Exam Number

Year 12
Physics
Trial HSC Examination
2020

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
- Draw diagrams using pencil
- Calculators may be used
- If extra space is needed for an answer, use the answer booklet provided. Make sure to clearly indicate which answer is being attempted.

Total marks – 100

This examination 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 21–34

• Allow about 2 hours and 25 minutes for this part

Note: Any time you have remaining should be spent revising your answers.

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Section I

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

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

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1 An object on Earth has a weight of W N. It is taken to Kashyyyk, a planet orbiting a distant star where the acceleration due to gravity is a ms^{-2}.

What will be the object's weight on Kashyyyk?

(A) W N

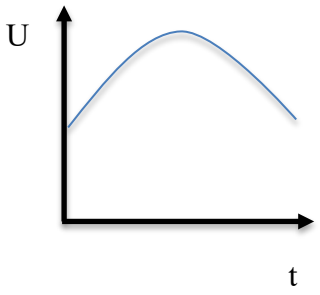
(B) $\frac{aW}{9.8}$ N

(C) aW N

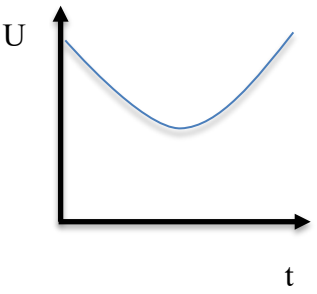
(D) $\frac{9.8W}{a}$ N

2 A ball is thrown upwards at an angle of 45°. It lands at the same height that it was thrown. Which graph best represents the gravitational potential energy of the ball during its time of flight?

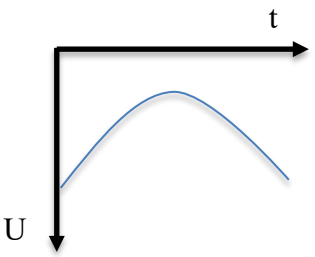
(A)



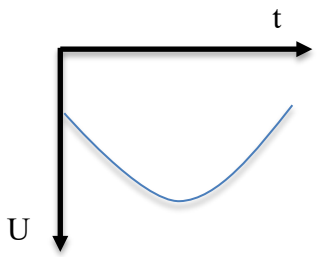
(B)



(C)



(D)



3 A car can safely negotiate a corner travelling at a maximum velocity of v, when the corner has a radius of r. If the radius of the corner is decreased to $\frac{r}{2}$, then what is the maximum velocity that the car can safely navigate the turn?

(A) $\frac{v}{2}$

(B) v

(C) $\frac{v}{4}$

(D) $\frac{v}{\sqrt{2}}$

4 Two DC electric motors of similar design have the following characteristics:

Variable affecting torque	**Motor 1**	**Motor 2**
Total number of loops in the armature	200	300
Diameter of the armature (m)	0.10	0.20
Current through the armature at operating speed (A)	3.0	2.0
Field strength of stator magnets (T)	0.50	0.30

Ignoring friction, how will the operating torque of Motor 2 compare to Motor 1?

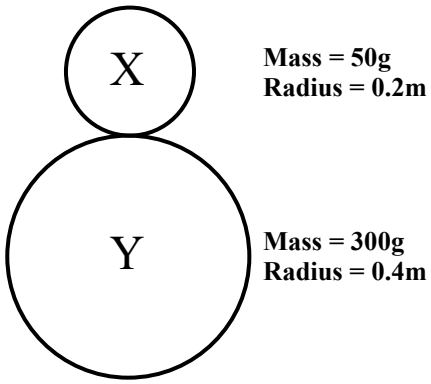
(A) It will be less than Motor 1

(B) It will be equal to Motor 1

(C) It will be 1.2 times that of Motor 1

(D) It will be 2.4 times that of Motor 1

5 Consider the two objects shown in the diagram at right.



What is the ratio of the gravitational force of object X on object Y to the gravitational force of object Y on object X?

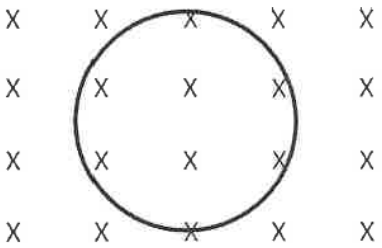
(A) 1:1

(B) 2:3

(C) 1:3

(D) 1:6

6 A circular loop of wire stands vertically within a horizontal magnetic field as shown.



Which of the following will produce the largest current in the loop of wire.

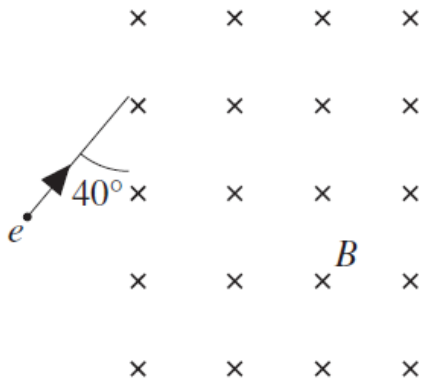
(A) Doubling the magnetic field in 10 seconds

(B) Halving the magnetic field in 10 seconds

(C) Reducing the magnetic field to zero in 10 seconds

(D) Rotating the loop on its vertical axis 1 time in 10 seconds

7 An electron moving with a velocity of 8.0×10^{6} ms^{-1} enters a uniform magnetic field of strength 2.1×10^{-2} T as shown in the diagram below.



The electron experiences a force that causes it to move along a circular path.

What is the radius of the path followed by the electron?

(A) 1.1×10^{-3} m

(B) 1.4×10^{-3} m

(C) 1.7×10^{-3} m

(D) 2.2×10^{-3} m

8 The Death Star orbits the planet Yavin at a distance of 50 000 km in 60 minutes. If the orbital radius of the Death Star was doubled, how long would it take to orbit Yavin?

(A) 120 minutes

(B) 170 minutes

(C) 145 minutes

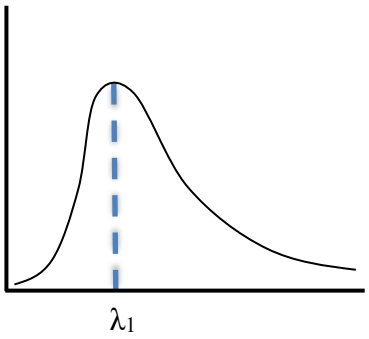
(D) 30 minutes

9 The wavelength of peak intensity radiation emanating from a source with temperature T_1 is measured as λ_1.

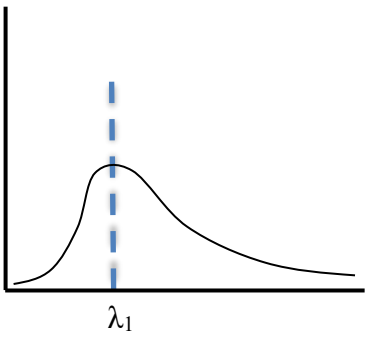
The temperature of the body is changed to T_2, where $T_2 = \frac{1}{2}T_1$

Which of the following graphs best shows the pattern of radiation produced at the new temperature?

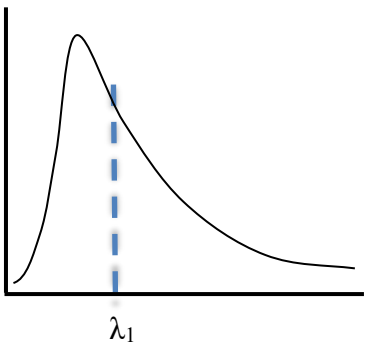
(A)



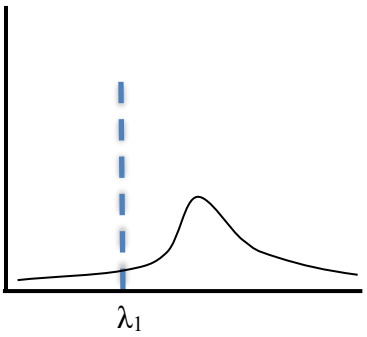
(B)



(C)



(D)



10 Yoda points a laser through a sheet of metal that has a pair of slits cut 90 µm apart. A wall is 6 m away from the sheet. 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?

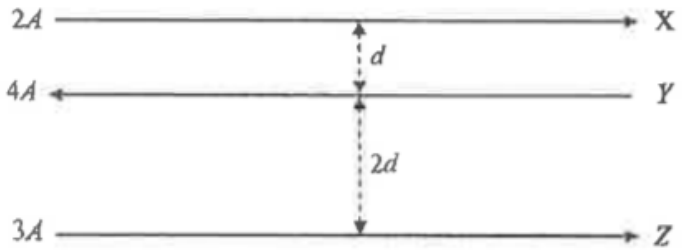
(A) 427 nm

(B) 439 nm

(C) 450 nm

(D) 459 nm

11 Three current carrying wires are set up as shown. The force on wire Y due to the other two wires is this situation is F.



What will happen to the force on Y if the distances are doubled but the currents stay the same?

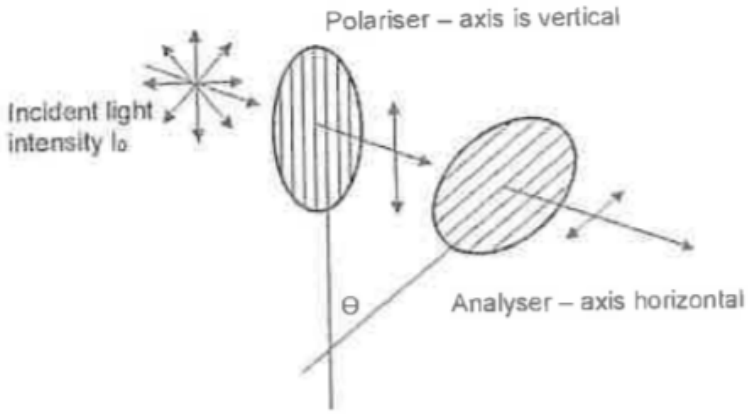
(A) It will halve to F/2

(B) It will be the same value but in the opposite direction

(C) It will double to 2F

(D) It will decrease to F/4

12 The diagram shows a polarizing filter which has its polarizing axis vertical and an analyser which has its polarizing axis at an angle (θ) to the first.



What value for angle θ will only allow for 30% of the incident light intensity to pass through the analyser?

(A) 20°

(B) 26°

(C) 39°

(D) 53°

13 Shortly after the Big Bang, subatomic matter and antimatter particles condensed from radiation. Given that matter and antimatter particles annihilate each other to produce energy, where did the matter in our universe come from?

(A) It was formed from the energy after all the matter and antimatter had disappeared

(B) It was formed later by fusion in stars

(C) For some reason, more matter condensed from the initial radiation than antimatter

(D) It was produced in the supernova explosions of very large stars

14 In a DC motor, the coil experiences a torque because of the current flowing through it.

What can ensure that this torque is directly proportional to the current flowing through the coil?

(A) A split ring commutator

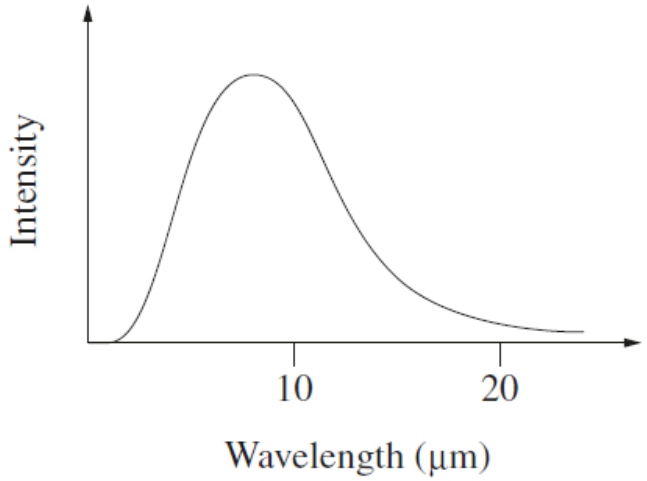
(B) A load to provide resistance

(C) A radial magnetic field

(D) A constant cross-sectional area of the coil

15 A company wishes to develop a sensor to detect thermal radiation from people.

Typical Human Blackbody Radiation Curve



Material	*Activation Energy (eV)*
Si	1.3
GaN	3.4
InSb	0.15
HgCdTe	0.03

Using the information provided, which material would be the most suitable for this purpose?

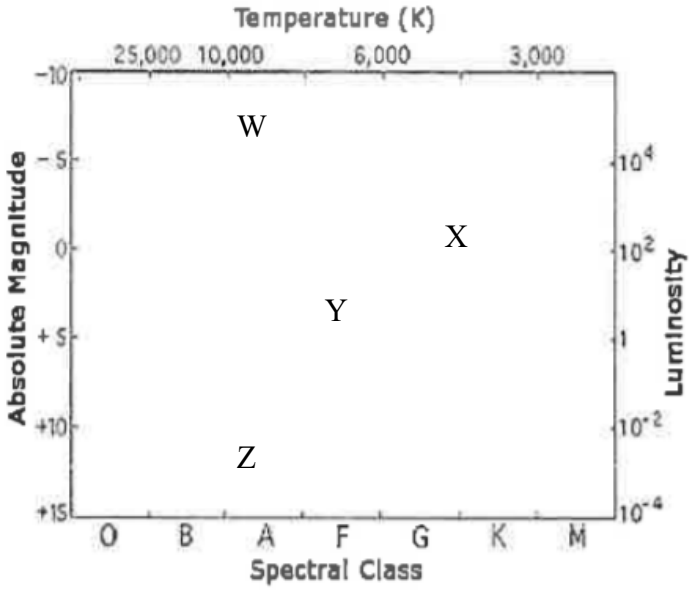
(A) Si

(B) GaN

(C) InSb

(D) HcCdTe

16 Consider the following Hertzsprung-Russel diagram showing four stars W, X, Y, Z.



Which statement about the stars is incorrect?

(A) W is the brightest star

(B) X is a giant star

(C) Y is coloured red

(D) Z is a dwarf star

17 Atom X undergoes beta minus decay to form atom Y.

How will the nucleus of Y be different to the nucleus of X?

(A) The nucleus will have two more protons and two more neutrons

(B) The nucleus will have two less protons and two less neutrons

(C) The nucleus will have one more proton and one less neutron

(D) The nucleus will have one less proton and one more neutron

18 Which of the following experiments directly helped develop a model of light?

(A) Millikan's oil drop experiment

(B) Einstein's thought experiments

(C) JJ Thomson's cathode ray experiments

(D) The Hafele-Keating experiment

19 If a specific isotope has a half life of 30 minutes, what percentage of the isotope would have decayed after 3½ hours?

(A) 100%

(B) 99%

(C) 97%

(D) 76%

20 Bohr's atomic model enabled the Balmer series to be explained. How did Bohr's model explain the minimum wavelength of the Balmer series?

(A) There is a fixed energy between the n=2 and n=3 levels

(B) There are an infinite number of orbitals an electron can occupy in the hydrogen atom

(C) The energy difference between adjacent orbitals approaches zero for very large values of the principal quantum number

(D) The principle quantum number has a specific limit for the Balmer series

Exam Number _____

Part B – 80 marks
Attempt Questions 21–34
Allow about 2 hours 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 (3 marks) **Marks**

Greedo shoots a projectile from the top of a cliff upwards at 60^{o} to the horizontal at $40ms^{-1}$. The cliff is 80m high.

Calculate the displacement of the projectile from the launch point 5 seconds later. **3**

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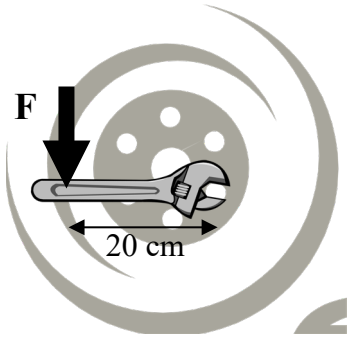
Exam Number _____

Question 22 (4 marks) **Marks**

A driver had a flat tyre. She struggled to remove the wheel until she used a spanner, rather than her hands, to undo the nut.

The diagram below models the set up she was using.



(a) Explain why using a spanner made it easier to remove the nut. **2**

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(b) Use an example calculation to show why it is most advantageous to put your hand at the far end of the spanner from the nut, rather than grip the middle of the spanner. **2**

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Question 23 (5 marks) **Marks**

A train passes a station at 88% of the speed of light. According to a passenger on the train, the length of the train carriage is 30 m from front to rear.

(a) As the train is passing the platform of the station, a light in the carriage is switched on.

Use Einstein's postulates to compare the velocity of the light beam as seen by the passenger, to that seen by an observer waiting on the platform. **3**

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(b) Calculate the length of the carriage as observed by the observer waiting on the platform. **2**

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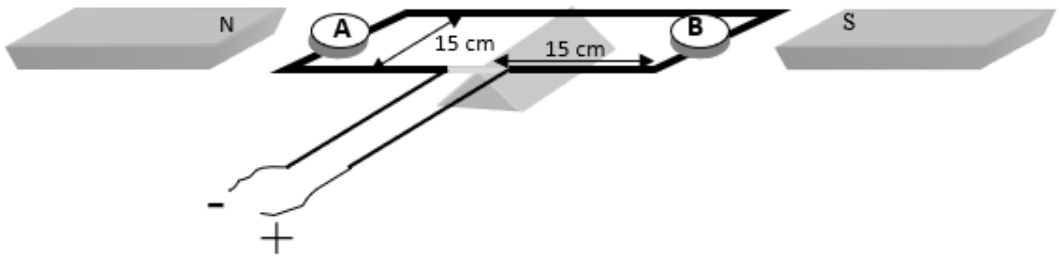
Question 24 (10 marks) **Marks**

Wicket constructs a delicate balance to determine the acceleration due to gravity on the planet Endor.

He does this by using a pivoting conducting loop placed in a magnet field of 25mT. It is connected to a variable DC power source and has two small discs at A and B on which masses can be placed.
In the diagram, the left stator magnet is a north pole, the right is a south pole.



He carries out the experiment with a range of small masses and then adjusts the current to balance the torque produced, with his results set out in the table below:

Mass in grams	*Current required in Amps*
1	2.5
2	5.0
4	7.5
6	15.0
8	20.0

(a) For this experiment to work, were the masses added on Disc A or Disc B? Justify your answer. **1**

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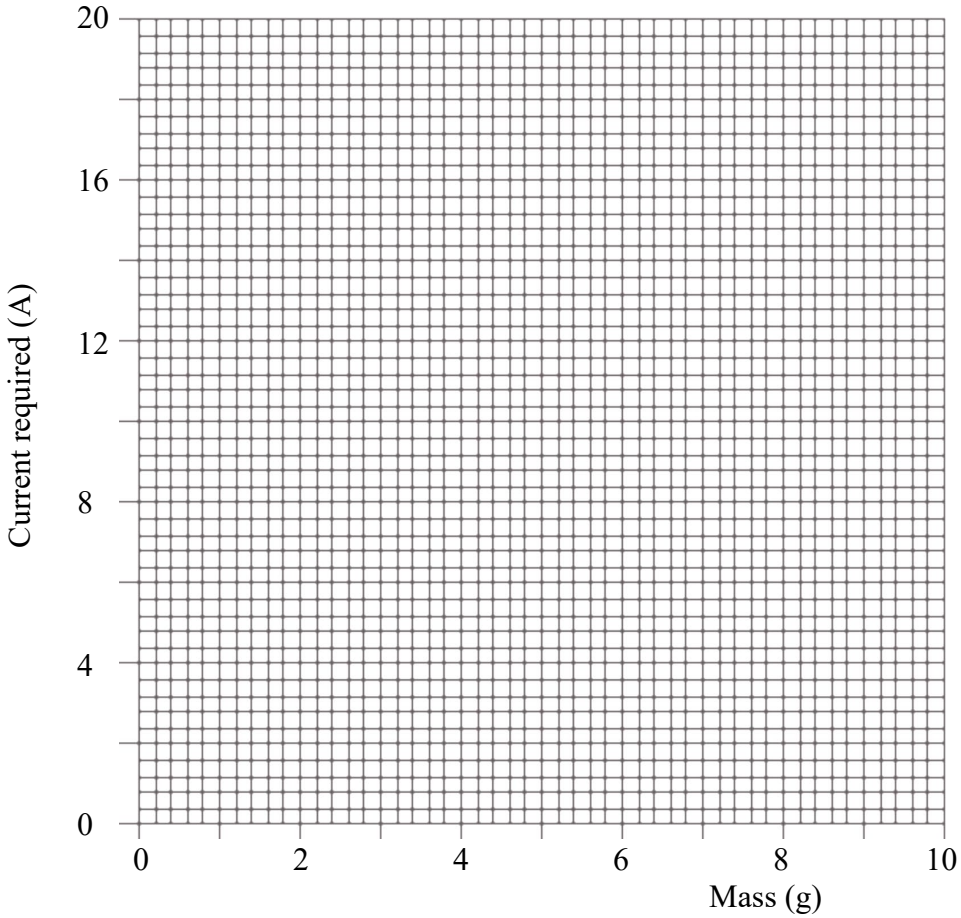
Question 24 continues on the next page

Question 24 (continued) **Marks**

(b) Plot Wicket's results on the grid below including a line of best fit. **2**



(c) Suggest a reason why Wicket conducted the experiment using several different masses, rather than repeating the same mass many times. Use the results to help justify your answer. **2**

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Question 24 continues on the next page

Marks

Question 24 (continued)

(d) Calculate the force produced by the current when balancing the 2g mass. **2**

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(e) Use the graph to calculate a reliable value for the acceleration due to gravity on Endor. **3**

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Question 25 (8 marks) **Marks**

Bohr's model of the atom was based on the theories of Rutherford, Balmer and Rydberg.

(a) Justify Bohr's postulates based on the available evidence. **3**

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(b) Draw a labelled diagram of the atomic model proposed by Rutherford, and a labelled diagram of the succeeding (Bohr) model. **2**

Rutherford's model

Bohr's model

Question 25 continues on the next page

Question 25 (continued) **Marks**

(c) Outline 3 limitations of the Bohr model. **3**

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Question 26 (9 marks) **Marks**

Spectroscopy is a key tool in identifying the characteristics of stars.

Justify this statement by explaining how a spectroscope works and how it can be used to gain a range of information about the characteristics of stars. **9**

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Answer for Question 26 (continued)

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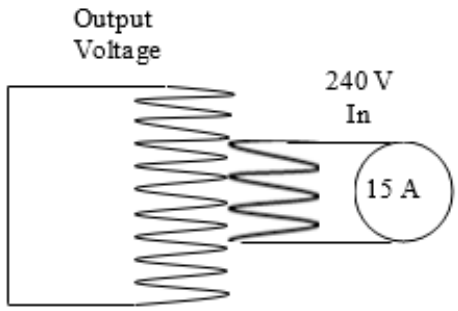
Question 27 (6 marks) **Marks**

A transformer is modelled below:



(a) Calculate the output current of this transformer. **2**

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(b) Explain two strategies used to improve the efficiency of transformers. **4**

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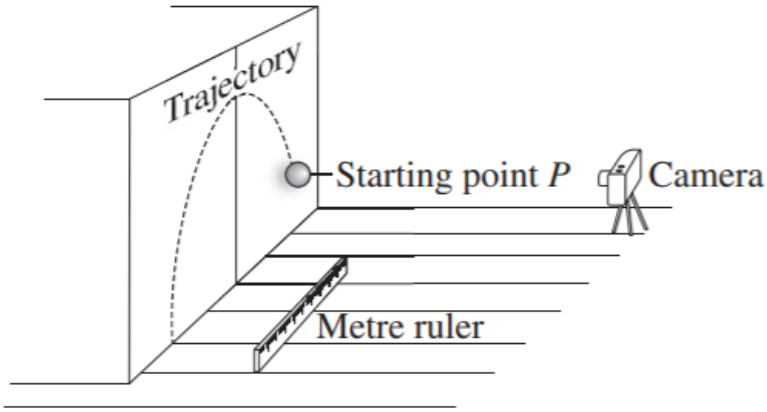
Question 28 (6 marks) **Marks**

The diagram shows a camera and a ruler set up to obtain data about a projectile's motion along the trajectory shown. The entire trajectory is visible through the camera.



(a) Identify ONE of the errors in this set-up and describe the effect of this error on the results. **3**

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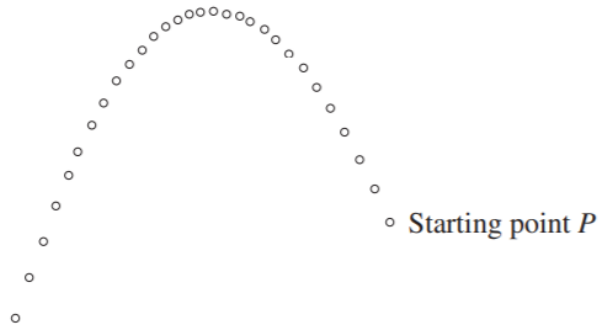
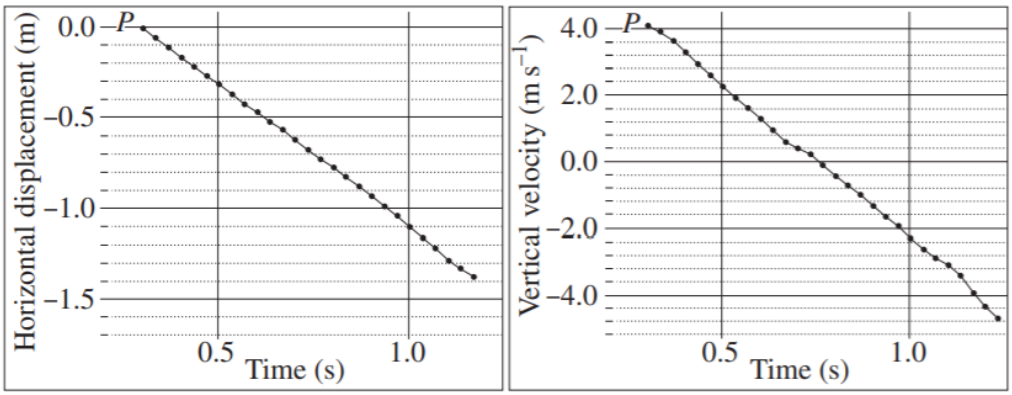
Question 28 (continued) **Marks**

An experiment was set up based on the method described in part (a), but conducted so that the data obtained were valid. The image shows the trajectory of the ball.



The graphs show data from this experiment.



(b) Using the graphs, describe the velocity and acceleration of the ball qualitatively and quantitatively. **3**

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Question 29 (5 marks) **Marks**

Describe the experimentation and underlying theories that enabled JJ Thomson to determine the charge to mass ratio of the electron. **5**

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Question 30 (5 marks) **Marks**

(a) Calculate the energy of a photon of wavelength 415nm. **2**

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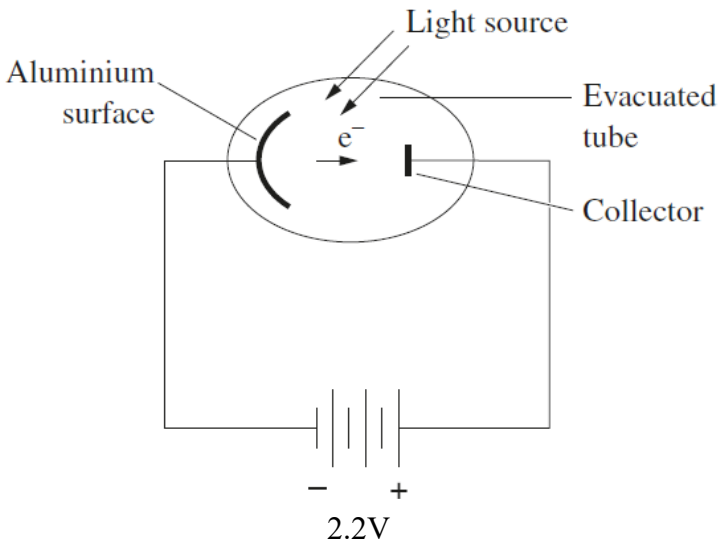
(b) An experiment was conducted using a photoelectric cell as shown in the diagram.



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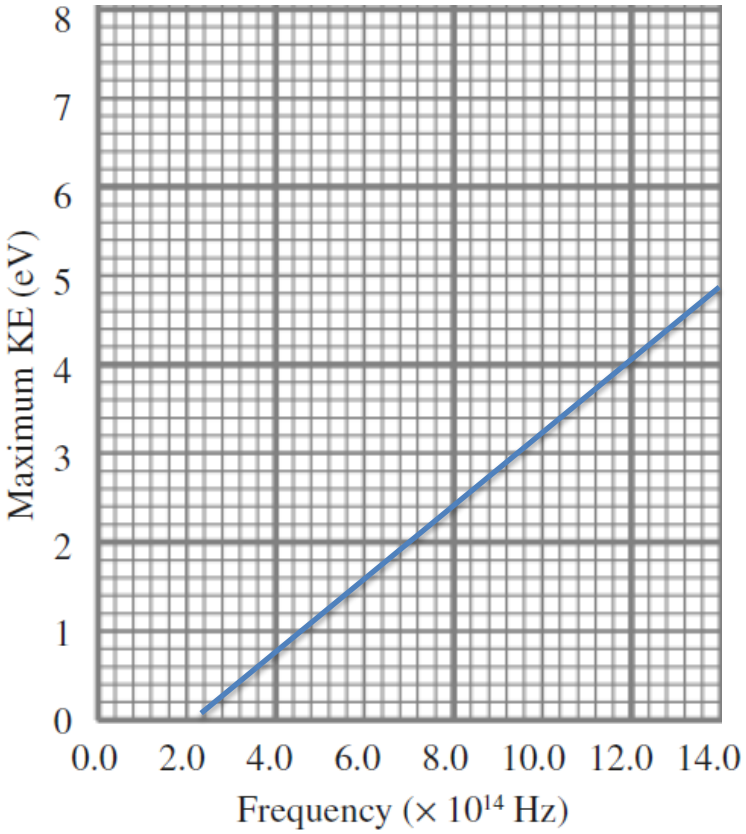
Question 30 (continued) **Marks**

The graph plots the maximum kinetic energy of the emitted photoelectrons against radiation frequency for the aluminium surface.



The experiment is planned to be repeated using a voltage of 0.0V

(i) Draw a line on the graph to show the predicted results of the planned experiment. **2**

(ii) The voltage was then reset to 2.2V. Determine the radiation frequency which would produce photoelectrons with a maximum kinetic energy of 1.2 eV. **1**

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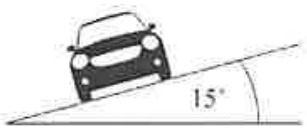
Question 31 (6 marks) **Marks**

A car is travelling at the design speed of a banked track with a turning radius of 20.0 m, as shown in the diagram. The centripetal force acting on the car is 3040 N.



(a) Calculate the mass of the car. **3**

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(b) Assuming the banked track is frictionless, explain in terms of forces acting what would happen to the car if it went faster or slower than the design speed. **3**

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Question 32 (5 marks) **Marks**

Newton and Huygens had competing models of light during the 17th century. Some characteristics of light could be explained by both models, and other characteristics by only one model.

(a) Explain how each model could account for the refraction of light through different mediums. **3**

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(b) Describe ONE piece of evidence that could be explained by one model, but not the other. **2**

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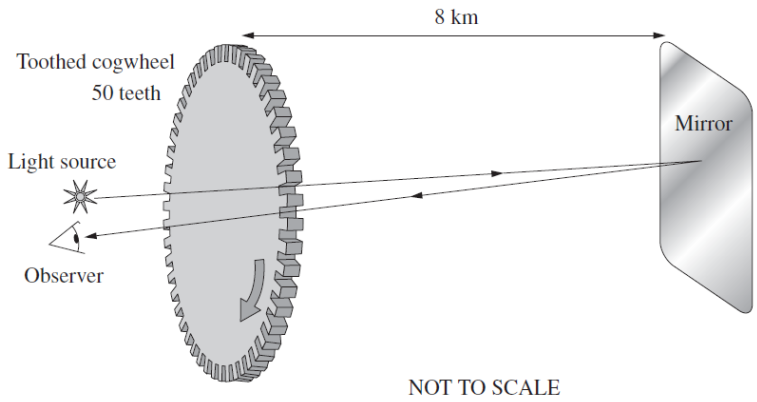
Question 33 (5 marks) **Marks**

In the 1840s, French physicist, Hippolyte Fizeau performed an experiment to measure the speed of light. He shone an intense light source at a mirror 8 km away and broke up the light beam with a rotating cogwheel. He adjusted the speed of rotation of the wheel until the reflected light beam could no longer be seen returning through the gaps in the cogwheel.

The diagram shows a similar experiment. The cogwheel has 50 teeth and 50 gaps of the same width.



Explain why specific speeds of rotation of the cogwheel will completely block the returning light. Support your answer with calculations. **5**

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Question 34 (3 marks) **Marks**

In your course you completed a first hand investigation modelling the principles involved in the working of an AC induction motor.

Outline the experimental procedure and the results you observed (space for a diagram has been provided below). **3**

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END OF EXAM

SHORE PHYSICS

2020 TRIAL

ANSWERS AND SUGGESTED MARKING SCHEME

Section I – PART A

QUESTION	1	2	3	4	5	6	7	8	9	10
ANSWER	B	C	D	D	A	D	D	B	D	C

QUESTION	11	12	13	14	15	16	17	18	19	20
ANSWER	A	C	C	C	C	C	C	B	B	D

Section I – PART B

Question 21 (3 marks)

Criteria	Mark
A valid method with correct substitutions throughout. Answer is presented with correct units and appropriate direction (may be shown in a diagram).	**3**
One error of logic or substitution **OR** Correctly calculates vertical displacement	**2**
Correctly calculates horizontal displacement **OR** Correct equations for both horizontal and vertical displacement identified **OR** Correctly calculates displacement (including direction) from incorrect values for horizontal and vertical displacements	**1**

Sample Answer

$u_x = 40cos60 = 20ms^{-1}$, $\Delta x = u_x t = 20 \times 5 = 100m$

$u_y = 40sin60 = 34.6ms^{-1}$ up, $\Delta y = u_y t + \frac{1}{2}a_y t^2 = 34.6 \times 5 - \frac{1}{2} \times 9.8 \times 25 = 50.5m$ up

$\Sigma r = \sqrt{100^2 + 50.5^2} = 112.0m$, $tan\theta = \frac{50.5}{100}$, $\theta = 26.8^o$

So r = 112.0m at an angle 26.8^o above the horizontal

Question 22a (2 marks)

Criteria	Mark
Explanation correctly relates force, torque and distance	**2**
Shos some knowledge of the relationship between force, torque and distance	**1**

Sample Answer

By applying a force at a large perpendicular distance, a greater torque can be achieved, since τ=Fd. The spanner has a greater distance than does your hand.

Question 22b (3 marks)

Criteria	Mark
Correct explanation with correct example calculation	**3**
Correct explanation OR correct example calculation	**2**
Outlines mechanical advantage or provides a calculation with a minor error.	**1**

Sample Answer
Assuming a force of 50N applied in the middle of the spanner,
$\tau = F_{\perp} d = 50 \times 0.1 = 5 Nm$

Assuming the same force of 50N applied at the end of the spanner,
$\tau = F_{\perp} d = 50 \times 0.2 = 10 Nm$

Therefore there would be twice the toque from the same applied effort (force) if you put your hand at the far end of the spanner.

Question 23a (3 marks)

Criteria	Mark
Clearly relates Einstein's postulates to the observed speed of light by the passenger and the observer on the platform	**3**
States Einstein postulates and relates them to the observed speed of light by either the passenger or the observer on the platform	**2**
States Einstein's postulates OR states the speed of light observed by either the passenger or the observer on the platform.	**1**

Sample Answer
Einstein's postulates are:
1. that all frames of reference are equal and that the laws of physics hold true in all frames of reference.
2. that the speed of light is constant for all observers in all reference frames.
The second postulate indicates that both the passenger and the observer on the platform would both measure the speed of light as c.

Question 23b (2 marks)

Criteria	Mark
Correct calculation of the carriage length	**2**
Correct formula with incorrect substitution of length	**1**

Sample Answer

$$l = l_o \sqrt{1 - \frac{v^2}{c^2}} = 30\sqrt{1 - 0.88^2} = 14.25m$$

Question 24a (1 mark)

Criteria	Mark
Correct identification with valid justification	**1**

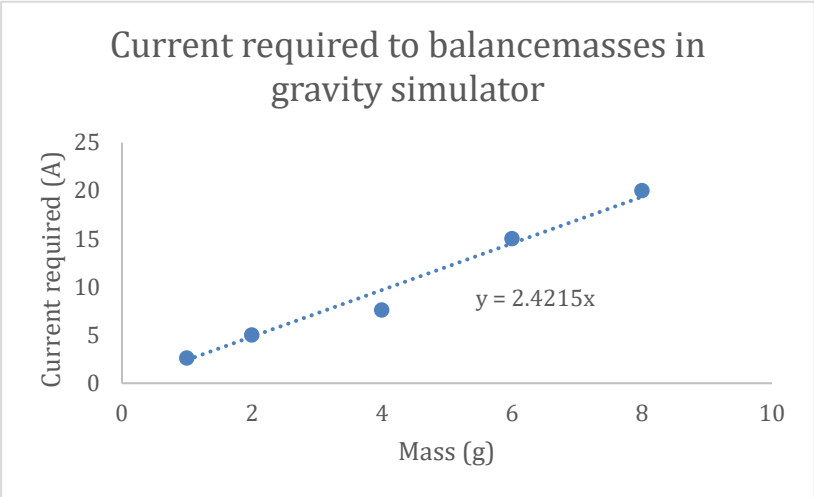
Sample Answer
Disc A, since the balance would rotate clockwise by the motor effect, so adding masses to A could bring balance to the force.

Quite a few students got quite "wordy" - KISS

Question 24b (2 marks)

Criteria	Mark
Correct plots and line	**2**
Correct plots	**1**

Sample Answer



Question 24c (2 marks)

Criteria	Mark
Relates reliability of results to use of a line of best fit	**2**
Some relevant information about reliability of results	**1**

Sample Answer
Using multiple masses allows for a relationship between mass and current to be seen, whilst also checking that the experimental data is reliable and consistent. In the case above, this result would make a linear relationship, whilst also showing reliability in that all points lie close to the line of best fit.

Conducting experiment for different masses is the clue – repetition = reliability. Use the results = graph. Points all close to line of best fit

Question 24d (2 marks)

Criteria	Mark
Correct calculation of the force with units	**2**
Correct calculation of force	**1**

Sample Answer

$F = BIl = 0.025 \times 5.02 \times 0.15 = 1.88 \times 10^{-2} N$

Question 24e (3 marks)

Criteria	Mark
Uses the gradient of the line of best fit to determine g on Endor	**3**
Calculates a value for g on Endor	**2**
Calculates the slope of the line of best fit	**1**

Sample Answer

Using the slope of the line of best fit as 2.4,

$F = ma = BIl$

$\therefore a = \frac{I}{m} lB = 2400 \times 0.15 \times 0.025 \approx 9.0\, ms^{-2}$

x-axis is in grams. The large majority missed this. Check your answer. Is a gravity of 0.09 ms^{-2} realistic?

Question 25a (3 marks)

Criteria	Mark
Relates Bohr's model to Rutherford, Balmer and Rydberg	**3**
Describes Bohr's model and relates it to the work of any one of Rutherford, Balmer or Rydberg.	**2**
Describes Bohr's model	**1**

Sample Answer

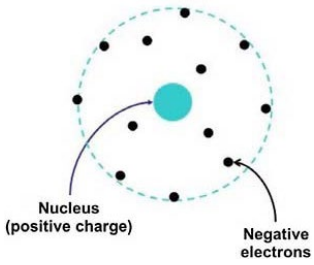
Bohr's postulates built on the atomic model of Rutherford, who suggested a dense positively charged nucleus with electrons orbiting at large distances. Bohr used the hydrogen spectral lines observed by Balmer, and the empirical equation which predicted the wavelength of these lines developed by Rydberg; to propose a new atomic model. Electrons would only be allowed to orbit at specific orbitals/energy levels/stationary states. Any Transition between these stationary states would result in the absorption or emission of a quanta of light (a photon).

Question 25b (2 marks)

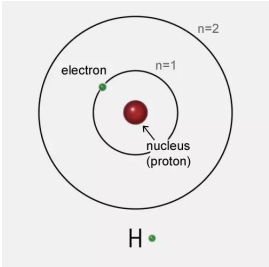
Criteria	Mark
Correct labelled diagram of both models	**3**
Correct labelled diagram of one of the two models	**2**

Sample Answer

Rutherford:



Bohr:



Question 25c (3 marks)

Criteria	Mark
Outlines 3 limitations of Bohr's model	**3**
Outlines 2 limitations of Bohr's model	**2**
Outlines1 limitation of Bohr's model	**1**

Sample Answer

1. Spectral lines were not all of equal intensity, the model had no explanation for this
2. The model only worked in predicting spectral lines of hydrogen, it was not suitable forlarger atoms
3. The model could not explain the presence of hyperfine lines, wherein each spectral line was made of many smaller lines

Question 26 (9 marks)

Explains the workings of a spectroscope, describes absorption and emission spectra for stars, relates the spectra to stellar characteristics including relative velocity, rotational velocity, constituent elements, surface temperature.	**9**
Explains the workings of a spectroscope, describes absorption and emission spectra for stars, relates the spectra to stellar characteristics including at least TWO of relative velocity, rotational velocity, constituent elements, surface temperature.	**7-8**
Outlines workings of a spectroscope, describes some features of spectra and relates this to one or two characteristics of a star.	**5-6**
Explains relevant information about stellar spectra OR a spectroscope	**3-4**
Outlines relevant information about stellar spectra OR a spectroscope	**1-2**

Lots were vague with their details. Good on the characteristics of stars but not on how the spectroscope works and identifying difference between emission and absorption spectrum.

Sample Answer

A spectroscope works by allowing incident light to pass through narrow slits called diffraction grating. The slits diffract the incident light differently depending on wavelength, making it possible to see each incoming wavelength separately on a scale. The difference between absorption and emission spectra are that absorption lines are where light has been absorbed by the atom thus you see a dip in the spectrum whereas emission spectra have spikes in the spectra due to atoms releasing photons at those wavelengths. When observing the spectra, the position of the lines can tell you which atoms are present in the star, since each atom has specific allowed transitions between energy levels resulting in emission or absorption. The spectral lines may be shifted towards the red or blue if the star is moving away or towards us respectively due to Doppler shift. The surface temperature can be determined by the relative intensity of the spectral lines (hotter stars have more intense lines). The rotational velocity can also be seen, since as a star rotates, one side is moving differently to the other side, resulting in a wider spectral line, since there is a periodic red and blue shift from its radial velocity. The fuzziness of lines can also be used to measure the density of a star.

Question 27a (2 marks)

Criteria	Mark
Correctly calculates output current	**2**
One error of logic/substitution	**1**

Sample Answer

$$\frac{N_P}{N_S} = \frac{I_S}{I_P} \therefore I_S = \frac{N_P I_P}{N_S} = \frac{240 \times 15}{600} = 6A$$

Questions 27b (4 marks)

Criteria	Mark
Explains two strategies that would improve a transformers efficiency	**4**
Explains one strategy AND states one strategy that would improve a transformers efficiency	**3**
States two strategies that would improve a transformers efficiency OR Explains one strategy that would improve a transformers efficiency	**2**
States one strategy that would improve a transformers efficiency	**1**

Quite a few students were stating two differences without explaining

Sample Answer
Using a soft iron core will concentrate the magnetic field by preventing flux leakage from between the coils. Soft iron is ferromagnetic whilst not being a great conductor, this will also help to minimise eddy current loss.
The coils may also be placed in cooling oil, this will keep the temperature of the coils low enough to maximise efficiency of transmission (it keeps the resistivity value for the wire material as low as possible).

Questions 28a (3 marks)

Criteria	Mark
Identifies a valid error and describes why a subsequent measurement will be incorrect	**3**
Identifies a valid error and identifies a subsequent error in measurement	**2**
Identifies a possible error or effect	**1**

Sample Answer
Answers could include:
Error: The camera is off centre
Effect: When the object is closer to the camera, it will appear to be moving faster than when it is further away, therefore it will give an incorrect measurement of velocity.
Error: Ruler closer to the camera than the trajectory
Effect: Distance calculated on the trajectory using the ruler will be greater than the true distance and hence the calculated velocity will be greater than the true value.
Others: Camera too close/non-linearity of distances etc;

Questions 28b (3 marks)

Criteria	Mark
• Identifies constant horizontal speed • Identifies constant vertical acceleration • Valid method with substitution to calculate horizontal velocity from the graph • Valid method with substitution to calculate vertical acceleration from the graph	**3**
Any 2 of the above	**2**
Identifies some valid information regarding velocity OR acceleration from either graph	**1**

Sample Answer

The first graph shows that the ball is moving horizontally at a constant speed, the speed is given by the gradient of the graph, $v = \frac{-1.1-(-0.3)}{0.5} = -1.6ms^{-1}$. The second graph shows that the ball is accelerating at a constant rate, the acceleration is given by the gradient of the graph, $a = \frac{-2.4-2.4}{0.5} = -9.6ms^{-1}$.

Question 29 (5 marks)

Criteria	Mark
Describes the experimental method used by Thomson (stream of cathode rays, balanced deflections by E and B fields, radius of curvature of B field) AND correctly describes the mathematics used to derive the charge to mass ratio.	**5**
Outlines most of Thomson's method AND outlines the mathematics used to derive the charge to mass ratio in terms of both the electric and magnetic field.	**4**
Identifies aspects of Thomson's method AND mathematical principles used to derive the charge to mass ratio. **OR** Describes the experimental method used by Thomson **OR** Correctly describes the mathematics used to derive the charge to mass ratio.	**3**
Identifies aspects of Thomson's method AND/OR mathematical principles used to derive the charge to mass ratio.	**2**
Identifies one aspect of Thomson's work	**1**

Sample Answer

JJ Thomson carried out an experiment to explore the nature of cathode rays and to resolve the debate as to whether they were a form of electromagnetic radiation or charged particles. He had a cathode ray tube constructed that allowed him to manipulate the cathode rays into a beam and then deflect the beam using electric and magnetic fields. He first observed the deflection using only a magnetic field, seeing a circular path (constant speed). By balancing the deflection caused by magnetic and electric fields he was able to calculate a charge to mass ratio for the particles as shown:

$F = qvB = \frac{mv^2}{r} \therefore \frac{q}{m} = \frac{v}{Br}$ $\quad$ $F = Eq = qvB \therefore v = \frac{E}{B}$ $\quad$ $\frac{q}{m} = \frac{E}{B^2 r}$

Question 30a (2 marks)

Criteria	Mark
Correctly equation and substitution to calculate photon energy (in J OR eV)	**2**
One error of logic/substitution	**1**

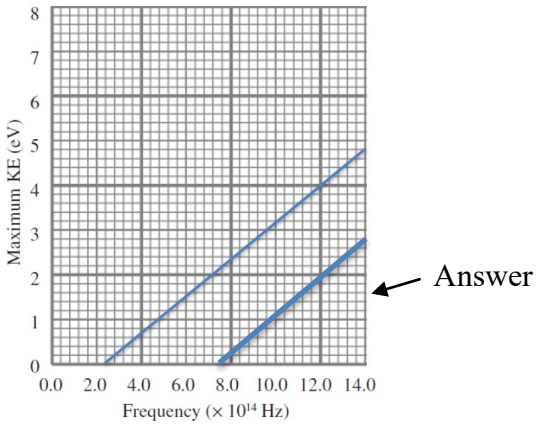
Sample Answer

$$E = \frac{hc}{\lambda} = \frac{6.626\times10^{-34}\times3\times10^{8}}{415\times10^{-9}}$$
$$= 4.79\times10^{-19}\,J$$

Question 30b(i) (2 marks)

Criteria	Marks
Correct slope AND correct intercept (7.6 x 10^{14}Hz – accept 7.2 – 8.0)	**2**
Correct slope OR correct intercept	**1**

Sample Answer



Question 30b(ii) (1 mark)

Criteria	Marks
Correct answer (accept 4.8 – 5.2 x 10^{14}Hz)	**1**

Sample Answer

$5.0\times10^{14}\,Hz$

Question 31a (3 marks)

Criteria	Mark
Valid method with correct substitutions	**3**
One error of logic/substitution OR Identifies $F_c = mg\tan\theta$	**2**
Draws a correct vector diagram **OR** Makes one error of logic in deriving $F_c = mg\tan\theta$	**1**

Sample Answer

$F_C = F_{N_x} = mg\tan\theta$, $3040 = m\times9.8\times\tan15$, $m = 1158kg$

Question 30b (3 marks)

Criteria	Mark
Correctly relates horizonal component of normal force to required F_c and the subsequent effect on the motion of the car at higher AND lower speed	**3**
Identifies a change in F_c and the resulting motion of the car at higher AND lower speed	**2**
Relates subsequent motion to F_c **OR** Identifies how the motion of the car will change at faster OR slower speeds	**1**

Sample Answer
A vehicle travelling at the design speed of a banked track requires no friction to turn because the horizontal component of the normal force creates sufficient centripetal force to turn the vehicle. If the speed of the vehicle increases, then a larger centripetal force is required, but there is no increase in the normal force, therefore the care would slide up the track. If the speed of the vehicle decreases, then the centripetal force decreases, but the normal force remains constant, therefore the car would slide down the curve.

Question 32a (3 marks)

Criteria	Mark
Identifies both wave and corpuscle models. Explains refraction of wave with reference to change in wavelength of wavelets in new medium. Explains refraction of corpuscles with reference to gravitational attraction.	**3**
Identifies both wave and corpuscle models AND identifies an aspect of refraction for either. **OR** Explains refraction (as above) in either model	**2**
Identifies a model AND identifies an aspect of refraction in that model. **OR** Identifies an aspect of refraction in both models	**1**

Sample Answer
Using Huygens wave model, the refraction of light through a denser medium could be understood as a change in the speed and wavelength (but not the frequency) of the light. Entering a denser medium, light would slow down, and the wavelength would decrease. Hence the wavefront of the wavelets extending into the medium would change so that the ray bent towards the normal.
Using Newton's corpuscular model, the particles of light experience gravitational attraction to the increased number of particles in the denser medium, accelerating towards them causing the ray to bend towards the normal.

Question 32b (2 marks)

Criteria	Mark
Identifies a valid piece of evidence and outlines important features of the evidence	**2**
Identifies a piece of evidence OR outlines a feature	**1**

Sample Answer
Diffraction could be explained by the wave model, but not by the particle model. Diffraction is the bending of light around an obstacle, defined by Huygens as "every point on a wavefront is a source of wavelets. Hence wavelets spread out in all directions from a point of diffraction such as an edge or a slit causing the wave to appear to spread out from the obstacle.

Question 33 (5 marks)

Criteria	Mark
• Clearly identifies that the light must travel to the mirror and back and that rotation of the wheel must occur such that a tooth blocks the return path. • Provides valid, correct calculations (of angular velocity OR RPM/s) to show that a specific speed of rotation will result in blockage. • Clearly shows that multiples of that speed will also block the path.	**5**
• Clearly describes how the path of the light can be blocked by the rotating wheel. • Provides valid calculations (of angular velocity OR RPM/s) with one error of logic or substitution.	**4**
• Outlines how the path of the light could be blocked by the rotating wheel. • Identifies the calculations that need to be made. **OR** • Clearly identifies that the light must travel to the mirror and back and that rotation of the wheel must occur such that a tooth blocks the return path. • Clearly shows that multiples of that speed will also block the path.	**3**
• Outlines how the path of the light could be blocked by the rotating wheel. **OR** • Identifies the calculations that need to be made.	**2**
• Identifies that the path of the light could be blocked by the rotating wheel. **OR** • Identifies a correct equation.	**1**

Sample answer
Light travels at 3.00×10^8 m s^{-1}, so for an 8 km journey to the mirror and 8 km back, the time taken will be: $t = \frac{s}{v} = \frac{2 \times 8000}{3 \times 10^8} = 5.33 \times 10^{-5}\ s$

If the wheel is stationary, the light travelling through a gap will return completely through the gap, but if the wheel is rotating, a cog (tooth) will begin to block the returning light. If a tooth moves exactly the width of a gap in the time it takes the light to return, it will completely block the light.
It takes 5.33×10^{-5} seconds for the light to travel to the mirror and back. To completely block the light, the tooth will have moved into the path of a gap in this time. Since there are 50 teeth and 50 gaps, the wheel will have rotated 1/100th of a rotation in this time. This is equal to $2\pi/100$ radians.

The rotational speed of the wheel is given by $\omega = \frac{\Delta\theta}{\Delta t} = \frac{\frac{2\pi}{100}}{5.33 \times 10^{-5}} = 1180 \text{ rad } s^{-1}$
Spinning the cogwheel at 3, 5 and 7 times this rate (or any odd multiple) would also completely block the returning light, as the light will be blocked by subsequent teeth.

Question 34 (3 marks)

Criteria	Mark
Correctly describes a valid experiment and observed results	**3**
Describes a valid experiment OR outlines aspects of an experiment and the results	**2**
Identifies aspects of an experiment and/or results OR Describes principles of operation of an AC induction motor	**1**

Sample Answer
An empty aluminium can was floated in a bucket of water. A magnet was suspended on a string above the can. The string was twisted up, and then released so the magnet could rotate in a horizontal circle. The can appeared to chase the magnet as it rotated (albeit at a slower speed).