NESA number: _____

2020

Year 12
Trial Examination

Physics

Wednesday 12 August 2020

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- Calculators approved by NESA may be used
- A data sheet, formulae sheet and Periodic Table are provided

Total marks: 100

Section I – 20 marks (pages 3 - 10)

- Attempt Questions 1 - 20
- Allow about 35 minutes for this section
- Use the multiple-choice answer sheet

Section II – 80 marks (pages 11 - 28)

- Attempt Questions 21 - 38
- Allow about 2 hours and 25 minutes for this section
- Answer the questions in the space provided

Section I – 20 marks

Attempt Questions 1-20

Allow about 35 minutes for this section

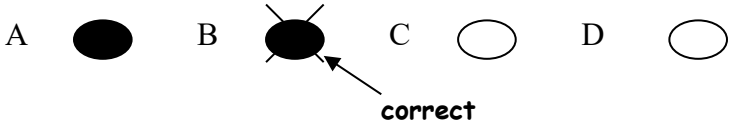
Use the multiple-choice answer sheet.

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

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

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

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



Teacher use ONLY

Section I: ☐

Section II: ☐ Total mark: ☐

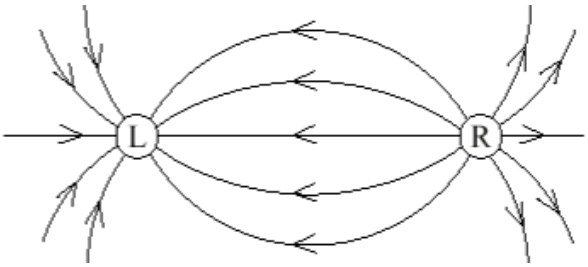
1. How would an increase in the value of "g", the acceleration due to gravity, affect the flight of a projectile launched with the same initial conditions?

   A) decreased range, decreased maximum height.
   B) decreased range, same maximum height.
   C) same range, decreased maximum height.
   D) same range, same maximum height.

2. Bohr's model of the atom differed from Rutherford's model of the atom by:

   A) allowing for the existence of protons.
   B) assuming electrons have a constant speed and constant acceleration.
   C) explaining the spectrum of the visible lines in the hydrogen spectrum.
   D) making firm predictions as to the location of the electron around the nucleus.

3. The diagram below shows the electric field near two-point charges L and R.



   What is the polarity of each charge?

   A) Both of them are positive.
   B) Both of them are negative.
   C) L is negative and R is positive.
   D) L is positive and R is negative.

4. The magnetic permeability of a material, μ, is:

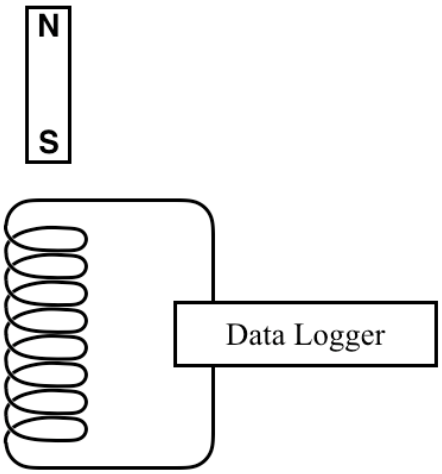
   A) the measurement of force between two wires carrying current.
   B) a measure of the strength of a magnetic field in a material subject to an external magnetic field.
   C) related to the electric current flowing through the material.
   D) a measure of the electromagnetic resistance of a material.

5. The transformer for an electric guitar tuner has an input voltage of 230V and an output voltage of 6V.

   Which of the following options could achieve this transformation?

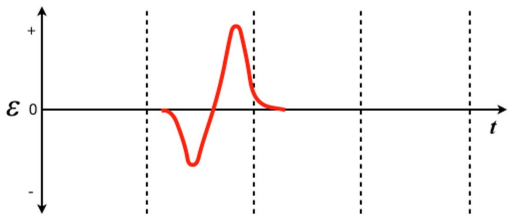
	Number of turns Primary	Number of turns Secondary
A)	690	12
B)	12	690
C)	2760	72
D)	72	2760

6. A bar magnet is dropped through a coil connected to a data logger as shown below

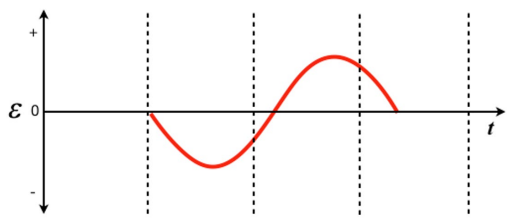


The emf trace produced by the data logger would look like:

A)



B)



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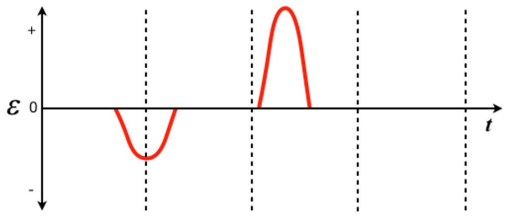
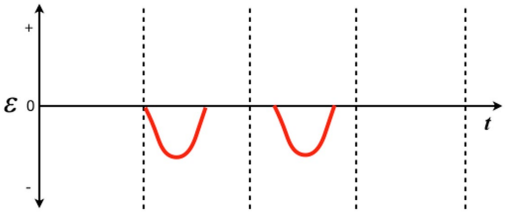


D)



7. Friction braking on cars obeys the Law of Conservation of Energy by generating heat energy from the car's kinetic energy.

   With magnetic braking, the same law is obeyed by the generation of:

   A) elastic potential energy
   B) magnetic fields
   C) eddy currents and heat energy
   D) gravitational potential energy

8. Which planet would have the lowest escape velocity?

	Planet name	**Planet mass (kg)**	**Planet radius (km)**
A)	Newton	5×10^{24}	8000
B)	Einstein	8×10^{24}	7800
C)	Bohr	5×10^{24}	9500
D)	Hawkins	8×10^{24}	10200

9. The surface temperature of the star Betelgeuse is 3500K.

   What is the peak wavelength of Betelgeuse's radiation?

   A) 502 nm
   B) 818 nm
   C) 823 nm
   D) 828 nm

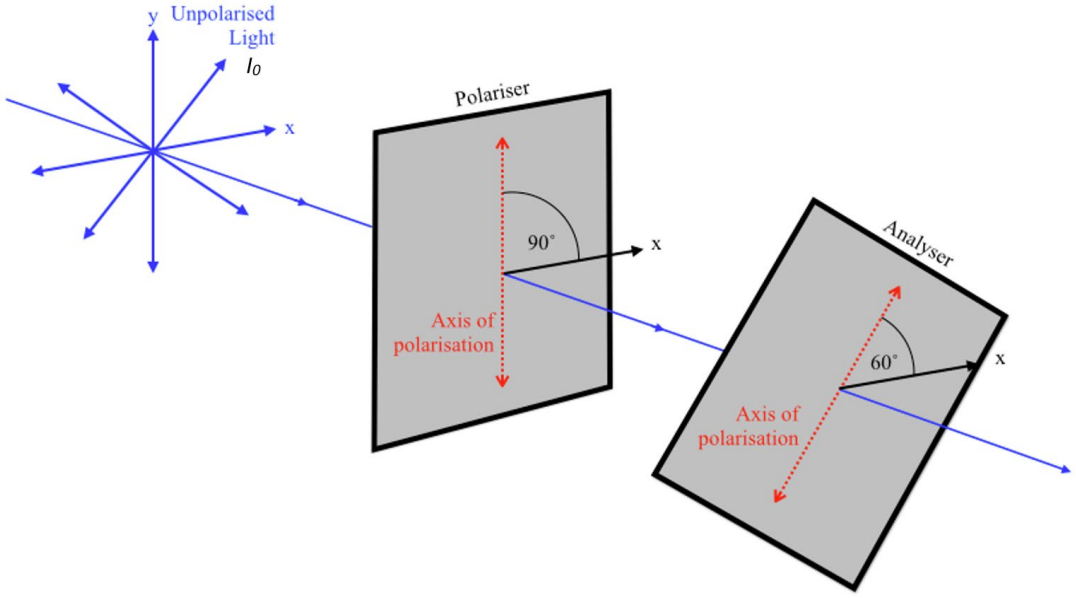
10. When light of a certain wavelength λ_0 is shone on a metal surface, it is observed that no electrons are emitted.

    When the intensity of this light is increased, still no electrons are emitted.

    This shows that light:

    A) is behaving as a wave.
    B) is not behaving as a wave.
    C) does not transfer energy.
    D) has no energy.

11. Unpolarised light of intensity I_0 is passed through a polariser followed by an analyser as shown in the diagram below.



Calculate the intensity of the light transmitted by the analyser.

A) 0.125 I_0
B) 0.375 I_0
C) 0.25 I_0
D) 0.75 I_0

12. When gaseous atoms have an electrical current passed through them, they can produce light.

Gaseous atoms absorb electrical energy, and then their electrons transition from ground state to a higher energy state. Later, the electrons can return to the ground state. As electrons return to the ground state, they release light; this light is particular to atoms of a particular element.

What is observed when an electron moves from a higher energy state to ground state?

A) absorption spectra
B) continuous spectra
C) radioactive decay
D) emission spectra

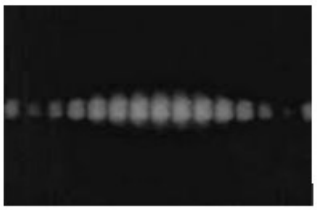
13. A cannonball is launched at 49 ms^{-1}. It reaches a maximum height of 105 m above its origin.

    To the nearest degree, what is the angle of elevation required to reach this height?

    A) 45°
    B) 58°
    C) 68°
    D) 93°

14. Laser light with a wavelength of 621 nm was passed through a double slit. The slits are 100 μm apart.

    The resulting interference pattern is reproduced below. The screen is placed 1.50 m from the slits.

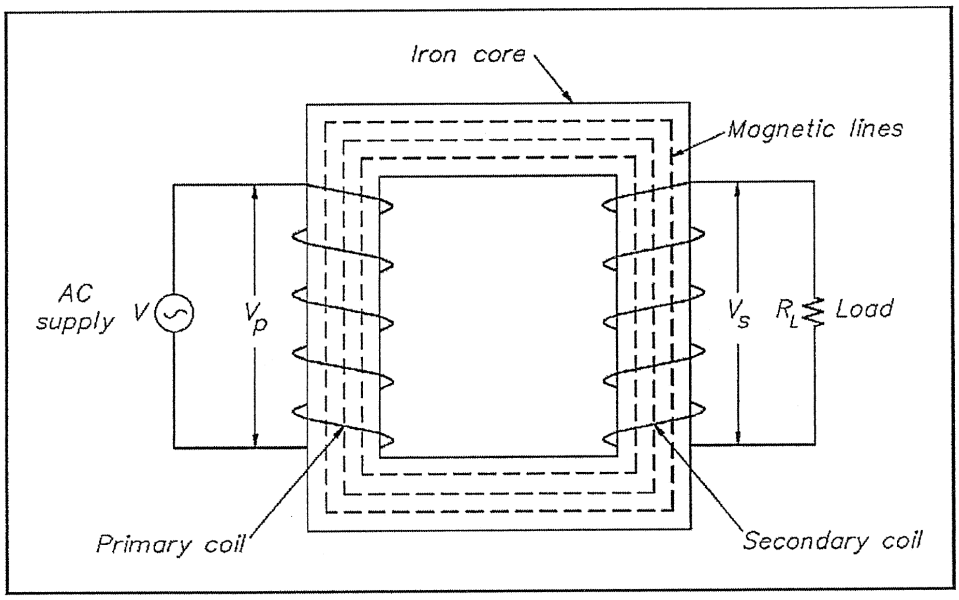


NOT TO SCALE

    What is the angle from the central maximum to the 2nd bright spot on the screen?

    A) 0.01°
    B) 0.71°
    C) 0.36°
    D) 1.07°

15. A student designed and built a step-up transformer as part of his practical work and included the diagram below of his design in the written report.



Which statement is a correct evaluation of his experimental design?

A) The design is correct because the output voltage will be larger than the input voltage.
B) The design is incorrect because the windings of the coils are drawn in opposite directions.
C) The design is incorrect because it represents a step-down transformer.
D) The design is incorrect because it has equal numbers of turns in both coils.

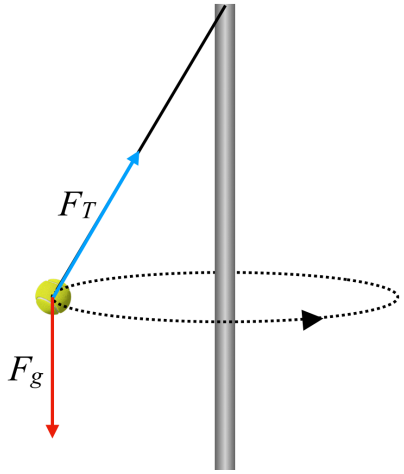
16. An electron enters a region where a uniform magnetic field is perpendicular to an electric field between two charged plates, as shown.

The electron passes through the crossed field without being deflected.

The electron's speed is:

A) 8.0×10^{-15} ms^{-1}
B) 1.6×10^{3} ms^{-1}
C) 5.0×10^{4} ms^{-1}
D) 2.5×10^{6} ms^{-1}

17. A tether ball is swinging around a pole in uniform circular motion on a horizontal plane as shown below.



Which of the following expression would correctly determine the mass of the ball?

A) $m = \sqrt{\frac{F_c r}{v}}$

B) $m = \frac{gr \tan\theta}{v^2}$

C) $m = \frac{F_c g}{\tan\theta}$

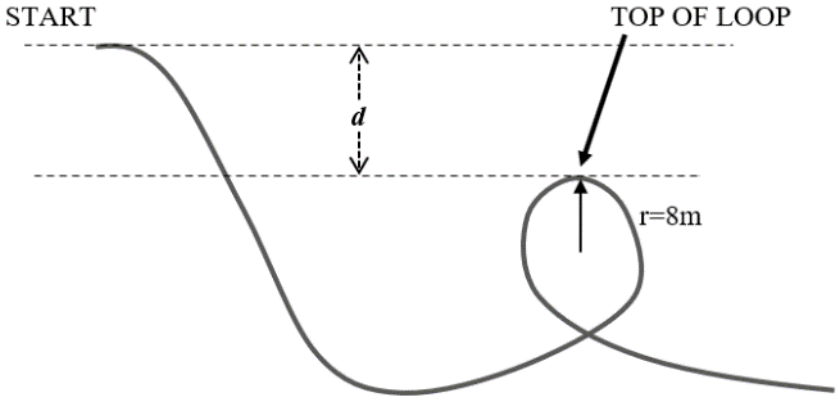
D) $m = \frac{F_T \cos\theta}{g}$

18. A consequence of having DC rather than AC electricity transmission from power stations to consumers would be:

A) using lower voltages in household appliances.
B) having power stations located much closer to the consumers.
C) needing fewer power stations.
D) less efficient appliances such as light globes.

19. A roller coaster track is designed so that at the top of the loop, passengers will be upside-down and undergo an acceleration equal to *g* while in their seats, making them feel weightlessness.

A view of the track from the side is shown.



The rollercoaster rides starts with negligible speed and there is no friction. The radius of curvature at the top of the loop is 8.0 m.

What is the height, ***d***, of the starting position vertically higher than the top of the loop?

A) 4.0 m
B) 8.5 m
C) 12.3 m
D) 14.7 m

20. The work function for tungsten is 4.5eV.

What is the minimum wavelength of radiating photons that will have this threshold energy?

A) 4.42×10^{-16} m
B) 2.74×10^{-9} m
C) 1.76×10^{-7} m
D) 2.76×10^{-7} m

NESA number: _____

2020 | TRIAL EXAMINATION

Physics

Section II
Answer Booklet

80 marks

Attempt Questions 21 – 38

Allow about 2 hours and 25 minutes for this part

Instructions

- Write your NESA number at the top of this page.
- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in questions involving calculations.
- Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which questions you are answering.

Question 21 (5 marks) **Marks**

Describe a valid method using projectile motion that could be used to calculate the value of gravitational acceleration. **5**

You have a ball launcher which launches a ball bearing at exactly 7.8 ms^{-1}.

You do NOT have a stopwatch or other timing device.

Equipment to measure distance is available, as well as everyday items you would usually find in a laboratory.

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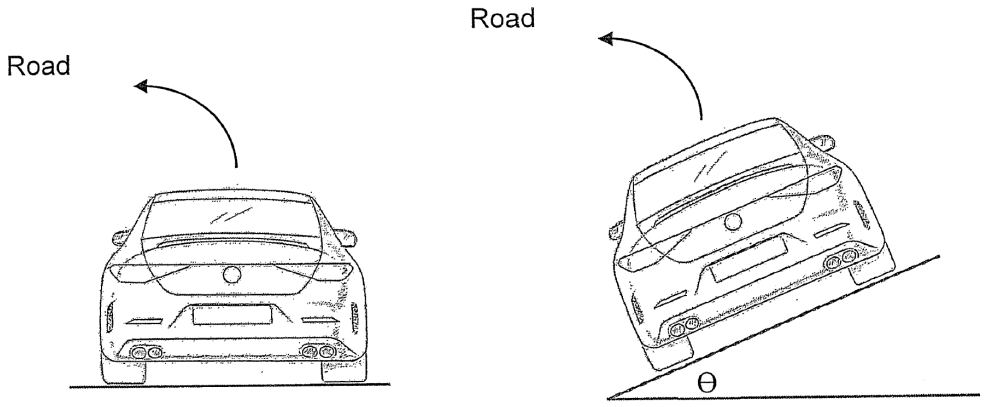
Question 22 (4 marks) **Marks**

The diagram shows identical cars on rough road surfaces.

The first car is on a curved horizontal road. The second car is on a curved road banked at an angle of θ. Both roads curve towards the left, with the curves part of the same radius circle.



With the help of additions to the diagram above, explain why the car can safely take the banked curve at a higher speed than the identical car driving on the horizontal curved road. **4**

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Question 23 (6 marks) **Marks**

(a) Define what is meant by the term "geostationary" when applied to satellites orbiting Earth. **1**

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(b) Calculate the orbital radius of a satellite which is in geostationary orbit. **3**

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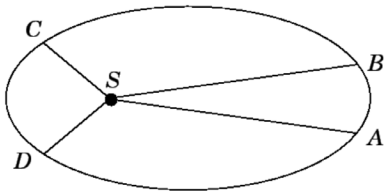
(c) The diagram illustrates Kepler's Second Law of Planetary Motion. **2**



Outline the relationship between Kepler's Second Law of Planetary Motion and the law of the conservation of energy, by referring to the changes in energy that occur.

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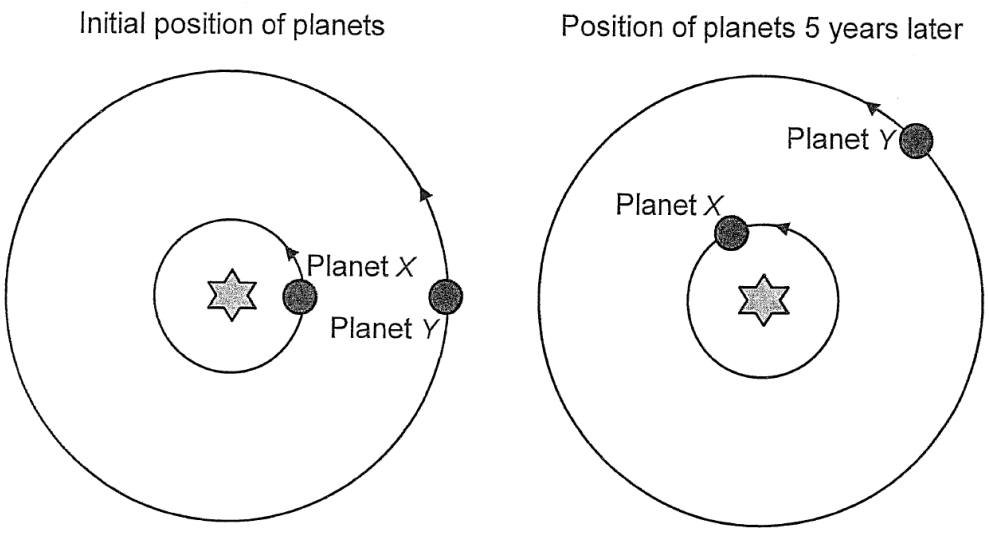
Question 24 (3 marks) **Marks**

Two planets *X* and *Y* travel anticlockwise in circular orbits about a star, as seen in the diagram. The radii of the orbits *X* and *Y* are in the ratio 2:5.

The planets are shown below at a time interval of 5 years. Initially they were aligned, making a straight line with the star. Five years later, planet *X* has rotated through 120°, as shown.



Determine how long it takes planet *Y* to orbit the star. **3**

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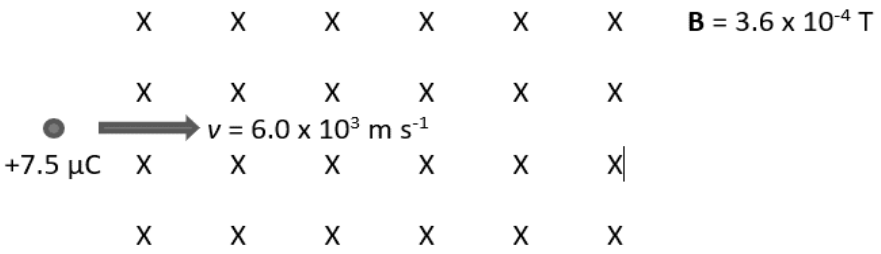
Question 25 (4 marks) **Marks**

A small charged particle with a charge of + 7.5 μC and a mass of 4.0×10^{-15} kg enters a uniform magnetic field with a speed of 6.0×10^{3} m s^{-1} as shown.



(a) What is the initial force on the charged particle when it enters the magnetic field? **2**

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(b) Hence quantitatively describe the subsequent motion of this particle, assuming that it remains within the magnetic field. **2**

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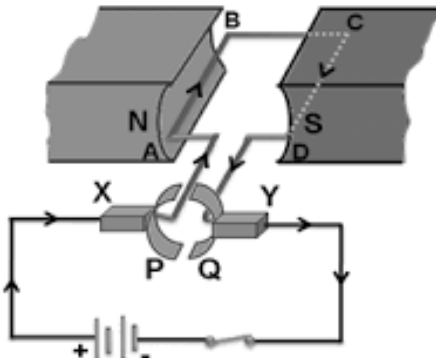
Question 26 (4 marks) **Marks**

A single current-carrying loop is within a magnetic field produced by two magnets, as shown. A commutator connects the loop to a battery that has a constant voltage.



(a) On the axes below, sketch how the speed of rotation of the loop would change with time, starting from the moment that the switch is turned on. **2**

(b) Explain why the speed of the loop changes from the time it is started until it reaches its operating speed. **2**

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Question 27 (3 marks) **Marks**

Outline an investigation to examine the spectra produced from two sources. Include the names of the two sources and describe the spectra seen. **3**

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Question 28 (4 marks) **Marks**

Huygens' wave model of light was supported by a number of observations. **4**

Outline TWO of these observations and explain how they support a wave model of light.

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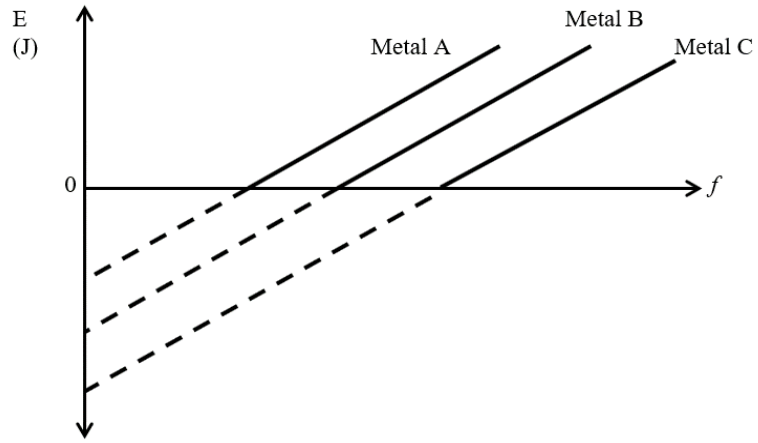
Question 29 (4 marks) **Marks**

The stopping voltage was measured while varying the frequency of incident light for an investigation of the photoelectric effect. Three different metals, A, B and C were used and the results plotted, as shown below.



(a) Outline the significance of the value of the frequency of light where the lines intercept the x-axis on the graph for each metal. **2**

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(b) Discuss why the plotted results for all of the metals are parallel. **2**

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Question 30 (5 marks) **Marks**

(a) Describe what is meant by the term "inertial frame of reference" and give an everyday example. **2**

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(b) A spaceship is 220 m in length. **3**

With what speed would the spaceship need to be travelling relative to an observer if that observer measures the length of the spaceship as 70 m?

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Question 31 (4 marks) **Marks**

The old definition of the ampere stated:

"The ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed on metre apart in a vacuum, would produce between these conductors a force equal to 2×10^{-7} *newtons per metre of length."*

(a) Explain how this definition of the ampere relates to Newton's Third Law. **2**

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(b) Calculate the size of the force between two parallel current carrying wires, each 0.65 m long, carrying 0.375 amperes each, and separated by a distance of 13.5 mm. **2**

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Question 32 (4 marks) **Marks**

Chadwick discovered the neutron in 1932. He used alpha particles to bombard a material rich in neutrons, causing neutrons to be emitted. These neutrons then displaced protons from paraffin wax, a proton rich material. The protons were detected and measured.

(a) Explain why the unknown rays, now known to be neutrons, were deduced to be particles rather than electromagnetic radiation. **2**

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(b) Why were neutrons difficult to observe, and therefore late to be discovered, compared to other subatomic particles? **2**

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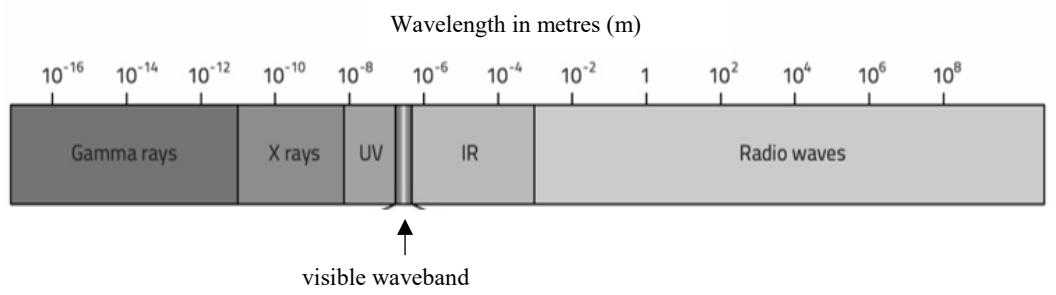
Question 33 (5 marks) **Marks**

The visible waveband is only a small part of the full electromagnetic spectrum.



(a) Using the diagram provided, show in which waveband of the electromagnetic spectrum a photon would be if it resulted from the transition of an electron in a hydrogen atom from energy level n=4 to energy level n=3. **3**

Show all your working.

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(b) Calculate the speed that an electron would need to travel so that its wavelength would be equal to 1.87 μm. **2**

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Question 34 (6 marks) **Marks**

Outline the contribution of James Maxwell to our understanding of the nature of light and describe the experimental evidence found afterwards that supported Maxwell's theory. **6**

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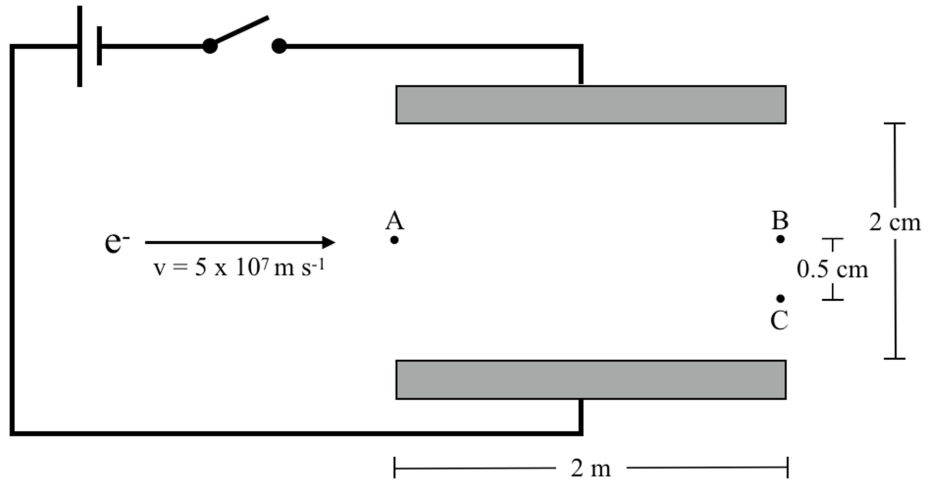
Question 35 (5 marks) **Marks**

Two parallel electric plates are connected to a power source as shown in the diagram below.



(a) Determine the time taken for the electron to get from point A to point B when the switch is open. **1**

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(b) Determine the voltage required so that the electron exits the field at C when the switch is closed. **4**

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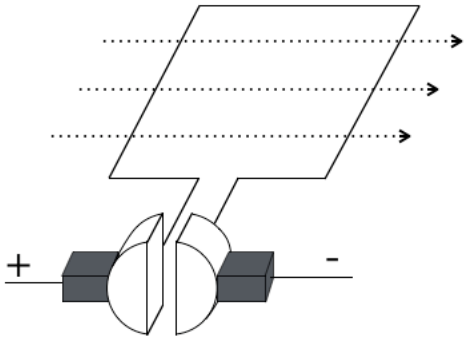
Question 36 (4 marks) **Marks**

A motor has a square coil with side length 3 cm in a magnetic field of 0.15 T as shown below. The coil rotates at 240 revolutions per minute when a 3A current flows to the coil.



(a) Determine the torque on the coil at the position shown. **2**

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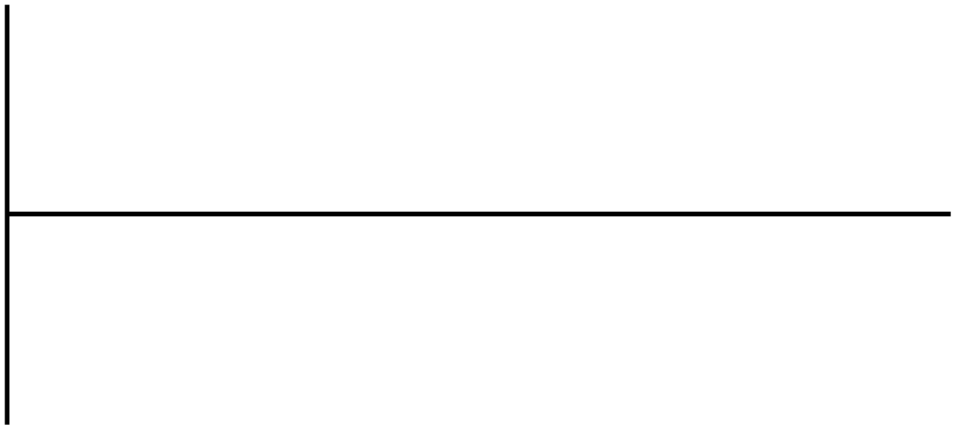
(b) Draw a torque vs time graph on the axis below for one revolution of the coil from the position shown. Label the axes using information you can analyse from the data given. **2**



Question 37 (6 marks) **Marks**

In the early 17th century Galileo Galilei made a notable attempt to measure the speed of light.

He and his assistant stood 1 km apart atop two tall hills at night-time. Galileo opened a lantern and began a timing device. His assistant opened his lantern when he saw the light from Galileo's lantern. Galileo stopped his timing device when he saw the light form his assistant's lantern.

(a) If the average human reaction time to visual stimulus is at approximately 0.25s, what is the fastest speed Galileo could have measured? **3**

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(b) Based on your answer to part (a), evaluate the accuracy of Galileo's method. **3**

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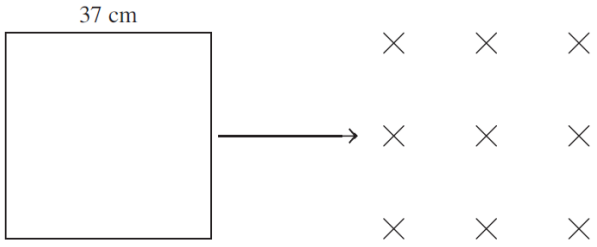
Question 38 (4 marks) **Marks**

The diagram below shows a square single loop entering a perpendicular magnetic field of 0.80 T. The square loop takes 0.04 s to enter the magnetic field.



(a) What is the magnitude of induced emf in the square loop? **3**

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(b) What direction does the induced current flow in the square loop? **1**

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Section II extra writing space.

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Section II extra writing space.

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2020 Physics Trial Examination.

Marking Guidelines and Model Answers.

Section I Multiple Choice

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

1. How would an increase in the value of "g", the acceleration due to gravity, affect the flight of a projectile launched with the same initial conditions?

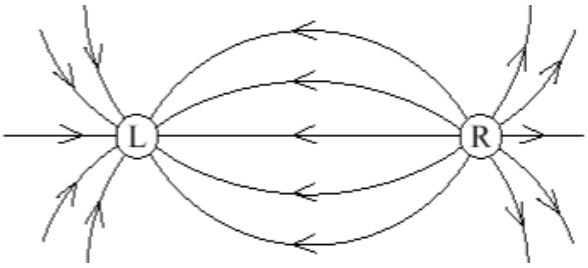
   A) decreased range, decreased maximum height.
   B) decreased range, same maximum height.
   C) same range, decreased maximum height.
   D) same range, same maximum height.

As g ↑ Weight force increases, so projectile won't move as high.
↑ F_W will also cause projectile to return to earth in a shorter time, hence range will also decrease.

2. Bohr's model of the atom differed from Rutherford's model of the atom by:

   A) allowing for the existence of protons.
   B) assuming electrons have a constant speed and constant acceleration.
   C) explaining the spectrum of the visible lines in the hydrogen spectrum.
   D) making firm predictions as to the location of the electron around the nucleus.

3. The diagram below shows the electric field near two-point charges L and R.



What is the polarity of each charge?

   A) Both of them are positive.
   B) Both of them are negative.
   C) L is negative and R is positive.

D) L is positive and R is negative.

4. The magnetic permeability of a material, μ, is:

A) the measurement of force between two wires carrying current.
B) a measure of the strength of a magnetic field in a material subject to an external magnetic field.
C) related to the electric current flowing through the material.
D) a measure of the electromagnetic resistance of a material.

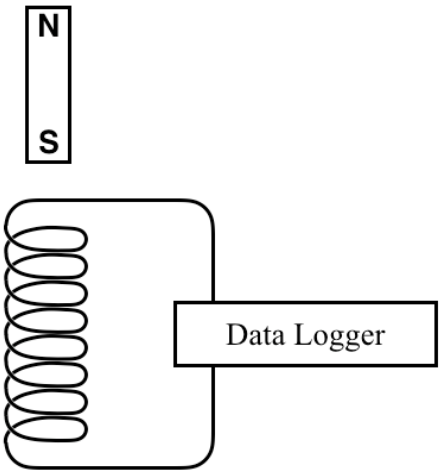
5. The transformer for an electric guitar tuner has an input voltage of 230V and an output voltage of 6V.

Which of the following options could achieve this transformation?

	Number of turns Primary	Number of turns Secondary
A)	690	12
B)	12	690
C)	2760	72
D)	72	2760

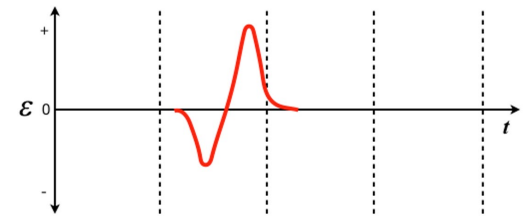
$\frac{V_2}{V_1} = \frac{6}{230} = \frac{3}{115}$ $\quad \frac{n_2}{n_1} = \frac{72}{2760} = \frac{3}{115}$

6. A bar magnet is dropped through a coil connected to a data logger as shown below

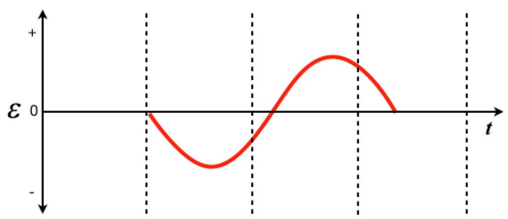


The emf trace produced by the data logger would look like:

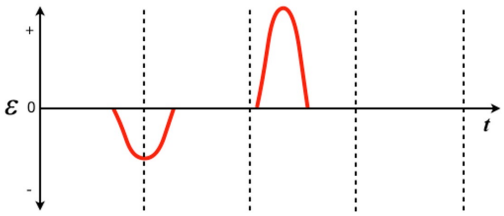
A)



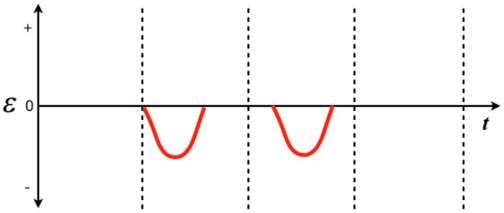
B)



C)



D)



EMF produced when magnet goes into and out of coil will be in opposite directions.
While in the coil there is no $\Delta\phi$ and hence no EMF, so answer is C.

7. Friction braking on cars obeys the Law of Conservation of Energy by generating heat energy from the car's kinetic energy.

   With magnetic braking, the same law is obeyed by the generation of:

   A) elastic potential energy
   B) magnetic fields
   C) eddy currents and heat energy
   D) gravitational potential energy

8. Which planet would have the lowest escape velocity?

	Planet name	**Planet mass (kg)**	**Planet radius (km)**
A)	Newton	5×10^{24}	8000
B)	Einstein	8×10^{24}	7800
C)	Bohr	5×10^{24}	9500
D)	Hawkins	8×10^{24}	10200

Use $\frac{1}{2}mv^2 = \frac{GMm}{r}$

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

Lowest is C 7.3×10^8

9. The surface temperature of the star Betelgeuse is 3500K.

   What is the peak wavelength of Betelgeuse's radiation?

   A) 502 nm
   B) 818 nm
   C) 823 nm
   D) 828 nm

$\lambda_{max} = \frac{b}{T}$

$= \frac{2.898 \times 10^{-3}}{3500}$

$= 828\,nm$

10. When light of a certain wavelength λ_0 is shone on a metal surface, it is observed that no electrons are emitted.

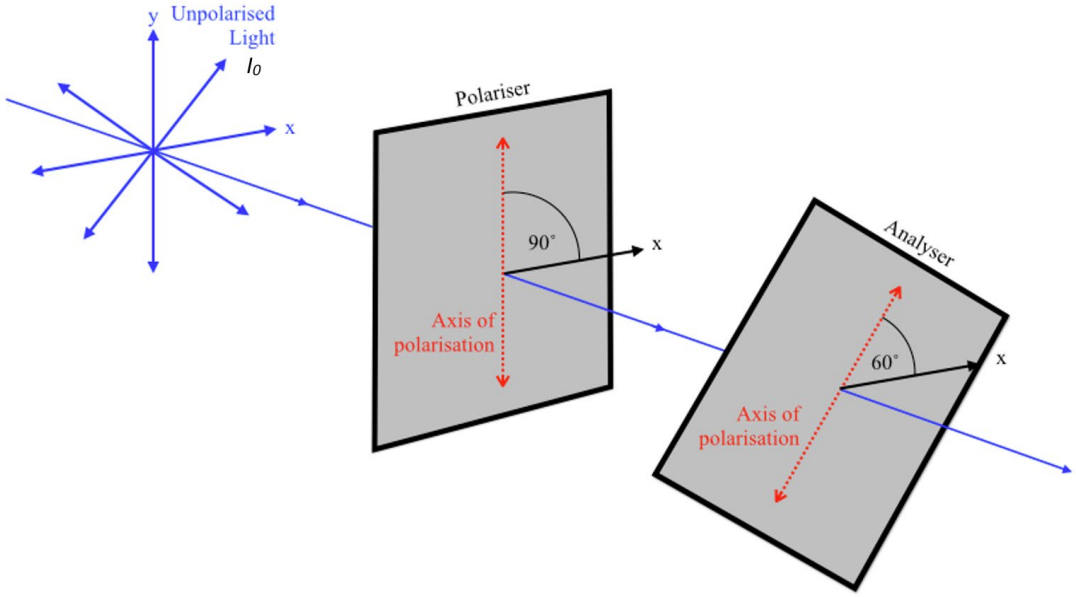
When the intensity of this light is increased, still no electrons are emitted.

This shows that light:

A) is behaving as a wave.
B) is not behaving as a wave.
C) does not transfer energy.
D) has no energy.

Here we see light acting as a photon

11. Unpolarised light of intensity I_0 is passed through a polariser followed by an analyser as shown in the diagram below.



Calculate the intensity of the light transmitted by the analyser.

A) 0.125 I_0
B) 0.375 I_0
C) 0.25 I_0
D) 0.75 I_0

When light is directed through the first polarizer I is reduced by half.
It is then sent through the 2nd polarizer at $\theta = 30^\circ$

$\therefore I = \frac{1}{2} I_0 \cos^2 30^\circ$

$= 0.375 I_0$

12. When gaseous atoms have an electrical current passed through them, they can produce light.

Gaseous atoms absorb electrical energy, and then their electrons transition from ground state to a higher energy state. Later, the electrons can return to the ground state. As electrons return to the ground state, they release light; this light is particular to atoms of a particular element.

What is observed when an electron moves from a higher energy state to ground state?

A) absorption spectra
B) continuous spectra
C) radioactive decay

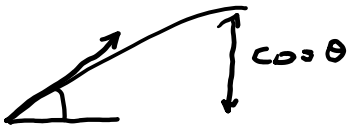
D) emission spectra

13. A cannonball is launched at 49 ms^{-1}. It reaches a maximum height of 105 m above its origin.

To the nearest degree, what is the angle of elevation required to reach this height?

A) 45°
B) 58°
C) 68°
D) 93°

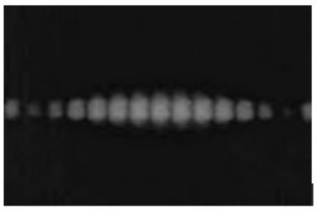
$u_y = u \sin\theta$
$v_y = 0$
$s_y = 105\ m$
$a_y = -9.8$



$v^2 = u^2 + 2a_y s_y$
$0 = 49^2 \sin^2\theta + 2 \times -9.8 \times 105$
$\sin^2\theta = \frac{2 \times 9.8 \times 105}{49^2}$
$\theta = 68^\circ$

14. Laser light with a wavelength of 621 nm was passed through a double slit. The slits are 100 µm apart.

The resulting interference pattern is reproduced below. The screen is placed 1.50 m from the slits.



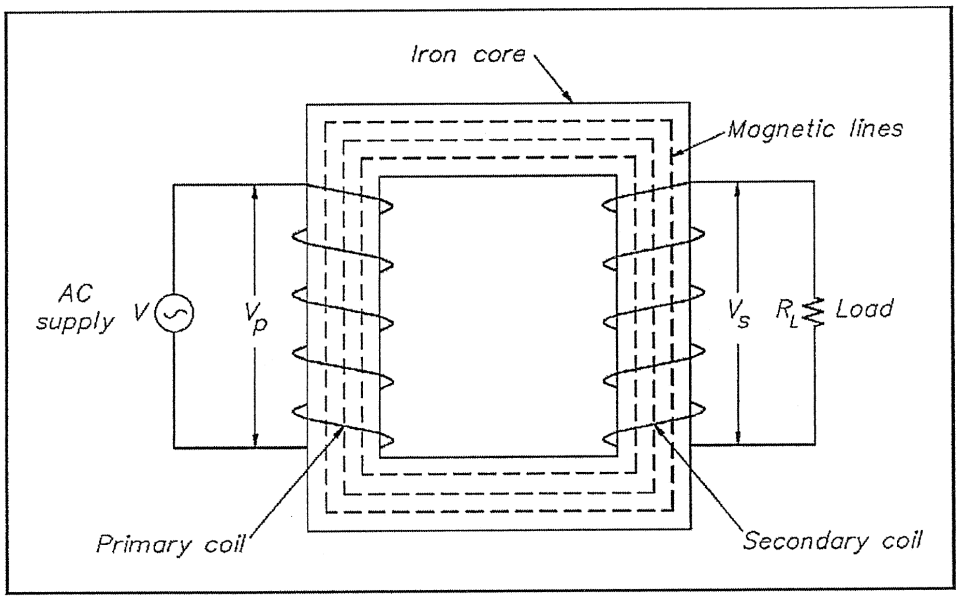
NOT TO SCALE

What is the angle from the central maximum to the 2nd bright spot on the screen?

A) 0.01°
B) 0.71°
C) 0.36°
D) 1.07°

Use $m = 2$
$d\sin\theta = m\lambda$
$100 \times 10^{-6} \times \sin\theta = 2 \times 621 \times 10^{-9}$
$\sin\theta = 0.01242$
$\theta = 0.71^\circ$

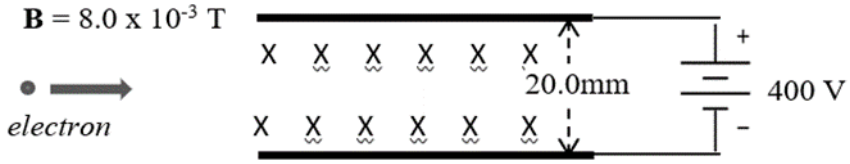
15. A student designed and built a step-up transformer as part of his practical work and included the diagram below of his design in the written report.



Which statement is a correct evaluation of his experimental design?

A) The design is correct because the output voltage will be larger than the input voltage.
B) The design is incorrect because the windings of the coils are drawn in opposite directions.
C) The design is incorrect because it represents a step-down transformer.
D) The design is incorrect because it has equal numbers of turns in both coils.

16. An electron enters a region where a uniform magnetic field is perpendicular to an electric field between two charged plates, as shown.



The electron passes through the crossed field without being deflected.

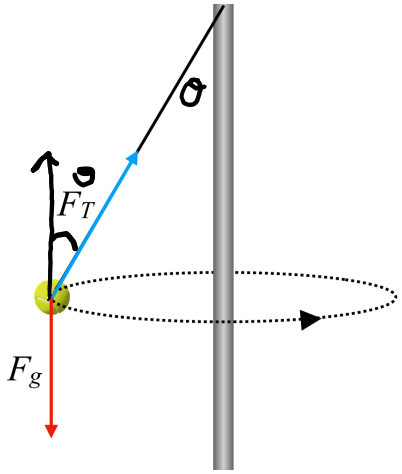
The electron's speed is:

A) 8.0×10^{-15} ms^{-1}
B) 1.6×10^{3} ms^{-1}
C) 5.0×10^{4} ms^{-1}
D) 2.5×10^{6} ms^{-1}

if undeflected
$F_e = F_B$
$qE = qvB$
$v = \frac{E}{B}$
$= \frac{20\,000}{8 \times 10^{-3}}$
$= 2.5 \times 10^{6}$

$E = \frac{V}{d}$
$= \frac{400}{20 \times 10^{-3}}$
$= 20\,000$

17. A tether ball is swinging around a pole in uniform circular motion on a horizontal plane as shown below.



Which of the following expression would correctly determine the mass of the ball?

A) $m = \sqrt{\frac{F_c r}{v}}$

B) $m = \frac{gr \tan\theta}{v^2}$

C) $m = \frac{F_c g}{\tan\theta}$

D) $m = \frac{F_T \cos\theta}{g}$

F_g = magnitude of vertical component of F_T

$mg = F_T \cos\theta$

$m = \frac{F_T \cos\theta}{g}$

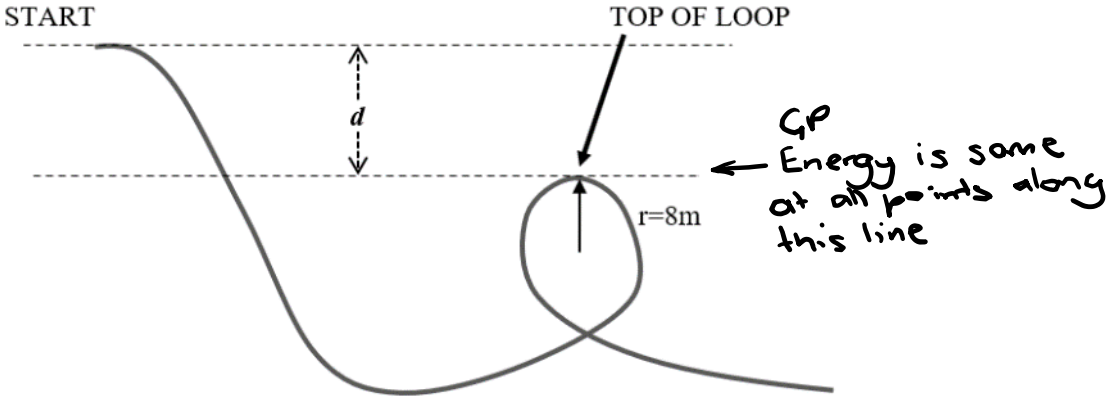
18. A consequence of having DC rather than AC electricity transmission from power stations to consumers would be:

A) using lower voltages in household appliances.
B) having power stations located much closer to the consumers.
C) needing fewer power stations.
D) less efficient appliances such as light globes.

Easier to transform AC than DC to higher V
DC ∴ has high transmission loss
So need to locate closer to consumers.

19. A roller coaster track is designed so that at the top of the loop, passengers will be upside-down and undergo an acceleration equal to *g* while in their seats, making them feel weightlessness.

A view of the track from the side is shown.



The rollercoaster rides starts with negligible speed and there is no friction. The radius of curvature at the top of the loop is 8.0 m.

What is the height, ***d***, of the starting position vertically higher than the top of the loop?

A) 4.0 m
B) 8.5 m
C) 12.3 m
D) 14.7 m

Magnitude of Centripetal force = weight force (experiences weightlessness)

$$F_c = \frac{mv^2}{r} = mg$$

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

$$v = \sqrt{rg}$$

And

$$mgd = \frac{1}{2}mv^2 \qquad \Delta U = \Delta K$$

$$2gd = v^2$$

$$2gd = rg \quad \text{(from above)}$$

$$2d = r$$

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

$$= 4$$

20. The work function for tungsten is 4.5eV.

What is the minimum wavelength of radiating photons that will have this threshold energy?

A) 4.42×10^{-16} m
B) 2.74×10^{-9} m
C) 1.76×10^{-7} m
D) 2.76×10^{-7} m

Key: remember to convert from eV to J

$$E = \frac{hc}{\lambda}$$

$$4.5 \times 1.602 \times 10^{-19} = \frac{6.626 \times 10^{-34} \times 3 \times 10^{8}}{\lambda}$$

$$\lambda = 2.76 \times 10^{-7}\ m$$

Section II

Question 21 (5 marks) **Marks**

Describe a valid method using projectile motion that could be used to calculate the value of gravitational acceleration. **5**

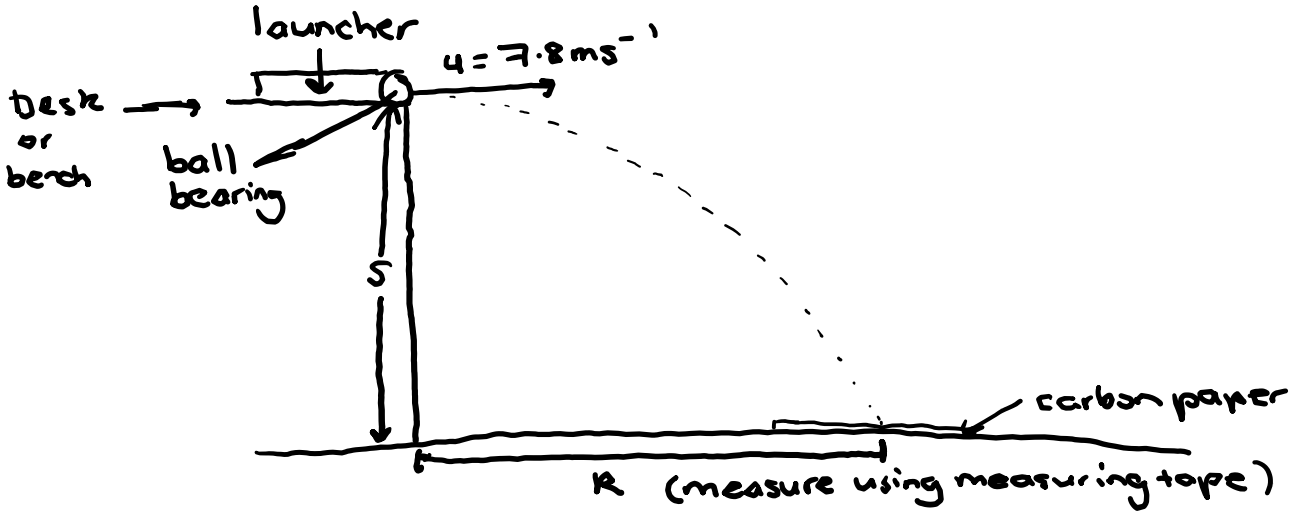
You have a ball launcher which launches a ball bearing at exactly 7.8 ms^{-1}.

You do NOT have a stopwatch or other timing device.

Equipment to measure distance is available, as well as everyday items you would usually find in a laboratory.

Marking Criteria	
All steps of a valid methodology are described concisely, and a correct analysis is included	**5**
A valid method is stated with minor errors in the methodology or analysis	**4**
An appropriate method is stated with some missing steps or little analysis	**3**
A vague method is provided which is not detailed enough to complete a valid experiment	**2**
Provides some relevant information	**1**

Sample answer



- Choose a position inside a lab that is not affected by wind, to reduce the effect of external forces.
- Set up the equipment as shown.
- Set up the launching device so that it launches a ball bearing horizontally from a table or desk top.
- Accurately measure the height s from the ground to the ball bearing using a metre ruler, and record the measurement for later.
- Practice launching the ball a few times to see where the ball is likely to land. Place a piece of carbon paper in position to help accurately record the range R of the ball bearing.
- Launch the ball bearing and measure the horizontal distance it travels, R, using a measuring tape.
- Repeat the experiment 5 times to improve reliability.
- Record all results in a table.
- Find the average value for R
- Using the average value for R, find the time of the flight using the formula:

$R = u_x t$

$t = \frac{R}{u_x}$

$= \frac{R}{7 \cdot 8}$ s

$u_x = u$

$= 7 \cdot 8 \text{ ms}^{-1}$

- Now look at the vertical motion of the projectile: Use $s = u_y t + 1/2at^2$, where s is the height of the desk, u=0 and a is the vertical acceleration due to gravity, i.e. g.
- We can derive the following:

$$s = u_y t + \frac{1}{2}at^2 \qquad \text{but } u_y = 0$$

$$s = \frac{1}{2}at^2$$

$$t^2 = \frac{2s}{a}$$

$$t = \sqrt{\frac{2s}{a}} \qquad \text{but } t = \frac{R}{7.8}$$

$$\frac{R}{7.8} = \sqrt{\frac{2s}{a}}$$

$$\frac{R^2}{7.8^2} = \frac{2s}{a}$$

$$a = \frac{7.8^2 \times 2s}{R^2}$$

- Using this derivation and our average R to find the value for acceleration due to gravity. This can be compared to the accepted value for g

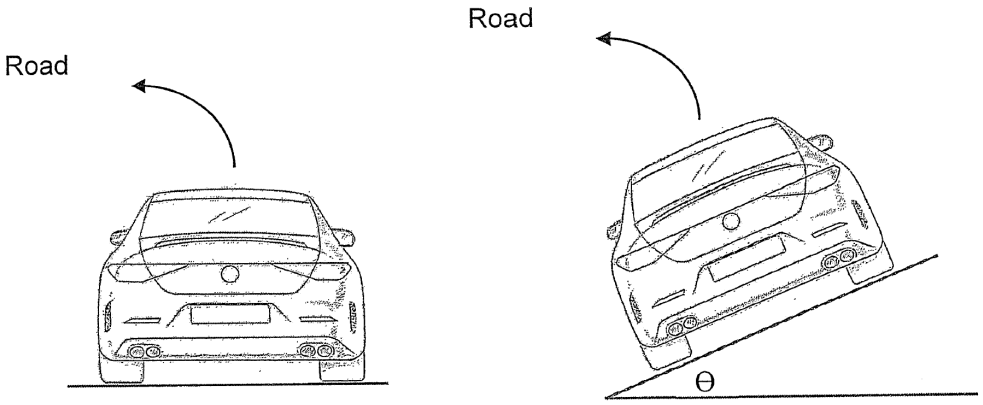
Marker Comments:

- For an experiment to valid it needs to be a fair test of the aim. To be fair we need to:
  - Control variables apart from the independent variable and dependent variable
  - Be accurate
  - Be reliable (make repeats)
  - Be precise (results should be similar)
- Students needed to show they were making efforts to do all these things.
- Read the question carefully. It said that you have equipment to measure distance, not angle. We were generous here and allowed a protractor to be an everyday piece of lab equipment.
- Students assumed a very well set up lab- sand, phones, etc. We were kind.
- Be careful with phones- they can time things so should not be allowed. We did not deduct marks if you used them for reasons other than timing.
- Be very specific about your steps. There were a lot of vague instructions.
- A lot of you mentioned using repeats, or testing at different angles, but did not explain how these were used.
- At least, you should have mentioned taking the average of your results and using this value to calculate g.
- Don't just pick a random SUVAT equation and hope that is enough analysis. Show how it will be used.
- If your first step is "set up as shown in the diagram" then your diagram MUST be accurate. There were a lot of sloppy diagrams, for example ranges that started well before or after the starting point of the ball bearing.

Question 22

The diagram shows identical cars on rough road surfaces.

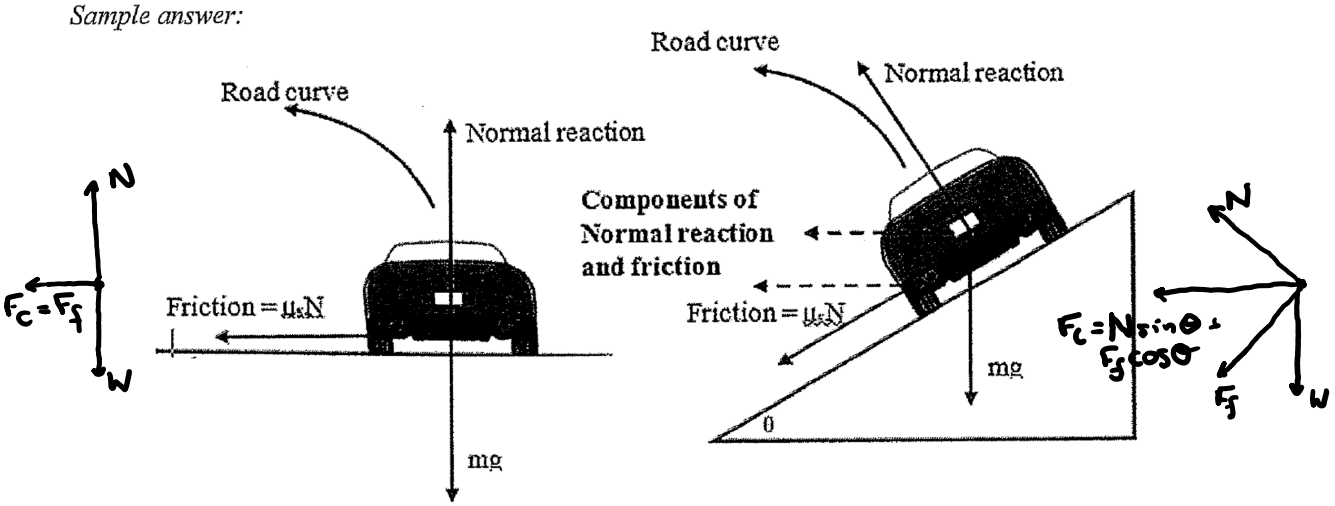
The first car is on a curved horizontal road. The second car is on a curved road banked at an angle of θ. Both roads curve towards the left, with the curves part of the same radius circle.



With the help of additions to the diagram above, explain why the car can safely take the banked curve at a higher speed than the identical car driving on the horizontal curved road. **4**

Marking Criteria	**Marks**
• Identifies ALL forces acting, draws components of forces on diagram and compares the magnitudes of their contribution to centripetal force	4
• Identifies all forces acting and draws components on diagram contributing to centripetal force, OR • Provides correct written comparison of forces acting on both cars and some relevant additions to the diagram	3
• Identifies the contribution of the normal reaction component to centripetal force for both diagrams	2
• Provides some relevant information	1

Sample answer:



On the horizontal road, the friction alone provides the centripetal force to hold car in curve. On the banked road, only a component of the frictional force is acting horizontally but the horizontal component of the normal reaction force contributes. This is significantly larger than the reduction in the frictional force towards the centre of the motion. Therefore, the net centripetal force is larger and since mass and radius of curvature are the same, the car can go faster around the banked curve.

Markers Comments:

- Read the question carefully. The majority of the marks in this question came from annotating the diagram. If the question asks you to do something, do it!
- Please revise vector diagrams. A lot of students drew vectors all over the place. A well-drawn vector diagram will help you understand what is happening.
- A better answer would assume some amount of friction in both scenarios, so the only difference we are comparing is the banked track.
- Marks were not deducted if the students assumed there was no friction on the banked track, as the physics still holds. Note: if you are assuming no friction you should say so.
- Some students mixed scenarios, and used the equations for a banked track with no friction even though they talked about the friction associated with the banked track in their explanation. Students who did this did not generally have enough correct information to receive full marks.
- Note: In a banked track without friction, we say that F_c is supplied by the horizontal component of the normal force. Many students talked about a contribution from F_W. This came from them not recognising that in the vector diagram for banked tracks without friction we use F_W=mg because it is equal in magnitude (but opposite in direction) to the vertical component of the normal force (Newton's Third Law).

Question 23 (6 marks) **Marks**

(a) Define what is meant by the term "geostationary" when applied to satellites orbiting Earth. **1**

Marking Criteria	Marks
• A correct definition given	**1**

Sample answer
A geostationary satellite orbits Earth such that its orbital period exactly matches Earth's rotational period (T=24 hours). The satellite is in orbit above the equator and stays over the same place on Earth's surface.

Marker's comments:
- The mark was only given if students mentioned the orbital period T=24 hours and that the satellite stays above the same position on the earth.
- Please be specific. A lot of students said that the earth had the same period as the earth. Which period did you mean- orbital period or rotational period. A number of students used T= 365 days in part b, which showed there is confusion about this.
- We did not accept "moves at the same rate as the earth". What are you talking about? You could mean orbital velocity.

(b) Calculate the orbital radius of a satellite which is in geostationary orbit. **3**

Marking Criteria	Marks
• Calculation is correct	**3**
• Correct formula and correct substitution	**2**
• A correct step is taken toward solving the question posed	**1**

Sample answer

Use: $\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$ where T = 24x60x60 s; M = mass of Earth

$$r^3 = \frac{GMT^2}{4\pi^2}$$

$$= \frac{(6.67\times10^{-11})\times(6.0\times10^{24})\times(24\times60\times60)^2}{4\pi^2}$$

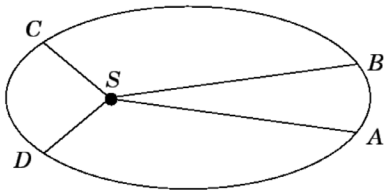
$$= 7.567\times10^{22}$$

$$r = \sqrt[3]{7.567\times10^{22}}$$

$$r = 4.23\times10^{7} \text{ m}$$

Marker's comments:
- Generally well done.
- Biggest issue was students using 365 days instead of 24 hours
- A number of students also dropped one of the squares from the equation

(c) The diagram illustrates Kepler's Second Law of Planetary Motion. **2**



Outline the relationship between Kepler's Second Law of Planetary Motion and the law of the conservation of energy, by referring to the changes in energy that occur.

Marking Criteria	Marks
• Kepler's 2nd Law correctly identified • Law of conservation of energy related correctly	**2**
• Kepler's 2nd Law correctly identified OR • Law of conservation of energy related to planetary orbit – i.e. loses GPE but gains KE if planet "falls" towards Sun	**1**

Sample answer

Kepler's 2nd Law of Planetary Motion states that a planet will sweep out equal area in equal time as it orbits the Sun. The reason for this is that as the planet orbit takes it closer to the Sun, it loses gravitational potential energy (U) and thus gains kinetic energy (K), and thus speed, as energy is conserved. Conversely, when the planet is moving further from the sun (AB) then U is greater and hence K is lower, as again energy is conserved. This means that the speed is lower. The planet then sweeps out an equal area regardless of its distance to the Sun.

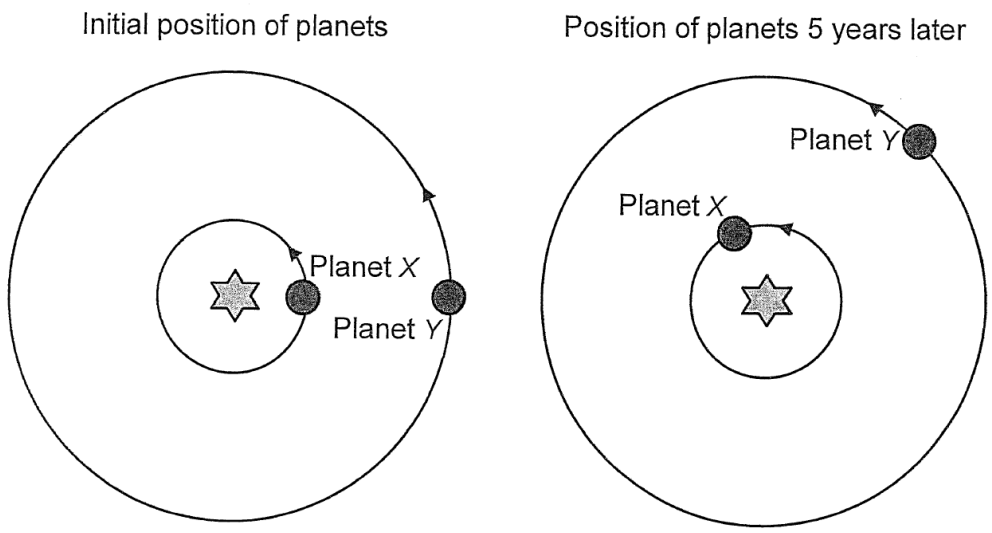
Marker's comments:

- A number of students misunderstood the diagram and thought there were 4 planets.
- Students lost marks because they failed to identify Kepler's second law.
- Students needed to mention the phrase "sweep out equal area in equal time".

Question 24 (3 marks) **Marks**

Two planets *X* and *Y* travel anticlockwise in circular orbits about a star, as seen in the diagram. The radii of the orbits *X* and *Y* are in the ratio 2:5.

The planets are shown below at a time interval of 5 years. Initially they were aligned, making a straight line with the star. Five years later, planet *X* has rotated through 120°, as shown.



Determine how long it takes planet *Y* to orbit the star.	**3**

24

Criteria	Marks
• Calculates period of planet Y	3
• Calculates period of planet X and correctly substitutes into Kepler's law of periods	2
• Calculates period of planet X OR • Correctly substitutes into Kepler's law of periods	1

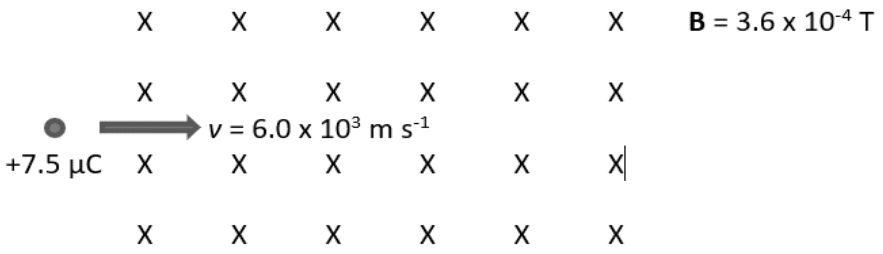
Sample answer: Planet X travels 120/360 = 0.33 rotation in 5 years
Therefore, X travels one rotation in 5/0.33 = 15 years
Kepler's law of periods states that $(T_Y^2)/(R_Y)^3 = (T_X^2)/(R_X)^3$
Hence $(T_Y^2)/(T_X^2) = (R_Y)^3/(R_X)^3$
$(T_Y^2)/(T_X^2) = 5^3/2^3$ $T_Y^2 = 15^2 \times 5^3/2^3$ $T_Y = 59$ years

Marker's comments:

- Incorrect substitution was the biggest issue
- Students also dropped squares and cubes from their equations.
- Please watch your rounding. You did not lose marks here but there are times when it is important.

Question 25 (4 marks) **Marks**

A small charged particle with a charge of + 7.5 μC and a mass of 4.0 x 10^{-15} kg enters a uniform magnetic field with a speed of 6.0 x 10^3 m s^{-1} as shown.



(a) What is the initial force on the charged particle when it enters the magnetic field? **2**

Marking Criteria	Marks
• Force is calculated correctly with direction	**2**
• An error or omission is made	**1**

Sample answer:
F = qvBsinθ
= 7.5 x 10^{-6} x 6.0 x 10^3 x 3.6 x 10^{-4} x sin90°
= 1.6 x 10^{-5} N up the page initially

Marker's comment:
- Generally well done.
- Remember all vectors require a direction.
- Some students did not recognise what μ meant.

(b) Hence quantitatively describe the subsequent motion of this particle, assuming that it remains within the magnetic field. **2**

Marking Criteria	Marks
• Nature of path and radius both correct	**2**
• Nature of path, i.e. circular stated	**1**

Sample answer:
The charged particle will follow a circular path in an anticlockwise direction with a radius found by:

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

(answer obtained retaining the value of F_c from part a)

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

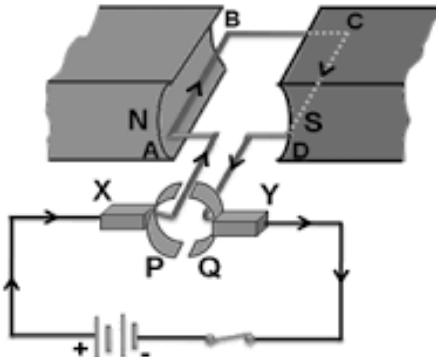
$$= \frac{4.0\times10^{-15}\times(6.0\times10^3)^2}{1.6\times10^{-5}}$$

$$= 8.9\times10^{-3}\ \text{m}$$

Marker's comment:
- Generally well done

Question 26 (4 marks) **Marks**

A single current-carrying loop is within a magnetic field produced by two magnets, as shown. A commutator connects the loop to a battery that has a constant voltage.

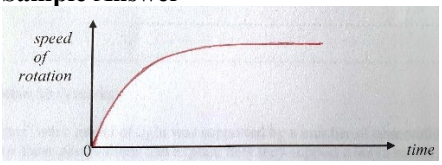


(a) On the axes below, sketch how the speed of rotation of the loop would change with time, starting from the moment that the switch is turned on. **2**

26 a.

Marking Criteria	Marks
• Correct appropriate shape drawn showing an upper limit and gradient decreasing	**2**
• One aspect of the graph shown	**1**

Sample Answer



Marker's comment:

- Reasonably well done.
- Some students drew graph for EMF.

(b) Explain why the speed of the loop changes from the time it is started until it reaches its operating speed. **2**

26 b.

Marking Criteria	Marks
• Thorough explanation provided that describes the way in which the rate of increase in speed decreases until operating speed is reached as back EMF increases with speed of motor.	**2**
• One aspect of back EMF is described	**1**

Sample answer
Initially, as a motor begins to rotate, there is no back EMF being produced so a larger current and hence large torque accelerates the motor quickly. As the motor's rotational speed increases, the flux through the coils in the motor changes faster, increasing the back EMF which opposes the supplied EMF. This decreases the net EMF and thus current in the coils, in turn reducing the torque until at a certain speed, the reduced torque is equally opposed by the friction and the motor's speed remains constant.

Marker's comment:
- Better students talked about the difference in the rate of change of flux. Note that it is Δt that is changing as the speed of rotation increases.

Question 27 (3 marks) **Marks**

Outline an investigation to examine the spectra produced from two sources. Include the names of the two sources and describe the spectra seen. **3**

27

Marking Criteria	Marks
• Investigation is outlined, including apparatus required • Two sources named with correct description of each observed spectra	**3**
• Investigation is outlined, including apparatus required • One source named with correct description of observed spectra OR • Two sources named with correct description of each observed spectra	**2**
• One aspect of a suitable investigation is provided OR • One spectrum is described	**1**

Sample answer
An incandescent globe, a fluorescent light and a sodium (or other elemental) discharge lamp were set up and switched on in separate darkened areas. A hand-held spectroscope was used to observe each source. The incandescent globe was observed to produce a continuous spectrum, rather like a rainbow, with no features such as dark or bright lines present. The fluorescent globe produced a spectrum with bright emission lines especially at purple and green against a fainter background continuous spectrum. The sodium discharge lamp produced only bright emission lines, especially at orange (emission spectrum). Finally, indirect sunlight was observed by focusing the spectroscope at the sky away from the sun. Many faint dark absorption lines were observed against a background of a continuous spectrum.

Marker's comment:
- This question was poorly done. "Outline an investigation to" means "explain an experiment that". You are expected to explain what you did and what the results were.
- Please remember the name of the equipment you use in physics experiment. A lot of students could not remember spectroscope.
- Choose obvious easy examples. The girls who did best chose indirect sunlight and a sodium or hydrogen lamp.

- Use the physics terms you know correctly. A large number of girls used the term "emission spectra" to mean all spectra. This is not correct. You have been taught the terms absorption spectrum, emission spectrum and continuous spectrum. Use them.
- Even though this is not an English exam you should try and use English correctly- don't use colloquialisms

Question 28 (4 marks) **Marks**

Huygens' wave model of light was supported by a number of observations. **4**

Outline TWO of these observations and explain how they support a wave model of light.

28

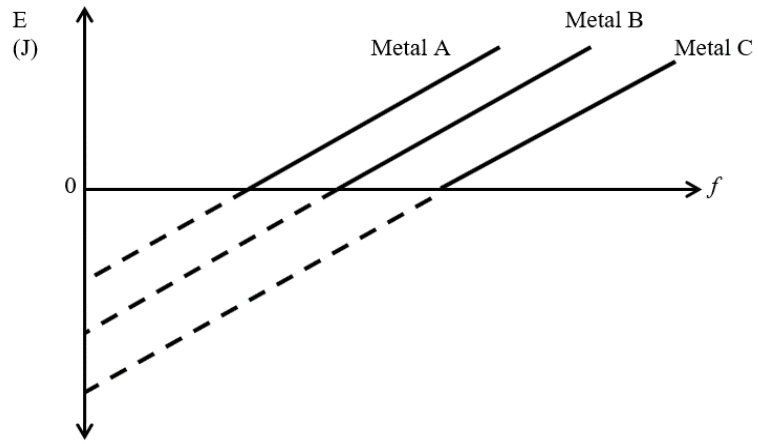
Marking Criteria	Marks
• Several wave model-supporting observations outlined • Observations linked to wave model with clear explanations	**4**
• Several wave model-supporting observations outlined • Observations linked to wave model	**3**
• Several appropriate observations outlined OR • An observation identified and linked to the wave model	**2**
• An appropriate observation outlined	**1**

Sample answer
Observation: Young's double-slit interference patterns. These patterns are the result of alternating constructive and destructive interference of the light waves from the 2 slits as the path length differences change from integer multiples of the wavelength used (constructive – bright spot) to integer + ½ wavelength (destructive – dark spot).
Observation: Interference pattern around a sharp edge – such a pattern again can only be produced by a wave model, as particles would not bend or be diffracted.

Marker's comment:
- Not very well done
- If the question is about the wave model of **light**, you must talk about light, not electrons, radiowaves or gold foil.
- Best answers all referenced Young's double slit experiment.
- In general, we use the double slit experiment to discuss interference and the single slit experiment to discuss diffraction. Make sure you choose the correct one for each property.
- Many students said reflection- this can be explained by the particle model. It does not just support the wave model.
- A number of students said refraction and this **was** allowed. However, in reality Huygen's model was purposely designed to work for refraction. So the fact that the model works for diffraction is not evidence to support it.
- A couple of students gave the example of polarisation. These students did not receive full marks as neither of them mentioned the key reason why Huygen's model can partially explain polarisation- he said the waves were **transverse**. Polarisation is a better fit as supporting evidence for later more complex wave models (post Maxwell).

Question 29 (4 marks) **Marks**

The stopping voltage was measured while varying the frequency of incident light for an investigation of the photoelectric effect. Three different metals, A, B and C were used and the results plotted, as shown below.



(a) Outline the significance of the value of the frequency of light where the lines intercept the x-axis on the graph for each metal. **2**

Marking Criteria	Marks
• Correct outline provided	**2**
• Incomplete outline provided OR • frequency identified, i.e. threshold frequency	**1**

Sample answer
These frequencies are known as the threshold frequencies for each metal. It is the minimum frequency of light required for the photoemission of electrons from the surface of the respective metals.

Marker's comment:
- Generally well done.
- We wanted to see the term threshold frequency or cut off frequency as well as the explanation for what happens at that frequency.

(b) Discuss why the plotted results for all of the metals are parallel. **2**

29 b.

Marking Criteria	Marks
• Reason for parallel lines explained fully	**2**
• Gradient of lines identified i.e. Planck's constant	**1**

Sample answer
The gradient of each line represents the quantity E/f. As E = hf, the gradient is therefore equal to the value of Planck's constant, which is the same for all photons.

Marker's comment:
- Generally well done

Question 30 (5 marks) **Marks**

(a) Describe what is meant by the term "inertial frame of reference" and give an everyday example. **2**

30 a.

Marking Criteria	Marks
• IFoR described thoroughly and example given is correct	**2**
• IFoR identified OR • example of an IFoR given	**1**

Sample answer
An IFoR is one which is not accelerating and in which the laws of physics appear to operate normally, i.e. no inertial forces are required to be added. For example, an aircraft moving at a constant velocity with no turbulence.

Marker's comment:
- Generally well done
- We were looking for three things here
  - Newton's laws hold
  - The frame is at rest or a constant velocity
  - A correct example

(b) A spaceship is 220 m in length. **3**

With what speed would the spaceship need to be travelling relative to an observer if that observer measures the length of the spaceship as 70 m?

Marking Criteria	Marks
• All calculations correct	**3**
• Several appropriate steps taken OR an error made	**2**
• One appropriate step taken	**1**

Sample answer

$$l = l_o\sqrt{1-\frac{v^2}{c^2}}$$

$$\frac{l}{l_o} = \sqrt{1-\frac{v^2}{c^2}}$$

$$\left(\frac{l}{l_o}\right)^2 = 1-\frac{v^2}{c^2}$$

$$\frac{v^2}{c^2} = 1-\left(\frac{l}{l_o}\right)^2$$

$$\frac{v}{c} = \sqrt{1-\left(\frac{l}{l_o}\right)^2}$$

$$\frac{v}{c} = \sqrt{1-\left(\frac{70}{220}\right)^2}$$

$$= 0.948$$

$$v = 0.95c$$

or 2.8×10^8 m s^{-1} (either answer acceptable)

Marker's comment:
- Generally well done

Question 31 (4 marks) **Marks**

The old definition of the ampere stated:

"The ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed on metre apart in a vacuum, would produce between these conductors a force equal to 2×10^{-7} *newtons per metre of length."*

(a) Explain how this definition of the ampere relates to Newton's Third Law. **2**

31a

Marking Criteria	Marks
Applies Newton's 3rd Law to ampere definition	**2**
Provides some correct information eg. identifies Newton's 3rd Law	**1**

Sample answer: In the definition the conductors exert equal and opposite forces on each other according to Newton's Third Law. The force on conductor 1 by conductor 2 (action) is equal in size but opposite in direction to the force on conductor 2 by conductor 1 (reaction). The forces may pull the conductors together or push the conductors apart.

Marker's comment:

- Generally well done

(b) Calculate the size of the force between two parallel current carrying wires, each 0.65 m long, carrying 0.375 amperes each, and separated by a distance of 13.5 mm. **2**

31b

Marking Criteria	Marks
Calculates force between the two wires	**2**
Makes a correct substitution into relevant formula	**1**

The size of the force is given by:

$$\frac{F}{L} = \frac{\mu_0}{2\pi} \times \frac{I_1 I_2}{r}$$

$$F = \frac{\mu_0}{2\pi} \times \frac{I_1 I_2 L}{r}$$

$$= 2 \times 10^{-7} \times \frac{0.375^2 \times 0.65}{13.5 \times 10^{-3}}$$

$$= 1.35 \times 10^{-6} \text{ N}$$

Marker's comment:

- Generally well done
- If you convert to correct significant figures, make sure you don't make a transcription error.

32 a.

Marking Criteria	Marks
• Thorough answer referring to the use of conservation laws in collisions mechanics, and how the mass of the neutron was deduced	2
• Some relevant information suggesting particles	1

Sample answer

From calculating the energy of the protons and equating this to E=hf, very high frequency gamma photons would have been needed to eject the protons. However, if the protons where hit by a neutral particle of similar mass (neutrons), according to the law of conservation of momentum, the neutrons would only need to be moving at a similar speed to the protons.

Comments:

- Direction in which the neutral "rays" were detected was only considered for 1 mark. The direction on its own is not enough evidence that the "rays" needed to be particles – you need evidence of mass. The question also states the "protons were detected and measured", so considering only the direction the "rays" were scattered ignores this part of the question.
- Some students had the misconception that electromagnetic radiation doesn't have momentum because it doesn't have mass. This might be true in classical wave theory… but since then, we've seen that photons also behave as particles and can impart momentum to a particle (for example in the photoelectric effect). So saying that the "rays" had to be particles because EMR doesn't have mass is incorrect.

32 b.

Marking Criteria	Marks
Response refers to a property of neutrons and relates this to why neutrons are hard to detect	2
Response includes a reference to a property of the neutron.	1

Sample answer

Neutrons are neutral, so do not ionise substances or deflect in electric and magnetic fields. Therefore they are not as easily observed as charged particles. They are also held in the nucleus of atoms and are difficult to remove.

Tip: Use precise terminology. "Interact with electromagnetism" isn't nearly as clear as "deflect in electric and magnetic fields".

33 a.

Marking Criteria	Marks
• Wavelength of photon calculated • Correct waveband identified using diagram	3
• Correct formula employed with error made in calculation OR • Correct calculation made but waveband incorrect	2
• One correct step undertaken	1

Sample answer

$\frac{1}{\lambda} = R\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]$ where $n_i = 4$ and $n_f = 3$

$\frac{1}{\lambda} = 1.097 \times 10^7 \left[\frac{1}{3^2} - \frac{1}{4^2}\right]$

$= 5.33 \times 10^5 \text{ m}^{-1}$

$\lambda = 1.87 \times 10^{-6} \text{ m}$

So this photon would be in the infra-red waveband. (or near infra-red)

33 b.

Marking Criteria	Marks

• Correct substitution for all values (no marks deducted for calc error or algebra) (We were nice)	**2**
• Appropriate formula identified but with subsequent error(s)	**1**

Sample answer

$$\lambda = \frac{h}{mv}$$

$$v = \frac{h}{m\lambda}$$

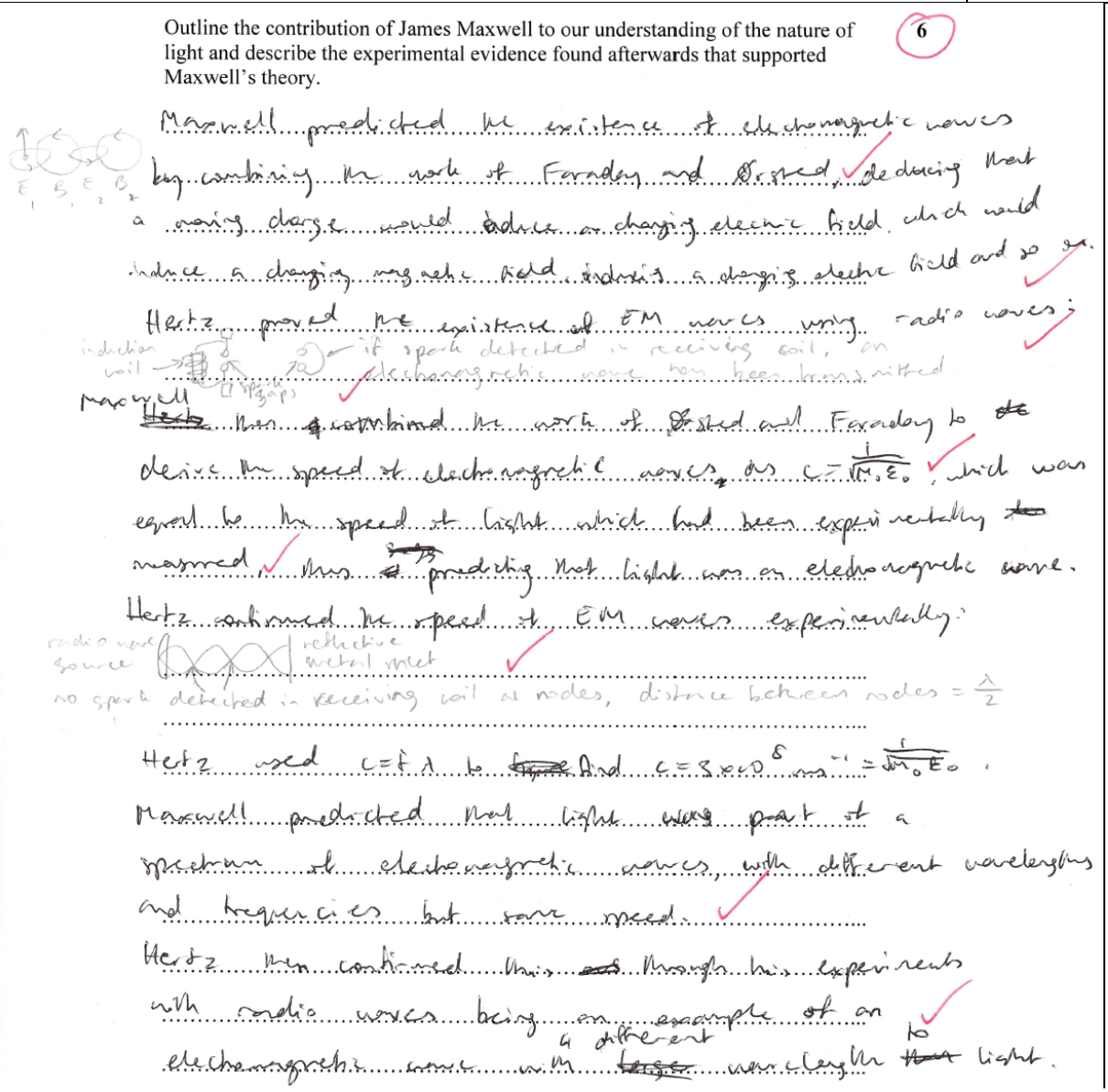
$$= \frac{6.626 \times 10^{-34}}{(9.1 \times 10^{-31}) \times (1.87 \times 10^{-6})}$$

$$= 3.89 \times 10^{2} \text{ m s}^{-1}$$

34

Marking Criteria	Marks
Outlines 3 features of Maxwell's work on electromagnetism AND Describes supporting evidence, clearly and logically linked to most of the features of Maxwell's work.	**6**
Outlines 3 features of Maxwell's work on electromagnetism AND outlines some supporting evidence OR Outlines 2 features of Maxwell's work and describes some supporting evidence	**5**
Outlines 2 or more features of Maxwell's work AND outlines some supporting evidence OR Outlines a feature of Maxwell's work AND describes some supporting evidence	**4**
Outlines 2 or more features of Maxwell's work OR Outlines a feature of Maxwell's work AND identifies some supporting evidence OR Identifies a feature of Maxwell's work AND outlines some supporting evidence	**3**
Outlines a feature of Maxwell's work OR identifies pieces of relevant information	**2**
Some relevant information	**1**

Outline the contribution of James Maxwell to our understanding of the nature of light and describe the experimental evidence found afterwards that supported Maxwell's theory. **6**



Tips:

- Many students did well. Well done for doing your homework and learning from feedback!
- Hertz made radio waves, not light.

35 (a)

Criteria	Marks
Correctly calculates time	1

Sample answer:

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

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

$t = \frac{2}{5\times10^{7}}$

$t = 4 \times 10^{-8}$ s

35 (b)

Criteria	Marks
Correctly calculates the voltage	4
Some correct substitution into formula for acceleration AND voltage supplied	2-3
Some correct substitution into formula for acceleration OR voltage supplied	2
Identifies a relevant formula	1

Sample answer:

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

$-0.005 = \left(\frac{1}{2}\right)(a)(4 \times 10^{-8})^2$

$a = -6.25 \times 10^{12}$ m s^{-1}

$F = qE$

$a = \frac{F}{m}$

$a = \frac{qE}{m}$

And $E = \frac{V}{d}$

So $a = \frac{qV}{dm}$

$\therefore V = \frac{dam}{q}$

$V = \frac{(0.02)(-6.25\times10^{12})(9.109\times10^{-31})}{-1.602\times10^{-19}}$

$V = 0.71$ V

Common mistakes:

- Confusing acceleration as acceleration due to gravity – This is NOT a gravitational field
- Mixing V for voltage and v for velocity
- Mixing up the x and y components

36 (a)

Criteria	Marks
Correctly calculates the torque and states direction	2
Attempts to substitute correct information into a relevant equation	1

Sample answer:

$\tau = nIA_{\perp}B$

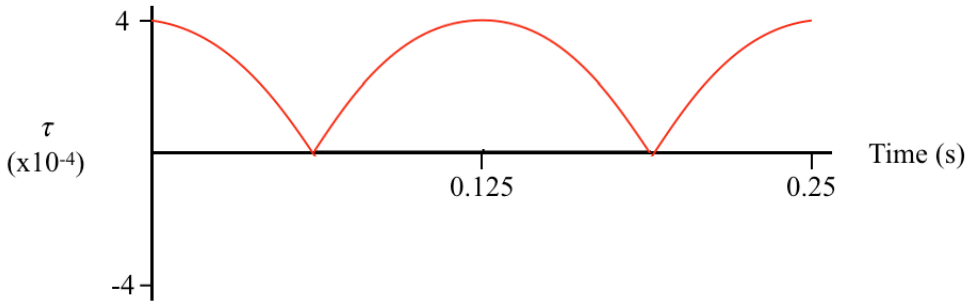
$\tau = 3 \times 0.0009 \times 0.15$

$\tau = 4.05 \times 10^{-4}$ Nm anticlockwise

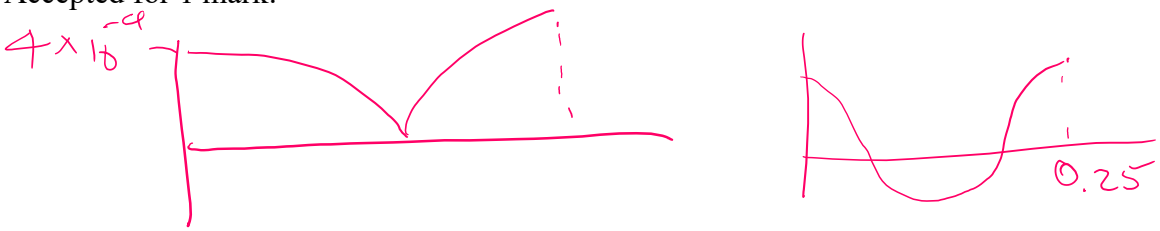
36 (b)

Criteria	Marks
Graph correctly drawn including correct scale on both axes (no mark deducted for correct working but careless mistake)	2
Some correct aspect with at least one axis correctly labelled	1

Sample answer:



Accepted for 1 mark:



Comments:

- Split ring commutator means torque is in the same direction
- Some people correctly calculated the torque in part (a) but started their graph at zero. Please check your graph matches your working!

37 (a)

Criteria	Marks
Calculates correctly Galileo's fastest possible speed measurement showing correct working, including time taken for light to actually travel 2km	3
Calculates the correct speed but does not include the time taken for light to travel 2km in working	2
Some correct attempt to calculate time taken or speed	1

Sample answer:

$t = \frac{2d}{c}$

$t = \frac{2\times1000}{3\times10^8} = 7 \times 10^{-6}$ s Don't assume this is zero – calculate it!

$v = \frac{2d}{t}$

$v = \frac{2\times1000}{7\times10^{-6}+0.5}$

$v = 4000$ m s^{-1}

37 (b)

Criteria	Marks
Makes a judgment of the accuracy, supported by an explanation and a calculation of the extent of the error from the real value	3
Makes a judgment of the accuracy, with a clear qualitative explanation OR a numerical comparison with the real value	2
Provides relevant information in regard to accuracy (just identifying reaction time is not enough for 2)	1

Sample answer:

The accepted value of the speed of light is 3 x 10^8 m/s, so compared to this, the calculated value in part (a) is very inaccurate. Compared to the true value, the error is:

$$\%\ error = \frac{3 \times 10^8 - 4000}{3 \times 10^8} \times 100\% = 99.999\%$$

The error is mostly due to human reaction time, which is very big compared to the time taken for light to travel 2 km.

38a

Criteria	Marks
Correct answer with units	3
Any two of the following: • Correct formula • Some correct substitution (at least 2 values, including for area or flux) • Units	2
Some relevant information	1

Please check your working – lots of careless mistakes!

38b – anticlockwise – 1 mark