VCE PHYSICS 2017

YEAR 12 TRIAL EXAM

Units 3/4
Reading time: 15 minutes
Writing time: 2 hours 30 minutes

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A. Multiple Choice Questions	20	20	20
B. Short Answer Questions	30	30	130
		Total	**150**

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Data Sheet VCE Physics 2017 Year 12 Trial Exam Units 3/4

Motion and related energy transformations		
1	velocity; acceleration	$v = \frac{\Delta x}{\Delta t}$; $a = \frac{\Delta v}{\Delta t}$
2	equations for constant acceleration	$v = u + at$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$ $s = \frac{1}{2}(v+u)t$
3	Newton's second law	$\Sigma F = ma$
4	circular motion	$a = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2}$
5	Hooke's law	$F = -kx$
6	elastic potential energy	$\frac{1}{2}k\Delta x^2$
7	gravitational potential energy near the surface of the Earth	$mg\Delta h$
8	kinetic energy	$\frac{1}{2}mv^2$
9	Newton's law of universal gravitation	$F = \frac{GM_1M_2}{r^2}$
10	impulse	$F\Delta t$
11	momentum	mv
12	gravitational field	$g = \frac{GM}{r^2}$
13	Lorentz factor	$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$
14	time dilation	$t = t_O\gamma$
15	length contraction	$L = \frac{L_O}{\gamma}$

16	rest energy	$E_{rest} = mc^2$
17	relativistic total energy	$E_{total} = \gamma mc^2$
18	relativistic kinetic energy	$E_K = (1-\gamma)mc^2$
Generation and transmission of electricity		
19	voltage; power	$V = RI \quad P = VI = I^2R$
20	resistors in series	$R_T = R_1 + R_2$
21	resistors in parallel	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$
22	transformer action	$\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{I_2}{I_1}$
23	AC voltage and current	$V_{RMS} = \frac{1}{\sqrt{2}} V_{peak} \quad I_{RMS} = \frac{1}{\sqrt{2}} I_{peak}$
24	electromagnetic induction	emf : $\varepsilon = -N \frac{\Delta\Phi}{\Delta t}$ flux : $\Phi = BA$
25	transmission losses	$V_{drop} = I_{line}R_{line} \qquad P_{loss} = I^2_{line}R_{line}$
Wave concepts		
26	wave equation	$v = f\lambda$
27	constructive interference	path difference = nλ
28	destructive interference	Path difference = (n-$\frac{1}{2}$)λ
29	fringe spacing	$\Delta x = \frac{\lambda L}{d}$
30	Snell's Law	$n_1 \sin\theta_1 = n_2 \sin\theta_2$
31	refractive index and wave speed	$n_1 v_1 = n_2 v_2$

The nature of light and matter		
32	photoelectric effect	$E_{K\max} = hf - W$
33	photon energy	$E = hf$
34	photon momentum	$p = \frac{h}{\lambda}$
35	de Broglie wavelength	$\lambda = \frac{h}{p}$
36	Heisenberg's uncertainty principle	$\Delta p_x \Delta x \geq \frac{h}{4\pi}$
Data		
37	acceleration due to gravity at Earth's surface	g = 9.8 ms^{-2}
38	mass of the electron	$m_e = 9.1 \times 10^{-31}$ kg
39	charge on the electron	$e = -1.6 \times 10^{-19}$ C
40	Planck's constant	$h = 6.63 \times 10^{-34}$ J s
41	speed of light in a vacuum	$c = 3.0 \times 10^{8}$ m s^{-1}
42	universal gravitational constant	$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}
43	mass of Earth	$M_E = 5.98 \times 10^{24}$ kg
44	radius of Earth	$R_E = 6.37 \times 10^{6}$ m
45	coulomb constant (in air)	$k = 8.99 \times 10^{9}$ Nm^{2}c^{-2}

Prefixes/Units

p = pico = 10^{-12}

n = nano = 10^{-9}

μ = micro = 10^{-6}

m = milli = 10^{-3}

k = kilo = 10^{3}

M = mega = 10^{6}

G = giga = 10^{9}

STUDENT NUMBER Letter

Figures									
Words									

Student Name....………………………...

VCE Physics 2017 Year 12 Trial Exam Units 3/4

Student Answer Sheet

Instructions for completing test. Use only a 2B pencil. If you make a mistake, erase it and enter the correct answer. Marks will not be deducted for incorrect answers.

Write your answers to the Short Answer Section in the space provided directly below the question. There are **20 Multiple Choice** questions to be answered by circling the correct letter in the table below.

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

VCE Physics 2017 Year 12 Trial Exam Units 3/4

SECTION A – Multiple-Choice Questions

(20 marks)

Instructions for **Section A**
Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.
Choose the response that is **correct** or that **best answers** the question.
A correct answer scores **1**; an incorrect answer scores **0**.
Marks will **not** be deducted for incorrect answers.
No **marks** will be given if more than one answer is completed for any questions.
Take the value of g to be 9.8 ms^{-2}.

Question 1
An asteroid has a mass of 7×10^{20} kg and its radius is 500 km. The gravitational field strength at the surface is equal to

A. g = 9.8 N kg^{-1}
B. g = 9.34×10^{4} N kg^{-1}
C. g = 1.9×10^{5} N kg^{-1}
D. g = 0.19 N kg^{-1}

Question 2
An alpha particle ($^{4}_{2}He^{2+}$) passes between two charged plates with an electric field strength of 5000 Vm^{-1}. What is the magnitude of the force exerted on the alpha particle?

A. F = 8.0×10^{-16} N
B. F = 1.6×10^{-15} N
C. F = 5000 N
D. F = 1.0×10^{4} N

Question 3
A small sphere carries a positive charge of 2×10^{-6} C. It is placed 20 cm from another small sphere with a negative charge of 1×10^{-7} C. You may assume that k = 9.0×10^{9}. What is the magnitude of the force between the spheres?

A. F = 4.7×10^{5} N
B. F = 4.5×10^{-6} N
C. F = 0.045 N
D. F = 9.0×10^{-3} N

Refer to the following information to respond to Questions 4 to 6.
A physics student moves the north pole of a strong bar magnet swiftly into a copper coil in the direction shown in **Figure 1**. The copper coil has 5 turns and a diameter of 4.0 cm and the magnet has a uniform magnetic field strength of 0.010 T at its poles.

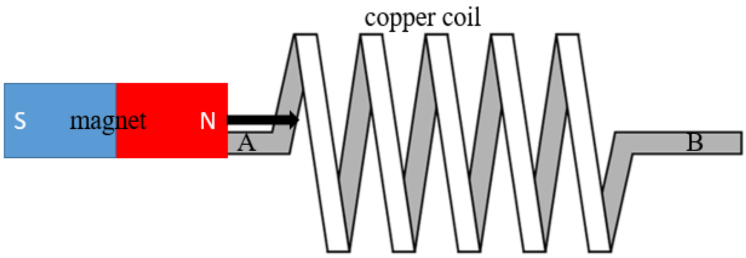


Figure 1

Question 4
Which of the following correctly describes the direction of the current induced in the copper coil and the length of time the induced current would last?

A. From A to B and it would occur continuously.
B. From A to B and it would occur for an instant only.
C. From B to A and it would occur continuously.
D. From B to A and it would occur for an instant only.

Question 5
The time taken to move the north pole of the magnet into the coil is 30 ms. What is the magnitude of the average induced emf in the copper coil?

A. 0 V.
B. 2.1 mV.
C. 21 mV.
D. 2.1 V.

Question 6
The magnet is removed from inside the coil and then flipped so that the south pole is where the north pole was before. The south pole of the magnet is then moved into (same direction as in **Figure 1**) and then out of the copper coil. Which of the following correctly describes what would be observed?

A. The induced current will flow from A to B, stop and then flow from B to A.
B. The induced current will flow from A to B for an instant only and then stop.
C. The induced current will flow from B to A, stop and then flow from A to B.
D. The induced current will flow from B to A for an instant only and then stop.

Question 7
Which of the following statements best describes the purpose of the slip rings in the configuration shown in **Figure 2**?

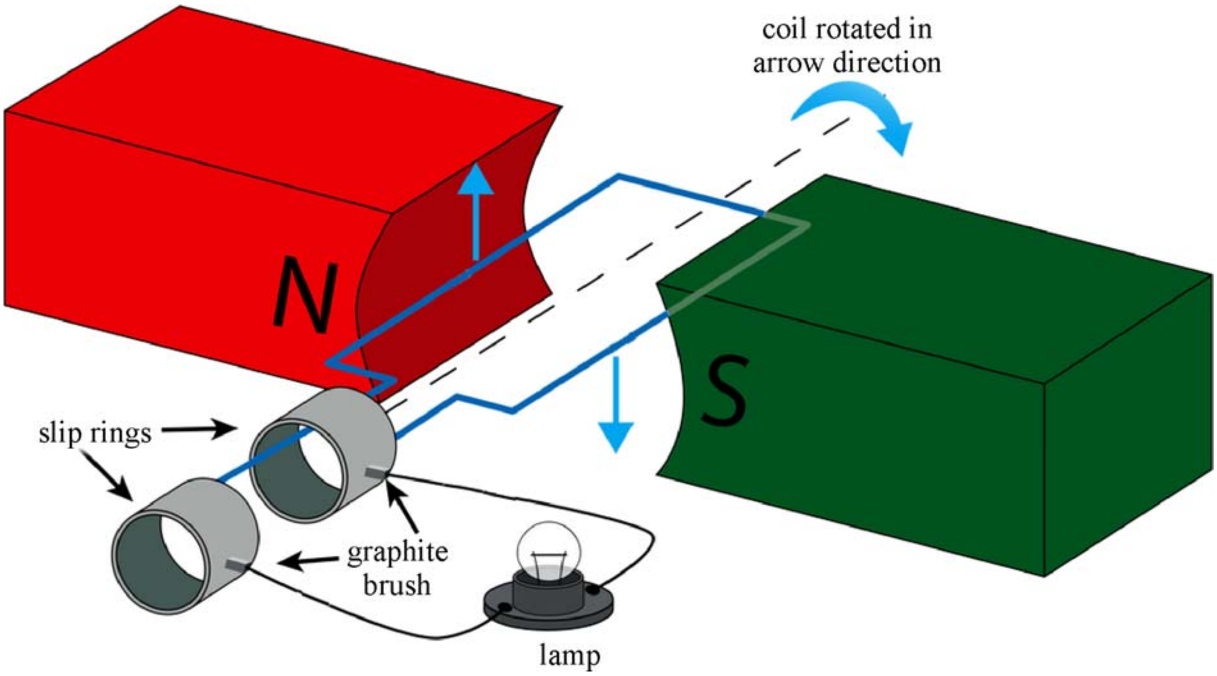


Figure 2

A. To ensure that the coil keeps moving in the same direction.
B. To ensure the current stops flowing when the graphite brush is in contact with the slip rings.
C. To ensure an AC current passes through the lamp as the coil rotates in the same direction.
D. To ensure a DC current passes through the lamp as the coil rotates in the same direction.

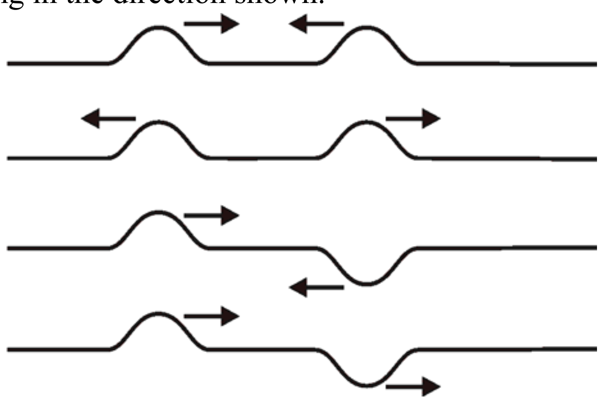
Question 8
The number of muons reaching the Earth's surface greatly differs from the expected result using Newtonian mechanics. Choose the **best** explanation for this.
A. Far more muons reach the Earth's surface because of time dilation.
B. Far fewer muons reach the Earth's surface because of time dilation.
C. Far more muons reach the Earth's surface because muons travel at close to the speed of light, so the muon's frame of reference experiences time dilation and the ground viewer experiences length contraction.
D. Far fewer muons reach the Earth's surface because muons travel at close to the speed of light, so the muon's frame of reference experiences length contraction and the ground viewer experiences time dilation.

Question 9
A 1 tonne car traveling east at 20 ms^{-1} hits a hay wagon of 3 tonnes at rest. They are locked together after collision, and continue to move east. The collision is
A. elastic, because momentum is conserved.
B. inelastic, because kinetic energy is not conserved.
C. elastic, because kinetic energy is conserved.
D. inelastic, because momentum is not conserved.

Question 10
The mass of a hydrogen atom is 1.008 atomic units, while the mass of a helium atom is 4.003 atomic units. If 1 atomic unit has an actual mass of 1.66×10^{-27}kg , what is the energy released when four hydrogen atoms fuse to make 1 helium atom?
A. 4.3×10^{-12} J
B. 4.8×10^{-29} J
C. 936 MeV
D. 0.29 MeV

Question 11
Which of the diagrams below represents an arrangement where complete destructive interference can occur along a rope. All waves are identical in shape, symmetrical and travelling in the direction shown.

A.
B.
C.
D.



Question 12
Two students are hiding behind a thick stone wall in their country school. A teacher passes by and can clearly hear them talking quietly about the upcoming exams. Which answer below explains why the teacher can clearly hear the students even though the teacher cannot see them?
A. Sound is a transverse wave.
B. The students' conversation is refracted by the stone wall.
C. Diffraction around the wall allows the conversation to be heard.
D. The students' conversation is reflected by the stone wall.

Question 13
A neighbour starts his ride on mower at 7.00 am on a Sunday morning; the mower lets out a long steady sound. An English teacher is lying in bed trying to work out which neighbour has started his gardening so early. He listens to the noise and finds the frequency rises and then falls.
Which situation would account for the frequency rising and falling?

A. The mower is behind the teacher's house.
B. The mower travels past the teacher's house.
C. The mower travels towards the teacher's house and then away from the house.
D. The mower travels towards the teacher's house.

Question 14
Young's double slit experiment is evidence for

A. quantum theory of light.
B. polarisation of light.
C. tranvervse nature of light.
D. the wave properties of light.

Question 15
Which of the following light phenomena cannot be explained by the pure wave model of light?

A. Refraction.
B. The photo electric effect.
C. Reflection.
D. Diffraction.

Question 16
The threshold frequency of platinum lies in the ultraviolet region of the electromagnetic spectrum.
In an investigation of the photoelectric effect, ultraviolet light of a set intensity is found to cause the photoelectric effect from a platinum surface. The ultraviolet light is replaced by infrared light of the same intensity. What will happen?

A. The same number of electrons will be emitted with the same range of energies.
B. No electrons will be emitted.
C. The same number of electrons will be emitted with a reduced range of energies.
D. Fewer electrons will be emitted with the same range of energies.

Question 17
The photoelectric effect is evidence for the

A. transverse nature of light.
B. quantum theory of light.
C. wave properties of light.
D. polarisation of light.

The following information relates to Questions 18 to 20.

Some physics students needed to find the best method for measuring the extension of a stiff spring hanging on a metal rod between two retort stands that were securely clamped to the top of a bench as shown in **Figure 3**. The following equipment was proposed:

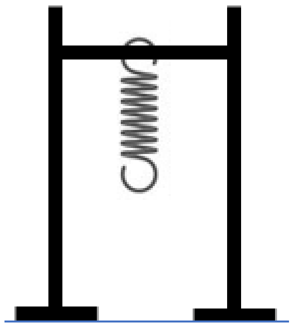


Figure 3

Mandy suggested using a 30 cm long metal ruler. Its smallest scale division was 1mm.

Tyler suggested using a 30 cm long metal ruler. Its smallest scale division was 0.5 mm along one side of the ruler.

Susan suggested using 150 mm Vernier callipers. Their smallest scale division was 0.02 mm.

Sam suggested using a measuring tape. Its smallest scale division was 0.5 cm.

The students chose one of these pieces of equipment and proceeded to measure the length of the un-stretched spring. The measurement was recorded as 61.75 ± 0.40 % mm in their log book.

Question 18

Based on the information provided, the most likely equipment used was

A. Mandy's ruler.
B. Tyler's ruler.
C. Susan's callipers.
D. Sam's measuring tape.

Question 19

Which of the suggested pieces of equipment would produce the most precise results?

A. Mandy's ruler.
B. Tyler's ruler.
C. Susan's callipers.
D. Sam's measuring tape.

Question 20

Mandy and Susan proceeded to measure the length of the spring using the chosen equipment. Masses in 100 g increments were added to the hook at the base of the spring. They then subtracted the original length of the spring from the extended length to calculate the extension of the spring as more masses were added to the spring. Which of the following statements is correct?

A. The percentage uncertainty in the calculated extension will now be zero.
B. The percentage uncertainty in the calculated extension value will be lower than the uncertainty in the measurement of the un-stretched spring.
C. The percentage uncertainty for the calculated extension will be the same as the uncertainty in the measurement of the un-stretched spring.
D. The percentage uncertainty for the calculated extension will now be higher than the uncertainty in the measurement of the un-stretched spring.

End of Section A

VCE Physics 2017 Year 12 Trial Exam Units 3/4

SECTION B – Short Answer Questions

(130 marks)

Instructions for Section B
Answer **all** questions in the space provided. Write using blue or black pen.
Where an answer box is provided, write your final answer in the box.
If an answer box has a unit printed in it, give your answer in that unit.
In questions where more than one mark is available, appropriate working **must** be shown.
Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.
Take the value of g to be 9.8 ms^{-2}.

Question 1 (10 marks)

The space ship Deep Space Twelve has a mass of 3.0×10^{12} kg . It may be assumed to be spherical, uniform in density, and the distance from the space ship's centre to the surface of the space ship is 6.0 km. Captain Diana Galt stands on the surface. She and her space suit have a combined mass of 180 kg.

a. Calculate the gravitational field strength due to the space ship at the surface of Deep Space Twelve. **1 mark**

b. Captain Galt pushes off lightly from the surface of the space ship and rises with an initial velocity of $0.033\ ms^{-1}$. What is the **maximum** height she will reach above the station? **1 mark**

c. On the graph provided in **Figure 1**, sketch a graph showing Captain Galt's gravitational potential energy PE above the surface of Deep Space Nine against her height above the surface. For this part, you may assume that the gravitational field strength is constant. On the same axes, sketch her kinetic energy against her height above the surface and label this curve E_K. **2 marks**

Figure 1

d. In fact, the gravitational field strength will vary with distance. Calculate the strength of the gravitational field at her highest point. **2 marks**

Nkg^{-1}

e. Captain Galt wants to examine the surface of the ship, so she engages a small hand-held power-pack for a moment and puts herself into a stable orbit around the ship at her maximum height. (Use your answer to **d** for this question.) At what speed will she orbit around the ship, and what is her period of revolution? **4 marks**

ms^{-1}

s

Question 2 (6 marks)
In a particle accelerator, a beam of electrons passes between two metal plates 10 cm apart as shown in **Figure 2** and then passes through a magnetic field with field lines coming out of the page. The potential difference between the plates is 4555 V. The magnetic field has a strength of 0.025 T.

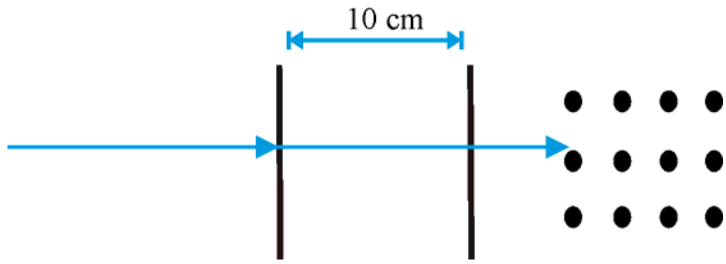


Figure 2

a. Calculate the strength of the electric field between the two plates. **2 marks**

Vm^{-1}

b. In which direction will the electrons be deflected once they enter the magnetic field? **1 mark**

c. Calculate the speed of the electrons as they enter the magnetic field. (You may assume they were at rest before entering the electric field, and you may also ignore relativistic effects.) **2 marks**

ms^{-1}

d. What is the speed of electrons after they exit the magnetic field? **1 mark**

ms^{-1}

Question 3 (4 marks)
A DC motor consists of a square loop of 200 turns and side length 4.0 cm, a commutator, a uniform magnetic field of 0.05 T, a battery pack of 9.0 V and a current of 1.5 A, as shown in **Figure 3**.

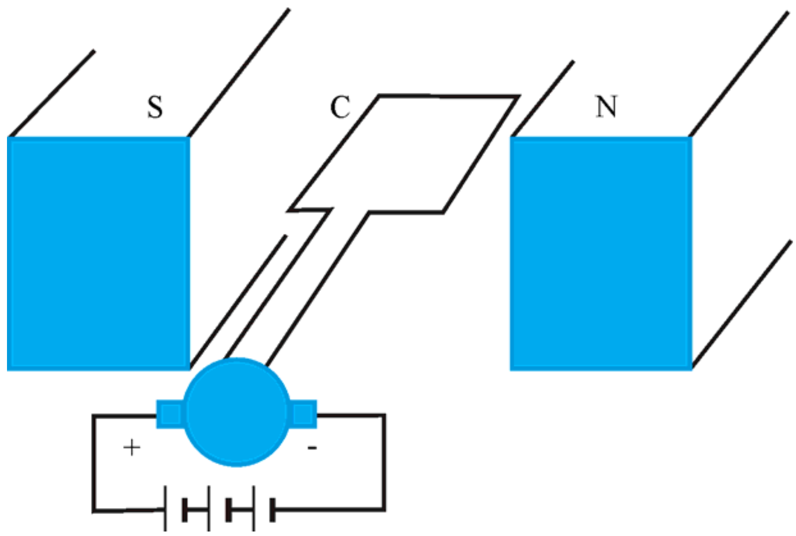


Figure 3

a. Explain the role of the commutator in this motor. **2 marks**

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b. **i.** On **Figure 3**, draw an arrow to show the direction of the magnetic force on side C. **1 mark**

ii. Calculate the magnitude of the magnetic force acting on side C. **1 mark**

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N

Question 4 (5 marks)

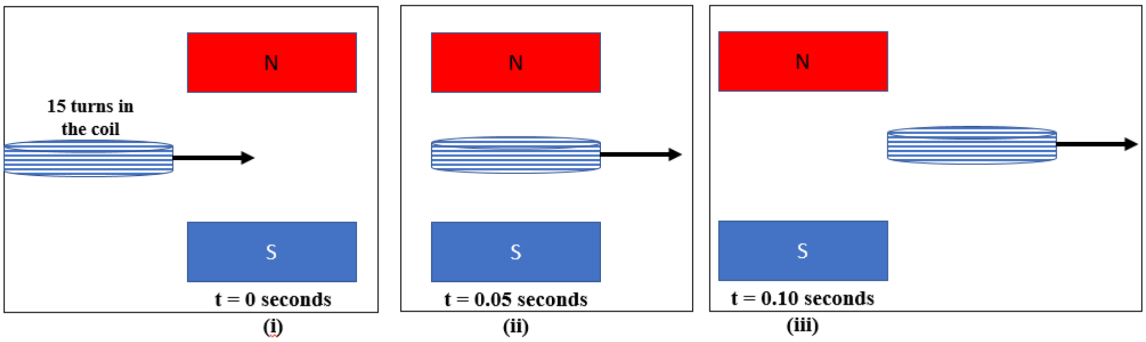

Figure 4a

Figure 4a shows a circular copper coil with 15 turns as it moves through a uniform magnetic field over a 0.10 second time interval. The area of the copper coil is 50 cm^2 and the magnetic field strength is 8.5×10^{-4} T.

a. Calculate the magnitude of the average emf induced in the coil as it moves from position (i) to (ii) in **Figure 4a**. **2 marks**

	V

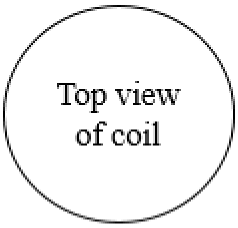

Figure 4b

b. Draw arrows on **Figure 4b** to indicate the direction of the current induced in the coil as it moves from (i) to (ii). **1 mark**

c. Sketch the expected shape of the emf generated in the coil as it moves through the positions (i) to (ii) to (iii) on the axes below in **Figure 5**. **2 marks**

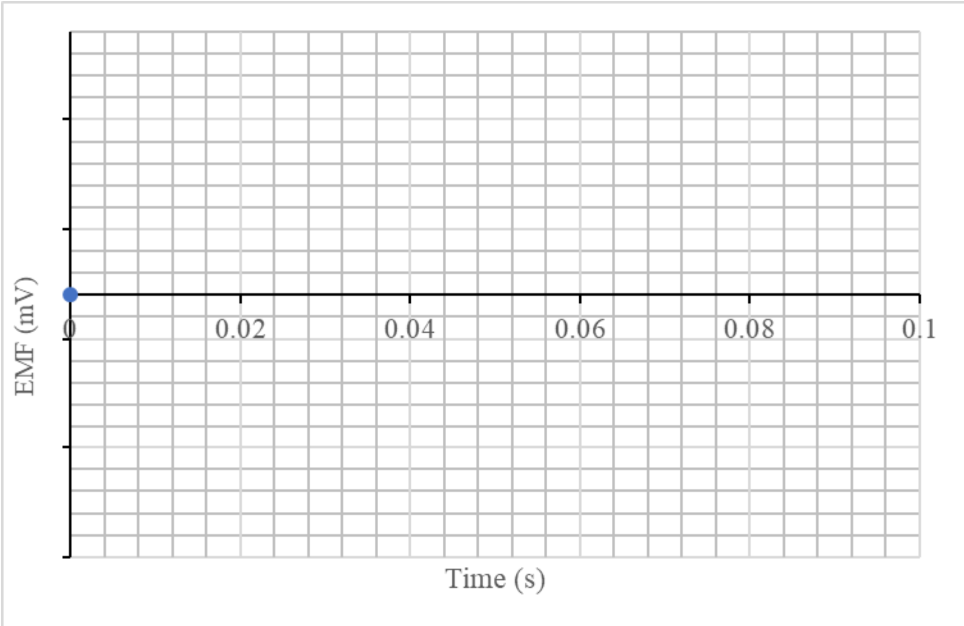

Figure 5

Question 5 (2 marks)

A split ring commutator is sometimes used in the configuration of an electricity generator. Explain the reason why a split ring commutator would be used in a generator and describe the nature of the electricity generated when it is. **2 marks**

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Question 6 (3 marks)
A physics student conducts the following experiment. Firstly, he lets a marble fall inside an aluminium tube and times its fall. He repeats this with a strong magnet as shown in **Figure 6**. The magnet and the marble are equal in size and mass. The marble falls quickly down the tube. The magnet takes more than twice as long as the marble to fall through the tube. He repeats the experiment and watches each object fall through the tube. This time, he notices the magnet appears to 'float' its way down, much like a leaf falling from a tree.

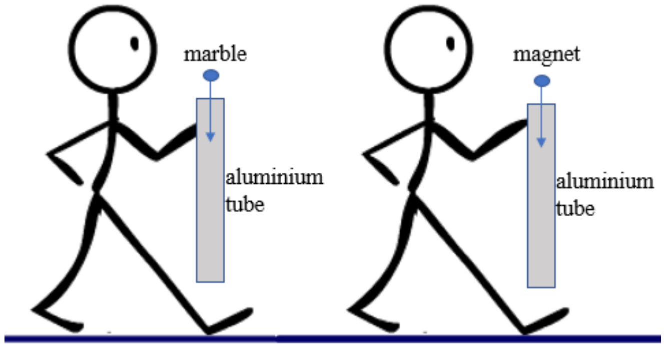

Figure 6

Use your understanding of electromagnetic induction to explain the student's observations. **3 marks**

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Question 7 (3 marks)
The current and emf produced by a small generator is measured and graphed over a 1.0 millisecond time interval as shown in **Figure 7**.

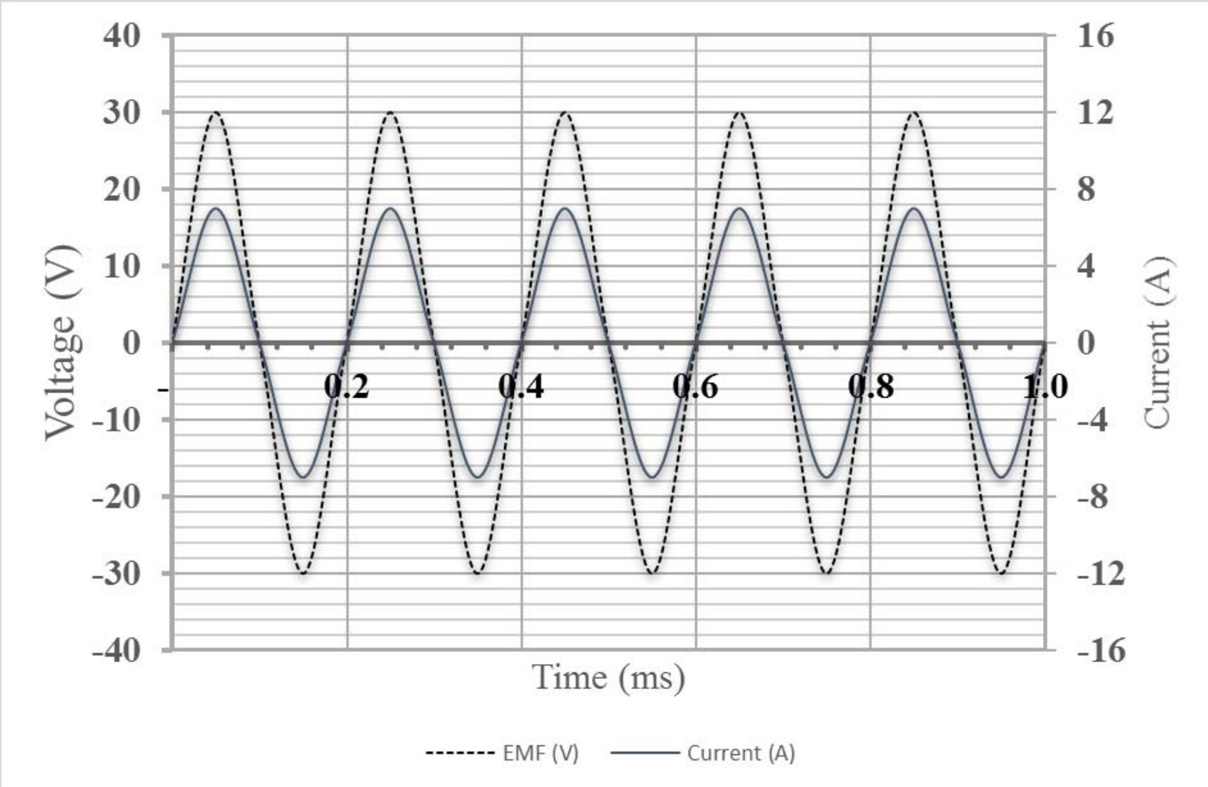

Figure 7

a. Calculate the RMS Power output of this generator. **2 marks**

W

b. Determine the frequency of rotation for the coil in this generator. **1 mark**

Hz

Question 8 (2 marks)
A plug-in mobile phone charger contains a transformer that will transform the 240 V RMS AC power at the wall into 5.0 V RMS AC before converting it to DC to charge the phone.

Assuming the transformer is an ideal one, calculate the ratio $\frac{\text{current at wall}}{\text{current into phone}}$ for this transformer. **2 marks**

Question 9 (6 marks)

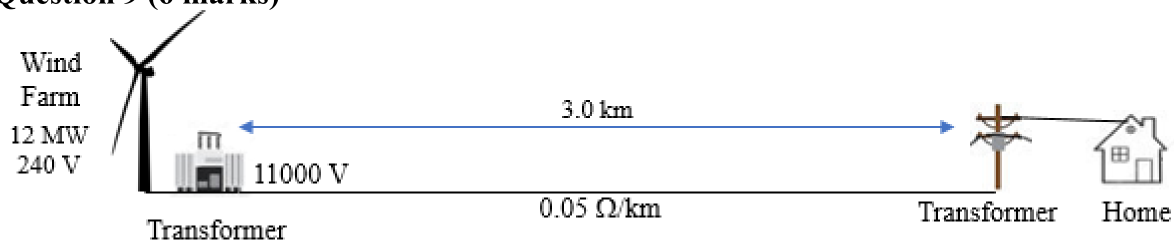

Figure 8

The Wonthaggi wind farm is located 3.0 km away from the town of Wonthaggi and generates 12 MW of power at 240 V RMS AC. The electricity generated is then increased to 11000 V RMS AC with a step-up transformer and connected to the town's electricity supply through an underground cable, as shown in **Figure 8**. The resistance of the underground cable is rated at 0.05 Ω/km.

a. Calculate the RMS current in the underground cables. **2 marks**

A

b. Explain why the electricity is transmitted to the town by stepping up the voltage at the generator. **2 marks**

c. Calculate the percentage loss of power in the underground cables. **2 marks**

%

Question 10 (6 marks)
Subatomic particles are travelling straight towards the ground from deep space at $0.98\ c\ ms^{-1}$ from a frame of reference on the Earth's surface. When at rest they decay with a half-life of 1.0×10^{-6} s.

a. Calculate γ for this relativistic speed. **1 mark**

b. These particles are counted at the Earth's surface, and again in an underground cave 1.0 km beneath the surface of the Earth. These particles pass without slowing down through the Earth's mantle. Calculate the particles' half-life as measured by a stationary observer in the cave. **1 mark**

s

c. From the particles' frame of reference, calculate the depth of the cave. **2 marks**

m

d. Explain why more of these particles appear in the cave than you would expect from the half-life when at rest. **2 marks**

Question 11 (11 marks)

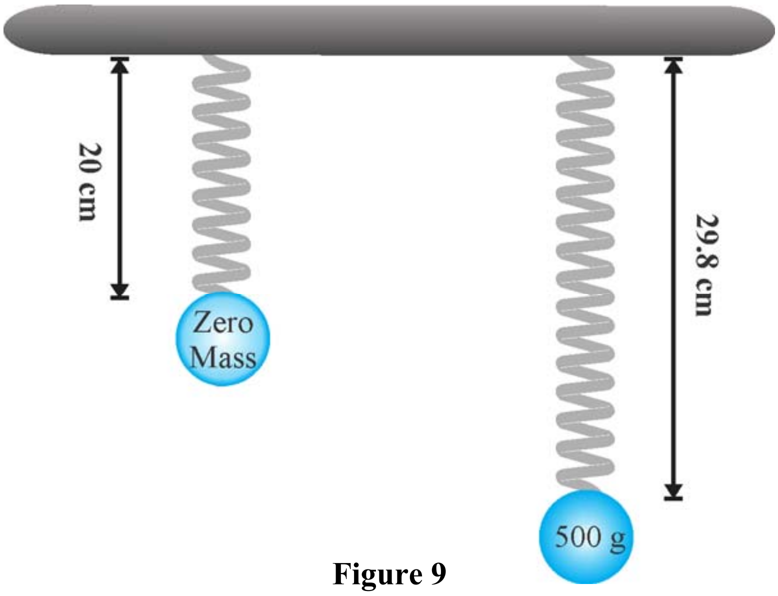

Figure 9

a. A 20 cm spring hangs vertically as shown in **Figure 9**. When a 500 g mass is added to it, the spring is now 29.8 cm. Determine the spring constant. **2 marks**

Nm^{-1}

b. A toy car with mass 2.0 kg is released from the top of a slope at A, as shown in **Figure 10**. It runs across the floor and compresses the spring from **Question 11a**. Ignoring the effects of friction, calculate the speed of the car across the floor between B and C. **2 marks**

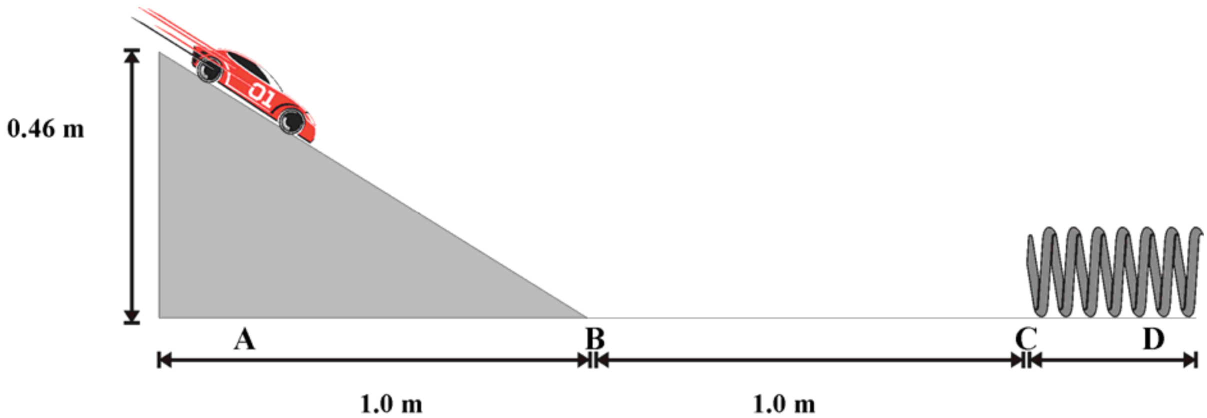

Figure 10

ms^{-1}

c. Calculate the distance from C to D, where D is where the car comes to rest temporarily after it has compressed the spring. **2 marks**

m

d. On **Figure 11**, graph the kinetic energy of the car against distance from point A through B, C and D. You will need to locate and label position D correctly on the axis. **2 marks**

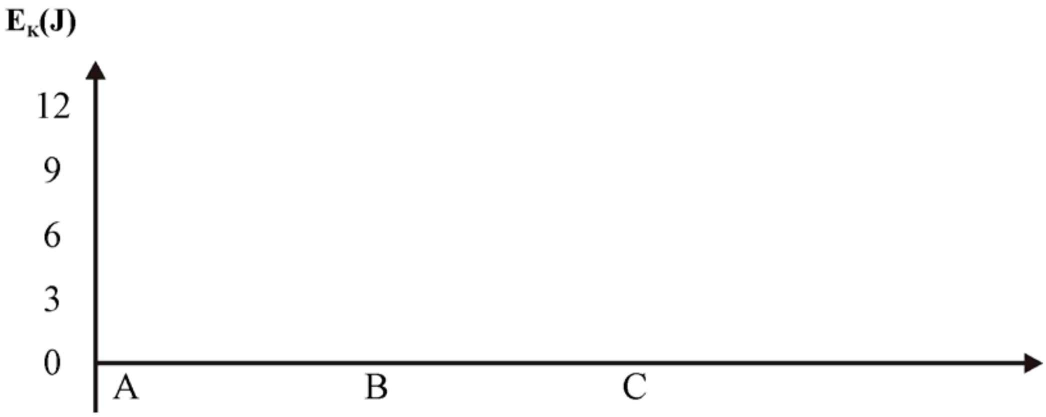

Figure 11

The same car is released from the top of **another** slope and runs through a vertical loop as shown in **Figure 12**. The diameter of the loop is 0.50m.

Figure 12

e. What is the minimum height from which the car in **Figure 12** is released so it traverses the loop without falling off the track? **3 marks**

m

Question 12 (6 marks)

A 3.0 tonne truck travelling at 10 ms^{-1} hits a 1.0 tonne barrier and sticks to it. The collision lasts for 0.5 s.

a. How fast does the barrier travel immediately after the collision? **2 marks**

ms^{-1}

b. What is the average force exerted by the barrier on the truck? **1 mark**

c. The two bodies slow to a complete stop after another 4.0 s due to frictional forces. How far do the two bodies travel before they stop? **2 marks**

N

d. The actual force used may be modelled by the following graph. Explain how the graph can be used to calculate the work done by the opposing forces on the truck and include calculations with your answer. **1 mark**

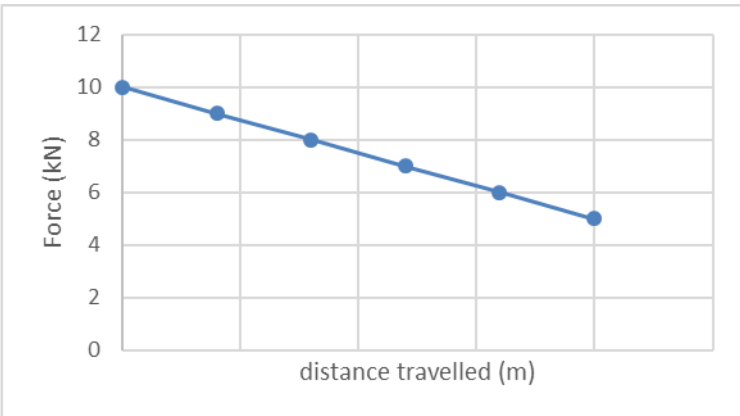

Figure 13

Question 13 (5 marks)
A 15 kg extremely strong border collie throws a ball (mass 50 g) horizontally with a velocity of 80 ms^{-1}.

a. Determine what limit of uncertainty is placed on the measurement of the position of the dog's ball, by the Heisenberg uncertainty principle of the uncertainty in measuring velocity is 0.01 ms^{-1}. Note that the uncertainty in the mass is negligible. **3 marks**

m

b. Explain why it is inappropriate to apply the Heisenberg uncertainty principle to either the dog or the ball in this instance. **2 marks**

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Question 14 (2 marks)
Explain the importance of the equation E=hf. **2 marks**

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Question 15 (2 marks)
Calculate the energy, in electron volts, of a photon of green light with a wavelength of 546 nm. **2 marks**

eV

Question 16 (2 marks)
Determine the de Broglie wavelength of a 0.2 g mass moving at 20 ms^{-1} in air. **2 marks**

m

Question 17 (4 marks)
Two physics students are busily studying light and waves; they decide to do an experiment investigating the photoelectric effect. They find that the metal surface they are using does not have any photoemissions for light with a frequency of less than 1.2×10^{15} Hz. The students increase the frequency to 2.0×10^{15} Hz. They find that it takes a retarding voltage of 3.0 V to cut off the photocurrent and therefore the most energetic electrons have 4.8×10^{-19} J.

a. Determine the value of Planck's constant using a graph of the students' results. **2 marks**

Js

b. Using the students' experimental results, estimate the work function, in joules, for the metal they are using. **2 marks**

J

Question 18 (6 marks)
Some students are revising for the upcoming exam. They have the following questions they would like your help with.

a. Explain what is meant by the dual nature of light. **2 marks**

b. Explain why we accept the dual nature of light. **2 marks**

c. Explain how the photoelectric effect does **not** support the wave theory of light. **2 marks**

The following information relates to Question 19.
A periodic wave has a period of 0.5s.

Question 19 (5 marks)

a. Calculate the wave's frequency. **2 marks**

Hz

b. How many waves will pass a fixed point in 4 seconds? **1 mark**

waves

c. Find the speed of a wave that has a frequency of 120 Hz and a wavelength of 3.0 m. **2 marks**

ms^{-1}

Question 20 (2 marks)
A student throws a stone into a calm pool that he passes every day on the way to school.

Clearly describe the energy changes that will occur with the stone and pool. **2 marks**

Question 21 (3 marks)
Explain the similarities and differences between transverse and longitudinal wave motion. **3 marks**

Question 22 (2 marks)
Describe the relationship between the critical angle of a substance and the total internal reflection of the light in that substance. **2 marks**

Question 23 (2 marks)
Explain why a rectangular prism is difficult to use to disperse white light to produce a spectrum. *Include a diagram in your answer.* **2 marks**

*Use **Figure 14** to answer Question 24a.*

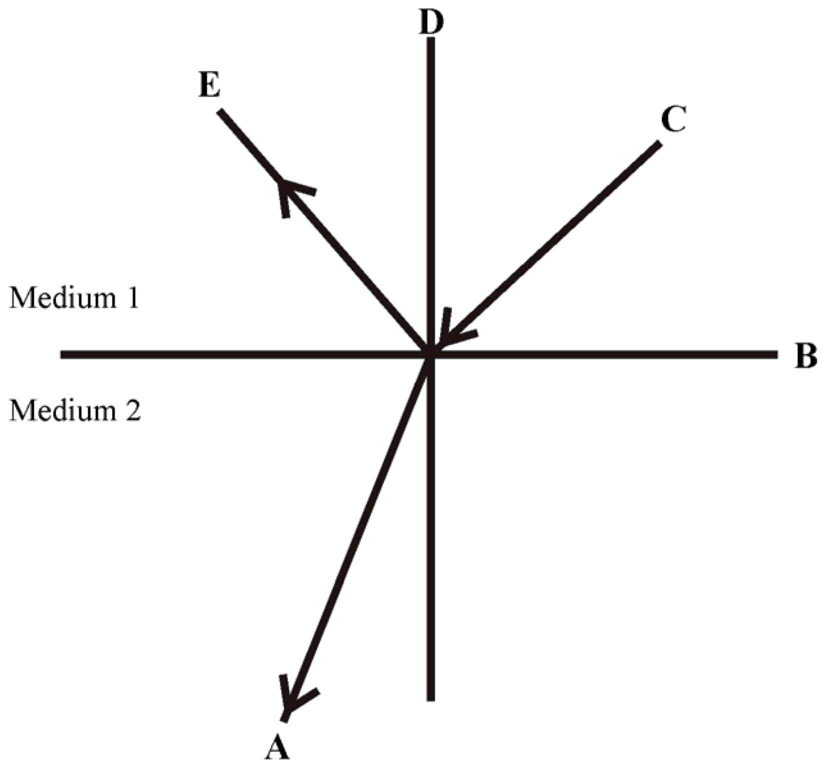

Figure 14

Question 24 (4 marks)

a. Write the corresponding name for each letter in **Figure 14**. Use the following words to help you: **2 marks**

- Boundary
- Normal
- Reflected ray
- Incident ray
- Refracted ray

***Figure 15** refers to Question 24b.*

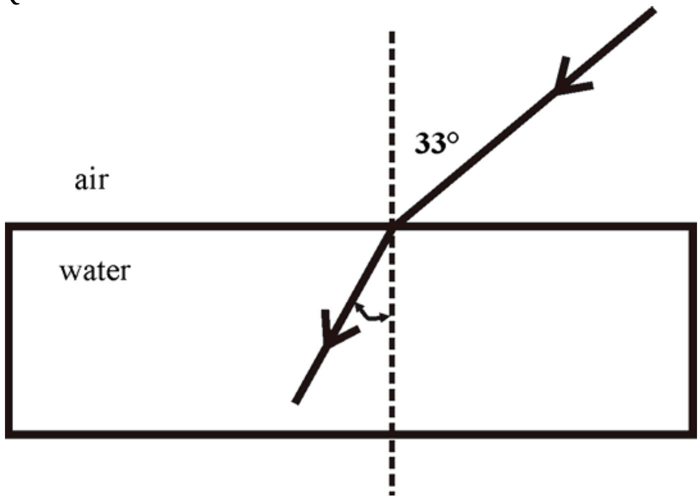

Figure 15

b. Calculate the angle of refraction in the situation in **Figure 15** where a beam of light is passed from air (n=1) to water (n=1.3). **2 marks**

°

Question 25 (2 marks)

A couple of physics students are at a Sunday market looking to buy some cheap sunglasses. They have taken an expensive pair of polarised glasses with them to help them check that the cheap glasses they buy will actually have polarising lenses. Explain how they would use these polarised glasses to check the polarising ability of the cheap sunglasses. **2 marks**

Question 26 (2 marks)

Young's Double Slit experiment provides evidence that supports the wave like nature of light. Explain how it does this. **2 marks**

Question 27 (11 marks)

Figure 16

An analogue ammeter must have a needle that is able to move when a current is passed through it (**see Figure 16)**. The greater the current, the greater the movement of the needle.
Jordan, a physics student, attempted to build a model for the ammeter to explain how it works.

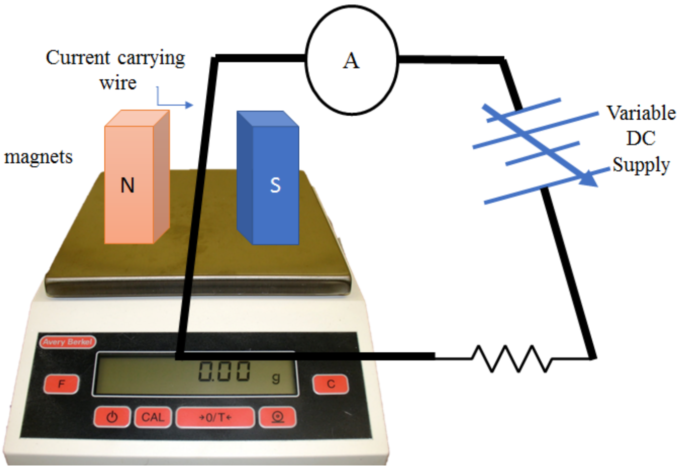

Figure 17

Jordan used a current carrying wire positioned at right angles to a uniform magnetic field configured as shown in **Figure 17**. The magnets and the current carrying wire were placed on electronic scales which were then zeroed. When Jordan switched on the power source, he was able to measure the current through the wire with the ammeter and determine the force in the current carrying wire by taking the mass reading on the electronic scales. The mass was used to calculate the force experienced by the wire by multiplying the mass (in kg) by a factor of 9.8 N/kg.
By increasing the supply voltage, Jordan was able to increase the current through the wire. Jordan changed the voltage 6 times and recorded the observed mass and ammeter reading each time. He then calculated the force for each mass value and plotted the calculated force against current. Jordan drew a line of best fit through the data, as shown in **Figure 18**

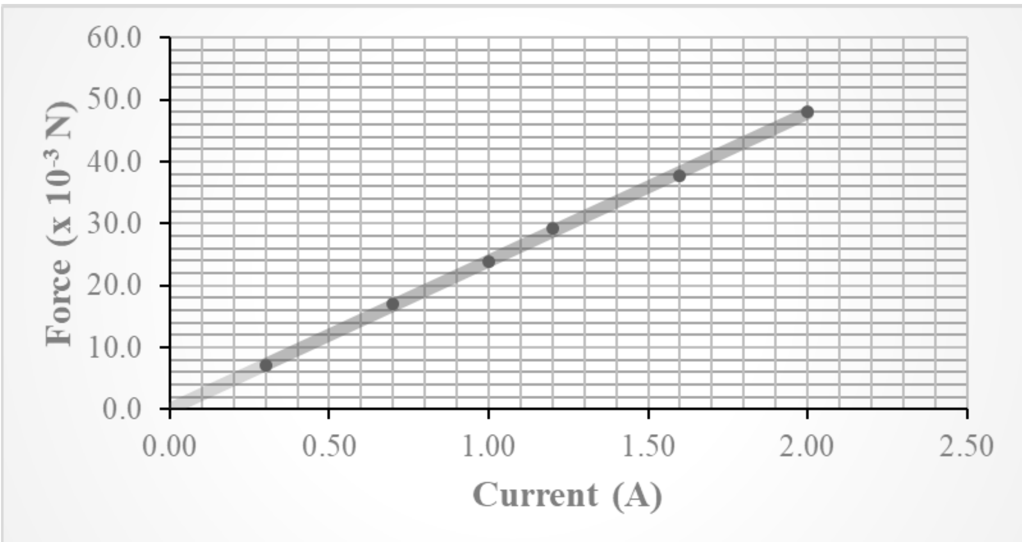

Figure 18

a. From the information provided in the experiment description above, determine the following variables. Explain your answer in each case.

i. independent variable(s) **1 mark**

___

ii. dependent variable (s) **1 mark**

___

iii. control variable(s) **1 mark**

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b. Describe the relationship between the variables, force and current, from the information provided in the graph. **1 mark**

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___

c. The students extended the line of best fit to the origin. Were they correct to do so? Explain your answer. **2 marks**

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d. Using the standard symbols for force and current, derive an equation expressing force in terms of current for this graph. **3 marks**

e. Do the results observed explain the working of the ammeter. Explain your answer. **2 marks**

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Question 28 (9 marks)

The Juno space probe entered orbit around the planet Jupiter, at an orbital height of 4300 m on the 4th July 2017. One keen scientist at NASA, known as The Doctor, noticed that one of Juno's solar panels had become loose on the probe's surface as it entered the orbit, and he decided to switch one of the many cameras on Juno to observe the panel. Not long after, the panel falls off the surface of the probe and falls towards the surface of Jupiter. The data from the fall are collected by the tracking camera and transmitted to The Doctor. The data are provided in **Table 1**.

Time (s)	Height (m)
0.0	4300
3.0	4183
6.0	3832
9.0	3247
12.0	2428
15.0	1375

Table 1

a. Plot the data in **Table 1** on the graph in **Figure 19** below. **1 mark**

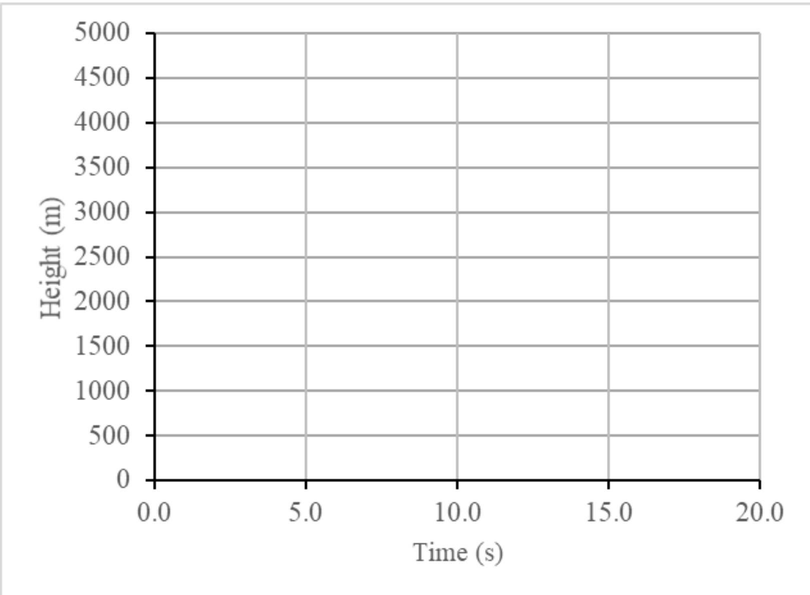

Figure 19

b. Describe the relationship between height and time based on the information provided. **2 marks**

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Unfortunately, The Doctor misplaced his sonic screwdriver. The screwdriver can do anything including determine the relationship between two variables in a graph. The Doctor, being ever resourceful and canny, thinks he can determine the relationship between height and time using a graphical method. He calculates time squared and produces the graph in **Figure 20**

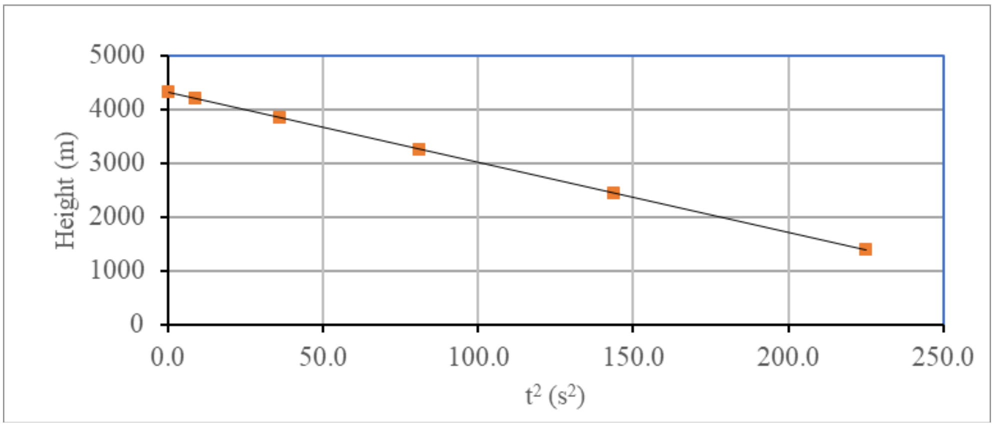

Figure 20

c. Explain why The Doctor was correct to graph height against t^2. **1 mark**

d. Derive an equation describing the relationship between height and time. **2 marks**

e. Explain the significance of the constants you derived in the equation in **Question 28d**. **2 marks**

f. Use your equation to predict the time when the solar panel will reach Jupiter's surface. **1 mark**

s

Question 29 (2 marks)
James completed an experiment and found that his observations agreed with his hypothesis. In his concluding statement, he writes: "It was found that the results prove the hypothesis."
What is the problem with James' statement? Explain your answer. **2 marks**

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Question 30 (1 mark)
When Harriet prepared her Physics poster for her Extended Practical Investigation, she included a discussion of the errors in her experiment. In this section, she described the fact that she misread the scale on the ammeter for two of her readings and stated this was an example of human error which contributed to the experimental error.
When her teacher marked her poster, she had to deduct a mark for the incorrect statement.

Explain why Harriet's explanation would have lost her a mark. **1 mark**

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End of Section B

End of Trial Exam

Suggested Answers

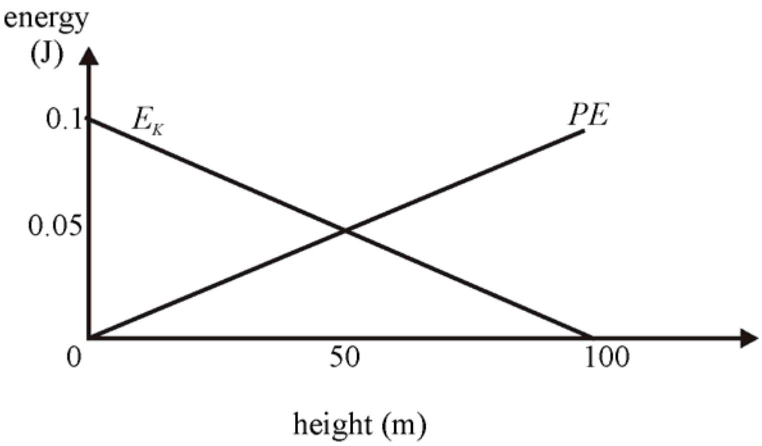
VCE Physics 2017 Year 12 Trial Exam Units 3/4

SECTION A – Multiple Choice Answers

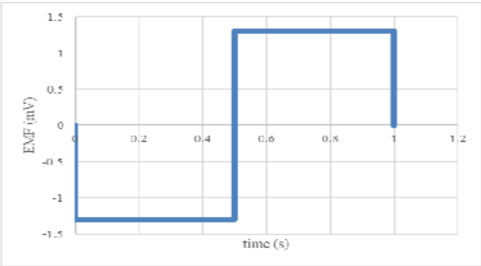
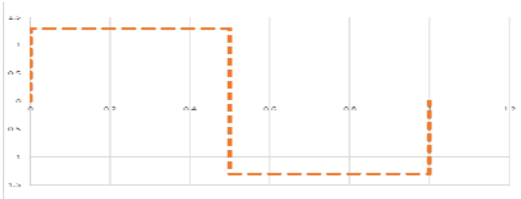
Question		Marks
1	**D** A only applies at the Earth's surface. B omits to square the radius and C assumes 500 m instead of 500 km.	1
2	**B** A assumes that there is only one elementary charge. C and D assume the elementary charge equals 1 rather than 1.6×10^{-19}C.	1
3	**C** A is obtained by adding the charges instead of multiplying. B is for those who mistake cm for m. D omits the square in the denominator.	1
4	**D** Using the Right Hand Grip Rule, the induced current in the coil would act to oppose the increasing magnetic flux going into the coil, so the current would be directed from B to A. Unless the magnet is moved outwards again (and this is not the case) then the induced current would stop as there is no more changing flux.	1
5	**B** Using $\varepsilon = -N\dfrac{\Delta\phi_B}{\Delta t}$ where $\phi_B = BA$ and $A = \pi\times0.02^2$ so $\varepsilon = -5\times\dfrac{(0.010\times\pi\times0.02^2)}{(30\times10^{-3})} = -2.1\times10^{-3}$ V (negative sign means that the emf is generated to oppose the changing flux).	1
6	**A** The increasing flux is directed out of the coil, so the induced current will move from A to B until the south pole of the magnet is inside the coil. The current then stops and as the magnet is moved outwards again, the current will flow from B to A.	1
7	**C** This is an AC generator and the slip rings allow the brushes to be in constant contact with the coil as the coil rotates in the same direction. Hence, an alternating current passes through the lamp. A DC generator has a split ring commutator instead of the slip rings. This reverses the connection of the coil to the lamp every half turn. As a result, a DC current flows through the lamp.	1

8	**C** A and B are too vague, while D is the wrong way round.	**1**
9	**B** Momentum is always conserved. The two vehicles' combined speed is 5 ms^{-1} afterwards and total momentum remains at 2×10^{4} $kgms^{-1}$. Kinetic energy is 200 kJ before collision, and 50 kJ afterwards.	**1**
10	**A** Mass deficit: $1.008\times4\text{-}4.003$ AU $=0.029$ AU $=4.84\times10^{-29}$ kg Energy released $= mc^2 = 4.3\times10^{-12}$ J B omits the square of the speed of light. C assumes 1 AU has been destroyed. D is the matter deficit with the wrong units.	**1**
11	**C** The waves cancel each other out, hence destructive interference.	**1**
12	**C** An example of diffraction.	**1**
13	**B** and **C** Doppler effect.	**1**
14	**D**	**1**
15	**B**	**1**
16	**B**	**1**
17	**B**	**1**
18	**B** 0.4 % of 61.75 mm is 0.25 mm which is half of the smallest division on Tyler's ruler, a measure of the uncertainty in the measurement using this instrument.	**1**
19	**C** The callipers have the smallest divisions and are therefore more precise and are able to measure down to the nearest 0.02 mm.	**1**
20	**D** The percentage uncertainty is added when two measurements with uncertainties are added.	**1**

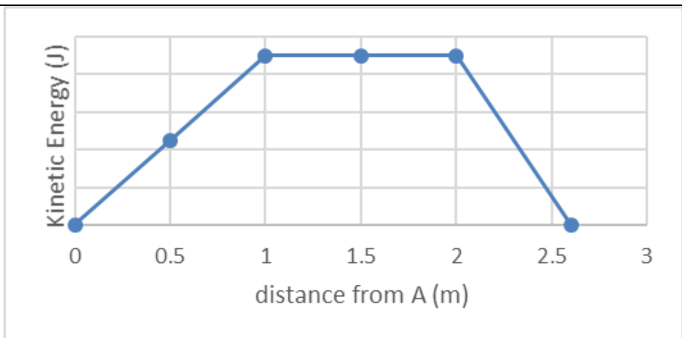
SECTION B – Short Answer (Answers)

Question		Marks
1a	$g=\frac{GM}{r^2}=\frac{6.674\times10^{-11}\times3\times10^{12}}{6000^2}$ $=5.56\times10^{-6}$ N kg^{-1}	**1**
1b	$v^2=u^2+2as$ $\therefore 0=0.033^2-2\times5.56\times10^{-6}\ s$ $\therefore s=\frac{0.033^2}{11.12\times10^{-6}}=100$ m	**1**
1c	 $mg=1.0\times10^{-3}$ N and PE = mgh, so we have a straight line with this gradient. 2.	**2**
1d	It won't be the same, because at 100 m above the surface the gravitational field is weaker: $g=\frac{GM}{r^2}=\frac{6.674\times10^{-11}\times3.0\times10^{12}}{(6.1\times10^3)^2}=5.38\times10^{-6}$ N kg^{-1}	**1** **1**
1e	$a=\frac{v^2}{r}\therefore v=\sqrt{ar}$ $=\sqrt{5.38\times10^{-6}\times6.1\times10^3}$ $=0.18$ ms^{-1} $a=\frac{4\pi^2 r}{T^2}\therefore T=2\pi\sqrt{\frac{r}{a}}$ $=2\pi\sqrt{\frac{6.1\times10^3}{5.38\times10^{-6}}}$ $=211$ s	**1** **1** **1** **1**

2a	Field strength = $\dfrac{4.555\times10^{3}}{0.1}=4.6\times10^{4}\,\text{Vm}^{-1}$ 2nd mark is for correct unit.	**1** **1**
2b	Right-hand slap rule: current goes **left**, magnetic flux out of page, so the force is directed up the page.	**1**
2c	W=qV= 0.5 mv^2 $\therefore v^2=\dfrac{2qV}{m}=\dfrac{2\times1.6\times10^{-19}\times4555}{9.11\times10^{-31}}=1.6\times10^{15}$ $\therefore v=4.0\times10^{7}\,\text{ms}^{-1}$	**1** **1**
2d	Since the magnetic field acts at right angles to the direction of motion, the electrons' speed will be the same as in **c**.	**1**
3a	The commutator is necessary to change the direction of the current at each half-turn. Otherwise the motor would stop in its tracks.	**1** **1**
3bi	The force acts up the page on side C.	**1**
3bii	$F=nIlB=200\times1.5\times0.04\times0.05=0.60N$	**1**
4a	Using ε= -N$\dfrac{\Delta\phi_B}{\Delta t}$ where $\phi_B=BA$ aso ε= -15$\times\dfrac{(8.5\times10^{-4}\times50\times10^{-4})}{0.05}=-1.3\times10^{-3}$ V so magnitude is 1.3×10^{-3} V	**1** **1**
4b	Anticlockwise (induced current will have a magnetic field which opposes the changing flux which is increasing in a downwards direction as coil moves from (i) to (ii).	**1**

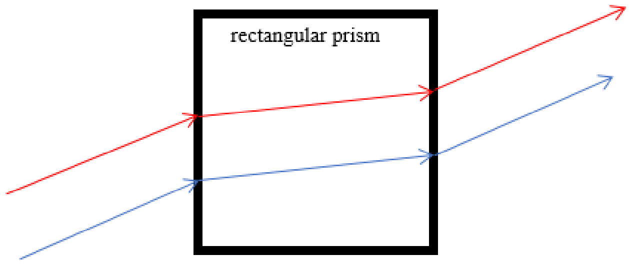
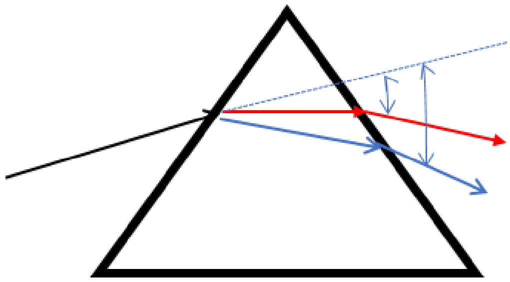
4c	  Either of the above graphs will be correct The reasoning is that the flux is increasing at a constant rate between 0 and 0.5 s, so the emf is the negative gradient of the flux over time for this time interval. Between 0.5 and 1.0 s, the flux is decreasing at a constant rate, so the emf is again the negative gradient of the flux over time for this interval. Value equals average magnitude calculated in **Question 4a**.	**2**
5	A split ring commutator is used in an electricity generator to change the connection to the load that is attached to the generator every half turn. This results in a DC current through the load.	**1** **1**
6	The marble is subject to only one force acting on it during its fall – the force of the earth's gravity acting downwards. The magnet is subject to two forces acting on it during its fall: • the force of the earth's gravity acting downwards (same magnitude as the force on the marble). • an upward force resulting from the current induced in the aluminium tube which will act to oppose the increasing magnetic flux in a downwards direction that induced the current in the first place– this is an example of Lenz's law in action. The net force on the magnet means that it will fall at a rate of acceleration much less than the acceleration due to the earth's gravity.	**1** **1** **1**
7a	$P_{RMS} = V_{RMS} \times I_{RMS}$ $= \frac{1}{2} V_P I_P$ $= \frac{1}{2} \times 30 \times 7.2$ $= 108\ \text{W}$ Should be able to divide 4 units by 5 divisions to arrive at 7.2.	**1** **1**

7b	1 period of rotation is 0.2 ms - read from the graph $\therefore\ f = \frac{1}{T} = \frac{1}{(0.2\times10^{-3})} = 5000\ \text{Hz}$	**1**
8	From the transformer equation, $\frac{\text{current at wall}}{\text{current into phone}} = \frac{5.0}{240} =$ $1:48$ or 2.1×10^{-2}	**1** **1**
9a	$\frac{I_2}{I_1} = \frac{V_1}{V_2}$ and $I_1 = \frac{P}{V_1}$ $I_2 = \frac{P}{V_2}$ $= \frac{12\times10^6}{11000}$ $= 1.09\times10^3\ \text{A}$	**1** **1**
9b	The underground cables are not perfect conductors so there will be energy lost during the transmission of electricity from the generator through the cables which have resistance, albeit a low amount. The amount of energy transformed from electrical energy into heat (measured as potential difference) will be the product of the current through the cable and the resistance across the length of cables. Given that the initial current is quite high, this amount of energy is significant. By stepping up the voltage, the resulting current through the same length of cables is much lower and therefore much less energy will be lost as heat and therefore more energy is available for the town to use.	**1** **1**
9c	$P_{loss} = I^2R$ $=(1.09\times10^3)^2\times(0.05\times3.0)$ $=1.8\times10^5\ \text{W}$ $\therefore \%\ \text{loss} = \frac{1.8\times10^5}{12\times10^6}\times\frac{100}{1} = 1.5\ \%$	**1** **1**
10a	$\gamma = \frac{1}{\sqrt{1-(0.98)^2}} = 5.0$	**1**

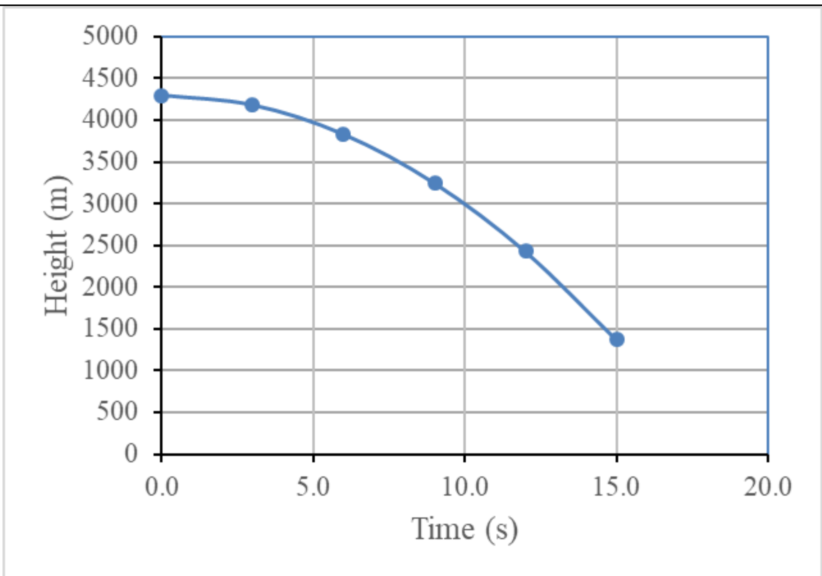
10b	$T=\gamma T_0=5.0\times10^{-6}\,s$	**1**
10c	The apparent depth of the cave is subject to Lorentz Contraction: $L=\dfrac{L_0}{\gamma}=200\text{ m}$	**2**
10d	From the ground, it appears that time has slowed down, so the apparent half-life is lengthened. From the perspective of the particles, the apparent distance travelled has shortened. In either case more particles will be found than expected under classical dynamics.	**1** **1**
11a	Net force acting on spring: $mg=9.8\times0.5=4.9N$ $k=\dfrac{-F}{x}=\dfrac{-4.9}{(0.20-0.298)}=50\text{ Nm}^{-1}$	**1** **1**
11b	$\dfrac{1}{2}\text{mv}^2=\text{mgh}$ $\therefore \text{v}=\sqrt{2\times9.8\times0.46}=3.0\text{ ms}^{-1}$	**1** **1**
11c	$\dfrac{1}{2}\text{mv}^2=\dfrac{1}{2}\text{kx}^2$ $\therefore \text{x}=\text{v}\sqrt{\dfrac{\text{m}}{\text{k}}}=3.0\sqrt{\dfrac{2.0}{50}}=0.6\text{ m}$	**1** **1**
11d	 **1 mark** for general shape**, 1 mark** for correct maximum value of 9.0 J.	**2**

11e	When the centripetal force equals the gravitational force: $\frac{mv^2}{r} = mg$ $\therefore v^2 = rg = 0.25\ g$ $\therefore v = \sqrt{0.25 \times 9.8} = 1.56\ ms^{-1}$ Kinetic energy = $\frac{1}{2}mv^2 = 2.45\ J$ at the top of the loop. Potential energy at the top of the slope = mgh = 19.6h J **<u>Total</u>** energy at the top of the loop = $mg \times 0.5 + 2.45 = 12.25\ J$ $\therefore PE_{top} = 19.6\ h = 12.25\ J$ $\therefore h = \frac{12.25}{19.6} = 0.63\ m$	**1** **1** **1**
12a	Total initial momentum mv = $3 \times 10^3 \times 10 = 3.0 \times 10^4 kgms^{-1}$ p_f = (M+m) $v_f = 3.0 \times 10^4$ $\therefore v_f = \frac{3.0 \times 10^4}{(3.0+1.0) \times 10^3} = 7.5\ ms^{-1}$	**1** **1**
12b	$F\Delta t = m\Delta v$ $\therefore F = \frac{3.0 \times 10^4}{4.0} = 7.5 \times 10^3\ N$	 **1**
12c	$F_{av} \times d = \Delta E_k$ $d = \frac{-0.5\ mv_i^2}{-7.5 \times 10^3} = \frac{150}{7.5} = 20\ m$	**1** **1**
12d	Distance travelled to come to a stop is 20 m from answer to question 12c. Work done = area under the force-distance graph Therefore, area under graph = area of a trapezium with parallel sides of length 5 kN and 10 kN and height of 20 m A = ½ × (5+10) × 10^3x20 = 150 kJ.	**1**
13a	$\Delta\rho_x\Delta x \geq h/(4\pi)$ Mass, m, is constant therefore $(\Delta x)(0.050)(0.01) \geq 6.63 \times 10^{-34}/(4\pi)$ $(\Delta x) \geq 5.275 \times 10^{-35} / 5 \times 10^{-4}$ $(\Delta x) \geq 1.06 \times 10^{-31}$ m	**1** **1** **1**
13b	With large objects, the uncertainty principle will impose no practical limits on position measurements.	**2**

14	This equation relates the energy of a quantum of electromagnetic radiation to its frequency, f, h, is Planck's constant. This equation is the link between twentieth century physics and nineteenth century physics. Electromagnetic radiation can only be emitted or absorbed in discrete packets or bundles whose size can only be specified by the E =hf equation.	**1** **1**
15	$E=hf=hc/\lambda$ $=(6.63 \times 10^{-34} \times 3.0 \times 10^{8})/546 \times 10^{-9} \times 1.6 \times 10^{-19}$ $= 2.28$ eV	**1** **1**
16	$\lambda=h/\rho = h/mv$ $=6.63 \times 10^{-34}/(2 \times 10^{-4} \times 20)$ $=1.66 \times 10^{-31}$ m (this wavelength is far too small to measure)	**1** **1**
17a	From the data 6.0×10^{-34} Js from the slope of their graph is the Planck's constant	**1** **1**
17b	The y intercept is 7.2×10^{-19} J and this is the work function	**1** **1**
18a	Light has a particle and a wave nature.	**2**
18b	Wave like nature of light explains reflection, refraction, diffraction and polarisation. However, the photoelectric effect is best described by considering light to be made up of individual photons.	**1** **1**
18c	According to wave theory, light of any frequency should cause photoelectric emission if it is intense enough.	**1** **1**
19a	$f=1/T$ $=1/0.5$ $=2$ Hz	**1** **1**
19b	2x4 = 8	**1**
19c	$v=f\lambda$ $=120 \times 3.0$ $=360 ms^{-1}$	**1** **1**
20	The stone will gain potential energy as the student lifts it up, this is converted to kinetic energy as it drops to the water, this kinetic energy is dissipated in the pool as wave energy, spreading out or kinetic energy of the water particles as the wave moves out.	**1** **1**

21	Similarities - energy is transferred, particles vibrate, the medium is not disturbed. The difference is the direction of the particle vibration in relation to the direction of the energy transfer.	**1** **1** **1**
22	TIR (total internal reflection) will occur when the incident angle is greater than the critical angle. This will occur when light passes from a substance of a greater optical density to one of lesser density.	**1** **1**
23	If the parallel sides are used then no spectrum will be produced, as the different colours are not split enough to be visible. However, if a ray of light passes through two adjacent faces then it will act like a triangular prism.  The entry beam angle is the same as the exit beam angle and there is a thin fringe of red and blue on the outer edges of the light beam emerging from the prism.  Blue light in the white light beam is refracted more than the red light and the beam is dispersed as it passes through the triangular prism.	**1** **1**
24a	A – refracted ray B – boundary C – incident ray D – normal E – reflected ray	**0.5 for each correct label up to a maximum of 2 marks**
24b	$\sin\theta_1/\sin\theta_2 = n$ $\sin\theta_2 = \sin 33/1.3$ $\theta_2 = 25°$	**1** **1**

25	Place the expensive, polarising sunglasses up against the cheap ones towards the sun, rotate the lenses and if they turn black and block the sun they are polarising. Polarising lenses will block out the horizontally polarised light	**1** **1**
26	Light is a wave, as it shows interference. Young produced interference patterns showing constructive and destructive interference, that light beams would cancel each other out.	**1** **1**
27a	**i.** The independent variables includes both the voltage supplied to the circuit and the resulting current each time the voltage is increased. **ii.** The dependent variables are the mass recorded on the scales and the calculated force experienced by the wire. **iii.** The controlled variables are the scales, the actual wires used in the circuit, the power supply, the load resistor, the magnets which provide the uniform magnetic field and the ammeter which is used to measure the current in the wire.	**1** **1** **1**
27b	There is a linear relationship between the force experienced by the wire and the current through it i.e. the force is directly proportional to the current.	**1**
27c	Yes, the students were correct to extend the line of best fit through the origin as this has a physical meaning. When no current goes through the wire, no force is experienced by the wire.	**1** **1**
27d	F is used for Force, and I is used for current as this is a linear relationship, the equation of the line follows F= mI+c and c = 0 because this goes through the origin m = the gradient of the line $m = \frac{48\times10^{-3}}{2.00} = 24\times10^{-3}$ $\therefore$ the equation for this relationship is F = 0.024I [Must write out equation with constants calculated.]	 **1** **1** **1**

27e	**Yes** As there is a linear relationship between the force and the current, the force can be used to move the needle a particular amount for a given amount of current. By testing this out through a number of iterations, a calibrated scale can be developed for the model ammeter.	**1** **1**
28a		**1**
28b	The relationship is not linear, the graph appears to be half of an upside-down parabola which suggests there is an exponential relationship between height and time. Given that the solar panel was falling, Height should decrease exponentially as time increases.	**1** **1**
28c	The linear relationship shows that height decreases proportionately with time squared. The relationship between H and t^2 can be easily determined using $H = mt^2 + c$ where m and c are the gradient of the line and the y-intercept or the initial height respectively.	**1**
28d	$c = 4300$ and $m = \frac{(1375-4300)}{(15^2-0)} = -13$ so, using H for Height and t for time, the equation for the motion of the solar panel is given by: $H=4.3\times10^3-13t^2$	**1** **1**

28e	4300 represents the initial height above the surface from which the solar panel commenced its fall. The coefficient -13 represents the acceleration of the falling solar panel (multiplied by a factor of 0.5). The units for this are ms^{-2} which are units of acceleration and this equation fits the pattern $x = ut + ½ at^2$.	**1** **1**
28f	H= 0 when the panel hits the surface of Jupiter $0 = 4.3 \times 10^3 - 13t^2$ so $t = \sqrt{\dfrac{-(4.3\times10^3)}{-(13)}} = 18$ s [Consequential **marks** for correct substitution in answer to d.]	**1**
29	James's statement is incorrect because evidence or findings from a single experiment do not prove a hypothesis, they only support the hypothesis. The word 'proof' suggests that the hypothesis will stand forever and against time – it is an absolute statement. Each experiment represents one piece of evidence not all evidence – therefore an absolute statement about the result is not possible.	**1** **1**
30	Errors in experimental results refer to the limitations of the equipment used for measurements, not mistakes made by the experimenter. Harriet would have been better to exclude the measurements taken entirely. Human error cannot be justified in scientific experiments. Experiments should be designed to reduce or eliminate human error.	**1**

End of Suggested Answers