Name: ______________________________ Teacher: ____________________________

PHYSICS
TRIAL HSC Examination 2019

Task Weighting: 30% of HSC Assessment

Write your NAME and Teacher on the FRONT of this page

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- Approved calculators may be used
- A data sheet, formulae sheets and Periodic Table are provided at the back of this paper
- Write your name and teacher's name in the space provided

Total marks – 100

100 marks
This exam has two parts, Part A and Part B

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

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

When completing the paper it is the student's responsibility to allocate time that is commensurate with the marks allocated to each question.

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

Use the multiple choice answer sheet for Questions 1-20

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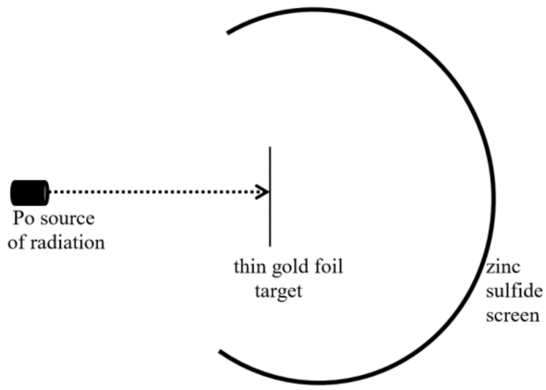
1 An investigation was set up as shown in the diagram.



The observations made from this investigation led to:

(A) the discovery of the nucleus.

(B) the discovery of the neutron.

(C) the discovery of cathode rays.

(D) the conclusion that electrons are a part of every atom.

2 An object is orbiting at a radius "r" from the centre of a large mass. If its radius is quadrupled, what will be the effect on the object's new gravitational potential energy?

(A) The gravitational potential energy is increased by 4 times.

(B) The gravitational potential energy is reduced by a quarter.

(C) The gravitational potential energy is twice as much.

(D) The gravitational potential energy is halved.

3 The equation which best represents beta decay is?

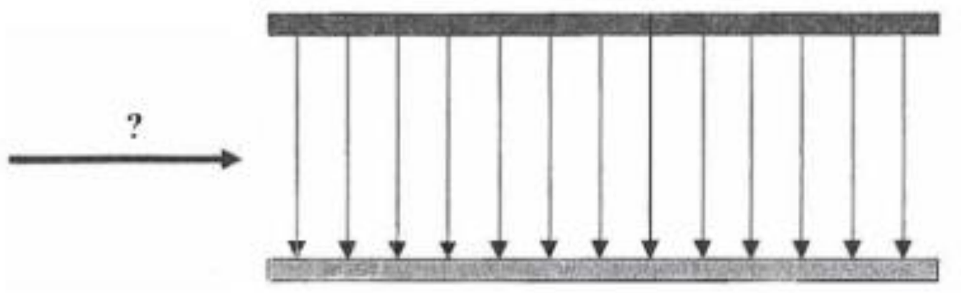
(A) $^{233}_{92}U \longrightarrow {}^{229}_{90}Th + {}^{4}_{2}He$

(B) $^{131}_{53}I \longrightarrow {}^{131}_{54}Xe + {}^{0}_{-1}e + \bar{v}$

(C) $^{235}_{92}U + {}^{1}_{0}n \longrightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3\,{}^{1}_{0}n$

(D) $^{4}_{2}He + {}^{4}_{2}He \longrightarrow {}^{8}_{4}Be + {}^{0}_{0}\gamma$

4 Consider the electric field between two parallel plates.



Which particle, fired horizontally from the left and moving into the field, would experience the greatest acceleration upwards?

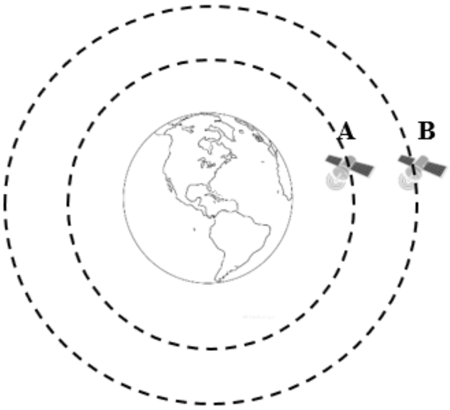
(A) An electron

(B) A proton

(C) An alpha particle

(D) A chloride ion, Cl^-

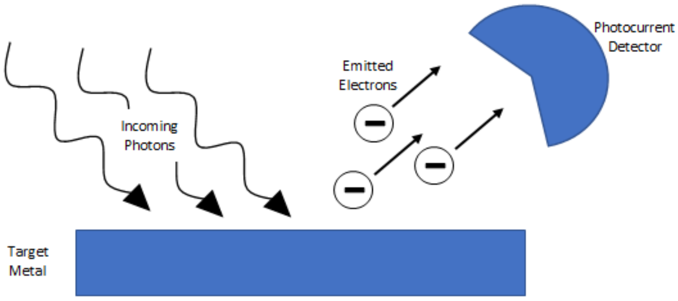
5 Two satellites, **A** and **B** are orbiting Earth at different altitudes, as shown.



Which comparison of the satellites' orbital velocities, orbital periods and centripetal accelerations is correct?

	Orbital velocity	Orbital period	Centripetal acceleration
(A)	A is greater	B is greater	B is greater
(B)	B is greater	A is greater	A is greater
(C)	B is greater	B is greater	B is greater
(D)	A is greater	B is greater	A is greater

6 The following experiment is set up to demonstrate the photoelectric effect:



The effect on the photocurrent as the intensity of light increases will be an increase in:

(A) Photon energy.

(B) Photon wavelength.

(C) Electron kinetic energy.

(D) Photocurrent magnitude.

7 The main difference between a controlled and an uncontrolled nuclear chain reaction is:

(A) the number of neutrons released at each fission.

(B) the amount of energy released at each fission.

(C) the amount of subsequent fission reactions.

(D) the amount of fuel available.

8 Foucault measured the speed of light by focusing a light onto a rotating mirror which reflected it onto a fixed mirror which in turn reflected it back. Whilst the light travelled to the fixed mirror and back, the rotating mirror rotated through an angle. By measuring the angle with a known angular velocity of the mirror, Foucault was able to calculate a value for the speed of light.

The smaller the measured angle the more uncertainty there was in the measurement.

What would be the easiest adjustment to make to the experimental design to increase the size of the angle and reduce the uncertainty in measurement?

(A) Increase the distance between the mirrors.

(B) Decrease the distance between the mirrors.

(C) Increase the rotational velocity of the rotating mirror.

(D) Decrease the rotational velocity of the rotating mirror.

9 A laser with an unknown wavelength is bought from a market stall. It is pointed through a card that has a pair of small slits cut 90 μm apart. A wall is 6 m away from the card.

When the laser is shone through the slits, bright spots appear on the wall and are measured to be 3 cm apart.

What is the wavelength of the laser?

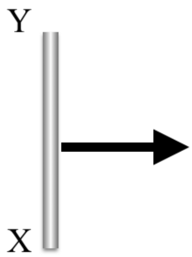
(A) 427 nm

(B) 439 nm

(C) 450 nm

(D) 459 nm

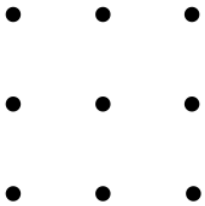
10 A wire conductor is moving to the right as shown below.



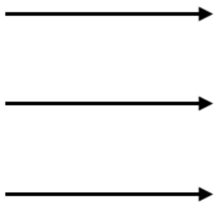
Which of the following magnetic fields would the conductor need to pass through in order to induce a current in the direction X to Y in the conductor?

(A)

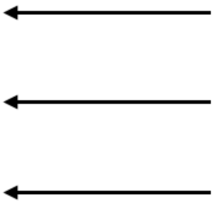
(B)



(C)

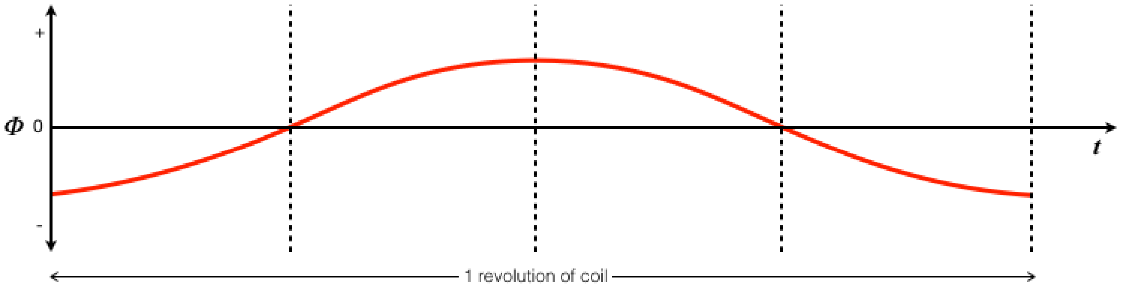


(D)



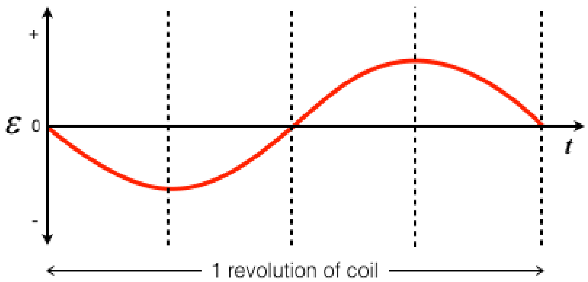
Use the following information to answer Question 11 and Question 12

11 The graph below shows the variation of flux through a generator coil as it completes a single revolution.

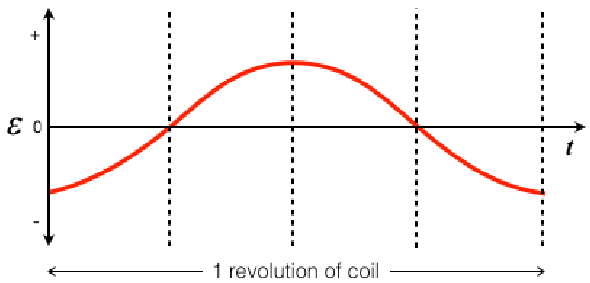


Which of the following graphs shows the corresponding EMF in the generator?

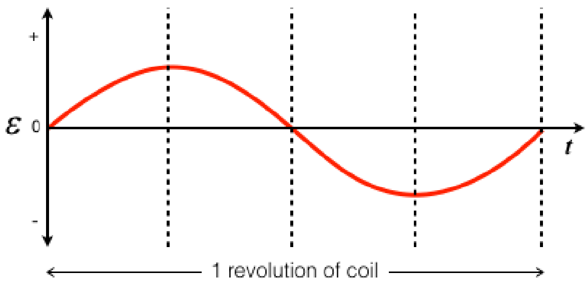
(A)



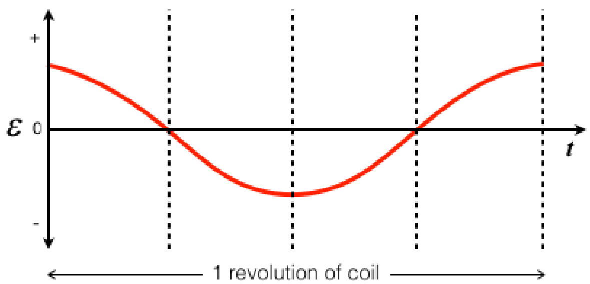
(B)



(C)



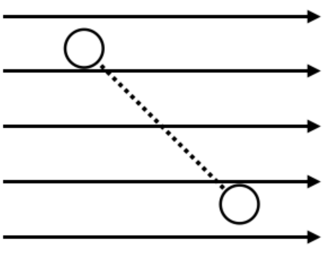
(D)



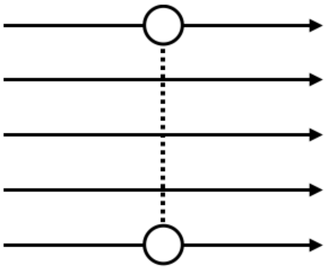
Question 12 continued over page

12 The following diagrams represent a cross section of the generator coil. Which position was the coil in at the beginning of the graph?

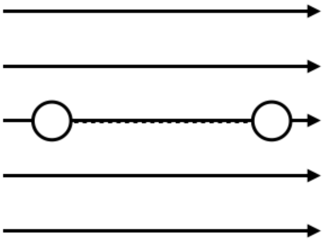
(A)



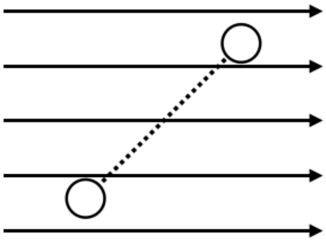
(B)



(C)



(D)



13 Calculate the work function for copper, which has a threshold frequency of 1.0 x 10^{9} MHz.

(A) 4.1 eV

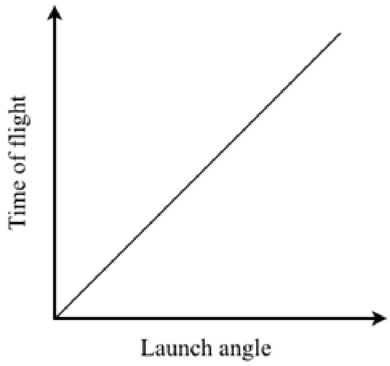
(B) 4.1 MeV

(C) 3.9 eV

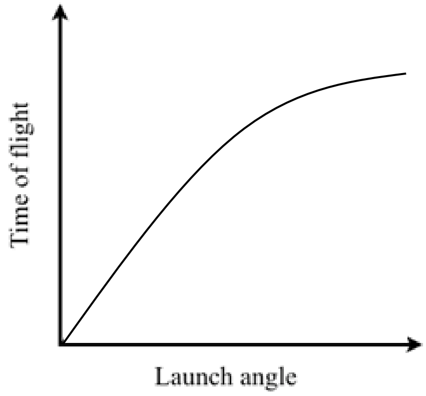
(D) 3.9 MeV

14 Which graph below best represents the relationship between launch angle and time of flight for a projectile fired from level ground?

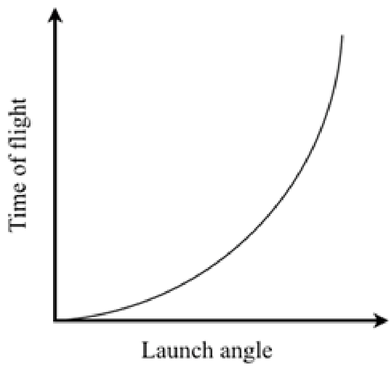
(A)



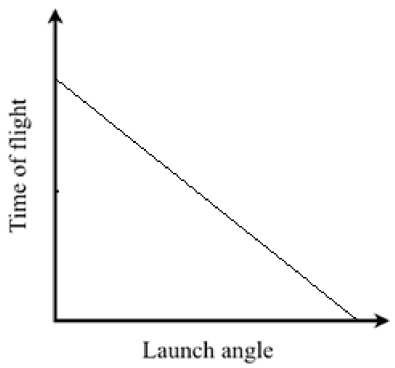
(B)



(C)



(D)



15 A beryllium-8 atom at rest undergoes double alpha decay as follows :

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

The atomic masses are: $^{4}_{2}$He. 4.002603
$^{8}_{4}$Be. 8.005305

The kinetic energy of each departing alpha particle, in keV, is closest to:

(A) 92

(B) 180

(C) 65

(D) 46

16 A student wanted to calculate the gravitational field strength (abbreviated to "GFS") for a planet. Which equation would be best used for this calculation?

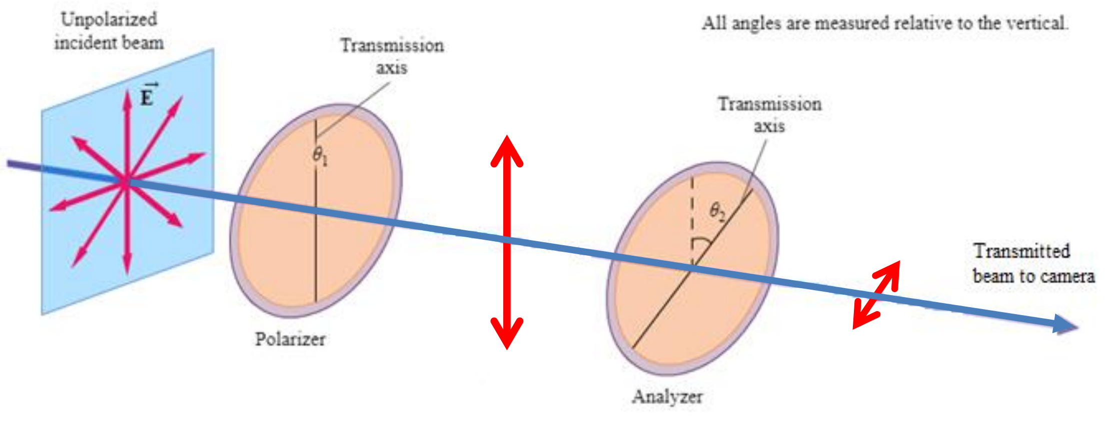
(A) $$\text{GFS} = -\frac{GM_1M_2}{r}$$

(B) $$\text{GFS} = \frac{GM_1M_2}{r^2}$$

(C) $$\text{GFS} = \frac{GM}{r^2}$$

(D) $$\text{GFS} = \frac{GM}{r}$$

17 A certain camera lens uses two polarizing filters to decrease the intensity of light entering the camera.



The light intensity of the unpolarized light at the scene is 20 W m^{-2}. If the light intensity transmitted into the camera is 4 W m^{-2}, what is angle (to the nearest degree) between the transmission axes of the polarizers?

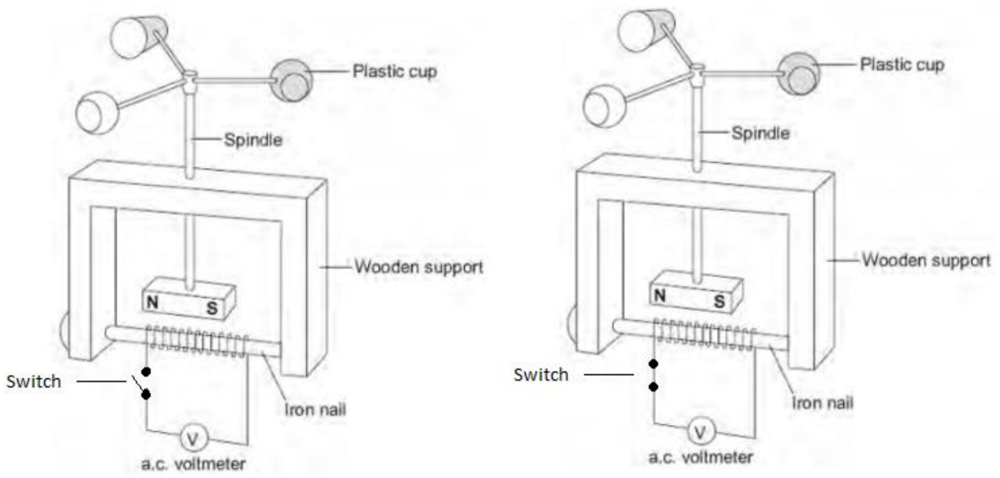
(A) 51°

(B) 63°

(C) 66°

(D) 78°

18 A device was constructed to measure wind speed. It uses the principle of electromagnetic induction.



When the wind blows, the plastic cups are rotating at a constant speed with the switch open. What would be the effect on the apparatus when the switch is closed? Ignore any mechanical friction between the spindle and the wooden support.

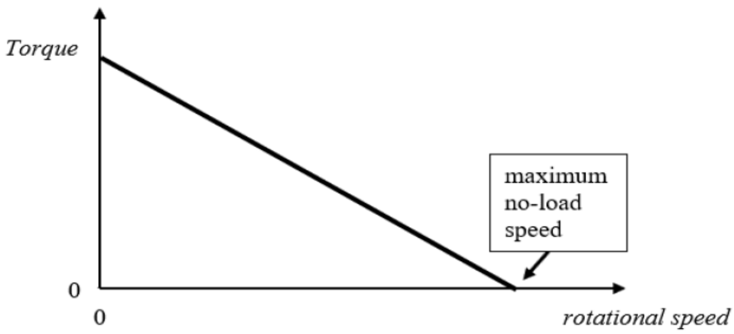
(A) There would be no effect because the speed of the wind is not changing

(B) The rotation would decrease because a back emf is induced in the coil

(C) The rotation will decrease because of an induced force on the magnet

(D) The rotation will increase because of the induced current in the coil

19 A typical DC motor has a torque versus rotational speed curve shown below.



The motor having a maximum rotational speed is due to:

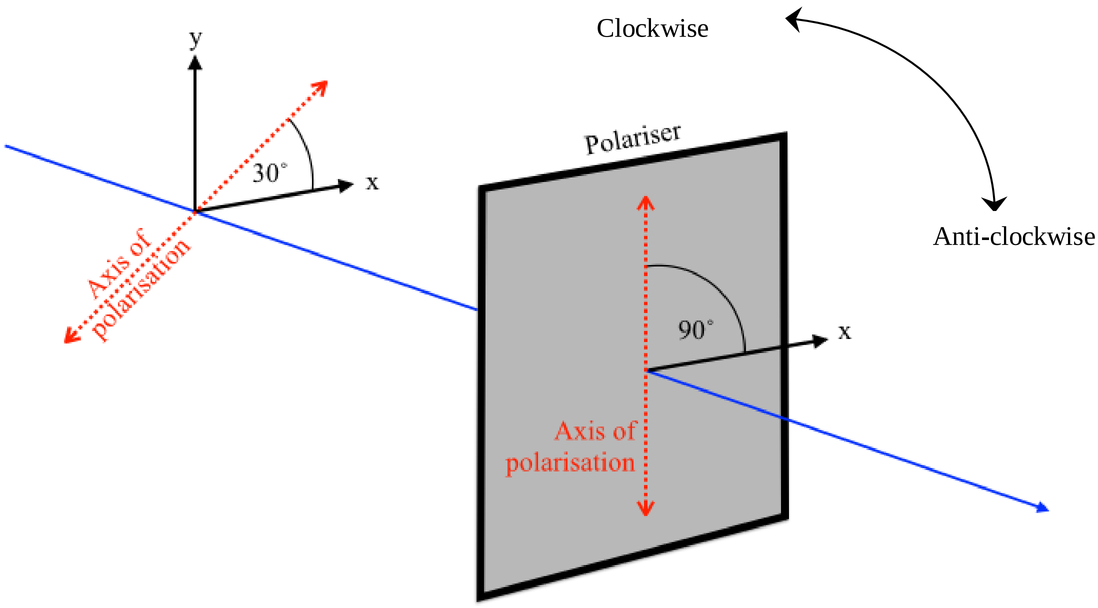
(A) a slight delay in the current reversing in the coils.

(B) back EMF.

(C) resistance of the coils.

(D) the coils not being sufficiently large.

20 A polarised light source is entering a polarising filter as shown below.



What adjustment would produce the greatest increase in light intensity?

(A) Rotating the light source anti-clockwise 80°

(B) Rotating the light source clockwise 10°

(C) Rotating the filter clockwise 150°

(D) Rotating the filter anti-clockwise 220°

End of part A

Teacher: ………………………………… NESA Barcode:…………………………………

PHYSICS
TRIAL HSC Examination 2019
Part B

General Instructions

- **NESA ID barcode or your name ONLY on the top of EVERY odd numbered page – NO HAND WRITTEN NUMBERS**
- **Write your teacher's name alongside your barcode**

- Write using black pen
- Draw diagrams using pencil
- Approved calculators may be used
- A data sheet, formulae sheets and Periodic Table are provided at the back of this paper
- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in questions involving calculations

Part B – 80 marks
Attempt questions 21-36
Allow about 2 hour and 25 minutes for this part

When completing the paper it is the student's responsibility to allocate time that is commensurate with the marks allocated to each question.

Teacher: ………………………………… NESA Barcode:…………………………………

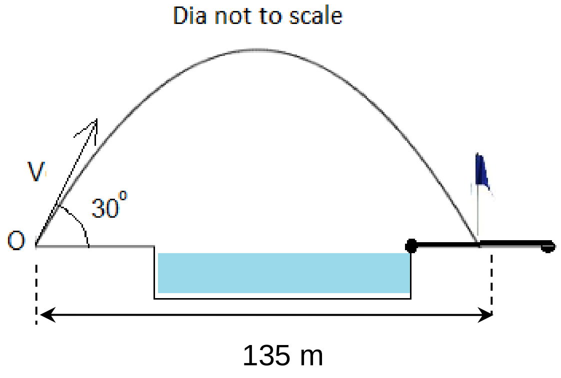
Part B – 80 marks
Attempt questions 21-36
Allow about 2 hour and 25 minutes for this part

Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.

Show all relevant working in questions involving calculations.

Question 21 (4 marks)

A golfer strikes the ball at 30° to the horizontal and hits a "hole-in-one" 135 m away as shown in the diagram below.



a) Calculate the magnitude of the initial velocity of the ball? **4**

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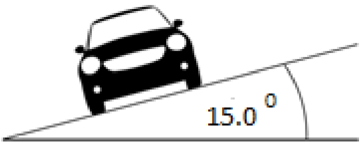
Teacher: ………………………………… NESA Barcode:…………………………………

Question 22 (5 marks)

(a) A car is travelling around a frictionless banked track, angled at 15.0°, and having a turning radius of 26.0 m, as shown in the diagram. The centripetal force acting on the car is 3040 N. **3**



Determine the mass of the car.

(b) If the above banked corner is no longer frictionless. Justify one way in which the frictional forces could impact on the motion of the car around the corner. **2**

Teacher: ………………………………… NESA Barcode:…………………………………

Question 23 (5 marks)

(a) Show that the total energy of an orbiting satellite is half its gravitational potential energy **3**

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(b) Explain why the gravitational potential energy of an orbiting satellite is negative. **2**

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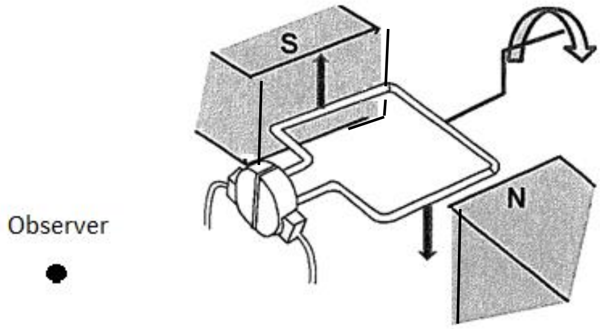
Question 24 (5 marks)

The diagram shows an electrical device where the coil is being rotated by an external force applied to a handle. An observer determines that the direction of rotation is clockwise.



(a) Identify this device. **1**

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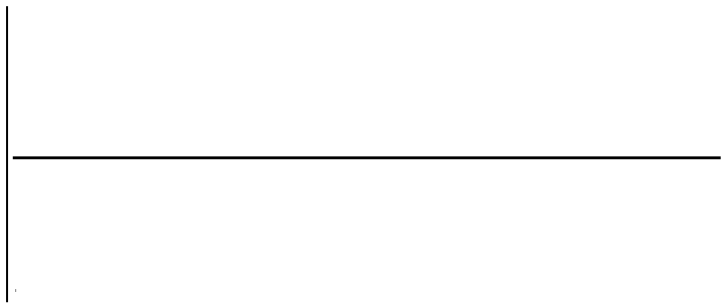
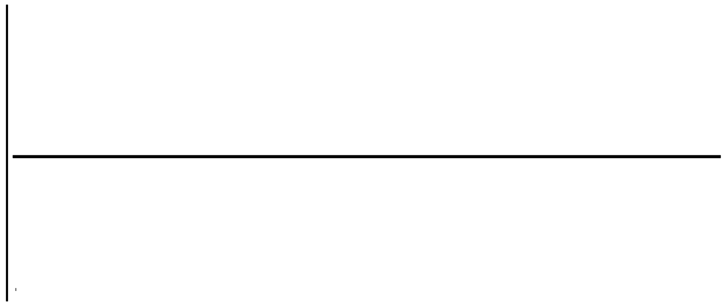
(b) On the diagram, draw arrows to show the direction of the current in the coil. **1**

(c) On the axes below, sketch labeled graphs to show the emf produced in the device AND the corresponding emf delivered to the external circuit in a single rotation from the starting position shown above. **3**

Emf produced in the device



Emf delivered to external circuit



Teacher: ………………………………… NESA Barcode:…………………………………

Question 25 (2 marks)

A coil has an area of 2.5×10^{-3} m^2. A magnetic flux of 0.15 Wb passes through the coil when the coil is perpendicular to field. Calculate the flux density when the coil is 25° to the magnetic field. **2**

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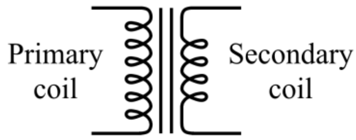
Question 26 (3 marks)

Explain how the device shown in the diagram below works. **3**



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Question 27 (6 marks)

A microscopic oil drop, which possesses 7 extra electrons, is placed in an electric field between two parallel plates that are spaced 3.00 cm apart. When the voltage between the plates is adjusted to 9.05 V the oil drop falls at a constant velocity.

(a) Draw a diagram of the oil drop showing the electric field and the forces acting on the oil drop and the when it is suspended between the plates. **3**

(b) Calculate the mass of the oil drop. **3**

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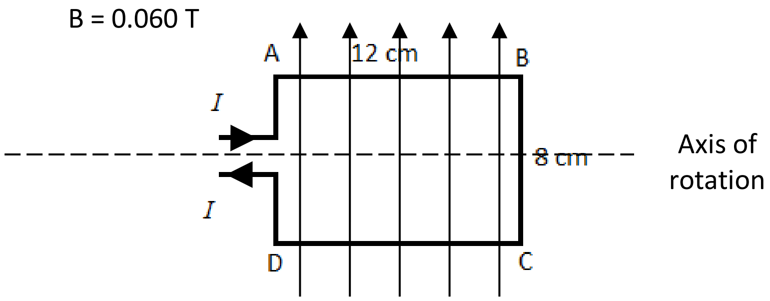
Question 28 (5 marks)

A motor uses a 150-turn coil that has dimensions of 8 cm by 12 cm, as shown in the diagram below. A current of 1.5 A flows through the coil and is in a magnetic field of 0.060 T directed up the page.



(a) What is the force exerted on side AB in the position shown? **3**

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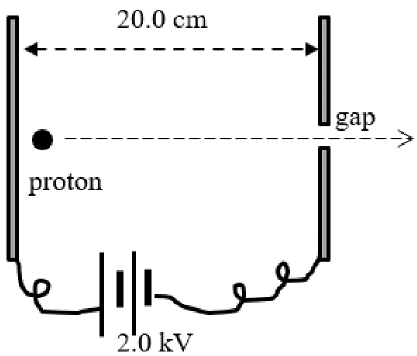
(b) Sketch a labelled graph to show the change(s) in the force exerted on side AB as it completes ONE full rotation from the starting position shown. **2**

Teacher: ………………………………… NESA Barcode:…………………………………

Question 29 (5 marks)

A single proton is accelerated from rest between two charged plates which have a potential difference of 2.0 kV. The plates are 20.0 cm apart.



The proton's path leads it through the gap in the negatively charged plate.

(a) What is the proton's speed as it passes through the gap in the negatively charged plate? **3**

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(b) Explain why the distance between the two charged plates has no influence on the proton's final speed. **2**

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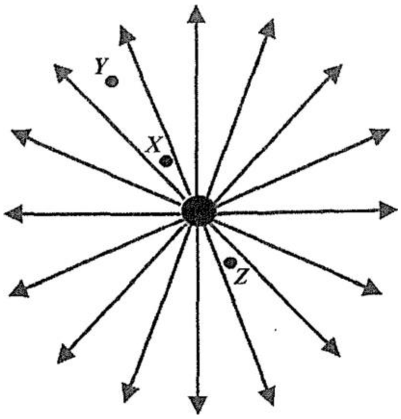
Question 30 (4 marks)

Consider the following diagram which shows three points *(X, Y* and *Z)* in the electric field around a point charge.



(a) What is the sign of the charge in the diagram? **1**

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(b) Compare the work done in moving identical negative charges from *X* to *Y* and from *X* to *Z*. Justify your answer. **3**

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Teacher: …………………………………… NESA Barcode:……………………………………

Question 31 (7 marks)

With reference to an investigation, or depth study, that you have performed in your Yr12 Physics course, justify and evaluate the use of variables and experimental controls to ensure a valid procedure was developed that allowed for the reliable collection of data. **7**

Teacher: ………………………………… NESA Barcode:…………………………………

Question 32 (6 marks)

(a) Muons travel through the atmosphere at a speed of 0.998c. The mean lifetime of a stationary muon is 2.2 µs. Show that muons formed at an altitude of 9 km can reach the surface of the Earth. **3**

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(b) Describe a thought experiment which Einstein used to show that time is relative. **3**

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Teacher: ………………………………… NESA Barcode:…………………………………

Question 33 (3 marks)

Calculate the wavelength of an electron transitioning from the 5th to the 3rd energy level in a hydrogen atom and predict which part of the electromagnetic spectrum to which it belongs. **3**

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Question 34 (4 marks)

A sample of iodine-131 has a half-life of 8 days and contains 1.2×10^{13} nuclei.

(a) Calculate the decay constant for iodine-131. **2**

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(b) Determine how many iodine-131 nuclei will remain after another 76 days. **2**

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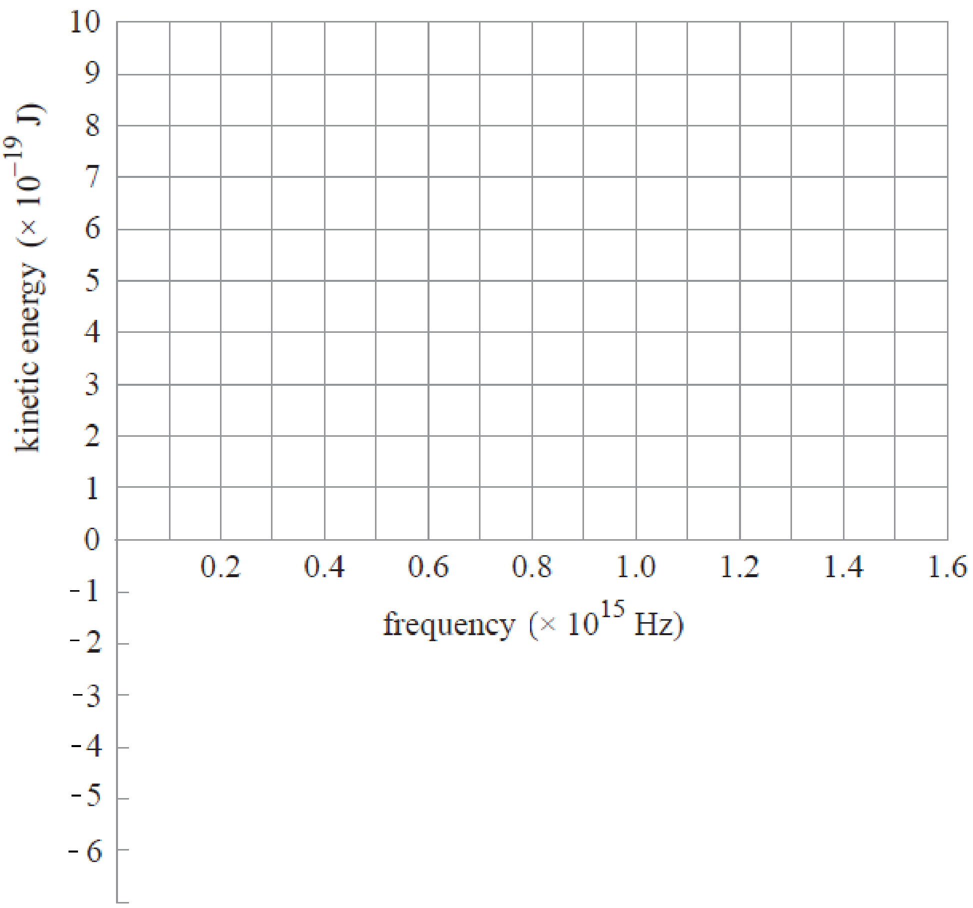
Teacher: ………………………………… NESA Barcode:…………………………………

Question 35 (7 marks)

A group of students conducted a photoelectric experiment in class to determine the work function of a given metal. Their results are shown in the following table.

Wavelength of light (nm)	*Frequency of light ($\times 10^{15}$ Hz)*	*Energy carried by light beam (eV)*	*Kinetic energy of emitted electrons ($\times 10^{-19}$ J)*
200	1.49	6.21	7.30
300	1.00	4.09	3.97
400	0.76	3.10	2.33
500	0.59	2.50	1.34
600	0.50	2.02	0.66
700	0.43	1.77	0.23

(a) Graph the appropriate data on the grid below. **2**



Question 35 continued on the next page

(b) Use your graph from part (a) to determine a value for Planck's constant. **3**

....

....

....

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....

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....

(c) Using your graph, determine the value for the work function of the emitter in electron volts. **2**

....

....

....

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....

....

Teacher: …………………………………… NESA Barcode:……………………………………

Question 36 (9 marks)

Analyse how experimental evidence was used by Planck, Einstein and Bohr to develop quantum ideas. **9**

Teacher: ………………………………… NESA Barcode:…………………………………

Extra writing space

PHYSICS
TRIAL HSC
Examination
2019

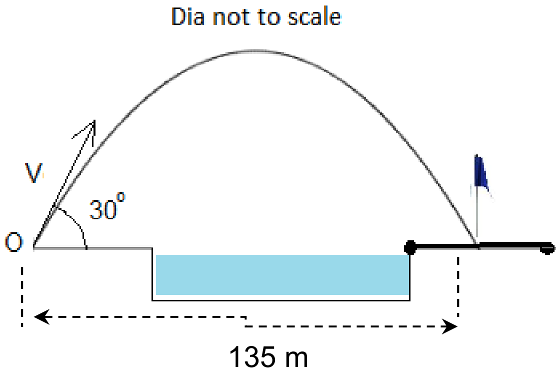
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
A	A	B	A	D	D	C	C	C	A
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
A	B	A	B	D	C	A	C	B	D

Part B – 80 marks
Attempt questions 21-37
Allow about 2 hour and 25 minutes for this part

Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.

Show all relevant working in questions involving calculations.

Question 21 (4 marks)
A golfer strikes the ball at 30° to the horizontal and hits a "hole-in-one" 135 m away as shown in the diagram below.



a) Calculate the magnitude of the initial velocity of the ball? **4**

Markers Comments:
There were several different ways to attack the solving of this problem. Therefore the marking scheme needed to be quite flexible.

The main problem was algebraic errors …….. Poor setting out was systemic across the board …. so ….. if I could not follow your working you were unlikely to obtain credit for carried errors.

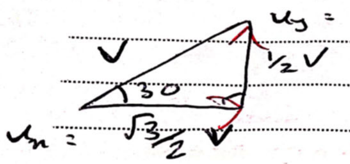
Proj. motion problems require vector diagrams to be drawn …. less than 50% of students bothered to draw something ……… of this 50% only 14 students bothered to put **arrows** on to make it a vector diagram!!! Should I go back and take a mark off anyone who didn't draw a "proper" vector dia???

If you produced an answer of 55.3 ms^{-1}, you used time to max height ….. not total time of flight.

Marking Criteria	Marks
Clear logical working which obtains the correct answer (39 ms^{-1})	4
Clear logical working with ONE algebraic error (late in solution) OR Used T_{half} Instead of total time	3
Two or more errors	2
Clearly shows or uses the correct horizontal AND vertical components	1

135 m

a) Calculate the magnitude of the initial velocity of the ball? **4**



now $x = u_x t$

$135 = \frac{\sqrt{3}}{2} V \times t$

$t = \frac{270}{\sqrt{3}V}$

now $y = 0$ at $t = \frac{270}{\sqrt{3}V}$

$0 = u_y t + \frac{1}{2} a_y t^2$

$0 = \frac{1}{2} V \times \left(\frac{270}{\sqrt{3}V}\right) + \frac{1}{2} \times -9.8 \times \left(\frac{270}{\sqrt{3}V}\right)^2$

$0 = \frac{270}{2\sqrt{3}} - 4.9 \times \frac{24300}{V^2}$

$\frac{4.9 \times 24300}{V^2} = \frac{270}{2\sqrt{3}}$

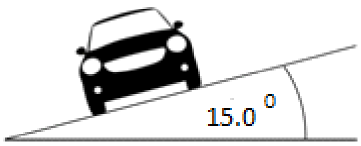
$V = \sqrt{\frac{4.9 \times 24300 \times 2\sqrt{3}}{270}}$

$V = 39 \ m\,s^{-1}$

(4)

Question 22 (5 marks)

(a) A car is travelling around a frictionless banked track, angled at 15.0°, and having a turning radius of 26.0 m, as shown in the diagram. The centripetal force acting on the car is 3040 N. **3**



Determine the mass of the car.

Markers Comments:
Well answered on the whole, however to answer this fully a "proper" vector diagram should be drawn. It really bugs me at this stage of the course, that I continue to see triangles, and other weird ways of identifying the forces acting. Although the marking criteria did not ask for a vector diagram, it is almost impossible to solve projectile motion Q's without one .... SO MAKE sure you start including them as part of your solution.

Marking Criteria	**Marks**
• Shows the forces acting as the car rounds the corner • Applies the correct trigometric relationship • Working shown to calculate the correct mass	3
• One of the above missing	2
• Some correct information	1

$\theta = 15.0°$ $r = 26.0\ m$ $F_c = 3040\ N$ $g = 9.8\ m\,s^{-2}$

$F_c = R\sin\theta = \frac{mg}{\cos\theta} \times \sin\theta$

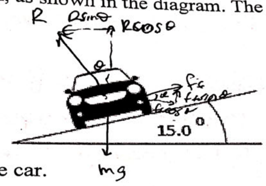
$F_c = mg\tan\theta$

$\therefore 3040 = m \times 9.8 \times \tan 15.0$

$\therefore m = \frac{3040}{9.8\tan 15.0} = 1157.6973...$

$\doteq 1.16 \times 10^3\ kg$ (3 sig. figs)

...turning radius of 26.0 m, ...frictionless banked track, angled at 15.0°, and having a ... on the car is 3040 N. ..., as shown in the diagram. The centripetal force acting



Determine the mass of the car. **3**

Horizontal:

$F_c = \frac{mv^2}{r} = R\sin\theta$

$3040 = R\sin 15$

$R = 11745.65\ldots$

Vertical: $mg = R\cos\theta$

$m = \frac{R\cos 15}{g}$

$= \frac{11745.65\ldots \times \cos 15}{9.8}$

$= ~~11.5~~\ 1157.697\ldots$

$= 1160$ kg (3 sig figs)

Data

$r = 26$ m

$F_c = 3040$ N

$\theta = 15°$

3

(b) If the above banked corner is no longer frictionless. Justify one way in which the frictional forces could impact on the motion of the car around the corner. **2**

Markers Comments:

This Q was not answered as well as the previous one. There were several misconceptions evident:

- Some believed that the frictional force (would oppose the motion) and so would slow the car down
- Others believed that the F_f would act **up the slope** instead of down the slope ……. remember that in order to drive a car around a corner on a **horizontal** surface, it is the frictional force between the tyres and the road that supplies the centripetal force …… so it must act towards the centre of the circle

Marking Criteria	Marks
• States that the F_f increases the total F_c AND provides a reason how/why • Identifies that EITHER the corner can be taken with an increased velocity OR a smaller radius	2
• ONE of the above	1

Frictional forces acting down the slope would have a vertical (downward acting) component & a horizontal (contributing to F_c) component. The horizontal component would increase the magnitude of F_c, allowing for a higher max velocity for a given radius to be reached, as according to $F_c = \frac{mv^2}{r}$, as $F_c \propto v^2$.

2

... on the motion of the car around the corner. ... way in which the **2**

The frictional forces between the tyres and the road would produce a force parallel to the plane of the road, proportional to the normal reaction exerted on the tyres by the road, and the coefficient of friction of the surface. The horizontal component of this frictional force would act towards the centre of the circle, increasing the centripetal force acting on the car. According to $F_c = \frac{mv^2}{r}$, an increase in centripetal force whilst keeping mass and velocity constant will result in a smaller turning circle than without friction (i.e. lower radius, r)

Question 23 (5 marks)

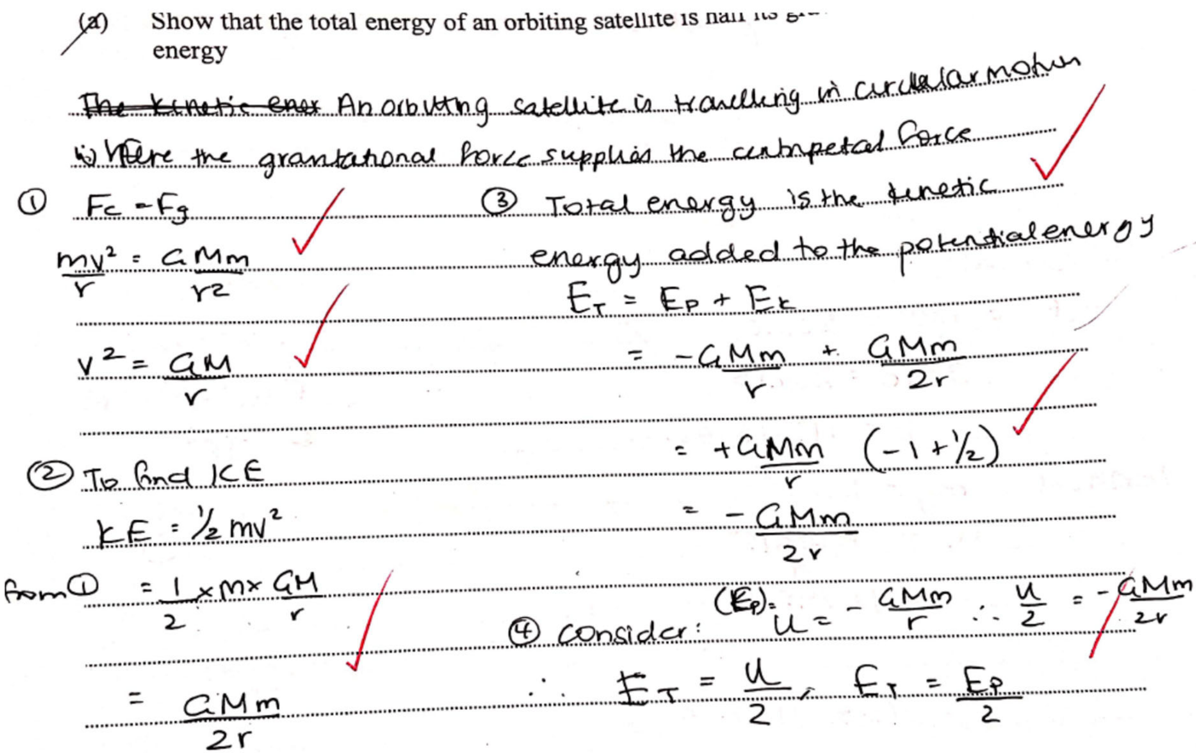
(a) Show that the total energy of an orbiting satellite is half its gravitational potential energy **3**

I believed many students would find this question would difficult, however I was pleasantly surprised.

Two areas why marks were not awarded were:

- Not showing the **full** working for each step
- Messy setting out / algebraic mistakes or inconsistencies ….. as some students knew where they had to end up BUT didn't really know how to get there.

Marking Criteria	***Marks***
• Equates the expressions for $F_G = F_c$ to show how the velocity is eliminated from the F_c expression (1 mark) • Shows that $K = \frac{Gm_1m_2}{2r}$ (1 mark) • Shows that $E_T = U + K$ (1/2 mark) • Obtains $E_T = 1/2U$ with correct algebraic manipulation (1/2 mark)	3



(a) Show that the total energy of an orbiting satellite is half its gravitational potential energy

~~The kinetic ener~~ An orbiting satellite is travelling in circular motion where the gravitational force supplies the centripetal force

① $F_c = F_g$

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

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

② To find KE

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

from ① $= \frac{1}{2} \times m \times \frac{GM}{r}$

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

③ Total energy is the kinetic energy added to the potential energy

$E_T = E_P + E_K$

$= -\frac{GMm}{r} + \frac{GMm}{2r}$

$= +\frac{GMm}{r}\left(-1 + \frac{1}{2}\right)$

$= -\frac{GMm}{2r}$

④ Consider: $(E_P) = U = -\frac{GMm}{r}$ $\therefore \frac{U}{2} = -\frac{GMm}{2r}$

$\therefore E_T = \frac{U}{2}$, $E_T = \frac{E_P}{2}$

3

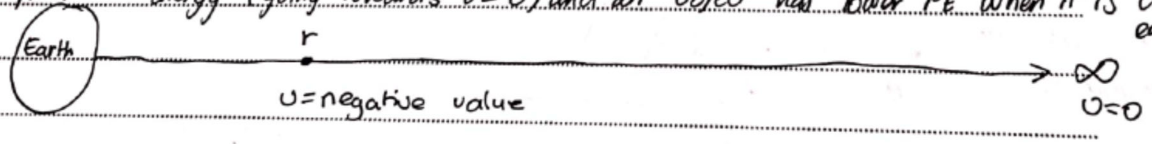
(b) Explain why the gravitational potential energy of an orbiting satellite is negative. **2**

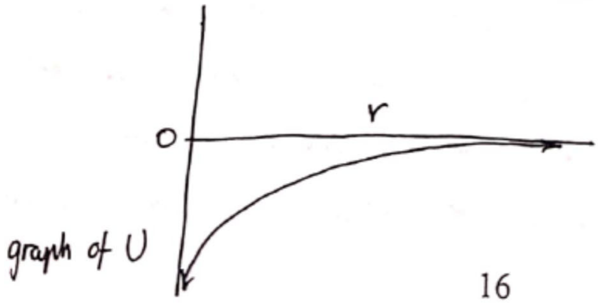
MARKERS COMMENTS

This Q was well answered, indicating that most students had a good understanding of this concept

(b) Explain why the gravitational potential energy of an orbiting satellite is negative. **2**

According to the equation $U = -\frac{GMm}{r}$ at a point $r = \infty$ $U = 0$ therefore all value less than ∞ must yeild an U of less than 0. Hence any number less than 0 is negative. Hence as a object moves away from earth, it gains potential energy (going towards $U = 0$) and an object has lower PE when it is closer earth



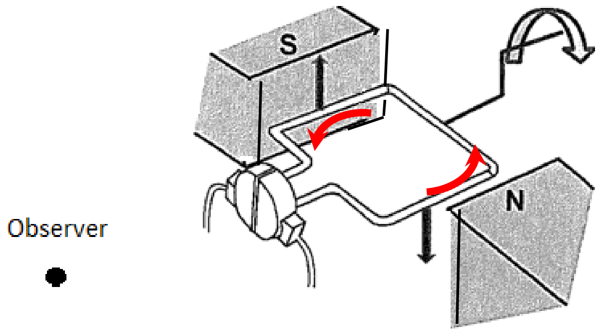


2

16

Question 24 (5 marks)

The diagram shows an electrical device where the coil is being rotated by an external force applied to a handle. An observer determines that the direction of rotation is clockwise.



(a) Identify this device. **1**

DC Generator ….. must have the DC to get the mark

1

(b) On the diagram, draw arrows to show the direction of the current in the coil. **1**

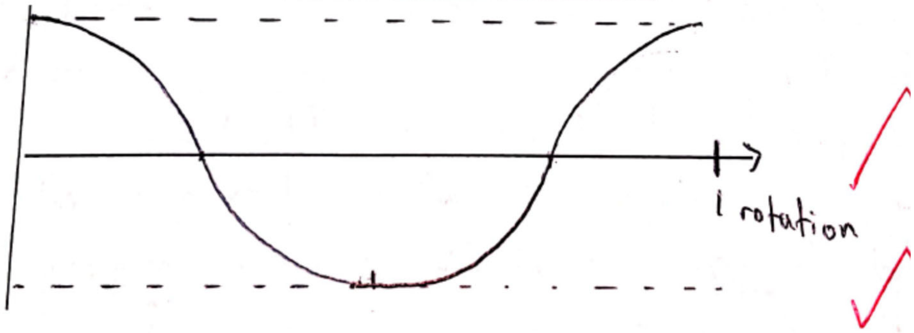
(c) On the axes below, sketch labeled graphs to show the emf produced in the device AND the corresponding emf delivered to the external circuit in a single rotation. **3**

MARKERS COMMENTS

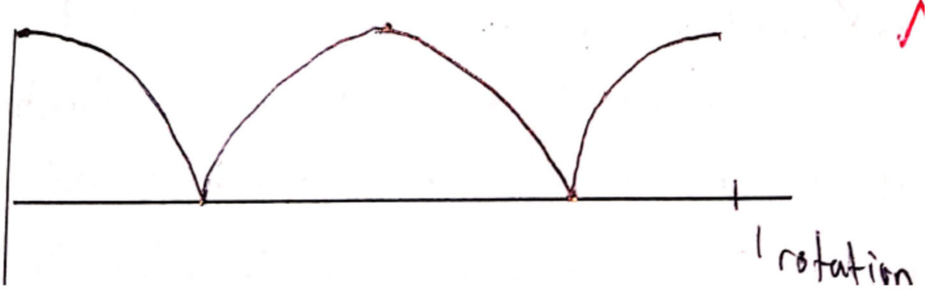
Since the coil is in the horizontal position at the starting point there would be a MAX change in flux at this position ∴ the graph needed to show a MAX Emf at time zero. This is where most students lost a mark if they did not obtain full marks

Marking Criteria	Marks
Shows the Emf being produced in the device for ONE full rotation with a MAX at time = 0 AND A DC current being delivered to the external circuit AND The two graphs show a corresponding time/position scale on the X-axis	3
Two of the above	2
One of the above	1

Emf produced in the device



Emf delivered to external circuit



Question 25 (2 marks)

A coil has an area of 2.5×10^{-3} m^2. A magnetic flux of 0.15 Wb passes through the coil when the coil is perpendicular to field. Calculate the flux density when the coil is 25° to the magnetic field. **2**

MARKERS COMMENTS

This may have been considered a pretty tough Q ….. and the fact that only 3 students achieved full marks probably backs this up.

The Q asks for **"flux density"** ….. now flux density refers to **HOW CLOSE THE FIELD LINES ARE TOGETHER** …….. this is also called **MAGNITIC FIELD STRENGTH ….. (ie "B")** Since the magnetic field strength is determined (in this case) by the magnets …… it will remain constant ….. irrespective of the angle of the coil which was thrown in to the question as a "Red Herring".

So just because your equation sheet list an equation, you need to think about each situation before you just plug values into it.

Marking Criteria	Marks
Calculates magnetic flux density (B) AND Realises that B is constant	2
Shows and uses the equation ϕ = BA CosΘ and substitutes the CORRECT values for ϕ & A	1

When perpendicular: $\phi = BA$

$0.15 = B \times 2.5 \times 10^{-3}$

$\therefore B = 60T$

When the coil is 25° to the magnetic field, the flux density (i.e. field strength) does not change - only the amount of magnetic flux $\therefore B = 60$ Teslas

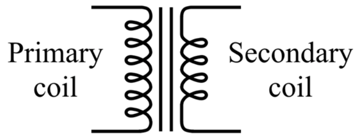
~~60 Teslas~~ (2

$= 6.0 \times 10^1$ T (2 s.f.)

2

Question 26 (3 marks)

Explain how the device shown in the diagram below works. **3**



MARKERS COMMENTS

It was really disappointing to see the number of students who either:

- Failed to identify that the device was a step down transformer
- And/or failed to state that an **AC** current is needed
- Very few students mentioned (correctly) the role of the soft iron core, with some students misinterpreting the symbol (above) used for transformers, while others said that the flux changes in the secondary coil are caused by the current that current passes through the iron core

Marking Criteria	Marks
Identifies the device as a Step-down transformer AND Identifies how an AC current creates a changing magnetic flux in primary coil AND Accounts for the **changing** magnetic field lines cutting through the secondary coil that induces a current in this coil AND … EITHER identifies the role of the iron core OR Relates that the Emf produced is proportional to the ratio of the turn in eah coil	3
Explains magnetic flux in primary coil inducing an EMF in the secondary coil that is lower in voltage	2
Identifies a step down in voltage	1

Sample answer:

The primary coil supplied with an AC current produces a constantly changing magnetic flux as the current alternates. The soft iron core links the two coils and amplifies the changing flux. The changing flux induces an EMF in the secondary coil. Because there are less turns in the secondary coil a smaller voltage is induced.

The device shown in the diagram is a step-down transformer The primary coil has an AC power supply which causes the coil to produce a ~~ch~~ constantly changing magnetic field. The secondary coil experiences a changing magnetic flux and applying Faradays Law $(E = \Delta\phi / \Delta t)$ an electromotive force must be induced. ~~If Many to~~ If secondary coil circuit is closed a current will pass through the circut which can be used ~~t~~ in other devices. The secondary coils has fewer coils than the primary coil and applying flux linkage $= n$ ~~BA~~ $BA = n\phi$ it experiences a smaller ϕ change in magnetic flux and hence a smaller induced emf.

Question 27 (6 marks)

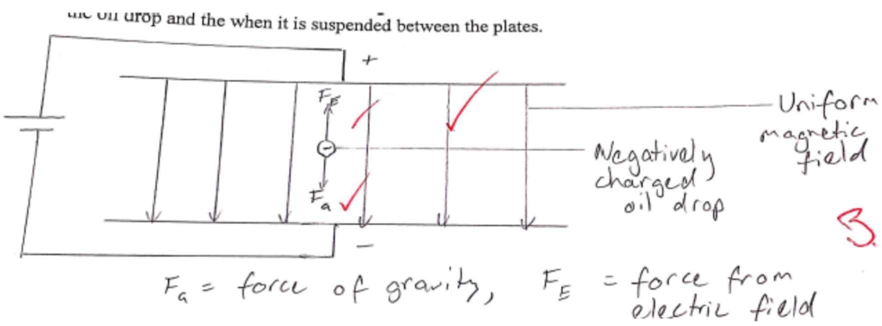
A microscopic oil drop, which possesses 7 extra electrons, is placed in an electric field between two parallel plates that are spaced 3.00 cm apart. When the voltage between the plates is adjusted to 9.05 V the oil drop falls at a constant velocity.

(a) Draw a diagram of the oil drop showing the forces acting on the oil drop and the electric field when it is suspended between the plates. **3**

MARKERS COMMENTS

Although well answered, some students (approx 12) tried to draw the electric field "sideways"

Marking Criteria	Marks
• Shows the electric field is in the vertical direction • Field lines travelling from +ive to –ive • BOTH forces acting on the oil drop are correctly identified and labelled	3
Two of the above	2
One of the above	1



(b) Calculate the mass of the oil drop. **3**

MARKERS COMMENTS

Well answered on the whole, however I am surprised at the number of either calculator errors or transcription errors.

Marking Criteria	Marks
• Identifies and applies the concept of Σ F= 0 • Uses the correct relationship for F_E ie (F_E = qE) • Uses the correct charge on the oil drop • Calculation correct with sig figs and units	3
Missing ONE of the above	2
Missing two of the above	1

Constant velocity ∴ $a = 0$ ∴ $F_g = F_E$

$E = \frac{V}{d} = \frac{9.05}{0.03} = 301.666\ldots \text{ Vm}^{-1}$

$F_g = F_E$ ✓

$mg = qE$ ✓

$m = \frac{qE}{g} = \frac{7 \times 1.602 \times 10^{-19} \times 301.666\ldots}{9.8}$

$= 3.451928\ldots \times 10^{-17}$

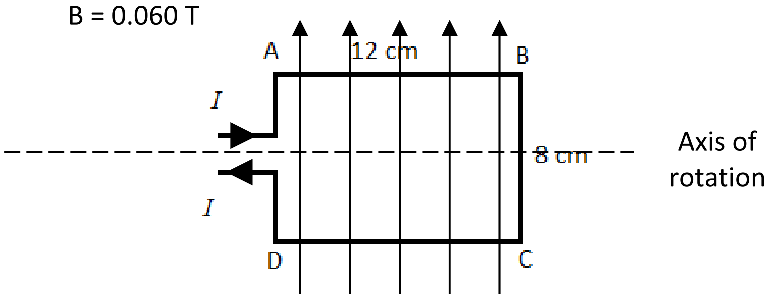
$\approx 3.45 \times 10^{-17}$ ✓ kg (3 sig figs)

3

Question 28 → 32 were marked by Miss Penson (green pen used)

Question 28 (5 marks)

A motor uses a 150-turn coil that has dimensions of 8 cm by 12 cm, as shown in the diagram below. A current of 1.5 A flows through the coil and is in a magnetic field of 0.060 T directed up the page.



(a) What is the force exerted on side AB in the position shown? **3**

<u>Marker's Comments</u>:

- many students did not include the 150 turns that was mentioned in the stem of the question, so they were out by a factor of 150 for the total force.
- many students gave the wrong number of significant figures – it should have been quoted to TWO as you did not use the 8 cm value and all other values used in the calculation had 2 significant figures in them.
- Many students forgot to include a direction – it is a vector quantity and it did not ask for the "magnitude" so you are expected to include direction…
- A couple of students wrote "up" or "upwards" for the direction and this is not specific enough – you had to have "out of the page" to get the direction correct.
- Some students tried to use the torque formula (τ = nBIAsinθ) but this calculates the torque on the whole coil – and THEN your significant figures should be ONE significant figure as you would have used the 8 cm value. Unfortunately, this cannot be used to work out the force on ONE side of a coil – you must use F – nBIlsinθ
- A few students used the torque equation and thought they had the force calculated…

<u>Marking Criteria</u>:

Marking Criteria	Marks
Correctly uses F = nBILsinθ to calculate a force of 1.6 N out of the page	3
Has ONE error such as: • only calculates the force on one loop • fails to convert the 12 cm to 0.12 m • has an answer that has more or less than 2 significant figures • does not include direction of out of page or has direction wrong	2
Some relevant working	1

DATA

$I = 1.5A$

$n = 150$ turns

$l = 12$ cm

$= 0.12$ m

$B = 0.060$ T

$F_{AB} = nBIl$

$= 150 \times 0.06 \times 1.5 \times 0.12$

$= 1.62$ N

$= 1.6$ N out of page (2sf)

✓

(b) Sketch a labelled graph to show the change(s) in the force exerted on side AB as it completes ONE full rotation from the starting position shown. **2**

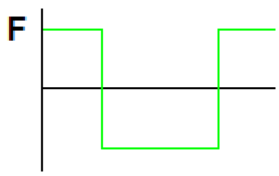
<u>Marker's Comments</u>:

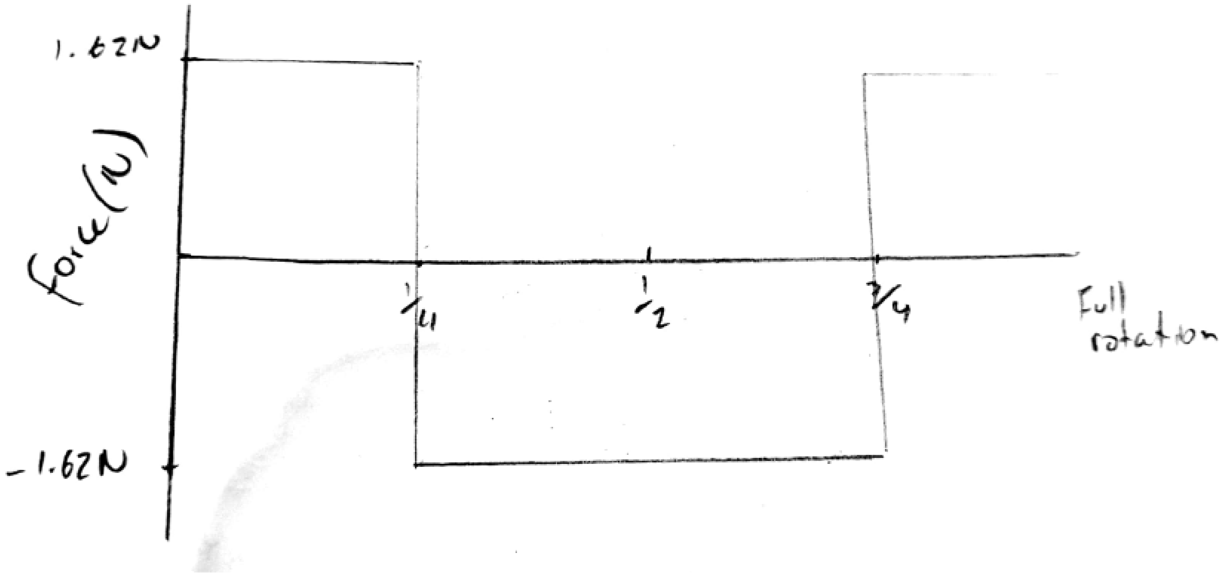
This was exceptionally poorly done (only 9 students gained 2 marks) and so many students fell for this "trick" – the formula for the force on a current-carrying conductor in a magnetic field is F = BIlsinθ and θ (the angle between the field and the wire) IS ALWAYS 90° so it has a constant MAGNITUDE as the other factors DO NOT CHANGE…
The force WILL change DIRECTION if it is a MOTOR (which it said it was in the question – and this doesn't change whether it is a DC or an AC motor) or it would "wobble" back-and-forth rather than TURN in one continuous direction.

The torque on this coil WOULD be a "cos" shaped graph if it was not in a radial field and I think this was what many students were thinking of???

5 students did not read the fact that the question asked for a sketch of a graph and sketched the coil in multiple positions OR gave a written answer – this was not given any marks…

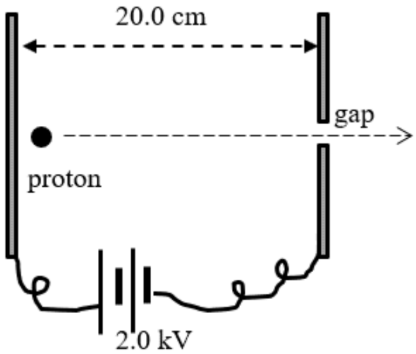
<u>Marking Criteria</u>:

Marking Criteria	Marks
Shows the force on the wire AB as a constant magnitude in the positive and negative quadrant with the following shape: 	2
Has a graph that shows the force is constant and (incorrectly) is only "positive" OR Has a graph that shows constant magnitude of force that change from positive to negative, but it doesn't match to correct points of the rotation	1


1.62N
force (N)
-1.62N
1/4
1/2
3/4
Full rotation

Question 29 (5 marks)

A single proton is accelerated from rest between two charged plates which have a potential difference of 2.0 kV. The plates are 20.0 cm apart.



The proton's path leads it through the gap in the negatively charged plate.

(a) What is the proton's speed as it passes through the gap in the negatively charged plate? **3**

<u>Marker's Comments</u>:

- **This was quite well done.**
- **You could either equate the work done by the field (W = qV = ΔK = ½ mv^2 – ½ mu^2 so qV = ½ mv^2 as u = 0) or calculate the force on the proton to work out the acceleration (F = qE = ma) and then use v^2 = u^2 + 2as to work out the velocity.**
- **A few students gave a direction which technically is wrong as the questions asks for speed…**
- **A few students still failed to convert the 20cm to 0.20 m.**

<u>Marking Criteria</u>:

Marking Criteria	Marks
• Correct process shown with full working to calculate a speed of 6.2 x 10^5 m s^{-1} (significant figures not considered in this question but should have been 2 sig figs)	**3**
• ONE error made in the process to calculate the speed of the proton	**2**
• A relevant step in the calculation is made correctly	**1**

$F = ma = qE$

$\therefore ma = q \times V/d$

$1.673 \times 10^{-27} \times a = 1.602 \times 10^{-19} \times \frac{2 \times 10^3}{0.2}$

$a = 9.5756 \ldots \times 10^{11} \ m\,s^{-2}$

now $v^2 = u^2 + 2as$

$v^2 = 0 + 2 \times 9.5756 \ldots \times 10^{11} \times 0.2$

$v = \sqrt{2 \times 9.5756 \ldots \times 10^{11} \times 0.2}$

$v = 6.188 \ldots \times 10^5 \ m\,s^{-1}$

$\approx 6.2 \times 10^5 \ m\,s^{-1}$

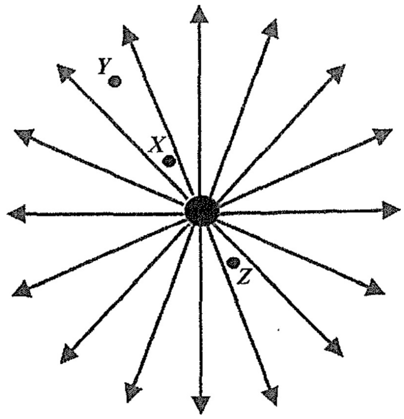
Marking Criteria	Marks
• Complete and correct explanation given	2
• Incomplete and/or partially correct explanation given	1

$E = \frac{V}{d}$, $F = q\frac{V}{d}$, $a = \frac{qV}{md}$, $v^2 = \frac{2qV}{md} \times d$, $v = \sqrt{\frac{2qV}{m}}$

As per the above derivative of the equations used to calculate velocity. It becomes apparent that the distance between the plates is cancelled out. This is because while a larger distance would give more time for the particle to accelerate to speed, the greater distance would lower the field strength and in turn the acceleration of the particle and vice versa

Question 30 (4 marks)

Consider the following diagram which shows three points *(X, Y* and *Z)* in the electric field around a point charge.



(a) What is the sign of the charge in the diagram? **1**

Marker's Comments:

- Don't be lazy – write the word "positive"
- Most students got this correct

Marking Criteria:

Marking Criteria	Marks
• Correctly identifies the sign of the charge as positive	1

(b) Compare the work done in moving identical negative charges from *X* to *Y* and from *X* to *Z.* Justify your answer. **3**

Marker's Comments:

- This was NOT well done.
- The question was about moving NEGATIVE charges from X→Y and X→Z and checked if students understood the concept of equipotential.
- Any movement PERPENDICULAR to the field DOES NOT REQUIRE ANY WORK TO BE DONE when considering it from a Physics point of view – you can move around from X→Z by going in a circular motion that would move at right angles to the field hence no work is done. This is like the person carrying a book at a height as explained in the booklet – you have to do work against the gravitational field to pick it up and the field will do work on the book if you release it BUT carrying it at a set height does not change its energy so NO WORK IS DONE…
- Even if you move the negative charge all the way out to infinity and back the forces involved would be supplied the field and then by an external force so the net work done would be zero.
- Some students used the terminology "the charge does work on the field" – this is WRONG…
- The most a student could get if this did not read the question and thought it was about moving POSITIVE charges was 1 mark…

Marking Criteria:

<table>
<tr><th colspan="3">Marking Criteria</th><th>Marks</th></tr>
<tr><td colspan="3">

- Has a **completely correct** comparison of work done from X→Y and X→ Z with justification for each (i.e. **no contradicting information)**;

</td><td rowspan="4">3</td></tr>
<tr><td></td><td>Work Done</td><td>Justification examples</td></tr>
<tr><td>X→Y</td><td>

- done **against** the field

</td><td>

- overcoming attraction force to positive charge
- field is defined as how a positive charge would move
- the force direction is form X→Y

</td></tr>
<tr><td>X→Z</td><td>

- NO work is done

</td><td>

- movement is perpendicular to field lines
- equipotential points
- same electric field strength at X and Z
- same radius in formula F = $\frac{1}{4\pi\varepsilon}\frac{q_1q_2}{r^2}$) so W=Fs does not change

</td></tr>
<tr><td colspan="3">

- Has a correct comparison for one of the movements (X→Y or X→Z) of a negative charge OR
- Correctly compares the two movements but **has some contradictory information**

</td><td>2</td></tr>
<tr><td colspan="3">

- some relevant information about work on charges in electric fields OR has some correct information about moving positive charges

</td><td>1</td></tr>
</table>

The work done on moving charges is W=qEd, however, electric field strength changes, so E changes with position of charge in field, so from moving X to Y, work would have to done against the field (as -ve charge moves further away), but there should be no work done from moving from X to Z as the distance to +ve central charge remains same, so so the E field is constant for both positions X and Z and thus, no work to move from X to Z.

Question 31 (7 marks)

With reference to an investigation, or depth study, that you have performed in your Yr12 Physics course, justify and evaluate the use of variables and experimental controls to ensure a valid procedure was developed that allowed for the reliable collection of data. **7**

Marker's Comments:

- The numbers at the bottom of the page indicate which of the 7 criteria you covered in your answer – for instance if I wrote "2, 3, 4, 6" then the tally would be 4 out of 7.
- You should start this answer by **defining validity** of experiments as this is the main concept.
- This question requires you to choose an experiment where you changed the independent variable and measured the dependent variable whilst controlling all other variables
- Initially I was looking for you to specifically identify the independent and dependent variable, for example, "the angle of the launch was the independent variable" etc. This is something that you SHOULD do in any further questions about experiments.
- Whenever you are talking about reliability you must give SPECIFICS and not just say "we repeated until we got consistent results". For example, "we performed multiple trials for a set current through the wire until we had 3 masses recorded from the balance that were consistent"
- The question asked for an evaluation **on the use of variables and experimental controls**, so I was looking for words such as **essential**, **imperative**, **crucial** etc. I did NOT accept an evaluation of the experiment as this DOES NOT ANSWER the question asked.

Marking Criteria:

Marking Criteria	Marks
1. identifies that a **fair test** (**only change one variable and measured one with all others controlled**) is needed to have a **valid** experiment OR design must **answer the aim**. 2. **Describes** their **experimental setup** 3. Identifies the variable that was **changed** in their experiment (**independent variable)** 4. Identifies the variable that was **measured** in their experiment (**dependent variable)** 5. identifies **several (at least 2) controlled variables** of their experiment 6. identifies the need **to repeat until consistent data is achieved for reliability – must mention the specific variable for their experiment – not just results!** 7. Has an **evaluation** on the **use of variables and experimental controls** in experimental design to allow you to perform a valid experiment and collect reliable data**.**	7

Exemplar

To ensure any experiment is valid it must answer the aim; this requires it to be a fair test where only the independent variable is changed, the dependent variable is measured, and all other variables are controlled.

An experiment that we performed was using a commercially produced photocell that had a photoemitter inside it so we could measure the stopping voltage (dependent variable) when we

changed the colour of the filters that the light travelled through so as we could change the frequency (independent variable) of the light hitting the photocell.
To ensure this experiment had all other variables controlled we blocked out any external visible light by using a piece of cardboard across the back of the device where the filter was placed, kept the voltage to the commercially-produced device constant, kept the same photocell in the device and tried to ensure that the environment that the device was in stayed the same.
To ensure we had reliable data we repeated the procedure for each filter (which controlled the frequency – our independent variable) multiple times until we got very consistent stopping voltages – any stopping voltage that was inconsistent was removed until we achieved 3 very clumped readings.
It was imperative that the variables were controlled, and experimental controls were in place to ensure that a valid experiment that achieved reliable data was performed.

Question 32 (6 marks)

(a) Muons travel through the atmosphere at a speed of 0.998c. The mean lifetime of a stationary muon is 2.2 μs. Show that muons formed at an altitude of 9 km can reach the surface of the Earth. **3**

Marker's Comments:

- Generally, well done but some students could still improve their setting out and finish with a sentence to confirm their proof.
- A few students forgot to "square" in their calculation, so it introduced an error.
- A couple of students did not use the Lorentz equations (relativistic motion equations) so they were not awarded any marks.

Marking Criteria:

Marking Criteria	Marks
Either • correctly calculates the time required to travel 9000 m at 0.998 c of 30 μs (or 3.0 x 10^{-5} s) and then shows that the dilated time is longer than the dilated time of 34.8 μs so it will make it to Earth **OR** • correctly calculates the time required to travel 9000 m at 0.998 c of 30 μs and then shows that the distance the muon will travel in the dilated time of 34.8 μs is 10 419 m so it will make it to Earth **OR** • correctly calculates **any variation** of **the Lorentz equations** that **supports their proof** that muons will make it to the Earth's surface	3
• only calculates the dilated time OR length contraction OR • has an error in proof it will make the 9 km	2
Some relevant working **using Lorentz equation(s)**	1

Data List

$v = 0.998c$

$t_0 = 2.2 \times 10^{-6}$ s

$t = ?$

$s = 9 \times 10^3$ m

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

$t = \frac{2.2 \times 10^{-6}}{\sqrt{1-\frac{(0.998)^2 c^2}{c^2}}}$

$t = 34.8024... \times 10^{-6}$ s ✓

$v = \frac{s}{t}$

$s = vt$

$= 0.998(3 \times 10^8)(34.8024... \times 10^{-6})$

$= 10419.85...$ m

$= 10.419...$ km ✓

$= 10$ km $\therefore$ since 10 km > 9 km, muons can reach Earth's surface.

(b) Describe a thought experiment which Einstein may have used to show that time is relative. **3**

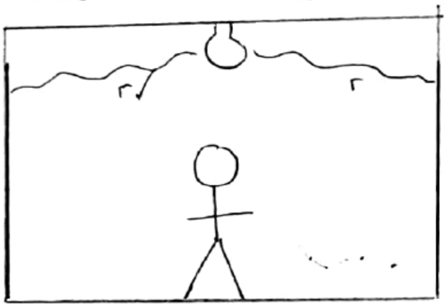
Marker's Comments:

- I cannot STRESS ENOUGH that YOU NEED **SPECIFICS** TO GAIN FULL MARKS IN PHYSICS ANSWERS - what **FRAME OF REFERENCE** are you talking about? What **DISTANCE** does the light need to travel? Are the distances the **SAME**? is the observer at the **MIDDLE** when the lightning bolts strike? Is the light at the **CENTRE** of the train carriage? Are you talking about the **PRINCIPLE** OF RELATIVITY?
- Some students did not use the space given to sketch a diagram – even though this was not requested in the question it makes it so much easier to describe your thought experiment- you are never marked on your ability to draw but it does need to be clear so labelling helps.
- Many students chose to use the "lightning strike" or "light sensors" and trains to explain this concept and generally answered the question well.
- Some students chose to use the idea of the theoretical light clock (it is ABSOLUTELY essential that you understand these DO NOT EXIST) and again generally answered the question well.
    - If using the **simultaneity idea with lightning flashes or light sensors,** then the SPECIFICS required include the fact that one of the people must be EQUIDISTANT from the two lightning strikes or sensors
    - If using **THEORETICAL light clocks** with light bouncing up and down inside a train (or equivalent frame of reference - FOR) then had to show increased distance for the observer in the external FOR.
    - If using the **person looking into a mirror** inside a fast-moving train, then needs to include the PRINCIPLE OF RELATIVITY
    - The TWIN PARADOX has ACCELERATING frames of reference and **SHOULD NOT BE USED** in this HSC course as we only cover inertial frames of reference

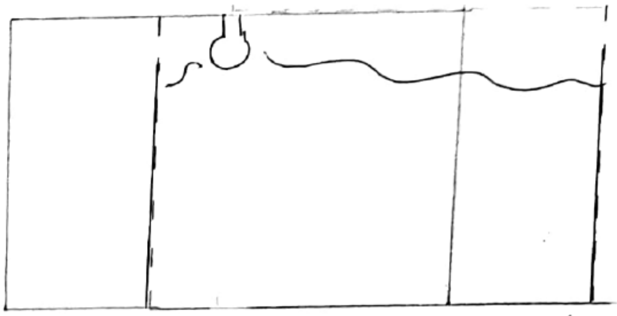
Marking Criteria:

Marking Criteria	Marks
Fully describes a relevant thought experiment, including specifics, that shows how time can be shown to be relative	3
Outlines a thought experiment that shows time is relative	2
Has some relevant information to show that time is relative	1

Obsv. In Carriage



Obsv. on Platform.



One of Einstein's thought experiments was about a light in the centre of a train carriage, with light operated doors at each end. How would an observer in the carriage and on the platform observe the event?

To the observer in the carriage, the light travels the same distance to each door, so they open at the same time.

To the observer on the platform, the back door moves towards the light & the front door moves further away as the train moves forward. Hence the light reaches the back door first & it opens first.

Hence Einstein showed that[25] time is relative, depending on your frame of reference.

Question 33 (3 marks)

Calculate the wavelength of an electron transitioning from the 5th to the 3rd energy level in a hydrogen atom and predict which part of the electromagnetic spectrum it belongs. **3**

Marking Criteria	Marks
Correctly calculates the wavelength of the electron showing full working, providing correct units and a viable prediction of the part of the electromagnetic spectrum	3
Correctly calculates the wavelength of the electron, incorrect units OR Calculates the wavelength of the electron showing full working, one error a viable prediction of the part of the electromagnetic spectrum	2
Recognises that the relevant equation is the Rydberg equation	1

Sample answer:

$R = 1.097 \times 10^7$
$n_f = 3$
$n_i = 5$

$$\frac{1}{\lambda} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

λ = 1281.9 nm

IR Range (accepted radio as well)

Markers comments

- Band 3 question
- Some students forgot to square the denominators (ni & nf) leaking a mark
- Carried error allowed for region of spectrum ie incorrect calculation but a correct part of spectrum for the calculated value.
- No units resulted in the loss of ½ mark
- As expected for a relatively simple calculation question – quite well done!

Question 34 (4 marks)

A sample of Iodine-131 has a half-life of 8 days and contains 1.2×10^{13} nuclei.

(a) Calculate the decay constant for Iodine-131. **2**

Marking Criteria	Marks
Calculates correct decay constant with correct units	2
Substitutes into the correct formula	1

Sample answer:

$\lambda = \frac{\ln(2)}{t_{1/2}}$

$\lambda = \frac{\ln(2)}{8}$

$\lambda = 0.087$ day^{-1}

Markers comments

- Band 3 question
- Some students forgot to include units leaking a ½ mark
- As expected for a relatively simple calculation question – quite well done!

(b) Determine how many Iodine-131 nuclei will remain after another 76 days. **2**

Marking Criteria	Marks
Calculates correct number of atoms	2
Substitutes or attempts to use the correct formula	1

Sample answer:

$N_t = N_0 e^{-\lambda t}$

$N_t = 1.2 \times 10^{13} \times e^{-0.087 \times 76}$

$N_t = 1.7 \times 10^{10}$ nuclei

Markers comments

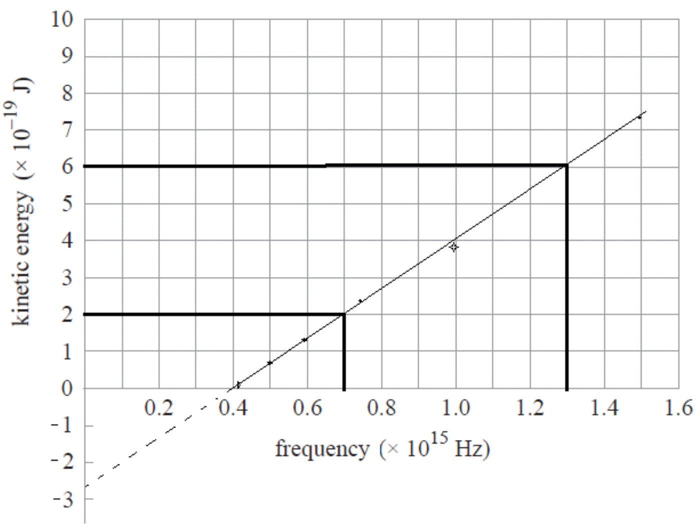
- Band 3 question
- I accepted both 76 days OR 84 days to compensate for any ambiguity in the question: suggested answer above is based on 76 days
- Quite well done – those students who did not achieve full marks may have improved their mark with clearer setting out.
- Carried error from part a allowed
- I did not consider sig figs, however many students included a silly (large) number in their answer!

Question 35 (7 marks)

A group of students conducted a photoelectric experiment in class to determine the work function of a given metal. Their results are shown in the following table.

Wavelength of light (nm)	*Frequency of light ($\times 10^{15}$ Hz)*	*Energy carried by light beam (eV)*	*Kinetic energy of emitted electrons ($\times 10^{-19}$ J)*
200	1.49	6.21	7.30
300	1.00	4.09	3.97
400	0.76	3.10	2.33
500	0.59	2.50	1.34
600	0.50	2.02	0.66
700	0.43	1.77	0.23

(a) Graph the appropriate data on the grid below. **2**



Marking Criteria	Marks
Accurately plots the data	1
Line of best fit extrapolated to the vertical axis (minus ½ for no extrapolation)	1

Markers comments:

- Band 2/3 question
- Very well done given that I used the criteria above, however I could have chosen PENCIL, APPROPRIATE HEADING, DATA POINTS USING A SMALL CROSS and very few students would have achieved full marks!
- Extrapolated LOBF should be a broken line – many students showed a solid line

Question 35 continued on the next page

(b Use your graph from part (a) to determine a value for Planck's constant. **3**

Gradient = rise/run

$= 4 \times 10^{-19} / 0.6 \times 10^{15}$

$= 6.7 \times 10^{-34}$ J s

Marking Criteria	Marks
Shows on the graph using vertical and horizontal lines how the values were obtained Uses a substitution of the graph values into the rise over run equation Correct (viable) answer with units	3
2 of the above	2
1 of the above	1

2

Markers comments:

- Band 3 question
- Quite well done
- Many students forgot to include the units for Planks constant which leaked ½ mark.
- Many students used values obtained from the data table – this cost 1 mark as you were required to use the graph.
- Make it clear using ruled lines how you obtained the gradient calculation values

(c) Using your graph, determine the value for the work function of the emitter in electron volts

$\Phi = 2.6 \times 10^{-19}$ J

$1eV = 1.602 \times 10^{-19}$

Φ eV = 2.6×10^{-19}

Φ eV = $2.6 \times 10^{-19} / 1.602 \times 10^{-19}$

= 1.6 eV

Marking Criteria	Marks
Correctly calculates the wavelength of the electron, incorrect units OR Calculates the wavelength of the electron showing full working, one error a viable prediction of the part of the electromagnetic spectrum	2
Recognises that the relevant equation is the Rydberg equation	1

Markers comments:

- Band 3 question
- Quite well done
- Many students calculated a value in Joules rather than EV which leaked ½ mark.
- Many students used values obtained from the data table – this cost 1 mark as you were required to use the y intercept on the graph.

Question 36 (9 marks)

Analyse how experimental evidence was used by Planck, Einstein and Bohr to develop quantum ideas. **9**

Marking Criteria	Marks
• Demonstrates a comprehensive and detailed understanding of how the experimental evidence used by Planck, Bohr and Einstein sequentially led to the development of quantum physics. • Clearly relates/shows how the contributions of each scientist are related (Bohr incorporated Planck's ideas, Einstein explained Planck's work)	9
• Demonstrates a detailed understanding of the experimental evidence used by Planck, Bohr and Einstein to develop quantum ideas about the atom	8
• Shows a sound understanding of the work of each scientist in relation to the development of quantum physics	7
• Outlines the relevant experimental evidence and how this contributed to the development of the atomic model of each scientist	5-6
• Relates contributions of at least two scientists	3-4
• Provides some relevant information	1-2

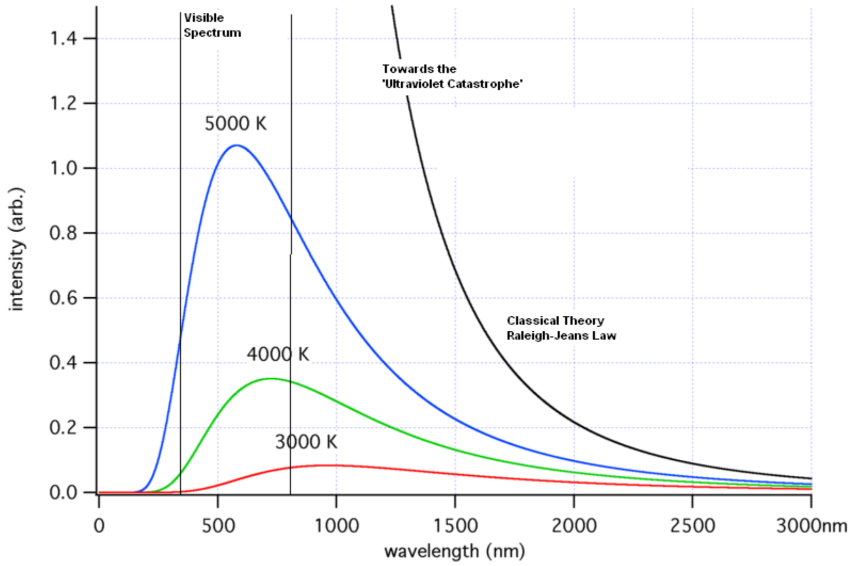
Markers comments:

- Band 5/6 question
- The difference between 8 marks and 9 marks was not huge: the 9 mark responses must explain AND include: at least 2 equations ($E = hf$, work function equation and or the Rydberg equation) AND a reasonably accurate Black body radiation curve diagram. Additionally the 9 mark responses referred specifically to the stem of the question about developing quantum ideas for each and every scientist, thus demonstrating extensive knowledge.
- 5 marks was the maximum allocated to students who only sufficiently addressed the wprk of 2 scientists.
- 10 students scored no (0) marks, 3 students scored 1 mark, 4 students scored 2 marks: if this was an HSC paper these students wold struggle to leave Band 4!

<u>**Sample answer:**</u>

Planck suggested that radiation was emitted or absorbed by a black body in discrete quanta (packets of energy) rather than continuously, as suggested by classical physics. Mathematically, Planck expressed the quantisation of energy emitted from a black body as: E=hf

According to Planck's hypothesis **an electromagnetic oscillator cannot be excited unless it receives an energy of at least hf** (as this the minimum amount of energy an electromagnetic oscillator of frequency f may possess above zero). It cannot have an amount of energy which is a fraction of hf, so it cannot accept an amount of energy less than hf**. For high frequency oscillators (large f), the amount of energy hf is too large to be supplied by the thermal motion of the atoms in the walls, and so they are not excited. This quantised approach explains the experimental shape of the blackbody radiation curves for very hot bodies.**



Bohr: when hydrogen is heated to incandescence, or when it is ionized in a gas discharge tube, it emits visible light and other radiation that can be broken into its component parts using a spectroscope and a glass prism or a diffraction grating a line spectra of the hydrogen atom - suggesting precise locations for the electrons. Bohr used results from Planck's experiments on black body radiation ie E = h.f for quanta or photons of E.M. radiation (n is frequency of the radiation). Postulated 1. electrons can move in an orbit without losing energy and 2. Energy is absorbed or released in fixed amounts called quanta and E2 - E1 = hf. **In successfully deriving the Rydberg equation from his basic postulates, Bohr had developed a mathematical model of the atom that successfully explained the observed emission spectrum of hydrogen and provided a physical basis for the accuracy of the Rydberg equation.** The physical meaning of the Rydberg equation was thus revealed. **The n_f and n_i in the equation represented the final and initial stationary states respectively of the electron within the atom.**

Einstein used his particle model of light to explain the photoelectric effect in the following way: **Light striking a surface consists of photons. Each photon carries an energy hf into the surface. Each photon gives up all its energy to a single electron. Part of that energy (ϕ) is used in causing the electron to just pass through the metal surface. The rest of the energy (hf - ϕ) is given to the electron as kinetic energy. This is the kinetic energy the electron will have outside the surface if it does not suffer any internal collisions on the way out. In** other words, **(hf - ϕ) is the quantised maximum kinetic energy, K_{max}, of the photoelectron.**