Student Number: _____

North Sydney Boys High School
Year 12 Physics 2019
Trial HSC Examination
Friday 5th July 2019

General Instructions

- Reading time – 5 minutes
- Working time – 135 minutes
- Board approved calculators may be used
- Write using black pen
- **Write your student number at the top of every separated page**
- **Use the multiple choice sheet provided**
- A NESA data and formulae sheet is provided

Total Marks – 75

Part A - 20 marks

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

Part B - 36 marks

- Attempt Questions 21–28
- Allow about 1 hour and 5 minutes for this part

Part C - 19 marks

- Attempt Questions 29-31
- Allow about 35 minutes for this part

Part A /20	
Part B / 36	
Part C / 19	
Total Mark / 75	

This paper MUST NOT be removed from the examination room

Part A – 20 marks

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

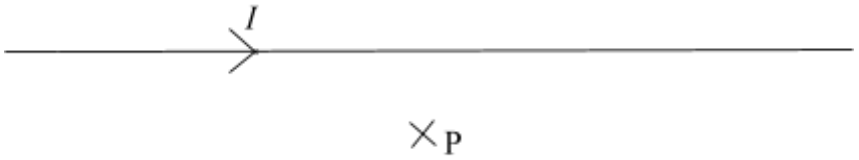
1. Which of the following are NOT assumptions made in analysing the motion of projectiles

(A) horizontal and vertical components are dependent on each other
(B) a constant acceleration due to gravity
(C) zero air resistance
(D) projectiles are point masses

2. Planet Falcon is 12 times more massive, with a radius 4 times that of Planet Unicorn. What is the ratio of gravitational acceleration at the surface of Planet Falcon to Planet Unicorn?

(A) 1 : 3
(B) 3 : 1
(C) 3 : 4
(D) 4 : 3

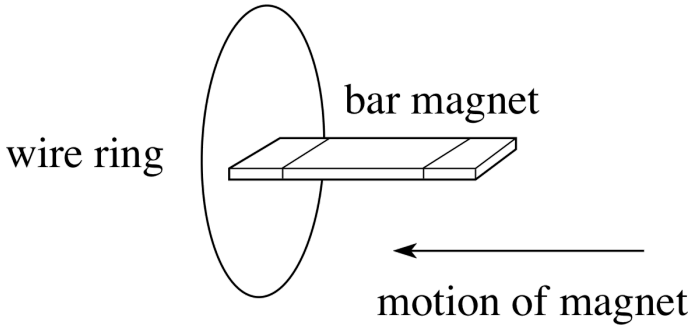
3. A long straight current carrying wire is shown below



What is the direction of the magnetic field at point P

(A) up the page
(B) into the page
(C) to the left
(D) to the right

4. A bar magnet is moved into a conductive wire ring as shown



Which of the following would increase the induced current in the ring?

(A) Increasing the speed of the magnet
(B) Rotating the wire ring
(C) Reversing the polarity of the bar magnet
(D) Moving the magnet away from the ring

5. Which of the following would increase the torque on the coil in a simple DC motor.

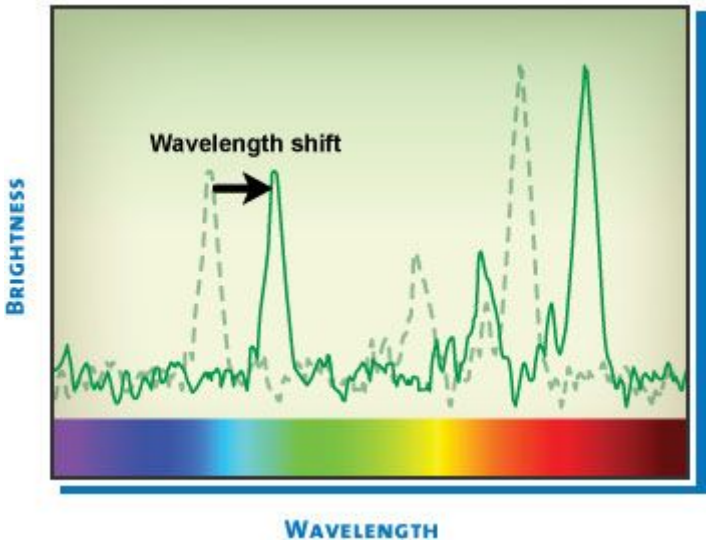
(A) reversing the direction of current
(B) decreasing the area of the coil
(C) decreasing the resistance of the coil
(D) decreasing the strength of the magnetic field

6. When a current flows through the coil below, the total flux through the interior of it is 80 mWb. If the dimensions of the cross-sectional area are 5 cm x 10 cm.

What is the magnetic field strength through the interior of the coil?

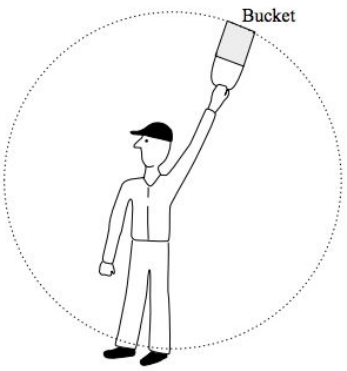
(A) 16000T
(B) 6.3mT
(C) 0.4mT
(D) 16 T

7. When examining a stellar spectra, what information does a wavelength shift in the diagram below provide?



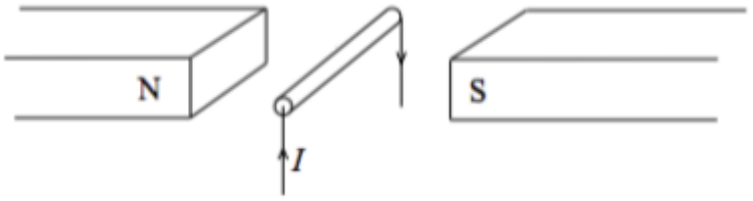
(A) Temperature of the star
(B) Translational velocity of the star
(C) Rotational velocity of the star
(D) Density of the star

8. A teacher swings a bucket full of water in a circular vertical path above their head as shown:



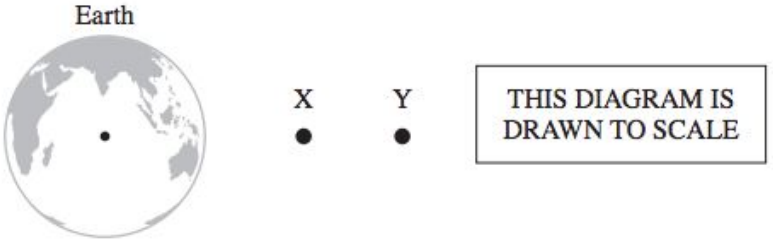
Why does the bucket have to remain above a certain speed to ensure the water does not fall out?
(A) to ensure there is enough lift to counteract the force of gravity
(B) so that there is the same acceleration for the bucket and the water
(C) to produce enough centrifugal force
(D) to allow the water to have no weight

9. A thin metal rod has a current passed through it as shown below



In which direction will the rod feel a force
(A) up the page
(B) down the page
(C) to the left
(D) to the right

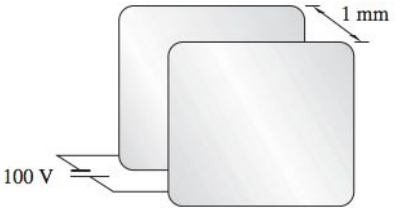
10. Two satellites of equal mass are in stable circular orbits at locations X and Y as shown in the diagram below.



What is the ratio of the kinetic energies of the satellite at position X to position Y

(A) 3:2
(B) 2:3
(C) 1:2
(D) 2:1

11. A deuterium nucleus (composed of 1 proton and 1 neutron) is placed in between the two charged plates shown in the diagram below, touching the centre of the positive plate.



What is the amount of work done by the electric field if it is allowed to move under the influence of the field?

(A) 1.6×10^{-17} J
(B) 1.6×10^{-18} J
(C) 3.2×10^{-17} J
(D) 3.2×10^{-18} J

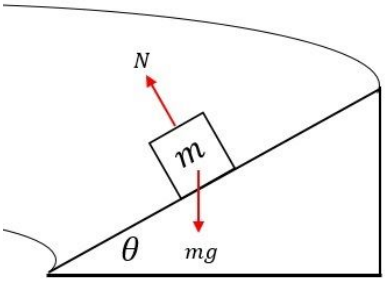
12. Which of the following phenomena could not be accounted for in Newton's model of light

(A) Colours
(B) Interference
(C) Reflection
(D) Refraction

13. Ganymede is a moon of Jupiter and has a mass of 1.48×10^{23} kg and a radius of 2 600 km. It has an orbital speed of 10.8 km/s and an orbital radius of 1.07×10^{3} km.
What is the gravitational force of Ganymede on Jupiter?

(A) 1.61×10^{22} N
(B) 6.64×10^{24} N
(C) 1.61×10^{25} N
(D) 3.56×10^{25} N

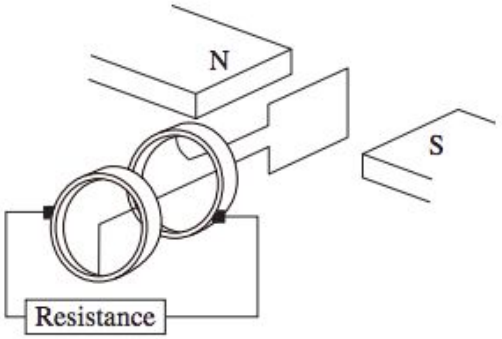
14. A mass on a banked track is undergoing circular motion and remaining at a constant height on the banked track



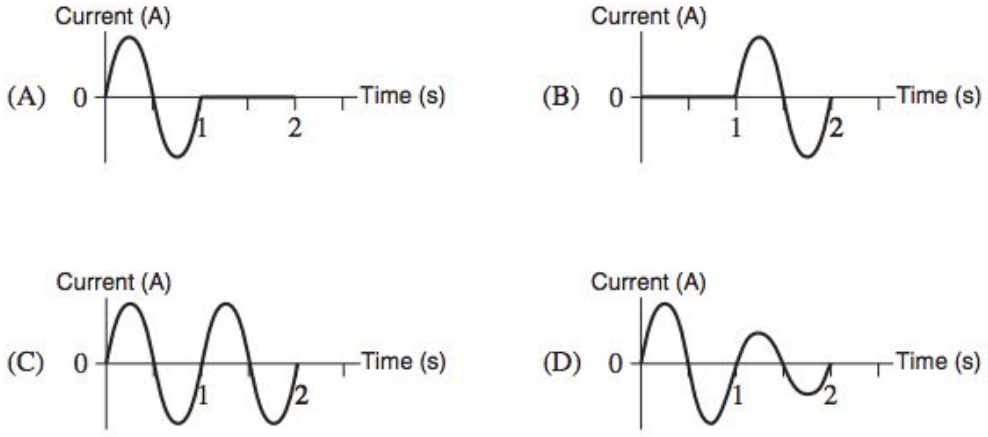
Which of the following expressions describes the centripetal force due to the banked track.

(A) $N \sin\theta$
(B) $N\cos\theta$
(C) $mg \sin\theta$
(D) $mg \cos\theta$

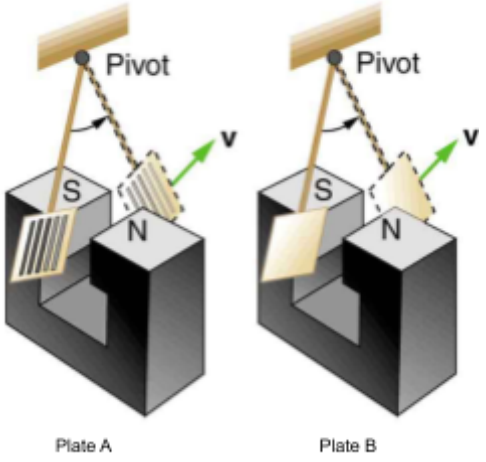
15. The coil in the generator below is rotated through 2 revolutions from the position shown



Which of the following graphs best represents the current flowing through the external resistance?



16. The following diagram shows conductive plates, swinging freely between two opposite magnetic poles. Plate A, the plate has segments cut out of it as shown:



What best describes what occurs?

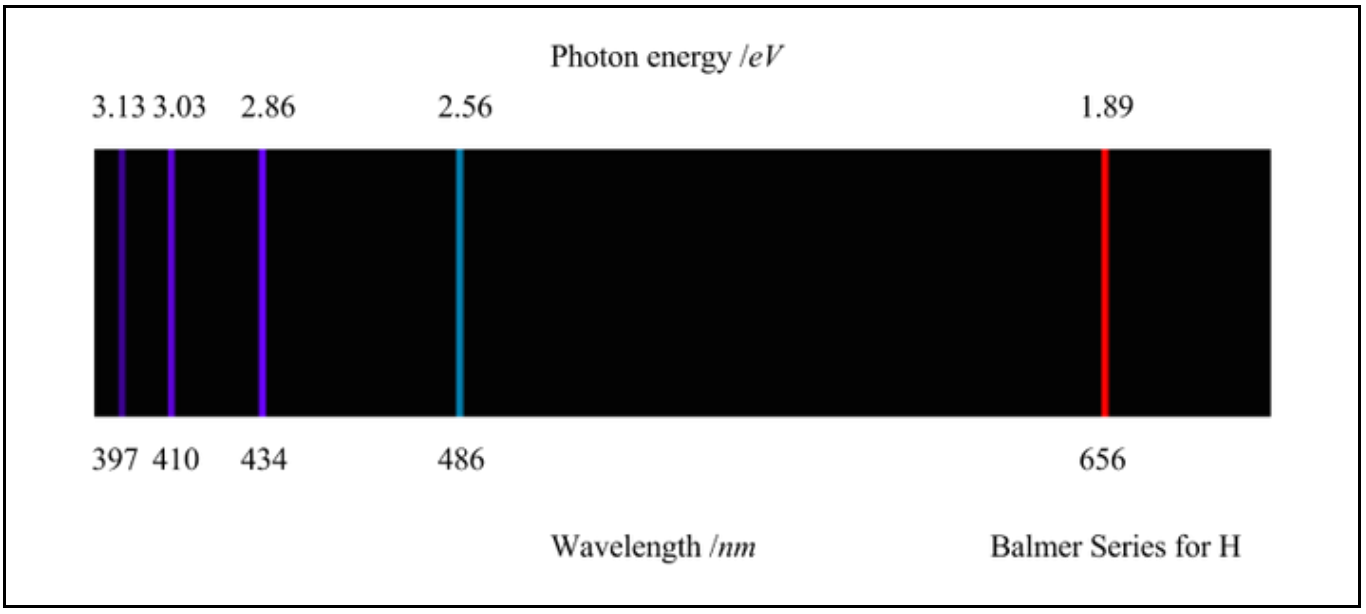
(A) Plate A comes to rest more quickly due to the repulsive interaction between eddy currents and the external magnetic field.

(B) Plate B to oscillates more quickly due to Lenz's Law

(C) Plate A is laminated, which restricts the size of the eddy currents that can form, causing it to slow down more quickly

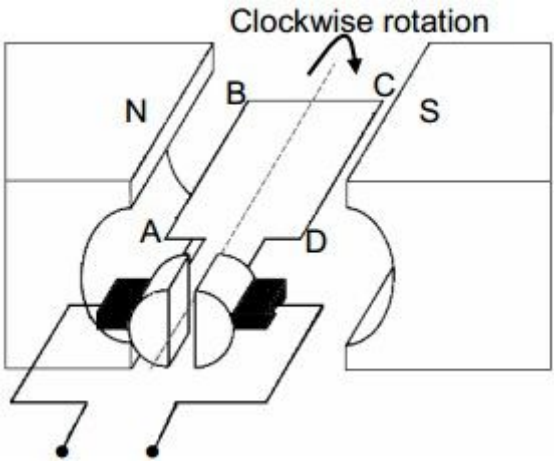
(D) Plate B has eddy currents induced in it due to Faraday's law, and because there are larger than Plate A, it comes to rest more quickly.

17.The emission spectrum for hydrogen in the visible range is shown below. These emission lines are called the 'Balmer Series'



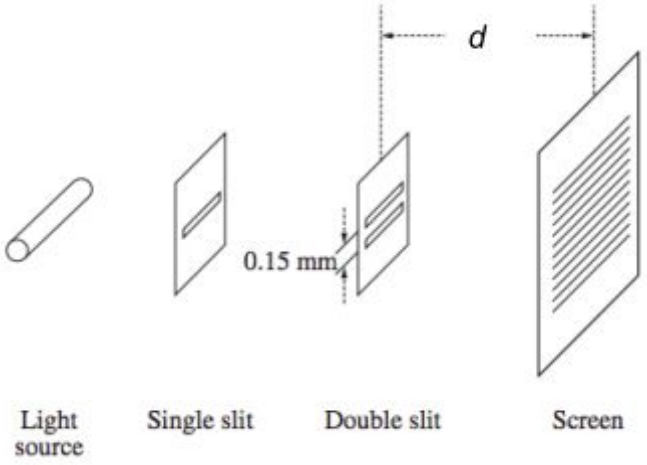
What is the frequency of the longest wavelength of light in the Balmer Series?
(A) 4.6 x10^{5} Hz
(B) 4.6 x10^{14} Hz
(C) 7.6 x10^{14} Hz
(D) 9.9 x10^{26} Hz

18. A simple DC motor is run as a generator by manually rotating the coil as shown in the diagram below



Which of the following is true?
(A) Current flows in the direction B to A
(B) The commutators ensure a direct current is generated in the coils
(C) Current constantly reverse direction in the coil as it rotates
(D) The voltage of the brushes constantly reverses

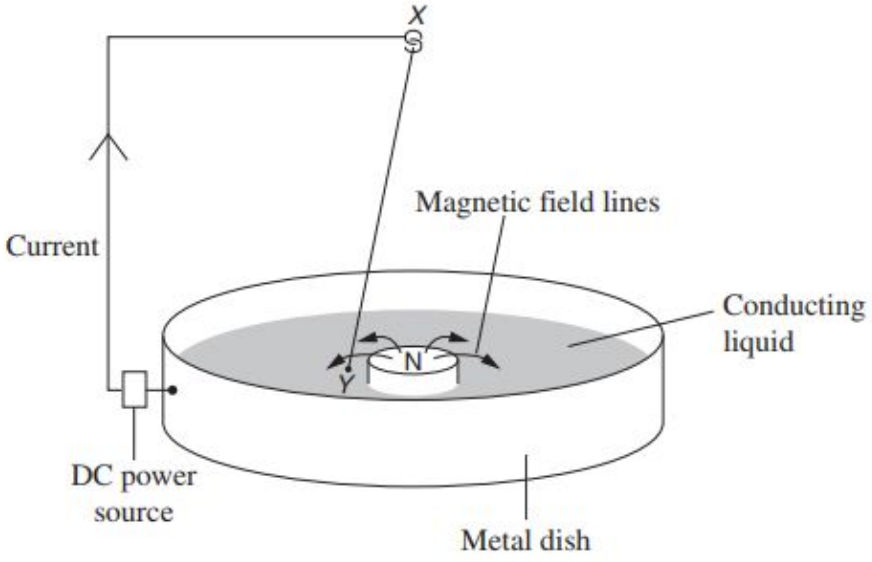
19. A monochromatic light source of wavelength 540nm is shone through slits onto a screen in a darkened room as shown:



If the distance between the central bright band and the 1st bright band is 1.5 cm, what is the distance between the double slit and the screen, *d*

(A) 0.04 m
(B) 1.2 m
(C) 4.2 m
(D) 417 m

20. Michael Faraday's first electric motor is shown in the diagram below. A solid conductive rod XY continually rotates in a clockwise direction .



Which of the following changes would decrease the period of the conductive rod?

(A) using an AC power source
(B) increasing the distance XY
(C) decreasing the distance XY
(D) reversing the polarity of the magnet

Part B – 36 marks

Answer each question in the space provided

Question 21 (7 marks)

As part of the North Sydney Boys Science Week activities, a 500g toy falcon is being launched into space.

(a) Calculate the weight of this model falcon on the surface of the Earth **2**

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(b) Derive the expression for escape velocity through the consideration of gravitational potential energy. Explain the steps of your derivation **3**

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(c) Does the toy falcon need to possess the escape velocity for Earth to be launched into space? Justify your answer **2**

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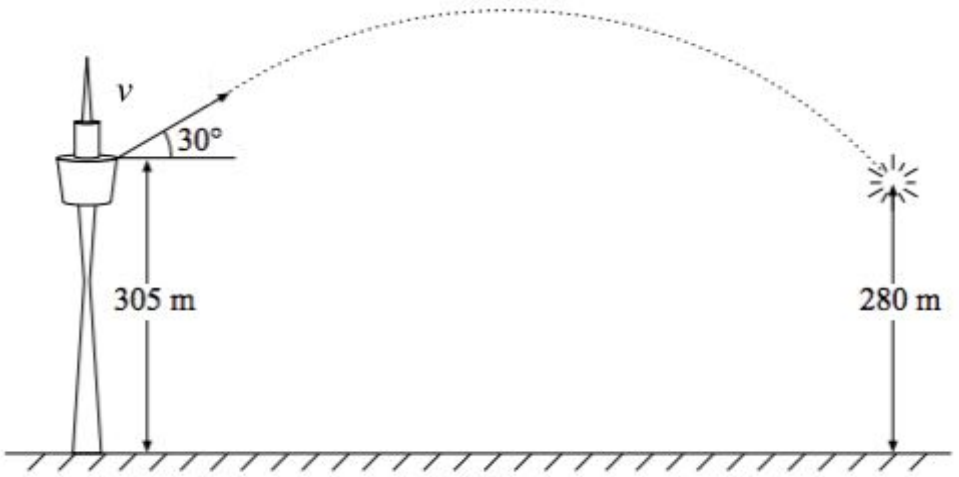
Question 22 (5 marks)
A bundle of fireworks are launched from a tower with a velocity, *v*, of 50 m/s.



(a) Calculate the horizontal distance away from the tower that the fireworks explode **2**

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(b) Describe quantitatively how increasing the launch angle to 45 degrees would change the situation **3**

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Question 23 (3 marks)
A Tungsten light bulb filament at 2800K is an approximate black body. Using Wein's law, plot a curve which represents the electromagnetic spectrum the light bulb emits:

Question 24 (2 marks)
A proton has a horizontal velocity of 1.5 m/s along the school's AF Henry Hall. In the hall, there is a vertical electric field of 0.001 V/m and a horizontal magnetic field of 0.02 mT, that runs perpendicular to the proton's velocity, of 1.5 m/s. If the forces of the fields are in the same direction, what is the acceleration of the proton at that instant?

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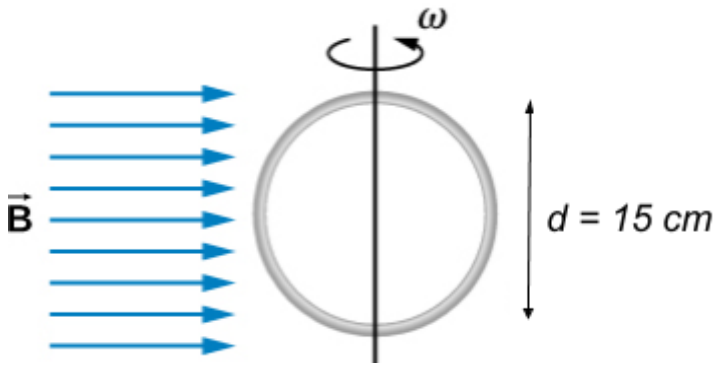
Question 25 (4 marks)

The diagram below is of aluminium ring (R = 2 Ω) rotating in a uniform magnetic field. The maximum B the ring experiences is 0.04 T. If its angular velocity is a constant 15 rad/s, what maximum current flows through the ring?



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Question 26 (4 marks)
An electrical transformer is labelled

Input: 120V, 60Hz, 0.55 A Output: 12VAC 12 W

Explain the principle for how transformers operate, referencing the quantities on the label

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Question 27 (3 marks)
A fiction novel describes physical units with different names than what is used in Science. In it, there are two planets that orbit the star Quill, which has a mass of 7.5 x10^{4} 'pet'. The data from their orbits is summarised in the table below:

Planet	Orbital period ('rics')	Orbital radius ('orts')
Dra	15	9
Groo	20	12

Assess whether the planets in the novel orbit in accordance with Kepler's 3rd Law

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Question 28 (8 marks)
Critically evaluate the role of experimental measurements, especially in how the Ampere was defined and in the development of understanding the speed of light

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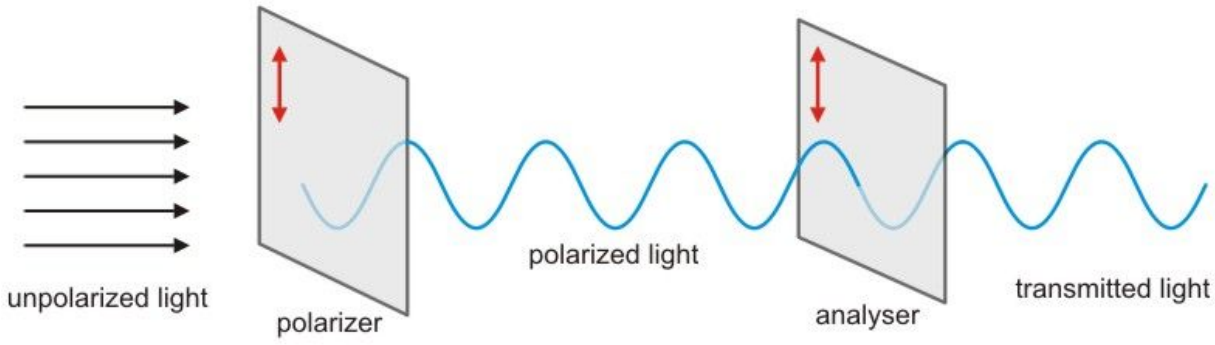
Part C – 19 marks

Answer each question in the space provided

Question 29 (8 marks)

Liz and Jack undertake an experiment to investigate the intensity of transmitted light as shown in the diagram below: (the double headed arrow represents the *plane of polarisation* for the polarizer and analyser sheets)

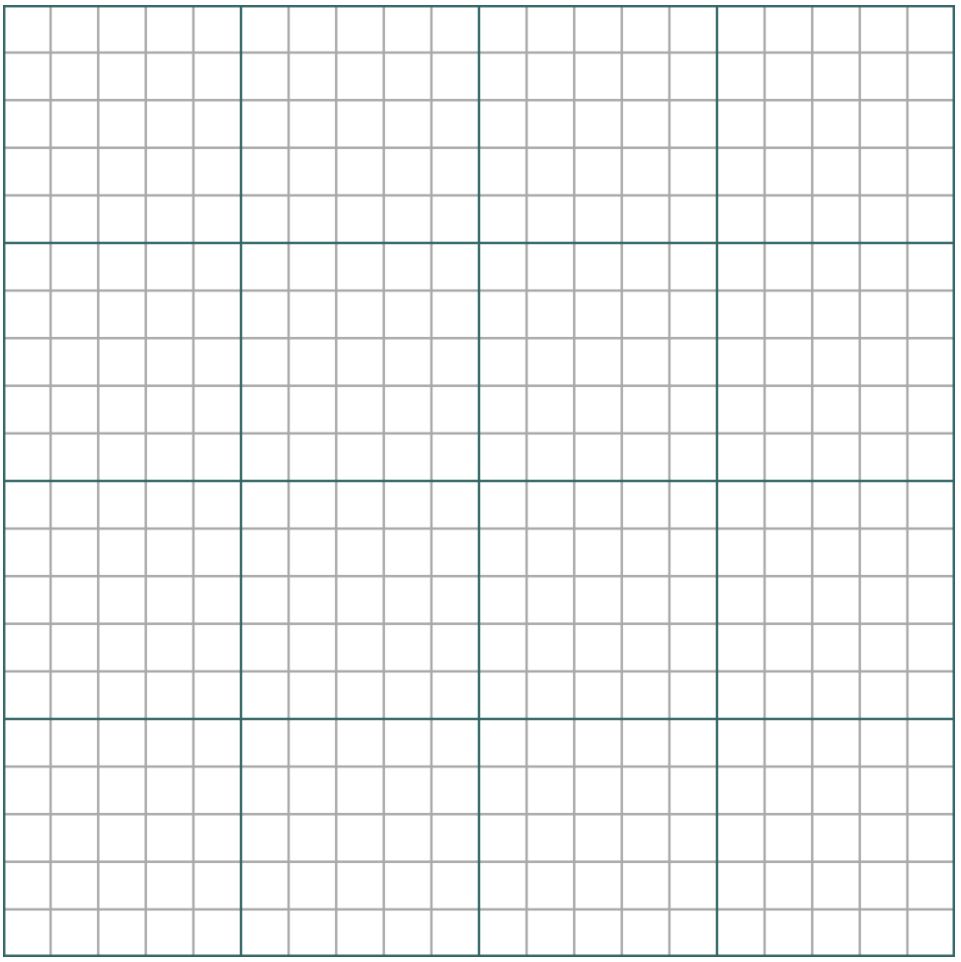


Reason for difference?

(a) Compute the theoretical intensity of the transmitted light as the analyser is rotated at various angles relative to the polarizer. The initial intensity of unpolarized light is 650 lux **2**

Relative angle (degrees)	Intensity (lux)	Theoretical Intensity (lux)
0	314	
20	240	
40	200	
60	105	
80	50	
90	15	

(b) Graph both sets of data on the same axis **4**



(c) Assess the accuracy of the Liz and Jack's data **2**

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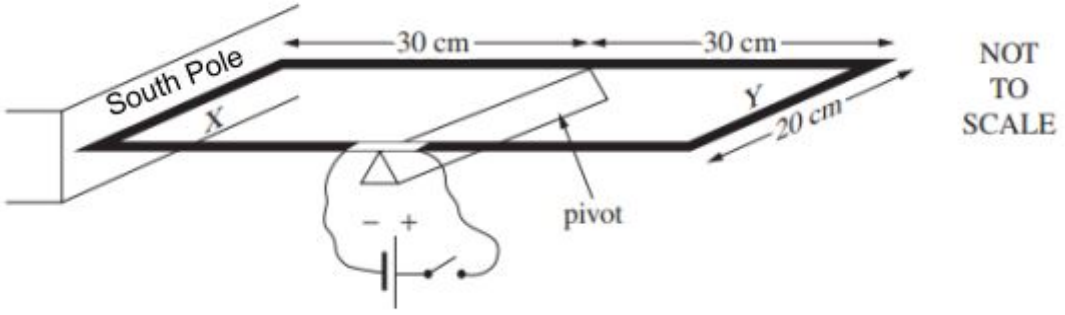
Question 30 (9 marks)

You have been tasked to conduct an investigation to validate a derived expression for the force on side X of this rectangular coil shown below



You are given small masses to hang them from side Y to investigate the effect of changing the current on the force experienced by side X. From this you are to validate that:

$$F_{side\ x} = B\,I\,L$$

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(a) Describe a method to undertake this scientific investigation. Construct an empty table of results to help illustrate your method

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(b) Explain the limitations of this investigation with the equipment and setup stated **3**

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Question 31 (2 marks)
With reference to a specific first hand investigation you have completed in the HSC Physics course, describe how you would assess the reliability of your collected data.

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End of Examination

North Sydney Boys High School
Year 12 Physics 2019
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Friday 5th July 2019

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Part C - 19 marks

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Part A /20	
Part B / 36	
Part C / 19	
Total Mark / 75	

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Part A – 20 marks

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

1. Which of the following are NOT assumptions made in analysing the motion of projectiles

(A) horizontal and vertical components are dependent on each other
(B) a constant acceleration due to gravity
(C) zero air resistance
(D) projectiles are point masses

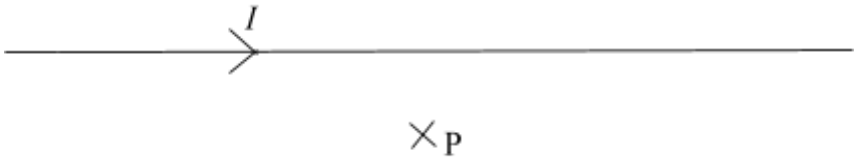
Average: 0.916

2. Planet Falcon is 12 times more massive, with a radius 4 times that of Planet Unicorn. What is the ratio of gravitational acceleration at the surface of Planet Falcon to Planet Unicorn?

(A) 1 : 3
(B) 3 : 1
(C) 3 : 4
(D) 4 : 3

Average: 0.807

3. A long straight current carrying wire is shown below

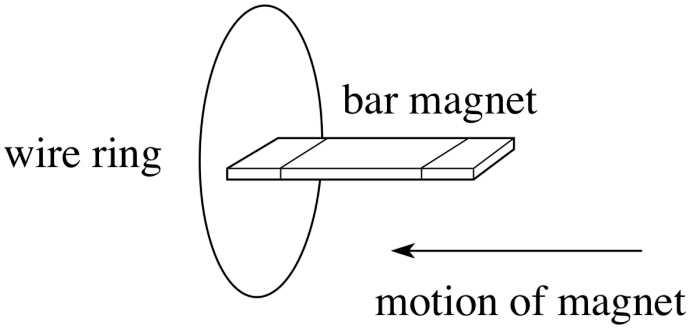


What is the direction of the magnetic field at point P

(A) up the page
(B) into the page
(C) to the left
(D) to the right

Average: 0.988

4. A bar magnet is moved into a conductive wire ring as shown



Which of the following would increase the induced current in the ring?

(A) Increasing the speed of the magnet
(B) Rotating the wire ring
(C) Reversing the polarity of the bar magnet
(D) Moving the magnet away from the ring

Average: 0.928

5. Which of the following would increase the torque on the coil in a simple DC motor.

(A) reversing the direction of current
(B) decreasing the area of the coil
(C) decreasing the resistance of the coil
(D) decreasing the strength of the magnetic field

Average: 0.94

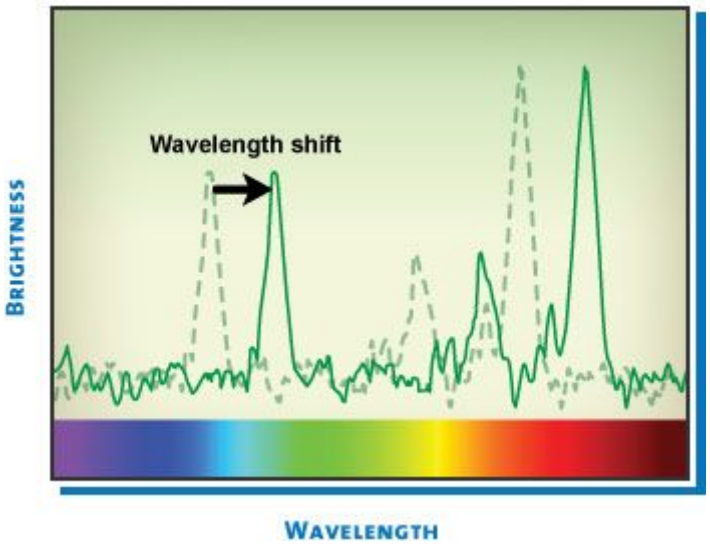
6. When a current flows through the coil below, the total flux through the interior of it is 80 mWb. If the dimensions of the cross-sectional area are 5 cm x 10 cm.

What is the magnetic field strength through the interior of the coil?

(A) 16000T
(B) 6.3mT
(C) 0.4mT
(D) 16 T

Average: 0.831

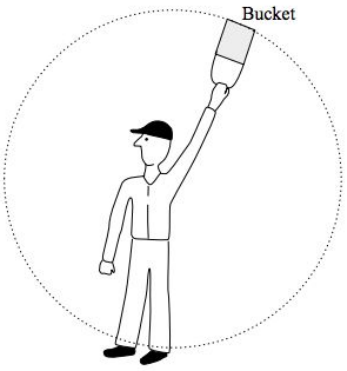
7. When examining a stellar spectra, what information does a wavelength shift in the diagram below provide?



(A) Temperature of the star
(B) Translational velocity of the star
(C) Rotational velocity of the star
(D) Density of the star

Average: 0.867

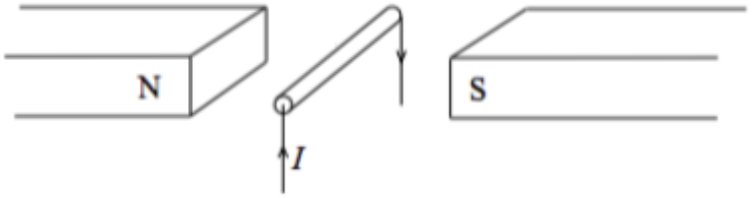
8. A teacher swings a bucket full of water in a circular vertical path above their head as shown:



Why does the bucket have to remain above a certain speed to ensure the water does not fall out?
(A) to ensure there is enough lift to counteract the force of gravity
(B) so that there is the same acceleration for the bucket and the water
(C) to produce enough centrifugal force
(D) to allow the water to have no weight

Average: 0.301

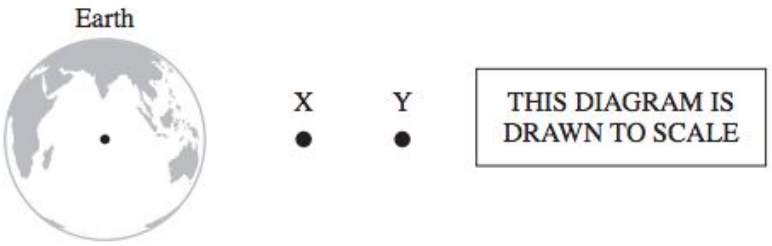
9. A thin metal rod has a current passed through it as shown below



In which direction will the rod feel a force
(A) up the page
(B) down the page
(C) to the left
(D) to the right

Average: 0.94

10. Two satellites of equal mass are in stable circular orbits at locations X and Y as shown in the diagram below.

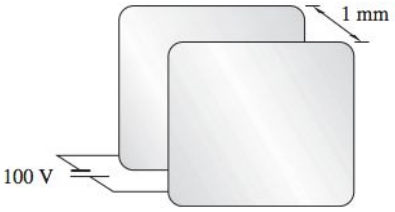


What is the ratio of the kinetic energies of the satellite at position X to position Y

(A) 3:2
(B) 2:3
(C) 1:2
(D) 2:1

Average: 0.723

11. A deuterium nucleus (composed of 1 proton and 1 neutron) is placed in between the two charged plates shown in the diagram below, touching the centre of the positive plate.



What is the amount of work done by the electric field if it is allowed to move under the influence of the field?
(A) 1.6×10^{-17} J
(B) 1.6×10^{-18} J
(C) 3.2×10^{-17} J
(D) 3.2×10^{-18} J

Average: 0.94

12. Which of the following phenomena could not be accounted for in Newton's model of light

(A) Colours
(B) Interference
(C) Reflection
(D) Refraction

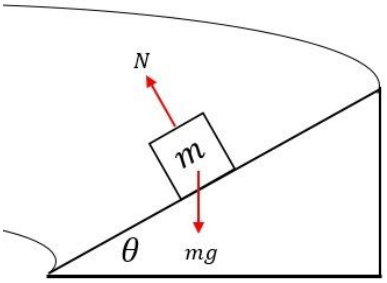
Average: 0.795

13. Ganymede is a moon of Jupiter and has a mass of 1.48 x10^{23} kg and a radius of 2 600 km. It has an orbital speed of 10.8 km/s and an orbital radius of 1.07 x10^{3} km.
What is the gravitational force of Ganymede on Jupiter?

(A) 1.61 x 10^{22} N
(B) 6.64 x 10^{24} N
(C) 1.61 x 10^{25} N
(D) 3.56 x10^{25} N

Average: 0.687

14. A mass on a banked track is undergoing circular motion and remaining at a constant height on the banked track

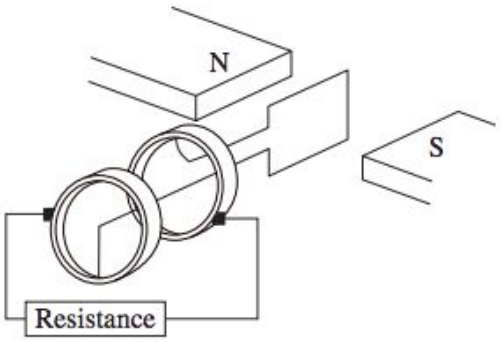


Which of the following expressions describes the centripetal force due to the banked track.

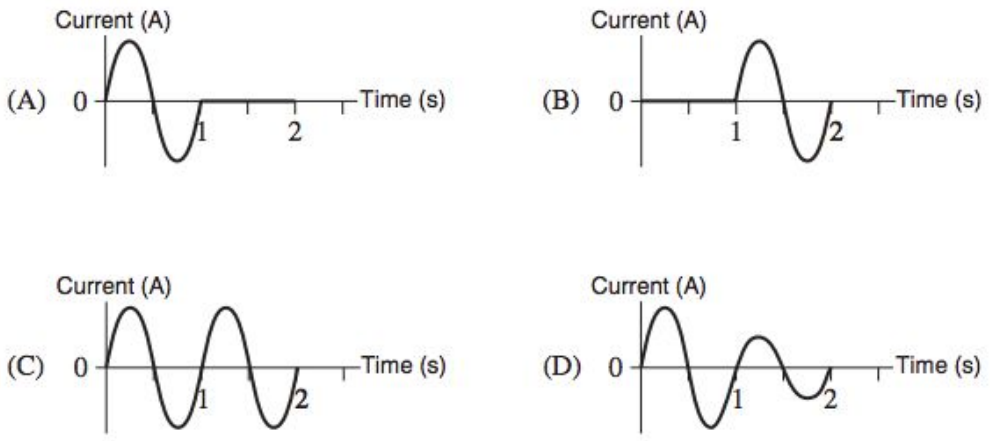
(A) $N\ sin\theta$
(B) $N cos\theta$
(C) $mg\ sin\theta$
(D) $mg\ cos\theta$

Average: 0.759

15. The coil in the generator below is rotated through 2 revolutions from the position shown



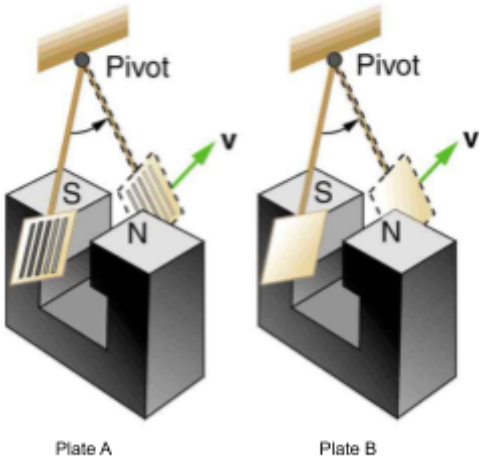
Which of the following graphs best represents the current flowing through the external resistance?



C

Average: 0.675

16. The following diagram shows conductive plates, swinging freely between two opposite magnetic poles. Plate A, the plate has segments cut out of it as shown:



What best describes what occurs?

(A) Plate A comes to rest more quickly due to the repulsive interaction between eddy currents and the external magnetic field.

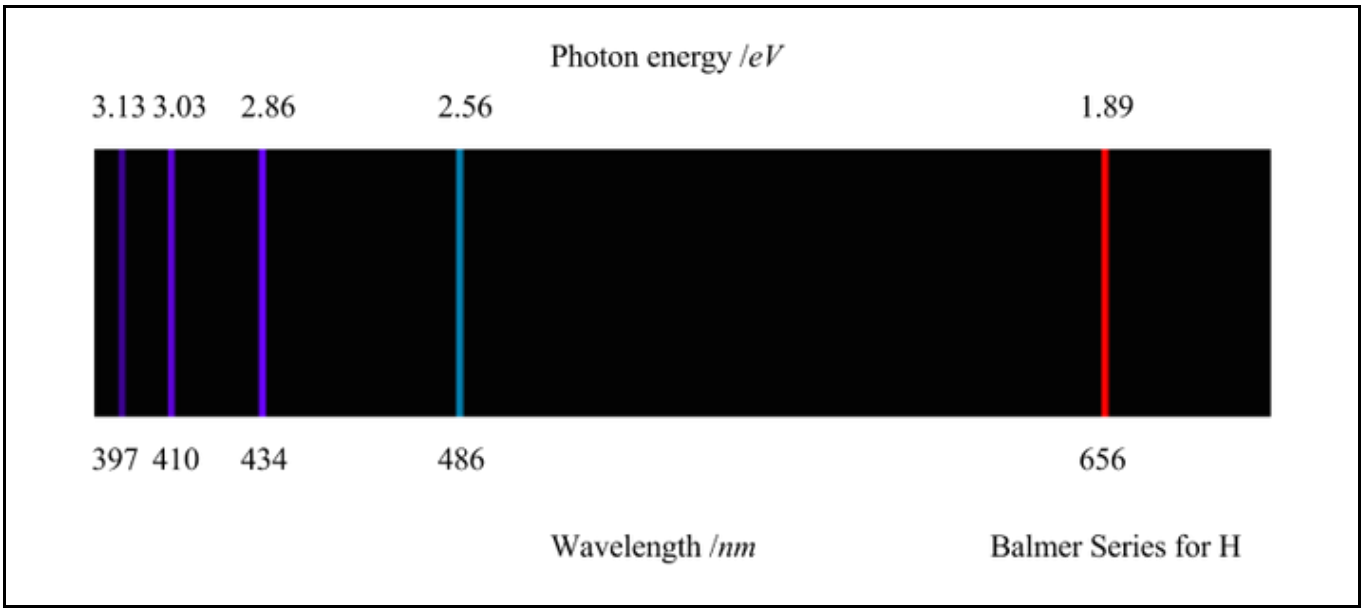
(B) Plate B to oscillates more quickly due to Lenz's Law

(C) Plate A is laminated, which restricts the size of the eddy currents that can form, causing it to slow down more quickly

(D) Plate B has eddy currents induced in it due to Faraday's law, and because there are larger than Plate A, it comes to rest more quickly.

Average: 0.819

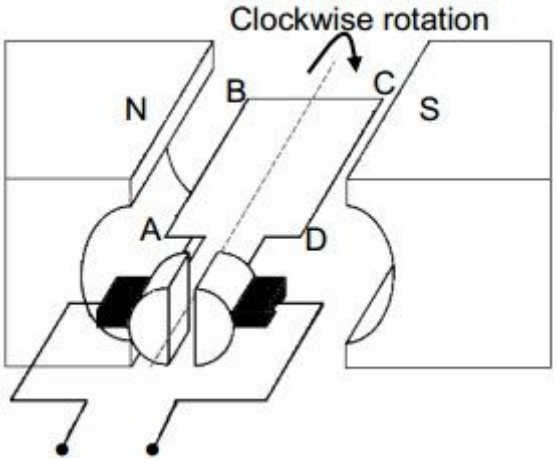
17.The emission spectrum for hydrogen in the visible range is shown below. These emission lines are called the 'Balmer Series'



What is the frequency of the longest wavelength of light in the Balmer Series?
(A) 4.6 x10^{5} Hz
(B) 4.6 x10^{14} Hz
(C) 7.6 x10^{14} Hz
(D) 9.9 x10^{26} Hz

Average: 0.855

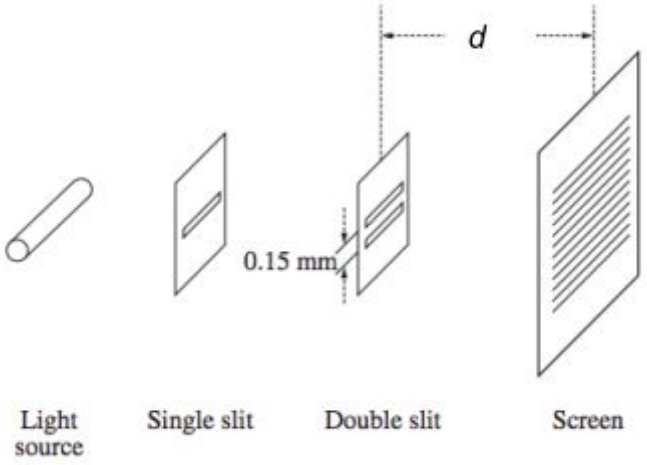
18. A simple DC motor is run as a generator by manually rotating the coil as shown in the diagram below



Which of the following is true?
(A) Current flows in the direction B to A
(B) The commutators ensure a direct current is generated in the coils
(C) Current constantly reverse direction in the coil as it rotates
(D) The voltage of the brushes constantly reverses

Average: 0.386

19. A monochromatic light source of wavelength 540nm is shone through slits onto a screen in a darkened room as shown:

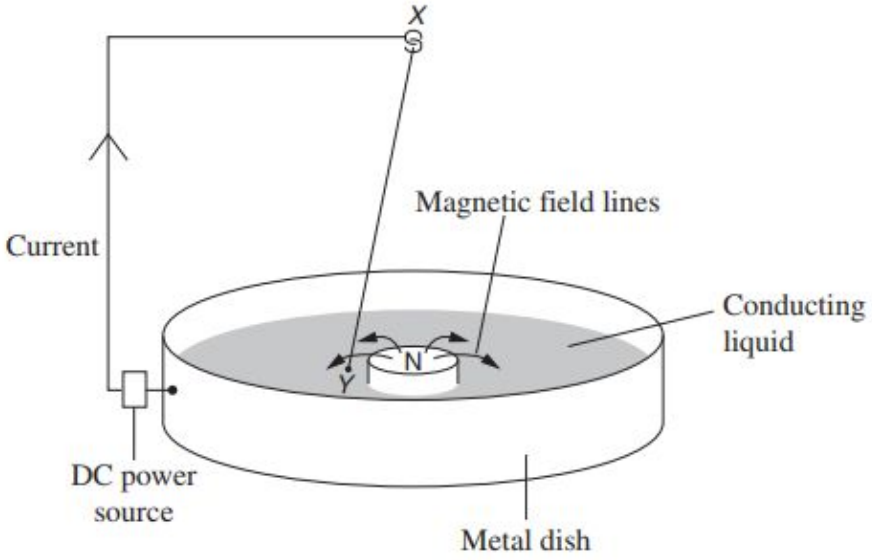


If the distance between the central bright band and the 1st bright band is 1.5 cm, what is the distance between the double slit and the screen, *d*

(A) 0.04 m
(B) 1.2 m
(C) 4.2 m
(D) 417 m

Average: 0.843

20. Michael Faraday's first electric motor is shown in the diagram below. A solid conductive rod XY continually rotates in a clockwise direction .



Which of the following changes would decrease the period of the conductive rod?

(A) using an AC power source
(B) increasing the distance XY
(C) decreasing the distance XY

(D) reversing the polarity of the magnet

Average: 0.458

Part B – 36 marks

Answer each question in the space provided

Question 21 (7 marks)

As part of the North Sydney Boys Science Week activities, a 500g toy falcon is being launched into space.

(a) Calculate the weight of this model falcon on the surface of the Earth **2**

Weight = mg = 0.5 × 9.8

= 4.9 Newtons

Criteria	Marks
• Correct answer provided with units included	2
• Relevant calculation presented	1

Sample answer: W = m x g = 0.500 x 9.8 = 4.9 N

Note from markers: Most students were able to calculate the correct weight.

Some students used 500kg instead of 500g, so lost a mark

Average: 2.0/2

(b) Derive the expression for escape velocity through the consideration of gravitational potential energy. Explain the steps of your derivation **3**

Energy required to achieve a zero G.PE = $\frac{Gm_1m_2}{r}$

So, $\frac{1}{2}mv^2 = \frac{Gm_1m_2}{r}$

$\frac{v^2}{2} = \frac{Gm}{r}$ $\therefore v = \sqrt{\frac{2Gm}{r}}$

Criteria	Marks
• Clear derivation presented • Includes key conditions $E_{k\,i} + U_i = E_{kf} + U_f$ (conservation of energy) • Includes definition of escape velocity as reaching infinity with zero E_k • Effective explanation linking steps provided	3
• Any 3 points listed above	2
• Demonstrated understanding of definition of escape velocity or conservation of energy and attempt at derivation	1

Sample answer:

Note from markers: Most students were able to derive the correct formula with a good explanation. Many students gave the correct formula, though failed to explain the derivation with correct reasoning or gave no explanation at all.

The key to the explanation is stating that the GPE at any height is given by $-Gm_1m_2/r$ and the GPE is zero at an infinite distance(which means you've escaped), and to achieve this at any height you must add Gm_1m_2/r to the GPE at any height (which is $-Gm_1m_2/r$),(because $-Gm_1m_2/r + Gm_1m_2/r = 0$) to give a zero final GPE. So the required KE ($mv^2/2$) has to equal the required GPE, which is Gm_1m_2/r. This means all you have to do is equate $mv^2/2$ with Gm_1m_2/r. **(But you need to explain why!!)**

Average: 2.4/3

(c) Does the toy falcon need to possess the escape velocity for Earth to be launched into space? Justify your answer **2**

Criteria	Marks
• Identification that it does not need it to start • Clear justification presented includes two or more physics principles	2
• Evidence ome physics understanding evidently applied to questions	1

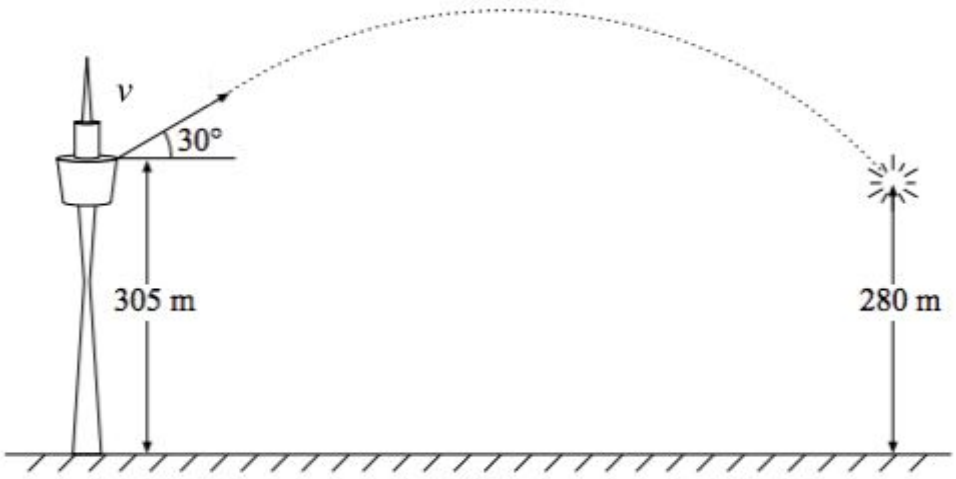
Sample answer:

You can be in orbit in space, but you haven't escaped, so no you don't need to possess escape velocity to be in space.

Note from markers: Most students were able to correctly state that escape velocity was unnecessary. Some students could not explain why it was unnecessary (because you can be in space when orbiting a planet, which is not escape). Some students incorrectly said yes to the question, but were still able to give an excellent explanation of escape velocity, so were able to score 1 mark.

Average: 1.3/2

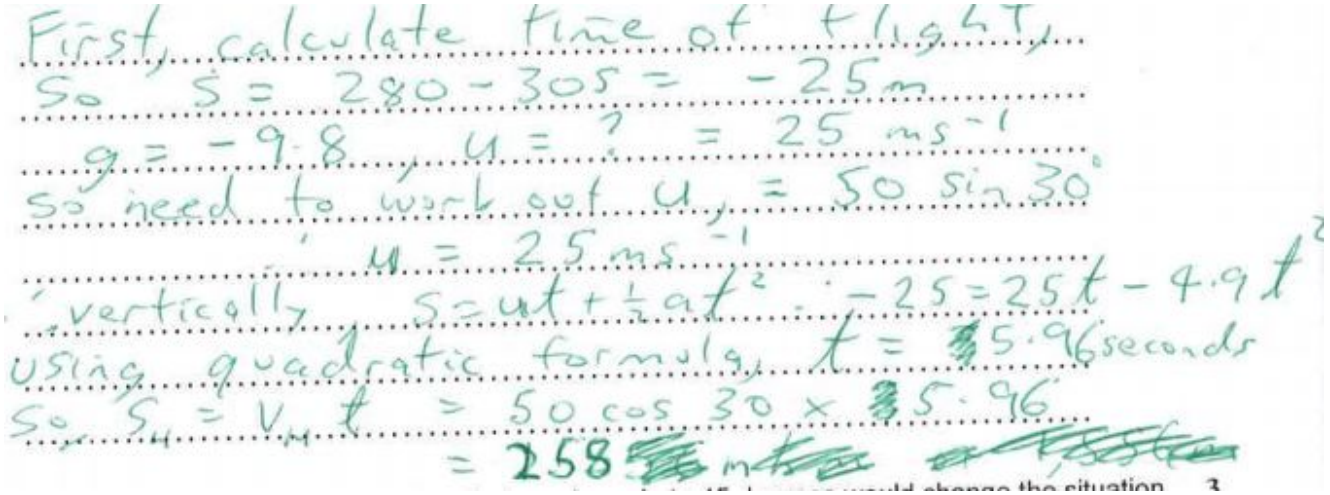
Question 22 (5 marks)
A bundle of fireworks are launched from a tower with a velocity, *v*, of 50 m/s.



(a) Calculate the horizontal distance away from the tower that the fireworks explode **2**

Criteria	Marks
• Correct calculation provided with units	2
• Correct methodology evident (finding t and then applying it to $s_x = u_x t$)	1

Sample answer:

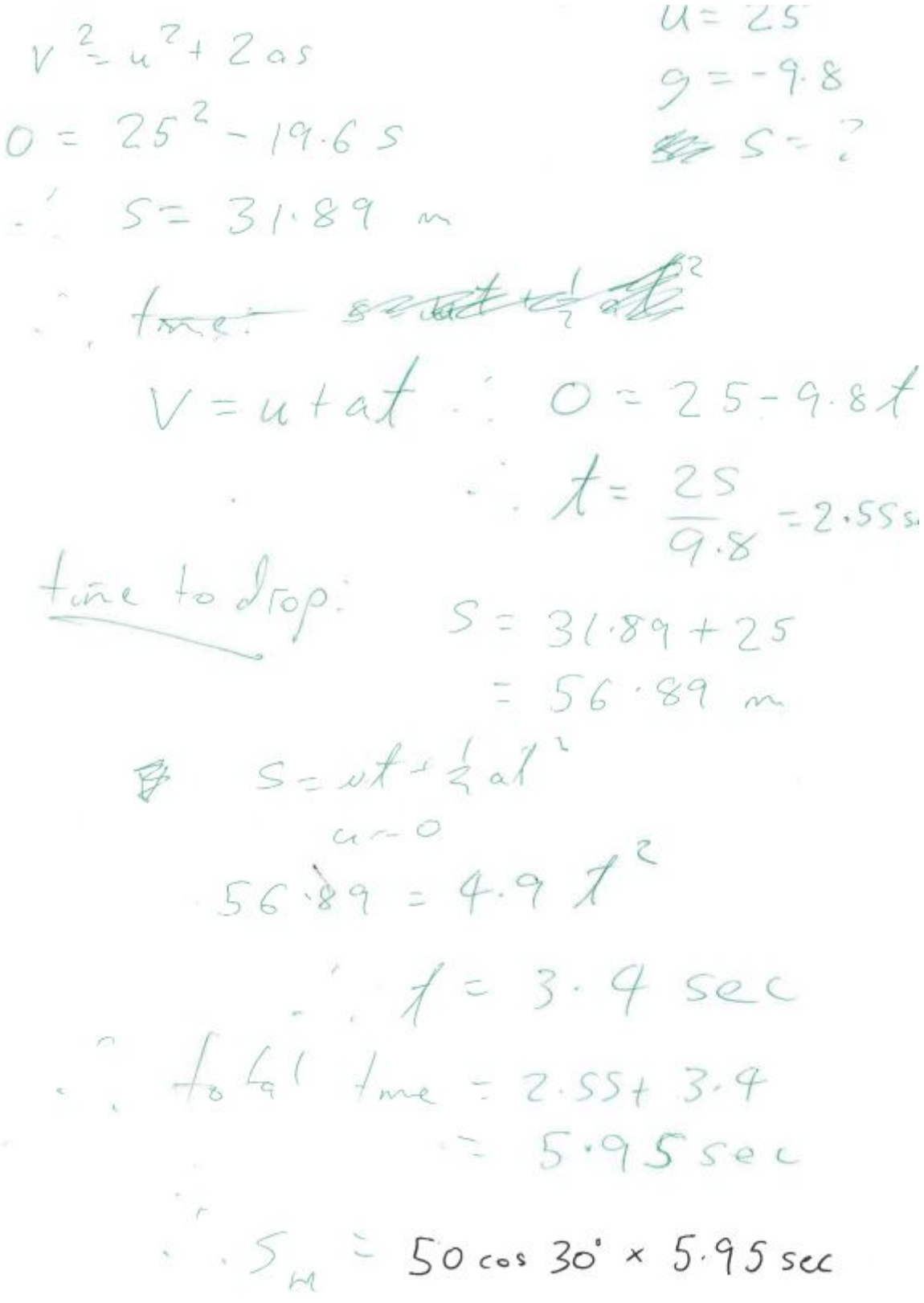


$S = ut + 1/2at^2$

$25 = u_y t + 1/2\ a_y t^2$

The other way to work out time of flight is to split it into 2 sections

1. Time to get to top, then work out that height, then
2. Time to drop,
3. Then add them together., so



Working through gives a drop time of 5.96 seconds, then applying $S_H = v_H t$ gives 50 cos 30 x 5.96,

Gives a final answer of 258m

Note from markers:

Most students were able to calculate the correct distance. Some students incorrectly calculated the drop time, then correctly applied it to find the distance, so lost a mark.

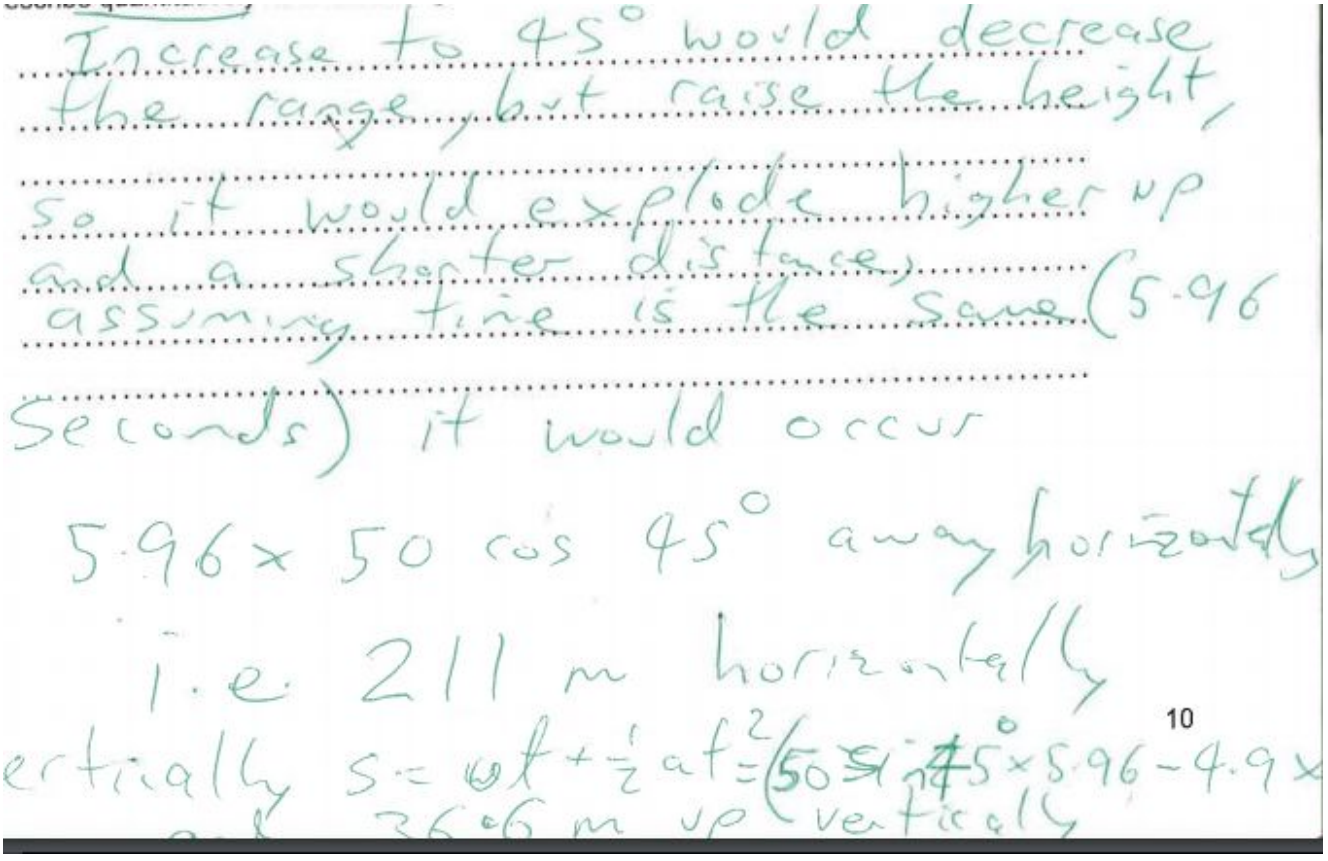
Average: 1.6

(b) Describe quantitatively how increasing the launch angle to 45 degrees would change the situation **3**

Criteria	Marks
• Clear description of the increased time of flight and increased range. Quantitative calculations or examples provided	3
• Description of the increased time of flight or increased range. Some quantitative descriptions.	2
• Some description of the increased time of flight or increased range	1

.

Sample answer:



OR

If you assume the same height when it explodes, the s_H becomes 278m

Note from markers: Most students were able to calculate the correct height and distance, since the time to explode will be the same.

An allowance was made if some students figured the drop height is still 25m, so often did not lose any marks since it was a carry through error.

Each students answer was marked on it merits, with allowance made for carry-through errors as long as the working was clear and well explained

Average: 2.3

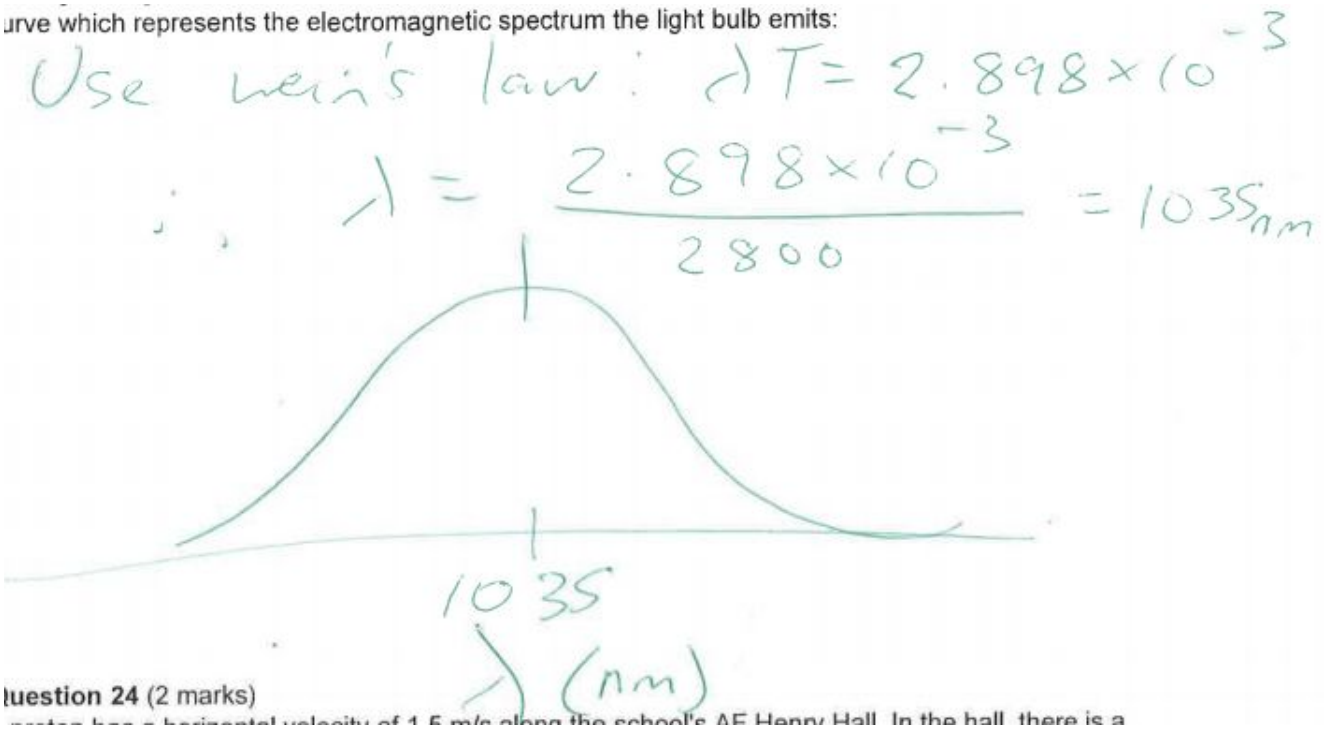
Question 23 (3 marks)

A Tungsten light bulb filament at 2800K is an approximate black body. Using Wein's law, plot a curve which represents the electromagnetic spectrum the light bulb emits:

Criteria	Marks
Plot includes ● Appropriate y axis (intensity/radiance/luminosity etc.) ● Appropriate x axis (wavelength or frequency) ● Appropriate rough shape of BB curve ● Correct peak wavelength indicated accurately on the graph = 1.04 x10^{-6} m	3
Plot includes ● Any 3 of the above points	2
● Any 2 of the above points	1

Sample answer: $\lambda_{max} = b/T = 2.898 \times 10^{-3}/2800 = 1.035 \times 10^{-6}$ m

urve which represents the electromagnetic spectrum the light bulb emits:



Question 24 (2 marks)

Note from markers: Most students were able to calculate the correct brightest wavelength with correct graph shape and correct axes.

Some students made an error, like not labelling both axes correctly, or not giving the wein's law value and were marked accordingly. Almost everyone got the shape correct, so got at least 1 mark

Average: 2.6 /3

Question 24 (2 marks)

A proton has a horizontal velocity of 1.5 m/s along the school's AF Henry Hall. In the hall, there is a vertical electric field of 0.001 V/m and a horizontal magnetic field of 0.02 mT, that runs perpendicular to the proton's velocity, of 1.5 m/s. If the forces of the fields are in the same direction, what is the acceleration of the proton at that instant?

–Criteria	Marks
• Correct calculation of acceleration of proton = 98629 m/s^2	2
• Demonstrated understanding of $F_{tot} = F_B + F_E$ or correct calculation of acceleration missing F_E or F_B	1

Sample answer:

$F_{tot} = F_B + F_E = qvB + qE = (1.602 \times 10^{-19} \times 1.5 \times 0.02 \times 10^{-3}) + (1.602 \times 10^{-19} \times 0.001) = 1.65 \times 10^{-22} N$

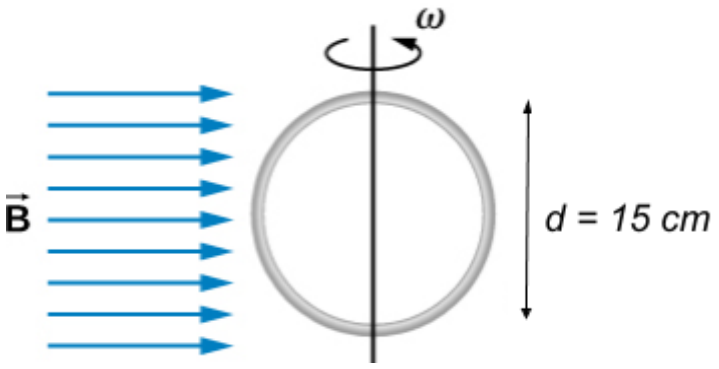
$a = F_{tot}/m = 1.65 \times 10^{-22} / 1.673 \times 10^{-27} = 98629\ m/s^2$

Note from markers: direction should have been included, but was not needed to get 2 marks. This was a bit of a 'big-step' question - essentially you had to get everything perfect to get 2 marks. Any small mistake or correct understanding demonstrated got the 1 mark.

Average: 1.4

Question 25 (4 marks)

The diagram below is of aluminium ring (R = 2 Ω) rotating in a uniform magnetic field. The maximum B the ring experiences is 0.04 T. If its angular velocity is a constant 15 rad/s, what maximum current flows through the ring?



Criteria	Marks
• Correct calculation of current, showing clear logical steps.	4
• All correct steps in calculation shown, with a mistake leading to an incorrect calculation of current	3
• Steps in calculation demonstrate an understanding of three of the following: ○ Faraday's law, ○ Ohm's law ○ angular velocity ○ Magnetic flux (phi = BA)	2
• Steps in calculation demonstrate an understanding of two of the following: ○ Faraday's law, ○ Ohm's law ○ angular velocity ○ Magnetic flux (phi = BA)	1

Sample answer:

ω = 15 rad/s / 2 = 2.387 rev/s

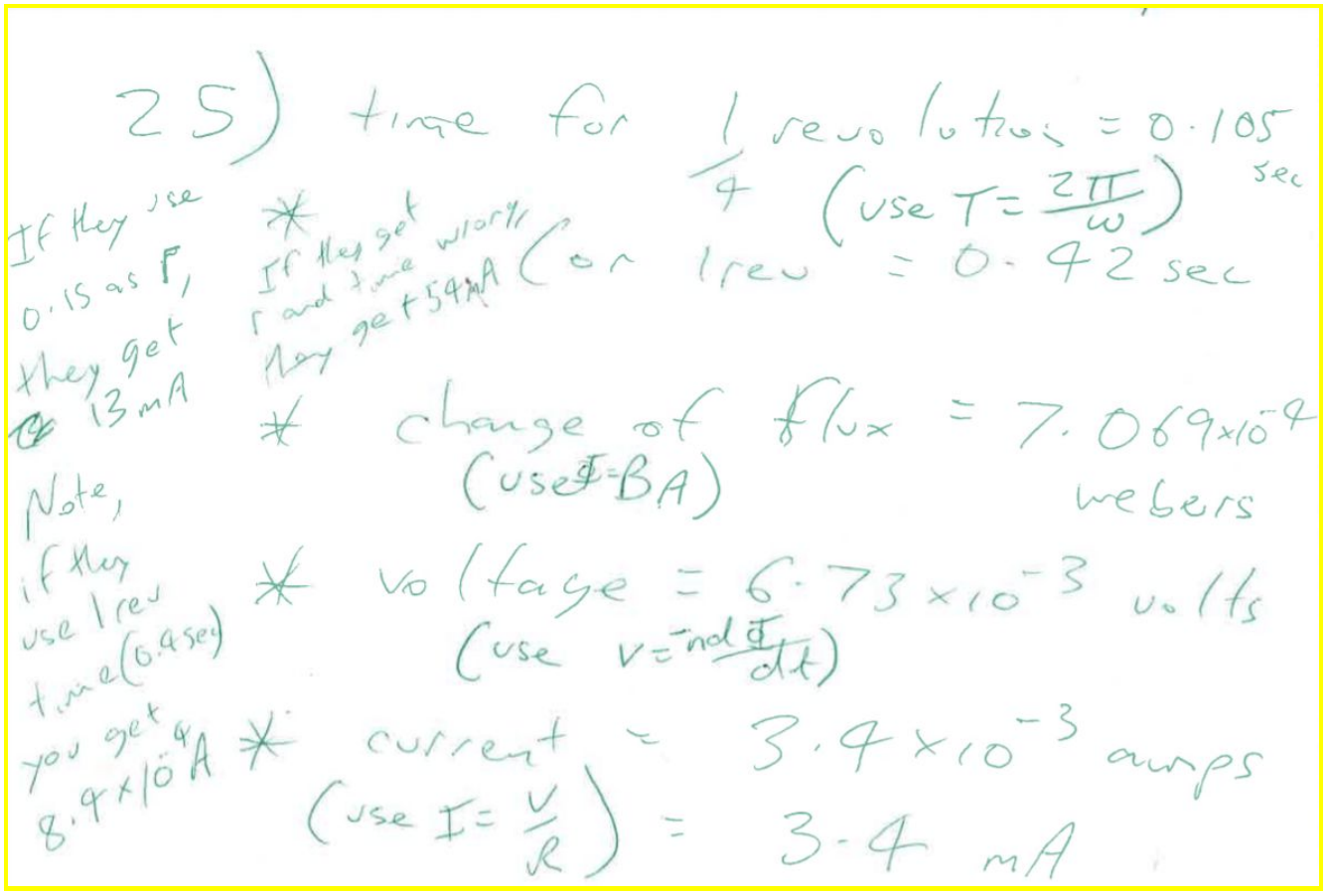
T = 1/2.387 = 0.4189 s

Δt for max to min = 0.4189/4 = 0.1047s

$\varepsilon = iR = \Delta\Phi/\Delta t = 0.04\pi r^2/0.1047 = (0.04 \times \pi \times 0.075^2)/0.1047$

$\varepsilon = 6.751 \times 10^{-3}$

$I = \varepsilon /R = 6.751 \times 10^{-3} /2 = 3.38 \times 10^{-3}$ A



Note from markers: This question is really a calculation that can be broken down into 4 parts.

1. Use w=2pi/T, rearranging to get period of rotation, T=2pi/w,

   So T = 2pi/15 = 0.42seconds

2. Maximum change in flux occurs after a quarter turn, so use a quarter of the period

OR you can use half the period to give a flux change of TWICE the flux, since the field vectors will point in the opposite direction with respect to the loop

So the second mark is to work out the flux change

3. The third mark is for working out the emf using change in flux divided by change in time

4. The fourth mark is for working out current using I = V/R

Average: 2.0

Question 26 (4 marks)
An electrical transformer is labelled

Input: 120V, 60Hz, 0.55 A Output: 12VAC 12 W

Explain the principle for how transformers operate, referencing the quantities on the label

Criteria	Marks
● Clear and logical explanation of the physics of transformers via electromagnetic induction. Faraday's Law clearly linked in explanation ● Each quantity (all 5) on the label is described accurately, in relation to transformer operation	4
● Logical explanation of the physics of transformers via electromagnetic induction. ● Each quantity (all 5) on the label is described in relation to transformer operation	3
● Understanding of the physics of transformers demonstrated ● Most quantities (3 or more) on the label are described in relation to transformer operation	2
● Understanding of the physics of transformers demonstrated ● Some quantities (2 or more) on the label are related to transformers	1

Sample answer: Electrical transformers operate on the principle of electromagnetic induction which is summarised in Faraday's law $\varepsilon = -n\Delta\phi/\Delta t$. In transformers, an AC is used in a 'primary coil' to create a constantly changing magnetic flux (shown on the label as 60Hz) which threads a 'secondary coil' and induces an AC in it by Faraday's law (see 12V**AC**). Depending on the number of turns in each coil 'n' the transformer will step up or down the emf induced in the secondary output coil. The electrical transformer label shows it is 'step down' (from 120V to 12V). The power output shown on the label as 12W also shows the power loss that occurs in real transformers, comparing the output of 12W with the input power of P = IV = 120 x 0.55 = 66W.

Note from markers: A number of students did not refer to Faraday's Law. Student also failed to engage with the stimulus material, and did not address the contents of the label. Students who only discussed the voltage part of the label were restricted to 1. Many students also forgot that the 'changing' magnetic field is a key part of everything, and did not include this in their response.

Average: 1.6

Question 27 (3 marks)
A fiction novel describes physical units with different names than what is used in Science. In it, there are two planets that orbit the star Quill, which has a mass of 7.5 x$10^{4.}$ 'pet'. The data from their orbits is summarised in the table below:

Planet	Orbital period ('rics')	Orbital radius ('orts')
Dra	15	9
Groo	20	12

Assess whether the planets in the novel orbit in accordance with Kepler's 3rd Law

Criteria	Marks
• Correct assessment provided (they do not follow Kepler's 3rd Law) clearly linked to quantitative calculations • Correct understanding of Kepler's 3rd Law applied to this situation evident	3
• Correct assessment provided (they do not follow Kepler's 3rd Law) linked to quantitative calculations	2
• Understanding of Kepler's 3rd Law evident	1

Sample answer:

Kepler's 3rd law states that for objects orbiting the same central mass (like Dra and Groo around Quill) the ratio of the period squared to radius cubed for each orbiting object is the same. Calculating this:

T^2/r^3 (Dra) = $15^2/9^3$ = .31

T^2/r^3 (Groo) = $20^2/12^3$ = 0.23

Therefore the planets in the novel do not orbit in accordance with Kepler's 3rd Law

Note from markers:

$GM/4\square^2$ does not work as fictional data is not is SI units. A number of students generally correctly answered the question but included a limited/wrong understanding of this. This limited these students to 2/3 as they did not demonstrate the correct understanding applies to the situation. This was the same for students who limited their responses to not include the key part of Kepler's 3rd - that it is for planets orbiting the same central mass' not 'all planets' or 'each other'. Students are reminded to interact with the stimulus in their responses.

Average: 2.0

Question 28 (8 marks)

Critically evaluate the role of experimental measurements, especially in how the Ampere was defined and in the development of understanding the speed of light

Criteria	Marks
● Clear evaluation provided. Judgement provided links strongly to details of at least 3 historical experimental measurements (on the speed of light and the Ampere) ● Added depth in synthesising the Ampere definition and speed of light experiments to reflect on the nature of experiments in Physics overall.	8
● Clear evaluation provided. Judgement provided links to details of at least 3 historical experimental measurements (on the speed of light and the Ampere) ● Synthesises the Ampere definition and speed of light experiments to reflect on the nature of experiments in Physics overall.	7
● Clear evaluation provided. Judgement provided links to details of at least 3 historical experimental measurements (on the speed of light and the	6

Ampere) ● Reflection on the nature of experiments in Physics provided.	
● Clear evaluation provided. Judgement provided links to details of at least 3 historical experimental measurements (on the speed of light and the Ampere)	5
● Evaluation provided. Judgement provided links to experimental measurements on the speed of light and the Ampere.	3-4
● Judgement provided of the role of experimental measurements in Physics in relation to measuring the speed of light or defining the Ampere.	1-2

Sample answer: Experimental measurements are a fundamental component in physics. Their role goes beyond the more well known 'verification of hypothesis'. They can also fundamentally underpin important consistent measurement systems such as the SI system and shape the direction of future development of theories and ideas about concepts such as light.

The SI system of measurement is at the core of our ability to 'do' physics, as it plays a vital role in standardising the measurements of the quantities that Physics aims to understand. In this system, some measurement quantities are necessary to **define experimentally**, and serve as a foundation for other units to be derived. One of these examples was the Ampere - which was defined as the amount of current required in each of two parallel conductors separated by 1 metre to produce a force of 2×10^{-7} N/m between them. Therefore, experimental measurements were vital in setting up this definition of the Ampere which supported further units derived from it. Without this, the ability of Physics to understand and explore the universe experimentally would have been limited

Various experimental measurements of the speed of light developed over time, converging to our accepted modern value, while also providing important evidence to support developing our understanding of light itself. From the beginnings of Galileo and his assistant timing light travelling using lanterns, to Romer's and then Bradley's astronomical methods, to Fizeau and Foucault's spinning experimental measurements - there has been a constant progression to what seems to be more 'accurate' values. The development of these values were important when considering their agreement with Maxwell's theoretical prediction, and therefore the justifying influence they may have played in his vitally important theory on electromagnetism. As a counter, one may consider the situation where Maxwell's prediction of 3×10^{8} m/s did not match to Galileo's most accurate 3×10^{3} m/s measurements, and the impact that may have had.

As such, the role of experimental measurements is broad in Physics, encompassing both a foundation-setting impact such as through SI definitions, and a theory-setting impact such as through the speed of light and Maxwell's theory of electromagnetism.

Note from markers: The judgement **based on criteria**, which is key to the assess verb, was quite weak in a large number of responses.
Many students did not include a discussion of Ampere (or to the same extent as for light). Student were only to achieve within the 1-2 mark range as stated in the criteria above
Many students also included details of experiments but barely/did not engage with the question at all

Many students struggled to provide correct information about the definition of the ampere of the various methods in measuring the speed of light. - this limited students who had provided a basic evaluation to a 3. Critically evaluate also needed more than the 'it was important' or 'it was vital' evaluation that most students provided (which capped marks at 4)

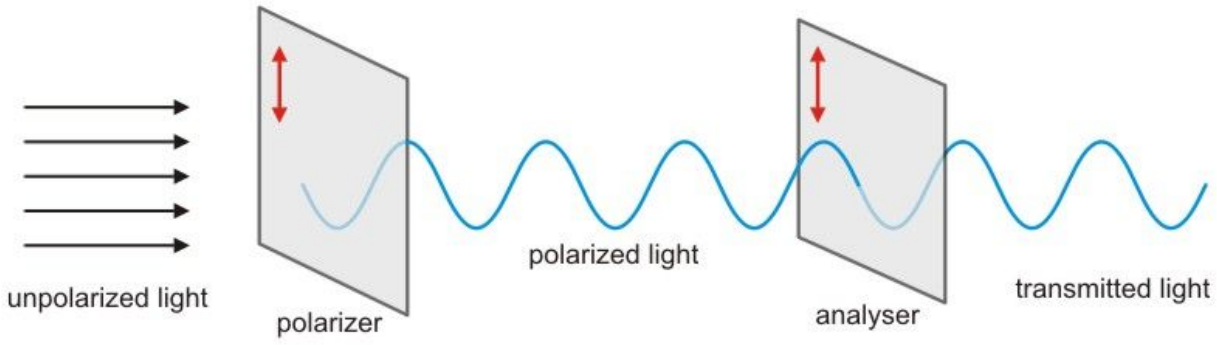
Average: 2.7

Part C – 19 marks

Answer each question in the space provided

Question 29 (8 marks)

Liz and Jack undertake an experiment to investigate the intensity of transmitted light as shown in the diagram below: (the double headed arrow represents the *plane of polarisation* for the polarizer and analyser sheets)



Reason for difference?

(a) Compute the theoretical intensity of the transmitted light as the analyser is rotated at various angles relative to the polarizer. The initial intensity of unpolarized light is 650 lux **2**

Relative angle (degrees)	Intensity (lux)	Theoretical Intensity (lux)
0	314	325/ 314
20	240	287/ 277
40	200	191/ 184
60	105	81/ 79
80	50	9.8/ 9.5
90	15	0/0

Criteria	Marks
• Correct computation of left hand side answers above	2
• Correct computation of right hand side answers above OR partially correct computation of right hand side.	1

Sample answer: (see red in table above)

Note from markers: There may be variations on how this is done. The values on the left are the most correct assuming perfect polarisers, the values on the right just use the first data point.

Average: 0.91

(b) Graph both sets of data on the same axis **4**

Criteria	Marks
● Graph drawn possesses all of the following features: ○ Appropriate Title ○ Axes labelled ○ Units included in each axis label ○ Correct clear marking of all theoretical data points ○ Correct clear marking of all experimental data points ○ Appropriate scale used (more than 75% of graph paper)	4
● Graph drawn possesses 6/7 of the above features	3
● Graph drawn possesses more than 4 or 5 of the above features	2
● Graph drawn has at least 3 of the above features	1

Sample answer:

Note from markers:

Students should use a cross to mark data points. No line of best fit is required, but may curve may be drawn.

Average: 3.7/4

(c) Assess the accuracy of the Liz and Jack's data **2**

Criteria	Marks
● Judgement provided linked to data and graph, that demonstrates a good understanding of Malus' law, and accuracy	2
● Judgement provided demonstrates an understanding of accuracy in relation to Malus's law and experimental data	1

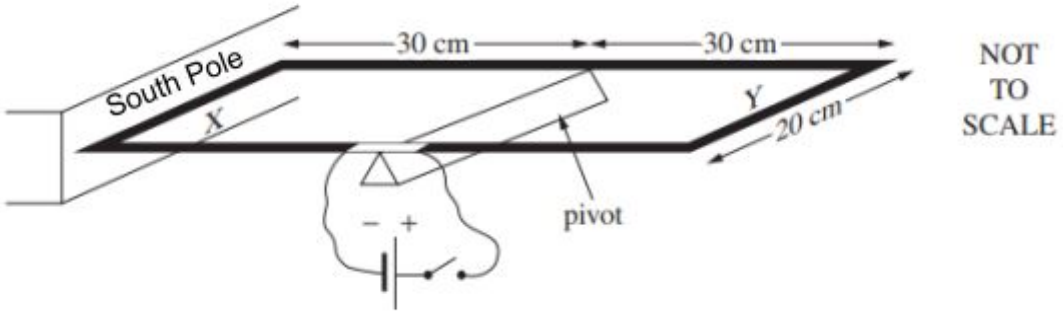
Sample answer: Liz and Jack's results are not accurate due to the large differences between the measured intensity and the theoretical intensity as shown in the graph or table. Some theoretical data are higher or lower, perhaps when setting the angles. A linear line of best fit in essence a linear trend of intensity , whereas Malus's law predicts a $\cos^2$ relationship. According to Malus law the intensity of linearly polarised light is directly proportional to the square of cosine of angle between transmitting plane of polarisation analyser.

Note from markers: The majority of students provided a good judgement and the relation to Malus's law.

Average: 1.1/2

Question 30 (9 marks)

You have been tasked to conduct an investigation to validate a derived expression for the force on side X of this rectangular coil shown below



You are given small masses to hang them from side Y to investigate the effect of changing the current on the force experienced by side X. From this you are to validate that:

$$F_{side\ x} = B\,I\,L$$

6

(a) Describe a method to undertake this scientific investigation. Construct an empty table of results to help illustrate your method

Criteria	Marks
● Method: ○ Logical and sequential ○ Demonstrates a good understanding of correct physics principles ○ Demonstrates understanding of control variables ○ Steps are clear and detailed ○ Exact numbers are provided to investigate to improve reliability ○ Repetition of trials or other steps to improve accuracy included ● Table: ○ Strongly links to method ○ Headers of tables labelled clearly ○ Units included in headers ○ Correct format, with first column being independent variable	6

● As above, with 1 component of method and 1 component table missing	5
● As above, with 3 component from method and/or table missing	4
● As above, with 4 component from method and/or table missing	3
● As above, with 3 components from method and 2 components from table missing	2
● As above, with 4 components from method and 2 components from table missing	1

Sample answer:

1. Set up the apparatus as shown in the diagram above.
2. To validate the equation Fside X= BIL and to investigate the effect of Force versus Current, the magnetic field (B) and the length (L) of the coil must be kept constant.
3. Current (I) is an independent variable, Force dependent variable.
4. When the switch is closed, the current will flow from the right side to the left side(anticlockwise). Hence , using the RHPR, there will there will be an upwards force on side Y, thereby needing to to hang masses to balance this upwards force. The force experienced by side X will be the same as the force of side Y, hence the weight of the mass can be directly compared to the force by side X.
5. At the start of the experiment, when the switch is open the rectangular coil should be balanced on the pivot. As there is no current flowing through, there should be no force acting on side X.
6. Hang a 50 mg mass on side Y and close the switch tweak the current until the rectangular coil once again will be parallel to the surface. Now, we know that current is directly proportional to the force on side X since F=mg
7. Repeat the experiment with different masses.
8. Collect data and plot out data in the table:

   Current (Amps) Mass (mg) Force (F=m x a) (N)

9. Repeat the experiment several times and average the result. If the experiment is performed correctly, there should be a linear relationship between the Force on side Y and the current.

Note from markers: Many students have not recognised the variables, so the table was incorrectly drawn. No correct Physics principles were stated. Some did not recognised control variables. Some did not mention the repetition of trials.

Average: 3.0/6

(b) Explain the limitations of this investigation with the equipment and setup stated **3**

Criteria	Marks
● Clear explanation incorporating at least 3 limitations related to the equipment/setup linked strongly to physics/experimental reasons	3
● Explanation incorporating at least 2 limitations related to the equipment/setup linked to physics/experimental reasons	2
● Explanation incorporating at least 2 limitations related to the equipment/setup	1

Sample answer: Limitations:

Masses are indirect ways of measuring force

Not in an accuracy. Non uniform magnetic field. Not accounting for side Y (force on side Y)

Note from markers: Many students provided errors instead the limitation. If all limitations provided students received 3 marks. If the students provided 2 limitations and errors - 2 marks.

Average: 1.5/3

Question 31 (2 marks)

With reference to a specific first hand investigation you have completed in the HSC Physics course, describe how you would assess the reliability of your collected data.

Criteria	Marks
● Clear description provided on a correct method of assessing reliability of data. Description references specific investigation and is not generic.	2
● Description provided on a correct method of assessing reliability of data.	1

Sample answer:

Students must refer to the particular experiment in Year 12 and state the reliability. A reliable experiment has the results which can be obtained consistently. To ensure the results are reliable the experiment should be repeated and consistent results must be obtained (within an acceptable margin or error). The experiment should be repeated at least twice (ie: carried out three times and the results averaged). This ensures that the effect of random error is minimised or that the outliers can be disregarded or removed.

Note from markers: Some students omitted either the experiment or repetition and averaging the results. The did not identify that by reliability is increased by repeating the experiment and averaging the results.

Average: 1.5/2

End of Examination