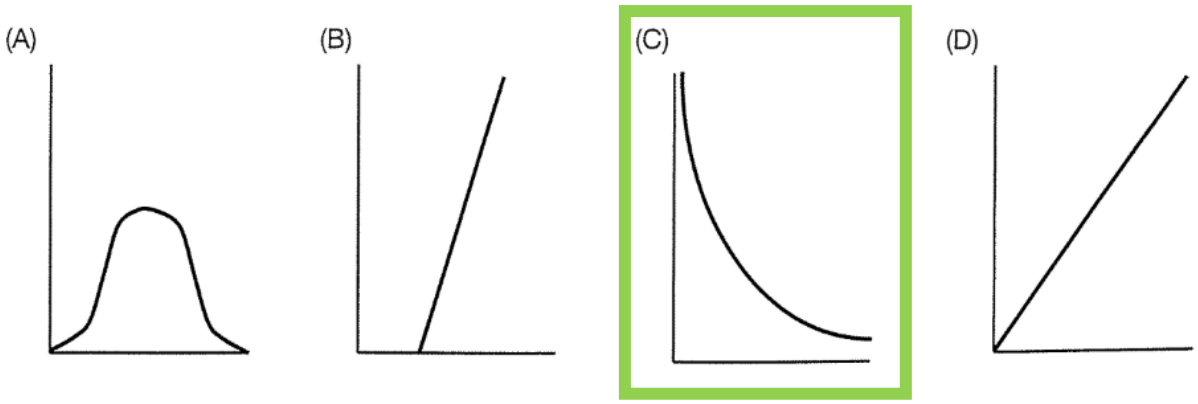
Answer	**Model of Light**	
	Light is a particle	**Light is a wave**
A.	The Photoelectric Effect	The Photoelectric Effect
B.	Young's Double Slit Expt.	Young's Double Slit Expt.
C.	Young's Double Slit Expt.	The Photoelectric Effect
D.	The Photoelectric Effect	Young's Double Slit Expt.

8. A student attaches a tennis ball to a piece of string 1.0 m long and swings the ball vertically in a circle.
   Which of the following best describes the energy of the ball as it moves from the bottom to the top of its rotational path?
   A. Its energy changes and work is done on the ball.
   B. Its energy changes and total work is a constant.
   C. Its energy remains the same and work is done on the ball.
   D. Its energy remains the same and total work is a constant.
9. Two identical current-carrying conductors are placed parallel to each other. Which of the following will **not** increase the magnitude of the force by a factor of 4?
   A. Doubling the current in both wires.
   B. Doubling the current in one wire and halving the distance between the wires.
   C. Decreasing the distance between the wires by a factor of 4.
   D. Halving the current in both wires and decreasing the distance between the wires by a factor of 8.

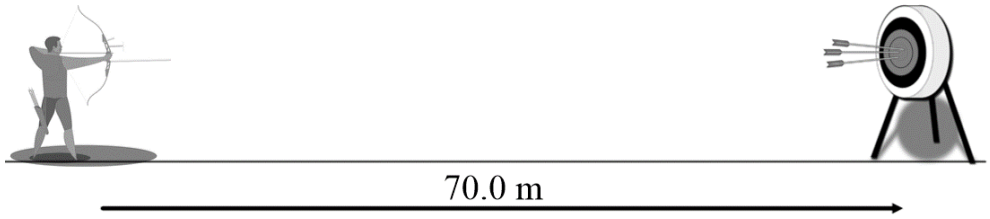
10. Which of the following core designs would be best in minimising heating effects due to eddy currents?



11. Which of the following was NOT a contribution made by Maxwell to developing ideas in physics in the 1870's?
    A. He was able to calculate the speed of light accurately.
    B. He proposed that light was a self-propagating electromagnetic radiation.
    C. He predicted an endless spectrum of electromagnetic radiation.
    D. He did follow-up experiments to analyse the photoelectric effect discovered by Planck.
12. Two planets have equal acceleration due to gravity on their surface. Planet 1 has 4 times the mass of Planet 2.
    Which of the following correctly shows the radius of Planet 1, r_1 , to Planet 2, r_2 ?
    A. $r_1 = 2r_2$
    B. $r_1 = 4r_2$
    C. $r_1 = 16r_2$
    D. $r_1 = 64r_2$
13. Which graph best shows the relationship between the energy (y-axis) carried by a photon and the wavelength (x-axis) of the photon?



14. An archer is competing in two events at the Olympics. Each event requires competitors to shoot an arrow to a bullseye (centre of the target) which is the same height off the ground as the release height of the arrow. The archer enters the 70 m and the 50 m events.



The archer shoots the first arrow horizontally over the 70.0 m under projectile motion and misses the centre of the target.

The archer fires a second arrow horizontally at an identical speed this time for the 50.0 m event.

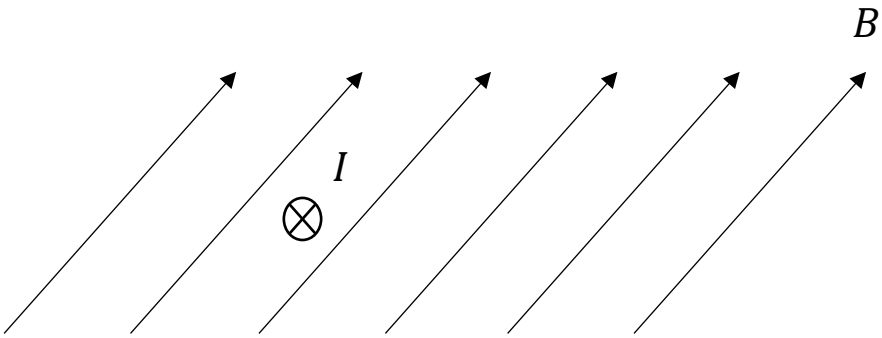
Which of the following would be the expected outcome of the two shots?

A. Both the arrows will hit the same spot on the target just below the bullseye and the time of flight will be shorter for the second arrow.
B. The first arrow will hit the target lower than the second arrow and the time of flight will be the same for both.
C. The first arrow will hit the target lower than the second arrow and the time of flight will be shorter for the second arrow.
D. The second arrow will hit the target lower than the first arrow and the time of flight will be the same for both.

15. How did Newton's particle theory of light explain refraction?

A. Stronger forces within the refracting medium changed the direction of travel of the light particles as they entered the medium.
B. Because the refracting medium was so dense compared to air, the light particles were forced to slow down.
C. The light particles scattered in the medium because the medium particles were closer together than air particles.
D. Newton's particle theory of light showed that the angle of incidence is equal to the angle of refraction.

16. A current-carrying conductor is placed in a magnetic field as shown in the diagram below. Which of the following represents the force experienced by the conductor?



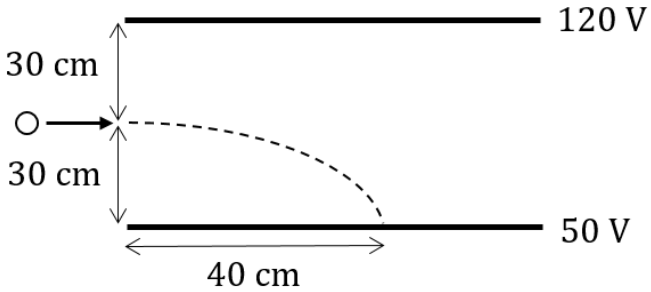
A. 

B.

C. 

D. 

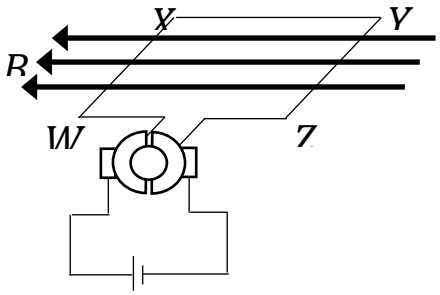
17. A particle has a charge of magnitude 2×10^{-4} C. It travels horizontally into an electric field as shown in the diagram below.



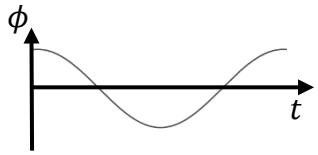
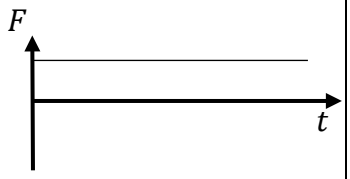
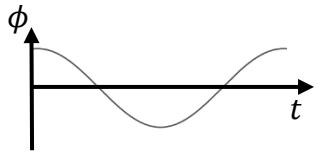
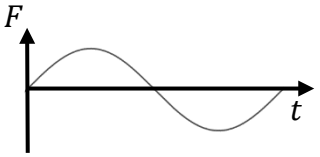
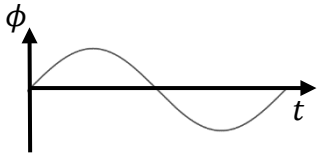
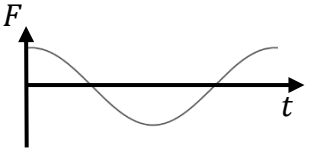
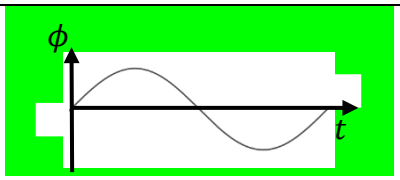
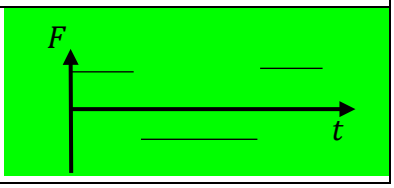
Using the motion of the charged particle, what can be concluded about the charge of the particle and the work done by the electric field?

	Charge	*Work done by the electric field*
A.	Positive	7.0×10^{-3} J
B.	Positive	1.4×10^{-2} J
C.	Negative	7.0×10^{-3} J
D.	Negative	1.4×10^{-2} J

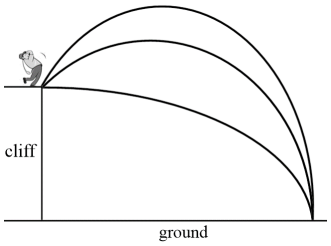
18. A DC motor has been set up as shown in the diagram below.



Which of the following represents the flux through the area $WXYZ$ and the force acting on wire WX starting from the position shown in the diagram through one revolution?

	Flux through WXYZ	*Force on WX*
A.		
B.		
C.		
D.		

19. A golfer hits three golf balls under projectile motion off a cliff top as drawn below.



Which of the following statements is correct about the balls being hit?

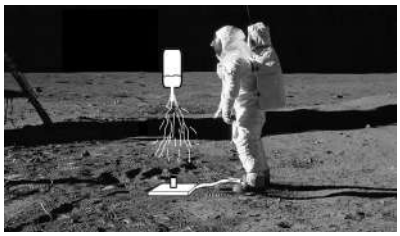
A. Each ball has the same initial velocity.
B. Each ball has the same initial horizontal velocity.
C. Each ball has the same initial vertical velocity.
D. None of the velocities are the same.

20. Starship "Alpha" travels at 0.9c past an identical starship "Beta", which is at rest. Both a cabin boy on the "Alpha" and a cook on the "Beta" measure the time required for the other ship to pass by their respective windows. Who measures the longer time?
    A. The cabin boy
    B. The cook
    C. Both measure the same time
    D. The measured times cannot be compared

Section II
80 marks
Attempt Questions 21-37
Allow about 2hr 25 minutes for this section.
Write your answer in the space provided.

Question 21 (5 marks)

A top secret photograph was leaked from NASA showing the analysis of projectiles on the Moon. It shows a feasibility study as to whether water propulsion systems could be used to leave the Moon's gravitational field (m_{moon} = 7.35 x 10^{22} kg, r_{moon} = 1.74 x 10^{6} m).



A typical high pressure water system can provide a constant thrust such that after 1.9 s a stationary, 120 g rocket is travelling at 22 ms^{-1}.

(a) Calculate the resultant force on the rocket assuming its mass remains at 120 g.

$$F = ma = \frac{m(v-u)}{t} = \frac{0.12(22-0)}{1.9} = 1.38947 = 1.4\ N\ (up)$$

(b) Calculate the work done by the water rocket.

$$\Delta E = K_f - K_i = \frac{1}{2}mv^2 - \frac{1}{2}mu^2 = \frac{1}{2} \times 0.12 \times 22^2 - 0 = 29.040 = 29\ J$$

(c) Calculate how high the water rocket is at 1.9 s.

$$v^2 = u^2 + 2as \ \therefore s = \frac{v^2-u^2}{2a} = \frac{22^2-0^2}{2\times\frac{22}{1.9}} = 20.9\ m \text{ or } s = ut + \frac{1}{2}at^2 \text{ also works}$$

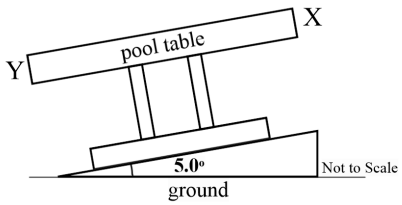
(d) Explain whether the rocket would escape the moon's gravitational field after this launch.

$$v = \sqrt{\frac{2GM}{r}} = \sqrt{\frac{2 \times 6.67 \times 10^{-11} \times 7.35 \times 10^{22}}{1.74 \times 10^{6}}} = 2.37 \times 10^{3}\ ms^{-1}$$

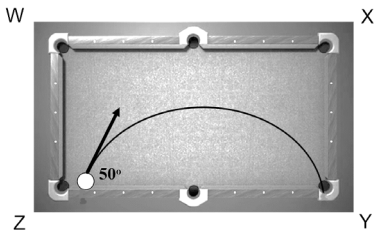
Since maximum velocity of the rocket is only 22 ms^{-1} the rocket would not escape the moon's gravity.
It was important that a calculation was included.
Some students used an incorrect equation but were still able to show that after comparing the two values said that the rocket was unable to escape = 1 mark

Question 22 (5 marks)

Bob sets up his brand new friction free, snooker table in his house. Bob doesn't know that his floor is slightly tilted by 5.0° as shown here.



Bob places a frictionless white ball on the table and hits the ball at a velocity of 1.10 ms^{-1}, 50.0° from the long side of the table.



(a) Calculate the net acceleration on the ball.

$$a = gsin\theta = 9.8 \times sin5^{o} = 0.854126 = 0.85\ ms^{-2}$$

Sig. figs.

(b) Calculate the time it takes for the ball to reach the pocket (hole).

$$s_y = u_y t + \frac{1}{2}at^2 = 0 \ \therefore t = \frac{-usin\theta}{\frac{1}{2}a} = \frac{-1.10 \times sin50.0}{\frac{1}{2} \times (-0.854126)} = 1.97313 = 2.0\ s$$

or

$$v_{top} = u_y + a_y t_{top} \ \therefore \ t_{top} = \frac{v - u}{a} = \frac{0 - (1.10 \times sin50.0)}{-0.854126} = 1.07625$$

$$t_{total} = 2 \times 1.07625 = 2.15250 = 2.1\ s$$

(c) How far is the corner pocket (hole) from the position it was hit?

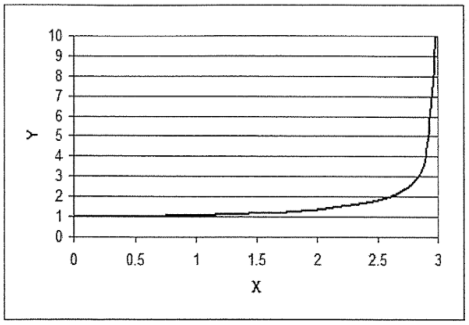
$$u_x = \frac{s_x}{t} \therefore s_x = u_x t = ucos\theta t = 1.10 \times cos50.0 \times 1.97313$$

$$= 1.39513 = 1.4\,m$$

Question 23 (3 marks)

The graph below shows a plot of the equation

$$Y = \frac{1}{\sqrt{1 - \frac{X^2}{3^2}}}$$

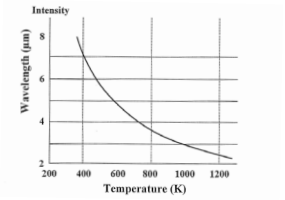


Explain the significance of the shape of the graph for our understanding of time in the special theory of relativity.

1 mark – Student has mentioned the 2 main sections of the graph: flat at start and massive increase after ~2.5.
1 mark – Student has linked how time dilation does not show effects at low velocities (starting part of graph).
1 mark – Student has linked how time dilation shows significant effects at velocities closer to c (last section of graph).
It was important that students specifically referred to the graph *shape*.

Question 24 (4 marks)

The graph below shows the wavelength of the peak intensity radiation emitted by a standard black body at different surface temperatures.



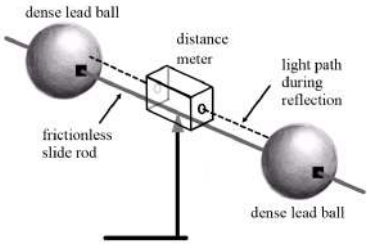
Using data points from the graph, show that the graph is consistent with Wien's law.

1 mark – Student states Wien's Law as $\lambda_{max} = \frac{b}{T}$
1 mark – Student correctly extracts at least 2 data points from the graph and calculates 2 values for b or subs values for T into the equation and finds λ
1 mark – Student averages the two values for b or specifically compares the calculated values for λ with those from the graph
1 mark – Student compares the calculated value with the stated value from data sheet.

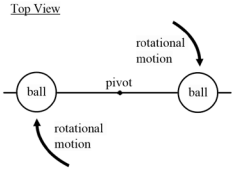
- **b is a constant so you should be using values for λ and T to confirm its value.**

Question 25 (4 marks)

Lucy was conducting a depth study in a school laboratory with the intension to validate Newton's Law of Universal Gravitation.
She set up two very dense 100kg lead balls on a frictionless slide rod such that each ball can move freely either out from the centre or into the middle. A distance meter was placed in the middle which works by reflecting light off the balls. The whole apparatus was suspended on a pivot which only allows rotation in the horizontal plane.



Lucy rotated the apparatus creating a centripetal force. The aim was to find the speed at which the centripetal force was equal to the gravitational force between the two dense lead balls.



(a) How would Lucy know when the force of gravity was equal to the centripetal force?

1 mark – Student identifies that Lucy would observe the distance between the balls to be constant.

(b) Lucy found the relationship between the rotational speed and the distance of one of the balls from the fulcrum to be $= \sqrt{\frac{Gm_2}{r}}$. Show support for this equation by deriving this formula.

$$F_g = \frac{GmM}{r^2} \quad and \quad F_C = \frac{mv^2}{r}$$

$$\frac{GmM}{r^2} = \frac{mv^2}{r} \quad \therefore \; v = \sqrt{\frac{Gm_2}{r}}$$

Justify why Lucy would not observe any measurable results in this experiment.

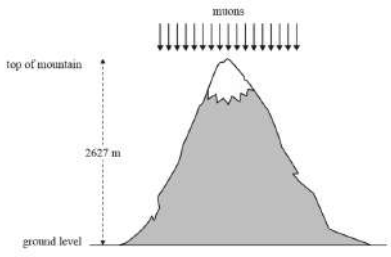
1 mark – Student calculates the velocity needed for the two balls to be at constant distance.

1 mark – Student states that this velocity is not observable to the naked eye.

Many students substituted the mass of the Earth into the equation instead of 100 kg.

Question 26 (4 marks)

Muons are elementary particles created in the upper atmosphere by cosmic rays. They are unstable and decay after 2.2 μs measured in the frame of reference of the muon.
In an experiment, muons with a velocity of 0.995c were observed to pass the top of a mountain of height 2627 m and reach the ground.



a) Calculate the life time of the muons as measured by a stationary observer on the ground.

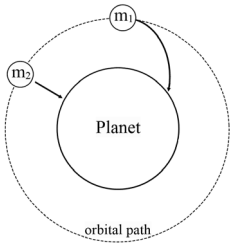
$$t_v = \frac{t_o}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{2.2}{\sqrt{1-\frac{0.995c^2}{c^2}}} = 22.0276 = 22\ \mu s$$

b) Explain why many more muons reached the ground than would be predicted by classical physics.

1 mark – Student identifies that the life time is increased by time dilation.
1 mark – Student states the idea that classical value is different to special theory.

Question 27 (3 marks)

Two objects of identical mass fall from space down to the surface of a planet with no atmosphere. Mass m_1 does not have enough speed to remain in orbit and follows a parabolic path down to the planet. Mass m_2 is stationary and starts to fall straight down.

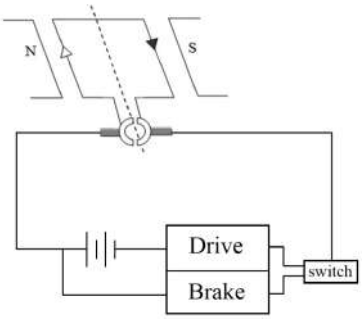


Compare qualitatively the impact velocities of m_1 and m_2. Refer to energy changes in your answer.

1 mark – Student identifies that the increase in velocity of both masses is the same according to Newton's Universal Gravity equation.
1 mark – Student identifies that Mass 1 has orbital velocity as well as U so will have a greater total energy.
1 mark – Student states that Mass 1 will impact at a greater velocity than Mass 2.

Question 28 (4 marks)

Most modern electric vehicles contain a switch that converts a DC motor to a DC generator in order to change their forward motion to braking.



With reference to the Law of Conservation of Energy, explain the difference between a DC Motor and a DC generator.

1 mark – Student identifies that a DC motor transform electrical energy into kinetic energy and a DC generator transform kinetic energy into electrical energy.
1 mark – Student explains that a DC motor utilises the motor effect.
1 mark – Student explains that a DC generator utilises Faraday's (Lenz's) Law.
1 mark – Student link their responses to the law of conservation of energy to state that there must be a loss of kinetic energy in order to create chemical potential energy in the battery e.g. stating that the direction of the induced current in a DC generator opposes the change in flux that causes it (Lenz's Law), thus the coil will slow down.

Most students were able to identify that a DC motor transforms electrical energy into kinetic energy and a DC generator does the reverse. However, not that many students explained how the two operate under different physics principles. In order to obtain the last mark, students need to explicitly draw links to the law of conservation of energy with reference to the operation of the DC motor/generator. Simply stating the transformation from electrical energy -> kinetic energy, or vice versa, is not enough.

A DC Motor operates by a supply current. Based on the motor effect, a current carrying wire ~~with~~ in a magnetic field will experience a force. This force causes the ~~motor~~ coil to experience torque which ~~the~~ allows the motor to spin. * In contrast, a DC generator does where mechanical energy is converted into electrical energy, as there coil experiences a change in magnetic field, ~~the~~ this change in magnetic flux induces an emf which ~~this is~~ a generates a current in the wire.

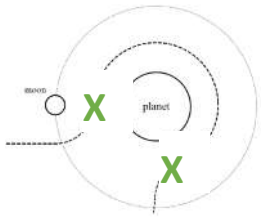
* However by law of conservation of energy, as the motor spins, a change in magnetic flux is created and thus an induced current is produced in the opposite direction, ~~resisting the~~ to oppose ~~the force of the~~ the direction of motion, this agrees with law of conservation of energy as the motor cannot have an infinitely increasing speed.

End of Question 28

(4)

Question 29 (3 marks)

A satellite is exploring a distance planet and its orbiting moon. It follows the path shown here with a dashed line and only uses its rockets to leave the planet's orbit. Picture not to scale.



(a) Indicate, using a cross, where in the diagram the net force on the rocket is zero.

1 mark – indicate one position where the net force on the rocket is zero

This question was not done well. Students need to recognise that the diagram is not drawn to scale as stated in the question. As the moon and planet both exert a force on the satellite, these two forces will be balanced between the two bodies.

(b) Describe how the model drawn above is useful in understanding satellite motion AND how the model has limitations.

1 mark – one aspect of the model that is useful (based on its purpose) e.g. the model gives the shape of the orbit, the model shows how the satellite would interact with the two gravitational field

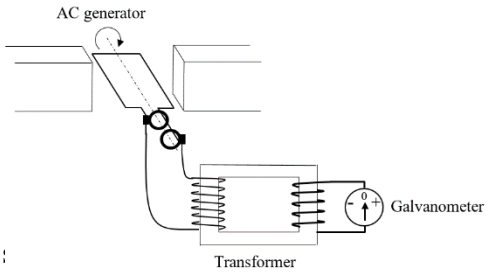
1 mark – one limitation e.g. model does not show relative distances, model is limited to circular orbits

Most students were able to state one usefulness and one limitation of the model. Students need to state these according to the purpose of the model.

Question 30 (7 marks)

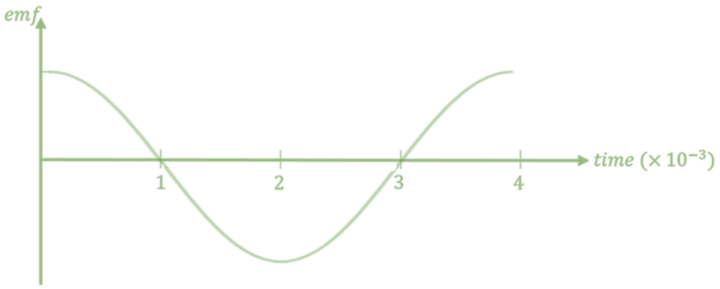
A stationary AC generator is connected to an ideal transformer as shown in the diagram below.

Magnetic field strength (B)	8.50×10^{-2} T
Area of the coil (A)	1.50 m^2
Period of rotation of the coil (T)	4.00×10^{-3} s
Resistance of the wire in the secondary coil (R)	5.25 Ω



The table shows the data for the generator and transformer :

(a) The AC generator starts from the position shown in the diagram above. Sketch a graph of the emf produced by the generator.



1 mark – correct period/frequency

1 mark – correct shape (starting with max emf)

Most students were able to draw a graph with the correct period/frequency.

However, most students did not recognise that the emf produced is proportional to the change in flux $\varepsilon = -\frac{\Delta\emptyset}{\Delta t}$ and therefore the graph should start at a maximum

(b) Identify the transformer as a step-up or step-down transformer.

Step down

(c) Given that the maximum emf produced by the AC generator can be calculated by $\varepsilon_{max} = 2\pi fBA$ where f is the frequency of the rotating coil, calculate the maximum reading on the galvanometer.

1 mark - $\varepsilon_{max} = 2\pi fBA = 2\pi \times \frac{1}{T} \times B \times A = 2\pi \times \frac{1}{4.00\times10^{-3}} \times 8.50 \times 10^{-2} \times 1.5$

$= 2.00277 \times 10^2 = 2.00 \times 10^2$

1 mark - $\frac{V_1}{V_2} = \frac{n_1}{n_2} \therefore V_2 = \frac{V_1 \times n_2}{n_1} = \frac{2.00\times10^{-2}\times5}{7} = 1.42857 \times 10^2 = 1.43 \times 10^2\ V$

1 mark - $V = IR \therefore I = \frac{V}{R} = \frac{1.43\times10^2}{5.25} = 27.2\ A$

Most students were able to calculate the maximum emf produced using the formula provided. However, a lot of students forgot to step-down the voltage (due to the transformer). Carry forward marks were given for this equation if correct working has been shown.

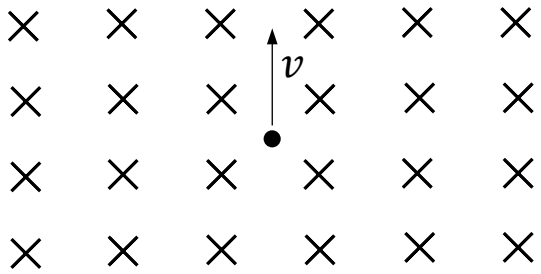
(d) The AC generator in the diagram is made into a DC generator by replacing the pair of slip rings with a split ring commutator. What would happen to the reading observed on the galvanometer?

1 mark – Student states that an observation that the reading would oscillate. (The generator produces a varying DC which means flux would vary)

Students need to recognise that the generator would produce a varying DC which means that there will still be a change in flux occurring at the primary coil of the transformer. Students only need to state that the reading on the galvanometer would oscillate to obtain the mark.

Question 31 (6 marks)

A particle with mass m and charge q moves with a constant velocity v. A magnetic field of strength B is then switch on as shown in the diagram below.



(a) Show that the period of rotation T of the particle is given by $T = \frac{2\pi m}{qB}$.

$$v = \frac{2\pi r}{T} \quad F = qvB \quad F_C = \frac{mv^2}{r} \quad \therefore qvB = \frac{mv^2}{r} \quad v = \frac{qBr}{m} \quad T = \frac{2\pi r}{v}$$

$$\therefore T = \frac{2\pi rm}{qBr} = \frac{2\pi m}{qB}$$

This question was done well. Most students were able to equate the three equations to obtain the given formula.

(b) Calculate the period of rotation if the particle is an electron and the strength of the magnetic field is 2.0×10^{-4} T.

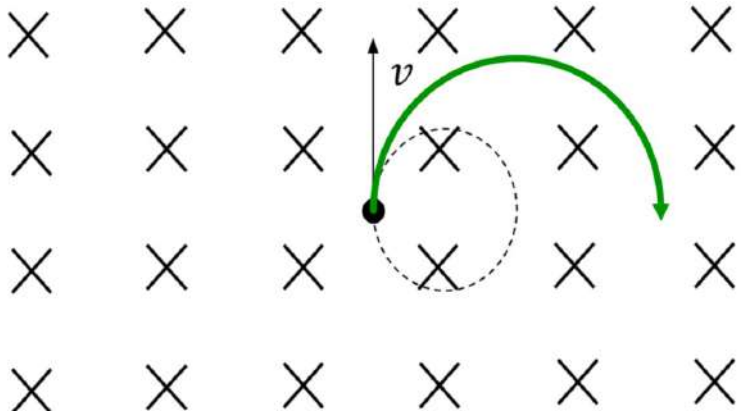
$$T = \frac{2\pi m}{qB} = \frac{2\pi \times 9.109 \times 10^{-31}}{1.602 \times 10^{-19} \times 2.0 \times 10^{-4}} = 1.78632 \times 10^{-7} = 1.8 \times 10^{-7}\ s$$

1 mark – correct substitution

1 mark – correct units

This question was done well. Almost all students were able to substitute the appropriate values into the formula and state the correct unit.

(c) The diagram below shows the path of the electron after one period, T. Draw the path of the electron for the same time T if the magnetic field strength was halved.

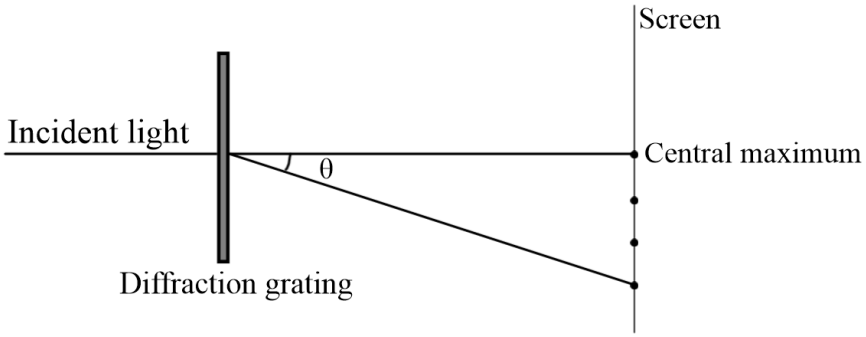


1 mark - indicating that the radius would double.
1 mark – indicating that it would only travel a semi-circle

Most students were able to recognise that the radius of the circular motion would double. However, students also need to recognise that the period of motion would be double as well based on the formula from i.). Hence the electron would only travel a semi-circular path in the same time frame.

Question 32 (5 marks)

Monochromatic light of wavelength 545 nm is shone onto a diffraction grating which has rulings of 1.2 x 10^3 lines per centimetre.



a) Calculate the angular deviation between the central maximum and the third-order bright spot.

$$d = \frac{1 \times 10^{-2}}{1.2 \times 10^{3}} = 8.333 \times 10^{-6}$$

$$d\sin\theta = m\lambda \quad \therefore \quad \theta = \sin^{-1}\left(\frac{3 \times 545 \times 10^{-9}}{8.333 \times 10^{-6}}\right) = 11^{o}$$

1 mark – correct substitution into the correct formula

1 mark – correct answer

Most students were able to use the correct formula to calculate the angular deviation.

Common mistakes involve: not converting the ruling into a distance, substituting an incorrect value of n, not converting into S.I. units before substituting into the formula

b) Explain why this experiment creates regions of bright and dark spots.

1 mark – Student states that constructive interference results in bright spots
1 mark – Student states that destructive interference results in dark spots
1 mark – Student states that distance the light travels from the slit creates a difference in the phase (position) of the crests and troughs resulting in the constructive/ destructive interference.

Most students were able to state the constructive and destructive interference results in bright and dark spots respectively. However, only a few students explained why/when these constructive and destructive interference occur.

b) Explain why this experiment creates regions of bright and dark spots. 3 3

when the path difference is an integer multiple of the wavelength (ie. $d\sin\theta = m\lambda$, $m=1,2,3\ldots$), this results in in-phase waves undergoing constructive interference which produces bright spots. When the path difference is an odd multiple of half-wavelength (ie. $d\sin\theta = (2m+1)\frac{\lambda}{2}$) where $m=1,2,3\ldots$, this results in out-of-phase waves undergoing destructive interference which produces dark spots.

b) Explain why this experiment creates regions of bright and dark spots. 3 3

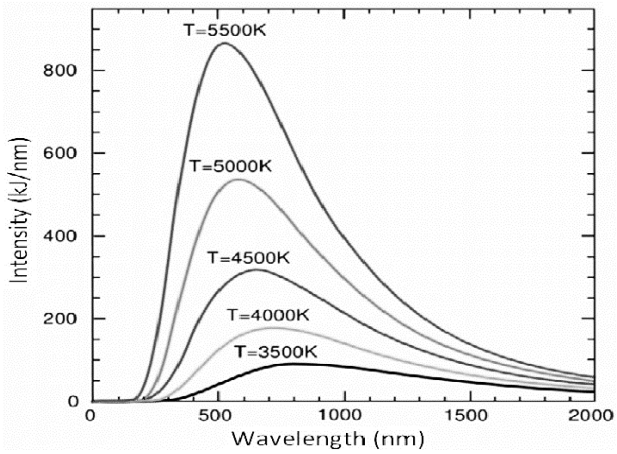
As the light passes through the diffraction grating, the light is diffracted and multiple sources of light are produced. Each light source (light from a slit) has to travel a different distance to reach the screen and therefore, will take different amounts of time and be in different phases by the time they reach the screen. When light waves in phase interfere, they create constructive interference and create the bright spot. this is because the amplitude of the wave (intensity of light is increased) in constructive interference. the waves out of phase will create destructive interference and therefore, the dark spots (since amplitude and intensity of intensity of light decreases).

End of Question 32

excellent!

Question 33 (4 marks)

Energy density versus wavelength curves are shown for blackbody radiation at various temperatures.



a) State Planck's two fundamental postulates that are used to explain the shape of the black-body radiation curve.

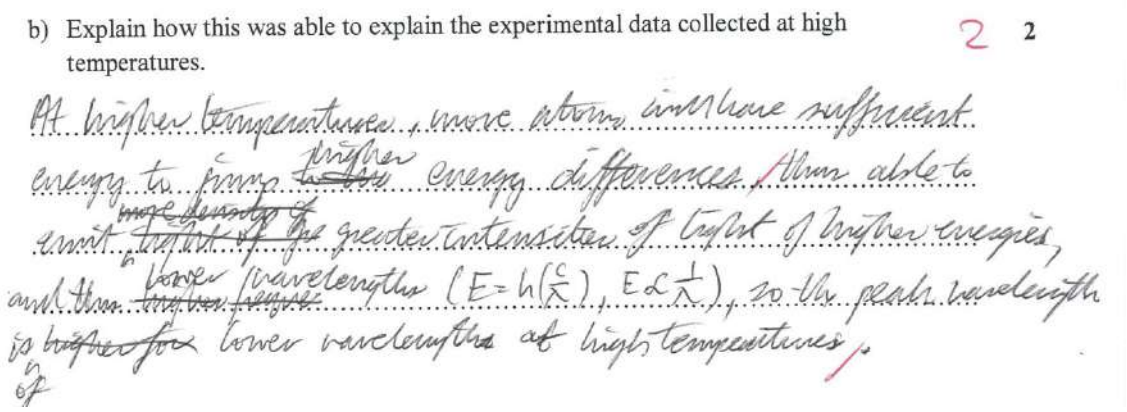
2 marks – Student correctly states the two postulates.

This question was not done well. Most students were able to state the postulate that energy released from blackbody radiation is quantised. However, numerous students stated Wien's Law as one of the postulates which is incorrect.

b) Explain how this was able to explain the experimental data collected at high temperatures.

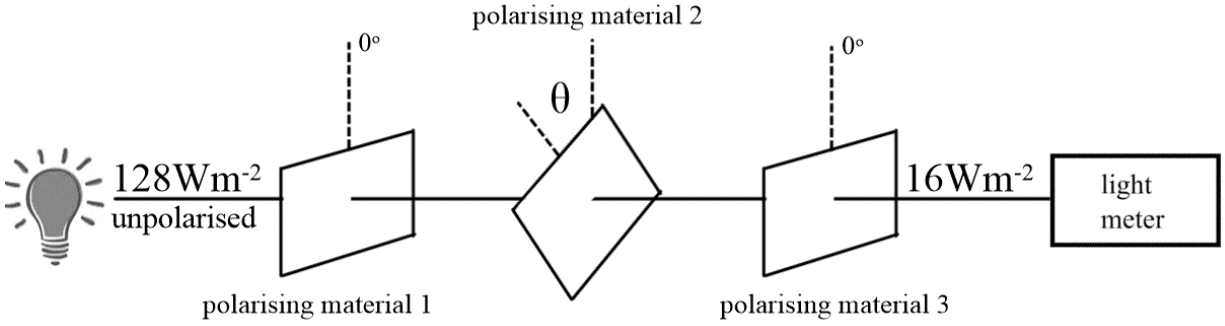
1 mark – describes the shape/trend from the graph
1 mark – explanation of experimental data linked to Planck's postulates.

This question was done poorly. Students need to revisit the concepts involved in analysing blackbody radiation. A lot of students have written a response that did not answer the question. Some students have described the experimental data but did not provide an explanation relating to Planck's postulates.



Question 34 (4 marks)

Unpolarised light of intensity 128 Wm^{-2} passes through three polarising filters. The polarising axes of the first and third filters are at 0°.



If the intensity of the light passing out of the third filter is 16 Wm^{-2}, calculate the angle (θ) with which the polarising material 2 is rotated?

1 mark – Student demonstrated the understanding to use the equation

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

1 mark – Student showed the first filter drops the intensity by 50%

$$I_1 = 0.5 \times 128 = 64.0$$

1 mark – Student shows that the second filter changes the intensity the same as the third

$$I_2 = 64.0cos^2\theta \quad (1) \qquad 16 = I_2cos^2\theta \quad (2)$$

1 mark – Student correct substitutes the values into the correct equation

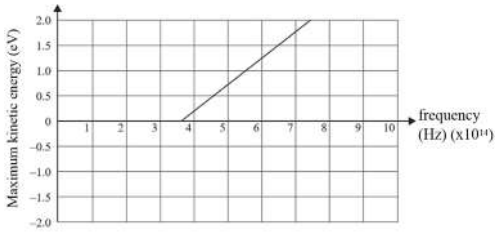
$$16 = (64.0cos^2\theta)cos^2\theta \;\; \therefore \;\; \theta = cos^{-4}\left(\frac{16}{64}\right) = 45^o$$

The phrase "Missed a step" means that you did not apply $cos^2\theta$ twice for both materials.

Common mistake was not halving the intensity at the first material. GOLDEN MARK RULE APPLIED.

Question 35 (5 marks)

Students are studying the photoelectric effect by measuring the frequency of incident light against the kinetic energy of the photoelectrons.
The graph below shows the results the students obtained for the maximum kinetic energy (K_{max}) of the emitted photoelectrons versus the frequency of the incoming light.



a) Using the data from the graph, determine the value the students would have obtained for:
   i) Planck's constant, *h*

1 mark – Student demonstrates the skill of calculating a gradient using a range of data.

1 mark – Converting to standard units in number correctly.

$$gradient = \frac{(2.0 - 0) \times 1.602 \times 10^{-19}}{(7.5 - 3.6) \times 10^{14}} = 8.432 \times 10^{-34}$$

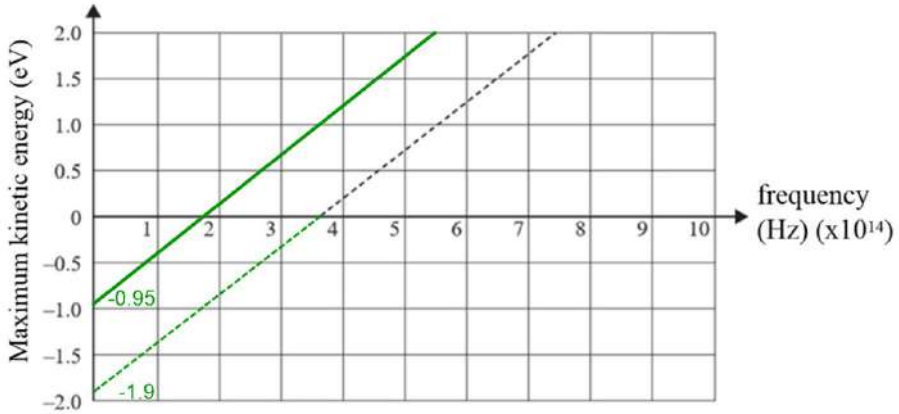
Students that did not use "more" than half the line of best fit to calculate the gradient lost a mark (4.5→6.5 = -1mk). Using one data point from a line to calculate a gradient is not and has never been correct in science.

ii) the maximum wavelength of light that would cause the emission of photoelectrons

1 mark – Student correctly extracts 3.6 x 10^{14} Hz and converts to 833 nm.

A range of values were excepted between 790nm and 833nm.

b) The work function for the original metal used is ∅.
On the graph below, draw the line that would be obtained if a different metal, with a work function of $\frac{1}{2}$∅, were used in the experiment. (The original graph is shown as a dashed line.)



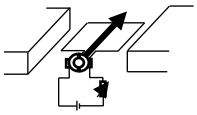
1 mark – Student draws a line starting at -0.95 on the y-axis. (0.9→1.0 ok)

1 mark – Student draws a line parallel to the original.

This was very well done! Yay!

Question 36 (8 marks)

A simple DC motor is used to drive a benchtop drill. The motor is connected in series with a variable resistor to protect the windings in the coil as sown in the diagram below.



The variable resistor is adjusted to have a large resistance when the motor is starting up and the resistance is slowly lowered as the motor reaches its operating speed.
Explain improvements that can be made to motors to minimise the issues with torque and back emf.

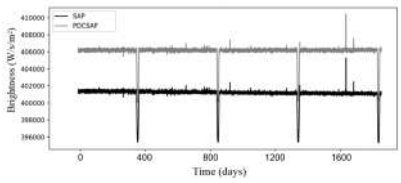
Marks	Scheme
7 - 8	**Student outlines *4* improvements to the DC motor drawn above and details the Physics principle that governs this improvement and how this principle plays role. Student must include *at least* 1 improvement that addresses torque and 1 improvement that addresses back emf.** **OR** **Student describes *3* improvements to the DC motor drawn above and explains the Physics principle that governs this improvement and details how this principle plays role (diagrams). Student must include *at least* 1 improvement that addresses torque and 1 improvement that addresses back emf.**
5 - 6	**Student outlines *3* improvements to the DC motor drawn above and details the Physics principle that governs this improvement and how this principle plays role. Student must include *at least* 1 improvement that addresses torque and 1 improvement that addresses back emf.**
3 - 4	**Student outlines *2* improvements to the DC motor drawn above and details the Physics principle that governs this improvement and how this principle plays role. Student must include *at least* 1 improvement that addresses torque and 1 improvement that addresses back emf.** **AND/OR** **Student simply lists improvements with no explanation of how they apply or thought that using the equation was an explanation.**
1 - 2	**Limited physical principles discussed and/or minimal improvements included.**

Common mistakes were:

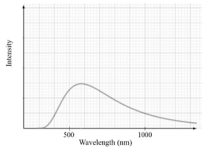
- **BACK EMF!!!! You need to go back and revise! Ahhh. Not the best explanation of this phenomenon in motors. Most were not only wrong but started to contradict yourselves mid-sentence. Back emf is not a source of energy loss. You can't stop/reduce back emf ever. It is inherent in the nature of the motor.**
- **Listing a set of improvements is not explaining.**
- **Using an equation to explain is not correct, e.g. "Increasing the current increases the torque because $\tau = nBIA$."**

Question 37 (6 marks)

The Australian Astronomical Observatory in Coonabarabran took many pictures of a distant star P3682 over many years. They used spectral analysis and found that there was a distinct change in brightness caused by an exoplanet (planet not from our solar system) blocking the light as it orbits around P3682. Here is a graph of the data they collected (measured in Earth days).



From further spectra analysis of brightness revealed that P3682 had a mass of 7.96 x 10^{30} kg. Specialised emission spectroscopy of P3682 revealed the following continuous spectra.



From much discussion with other institutions of astronomy, a set of ranges were established for an exoplanet orbiting a star such as P3682, such that human life could be maintained.

Property	**Range to suit habitat of exoplanet**
Orbital Radius of Planet	0.5 – 2.5 Earth radii
Orbital Velocity of Planet	2 – 80 km s^{-1}
Temperature of Central Star	5000 – 6000 K

Discuss reasons for whether humans should be sent to this exoplanet for habitation. *Justify* your reasons by using the information provided here.

Marks	**Scheme**
5 - 6	**Student has used the data to calculate the orbital radius of the exoplanet AND has calculated the orbital velocity of the exoplanet using Kepler's Law and compares it to the data in the table AND calculates the temperature of the Star using Wien's Law and compares it to the data in the table. Student has written an overall judgement as to whether the planet is habitable.**
3 - 4	**Student has missed one/two of the above underlined facts AND/OR has presented incorrect physics principles AND/OR has not put in a judgement.**
1 - 2	**Student has calculated one – two pieces of data from that given.**

Unfortunately, I did not realise you needed the orbital radius of the Earth to use the data in the table. Totally my fault. So, the marking scheme reflects that a calculation is needed for orbital radius but the analysis of the Earth radii is ignored. Instead that mark is given to the formation of a judgement.

Common mistakes:

- **People read a value off the first graph as less than or equal to 400. It is clearly greater than that.**
- **Some people read the peak intensity incorrectly as the scale went up in 20 not 10 nm.**
- **May student said "this is within the acceptable range" which is not using the data provided.**