TSSM
Creating VCE Success

2021 Trial Examination

THIS BOX IS FOR ILLUSTRATIVE PURPOSES ONLY

STUDENT NUMBER									Letter

PHYSICS

Units 3 & 4 – Written examination

Reading Time: 15 minutes
Writing Time: 2 hour and 30 minutes

QUESTION AND ANSWER BOOK

Structure of Book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	20	20	20
B	19	19	110
			Total 130

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, and rulers, pre-written notes (one folded A3 or two A4 sheets bound by tape) and one scientific calculator.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.

Materials supplied

- Question and answer book of 31 pages including formula sheets and multiple-choice answer sheet.

Instructions

- Print your name in the space provided on the top of this page.
- All written responses must be in English.
- Take the value of g as 9.8 m s^{-2}

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination room.

SECTION A – Multiple-choice questions

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 **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 question.
- Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.
- Take the value of g to be 9.8 m s^{-2}

Question 1

The magnitude of the net force between a 2 nC and a 3 nC charge that are 2 μm from one another is?

A. 13.5 N

B. 0.027 N

C. 1.35×10^4 N

D. 27 N

Question 2

If two electrons are in close proximity to one another, they will experience

A. An attraction force.

B. A repulsion force.

C. Centripetal force.

D. Magnetic force.

Question 3

Which of the following is not a feature of magnetic field lines?

A. They travel from the North pole to the South pole.

B. They can travel in non-linear paths.

C. The more lines in a space, the larger is the field in that space.

D. They can intersect with one another.

Question 4

An electron travels down the page in a magnetic field that is going into the page. The direction of the force acting on the electron will be

A. Out of the page

B. To the right

C. Downward

D. To the left

The following information is relevant to Questions 5 – 9

A generator is displayed in Figure 1 below, with the coil turning clockwise. The magnetic field is equal to 40 mT. The cross-sectional area of the coil is 0.048 m^2

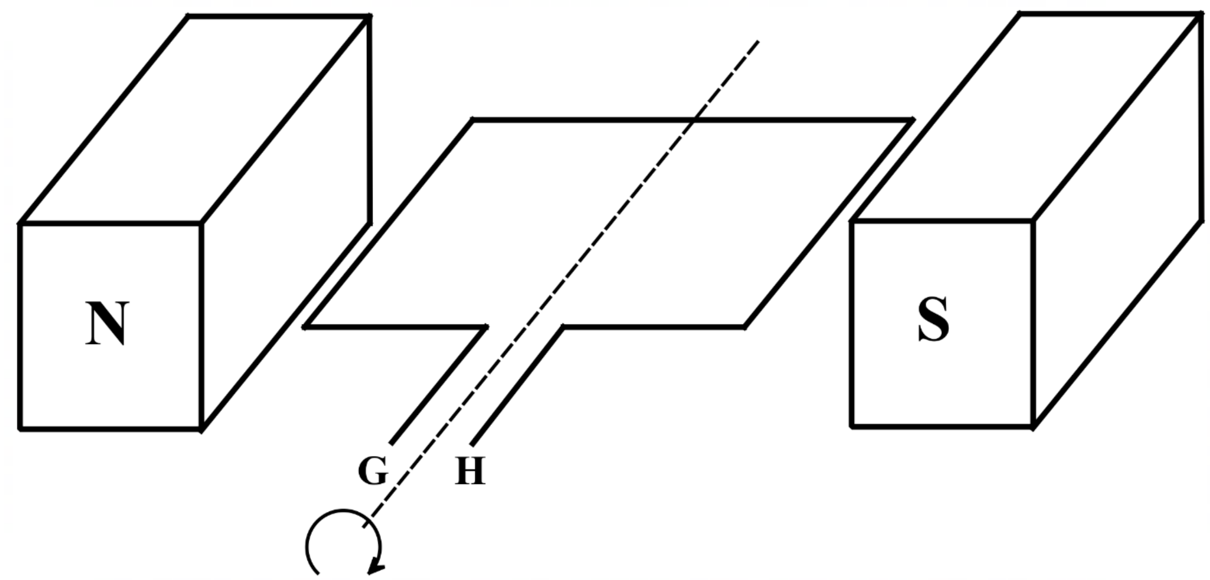

Figure 1

Question 5

When the coil is in the position shown in Figure 1, the current will be flowing from

A. G to H

B. H to G

C. N to S

D. S to N

Question 6

When the coil is in the vertical position (perpendicular to the magnetic field lines), the magnetic flux passing through it would be equal to

A. 0 Wb

B. 1.92 Wb

C. 1.92×10^{-3} Wb

D. 1.92×10^{-6} Wb

Question 7

When the coil is in the horizontal position (parallel to the magnetic field lines), the magnetic flux passing through it would be equal to

A. 0 Wb

B. 1.92 Wb

C. 1.92×10^{-3} Wb

D. 1.92×10^{-6} Wb

Question 8

The magnetic field is changed so that the maximum flux through the coil is 0.02 Wb. If the coil completes four turns per second, the average induced voltage would be

A. 0.18 V

B. 1.62 V

C. 0.32 V

D. 2.44 V

Question 9

If the magnetic field strength is halved, and the area of the coil is doubled, the average induced voltage would

A. Increase by 4 times

B. Decrease by 4 times

C. Increase by 16 times.

D. Remain the same.

Question 10
Which of the following options would not reduce power losses in transmission cables?

A. Using wires with less resistance.

B. Using wires with less cross-sectional area.

C. Using a step-up transformer on the generator end of the transmission lines.

D. Lowering the current passing through the transmission lines.

The following information is relevant to Questions 11 to 14

Andrew is conducting an experiment where he observes an object moving at a speed where the Lorentz factor is 2.29.

Question 11
The speed of the object would be closest to

A. 0.56c

B. 0.75c

C. 0.81c

D. 0.90c

Question 12
If Andrew states that the length of the object from his perspective is 20 cm, then the length of the object measured at rest in the stationary frame of reference would be closest to

A. 45.8 cm

B. 8.7 cm

C. 16.2 cm

D. 24.7 cm

Question 13
Andrew observes the object for four seconds. Such time measured in the object's frame of reference would be closest to

A. 9.17 s

B. 1.75 s

C. 3.24 s

D. 4.94 s

Question 14

The mass of the object when stationary is 2.7×10^{-7} kg. The relativistic mass of the object is closest to

A. 4.59 kg

B. 0.87 kg

C. 6.18×10^{-7} kg

D. 4.59×10^{-7} kg

Question 15

The difference between speed and velocity is

A. Speed is measured in m s^{-1} while velocity is measured in km h^{-1}

B. Speed is a vector quantity while velocity is a scalar one.

C. Speed has a magnitude only while velocity has a direction only.

D. Both speed and velocity have a magnitude, however, velocity has a direction as well.

Question 16

Which of the following statements about the theory of relativity is accurate

A. The larger the object, the more likely relativity will become significant

B. The closer an object's speed to the speed of light, the more likely relativity becomes significant.

C. The speed of light is dependent on the speed of its source.

D. The concentration of Ether in vacuum is what causes the speed of light to be constant.

The following information is relevant to Questions 17 and 18

Peter is investigating the effect of changing the angle of inclination on the time it takes for a ball to roll down a ramp. Peter plans to use a stopwatch on his phone to measure the time.

Question 17

The time it takes for the ball to roll down the ramp is considered to be

A. The independent variable.

B. The dependent variable.

C. The hypothesis.

D. The controlled variable.

Question 18
From the list below, the most accurate hypothesis for Peter's experiment is

A. The larger the angle of inclination, the larger the momentum of the ball at the end of the ramp.
B. The larger the angle of inclination, the larger the speed of the ball at the end of the ramp.
C. The larger the angle of inclination, the less time it takes for the ball to reach the end of the ramp.
D. The larger the angle of inclination, the larger the kinetic energy of the ball at the end of the ramp.

The following information relates to Questions 19 and 20

A 2 kg object is travelling at a speed of 5 m s^{-1}.

Question 19
If it continues to travel at such speed for 20 seconds, its acceleration would be

A. 0 m s^{-2}
B. 4 m s^{-2}
C. 100 m s^{-2}
D. – 4 m s^{-2}

Question 20
The magnitude of the force required to stop the object in 0.4×10^{-3} s is

A. 25 N
B. 25 m N
C. 25 k N
D. 0 N

SECTION B

Instructions for Section B

- Answer **all** questions in the spaces 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.
- Marks will not be deducted for incorrect answers.
- Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.
- Take the value of *g* as 9.8 N kg^{-1}

Question 1 (6 marks)

A magnetic field setup is shown in Figure 2,

a. On Figure 2, represent the magnetic field between the two poles using four arrows.

Figure 2

2 marks

A charge is travelling in the magnetic field as shown in Figure 3.

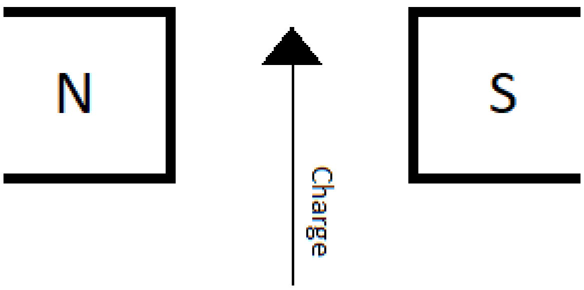

Figure 3

b. Complete the following sentence by circling the correct option

The charge will experience a force **(out of the page/into the page)** if it is a proton and **(out of the page/into the page)** if it is an electron

2 marks

c. Assuming the charge was an electron, and that the magnetic field strength is 40 mT, how much force would it experience if it enters the magnetic field at 5×10^{7} m s^{-1}.

N

2 marks

Question 2 (6 marks)

Two 5 C positive charges are placed near one another as shown in Figure 4.

a. Assuming the two charges are close enough to one another that they apply a force on one another, on Figure 4, sketch the electric field lines between the two charges.

2 marks

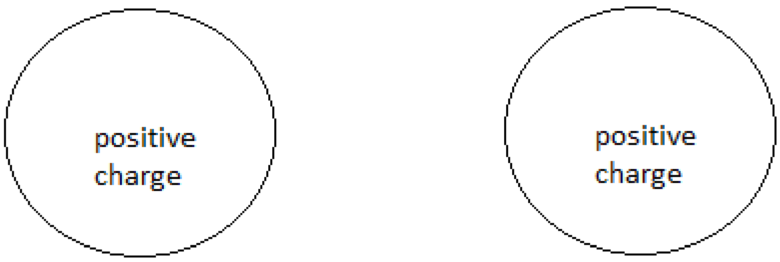

Figure 4

b. Find the magnitude of the force the charges would apply on each other if the distance between them is 5×10^{-6} m?

N

2 marks

A person calculates the force between the two charges as 9×10^{12} N when they are 5×10^{-6} m from one another.

c. What value of Coulomb's constant (k) did they use?

$\boxed{\quad\quad\quad\quad N\ m^2\ C^{-2}}$

2 marks

Question 3 (7 marks)

A 20 cm cable has 10 A of current passing into the page as shown in Figure 5.

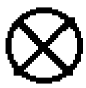

Figure 5

a. Would the resulting magnetic field be clockwise or anticlockwise? Explain your answer with reference to the relevant hand rule.

2 marks

The cable is placed between two magnetic poles as shown in Figure 6.

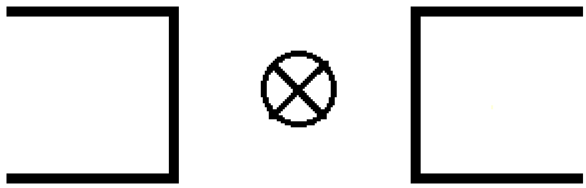

Figure 6

The entire length of the cable is experiencing the magnetic field, and a force of 20 mN upwards.

b. On Figure 6, write the polarity of each of the magnet poles, explaining your answer with reference to the relevant hand rule.

3 marks

c. Find the magnitude of the magnetic field that the cable is experiencing.

T

2 marks

Question 4 (13 marks)

Sam places a 100 turns coil in a 15 mT magnetic field as shown in Figure 7. The length AB is 20 cm and the length BC is 10 cm.

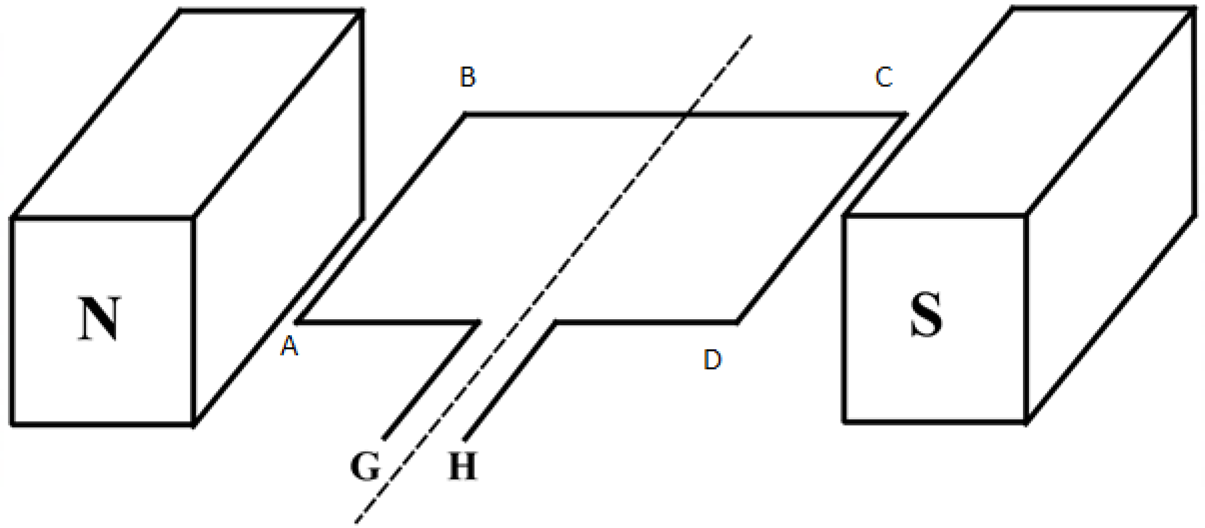

Figure 7

a. Once Sam passes current through the coil, side AB experiences a force of 2 N upward. Find the magnitude and the direction (G to H or H to G) of the current.

A	Direction:

3 marks

b. Sam wants to use this configuration as a motor. She connects the sides G and H to two slip rings connected to a DC power source. Would the DC motor function? Explain why or why not?

3 marks

Andrew uses the same configuration as a generator.

c. What is the maximum magnitude of magnetic flux that the coil would experience?

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Wb	marks 2

The Emf generated by the generator is shown in Figure 8, where the y-axis represents the Emf in Volts, and the x-axis represents the time in ms.

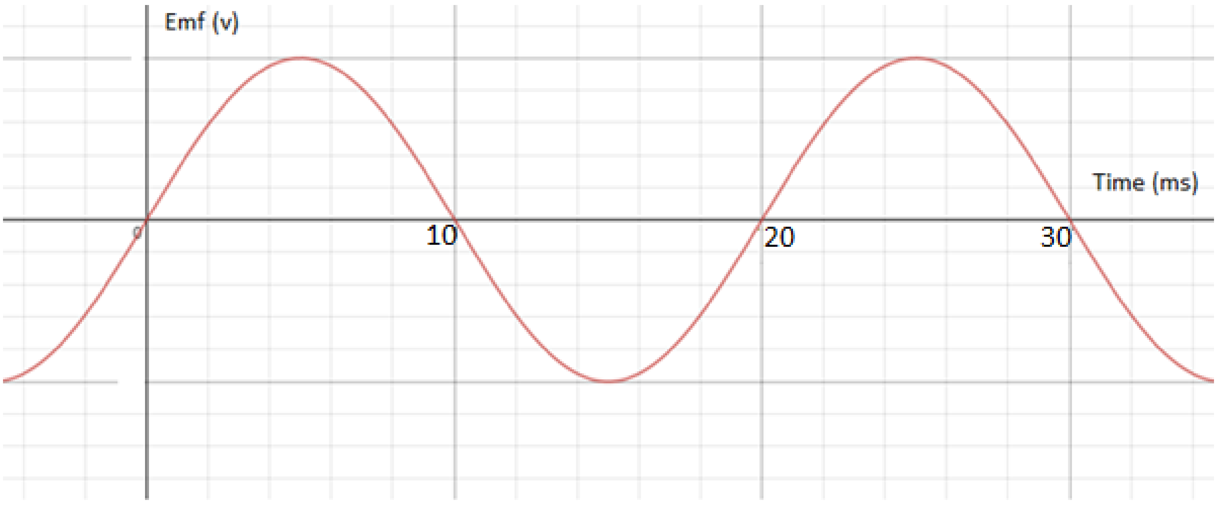

Figure 8

d. How many turns would the coil complete per minute?

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____

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turns	marks 2

e. What would be the magnitude of the average emf generated by the generator.

V

3 marks

Question 5 (10 marks)

Fabian is to transfer power from a generator source to his house as shown in Figure 9.

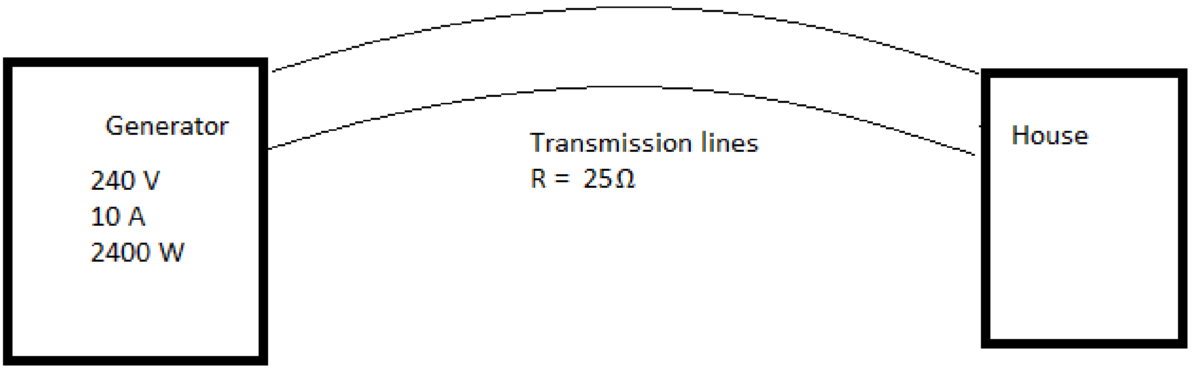

Figure 9

a. Explain, with the aid of relevant calculations, why the house would receive no power under this configuration?

3 marks

To resolve this, it is suggested to Fabian that he install a 1:100 step-up transformer at the generator end, and a 100:1 step-down transformer near the house.

b. Explain the role of transformers in reducing power loss in transmission lines.

4 marks

c. What would be the magnitude of the power delivered to the house if the transformers are to be used?

W

3 marks

Question 6 (6 marks)

Mariam is conducting an experiment where a 3 kg cart is towing a 2 kg cart as shown in Figure 10. Initially both carts are travelling at a speed of 1 m s^{-1}. Each of the carts experience a friction force of 20 N.

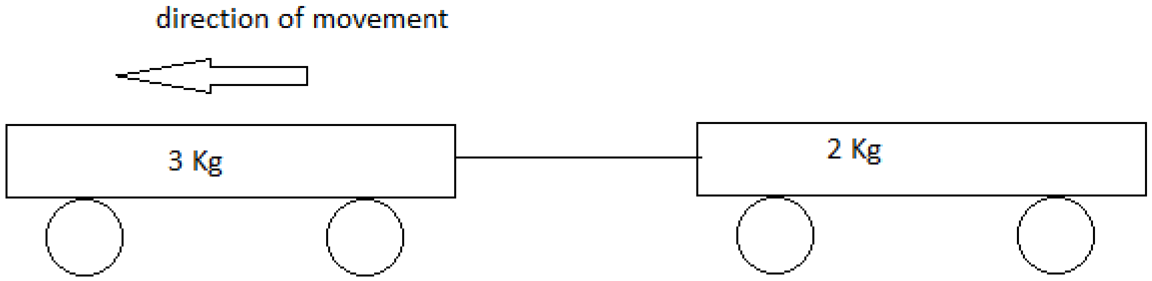

Figure 10

a. Calculate the driving force of the 3 kg cart.

N

2 marks

The carts then accelerate at a rate of 0.5 m s^{-2}.

b. Calculate the tension in the cable connecting the two carts.

N

2 marks

c. How much time will it take for the speed of the carts to reach 3 m s^{-1}?

s

2 marks

Question 7 (6 marks)

Adam is to conduct an experiment where the two carts, both travelling at a speed of 3 m s^{-1} are to collide as shown in Figure 11.

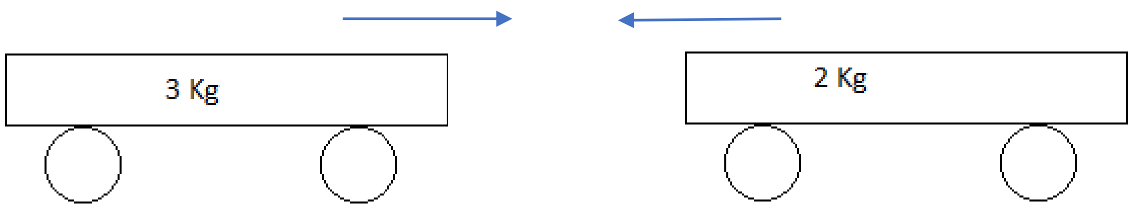

Figure 11

a. Given that the two carts will stick to one another, find the magnitude and the direction of the velocity of the carts after the collision.

m s^{-1}

3

Left / right

marks

b. With the aid of relevant calculations, explain whether the collision is elastic or inelastic.

3 marks

Question 8 (9 marks)

Isaac kicks a ball at an initial speed of 20 m s^{-1} and an angle of 30^{o} to horizontal from the top of a 40 m building. The path of the ball is shown in Figure 12.

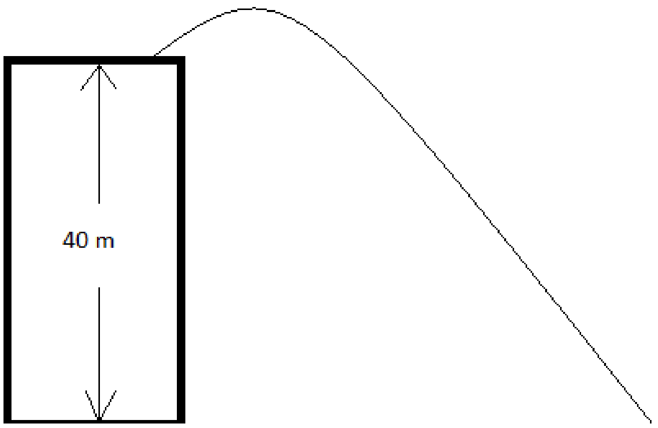

Figure 12

a. Calculate the maximum height the ball will reach, measured from ground level.

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m

3 marks

b. Calculate the time it takes for the ball to reach the ground.

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4 marks

s

c. Calculate the horizontal distance travelled by the ball.

2 marks

m

Question 9 **(7 marks)**

Michael is driving a car on a turn that is banked at an angle of 10^o to the horizontal as shown in Figure 13.The turn has a radius of 5 m. The combined mass of Michael and the car is 1200 kg. It is to be assumed that there is no friction force between the car and the road surface.

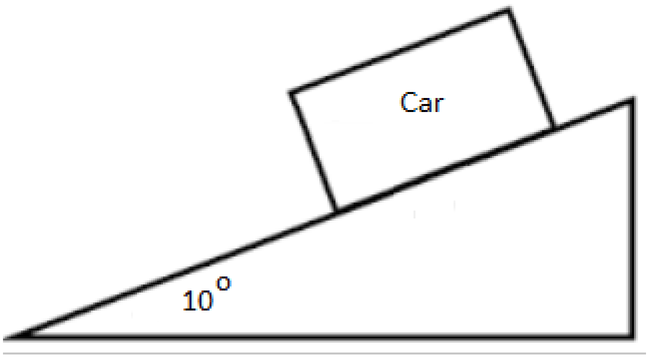

Figure 13

a. On Figure 13, using labelled arrows represent the forces that act on the car, and then represent the resultant force using a dotted arrow and label it F_c.

3 marks

b. Calculate the normal force acting on the car while it is going through the turn. (give your answer to 2 significant figures)

2 marks

N

c. Calculate the maximum speed at which Michael can make the turn without skidding out of the circular path.

2 marks

m s^{-1}

Question 10 (4 marks)

Harry is riding his bike on a hill of a circular shape of a radius of 3 metres. The combined mass of Harry and his bike is 80 kg. Harry is travelling at a speed of 4 m s^{-1} when he is on top of the hill.

a. Calculate the normal force acting on Harry when he is at the top of the hill.

2 marks

N

b. At what speed can Harry travel at the top of the hill without losing contact with the ground?

2 marks

m s^{-1}

Question 11 (8 marks)

Stephanie suspends a 2 kg mass from a spring with a spring constant of 80 N m^{-1}. Once it is released from its unstretched position, it falls 49 cm to its lowest point. It is to be assumed that the gravitational energy is equal to zero Joules at the lowest point.

a. Calculate the elastic potential energy of the spring at the lowest point.

2 marks

J

b. Calculate the change of potential energy of the mass between the unstretched position and the lowest point.

2 marks

J

c. Calculate the kinetic energy of the mass at the midpoint of movement, and then calculate its speed.

4 marks

J

m s^{-1}

Question 12 (5 marks)

A geostationary object of mass 180 kg is orbiting Earth.

a. How much time will the object need to complete one turn around the Earth?

2 marks

s

b. Calculate the radius of the object's orbit.

3 marks

m

Question 13 (4 marks)

A light beam is passing from water (n = 1.33) into air (n = 1) at an incident angle of 30^{o}.

a. Calculate the refractive angle in air.

2 marks

o

b. Calculate the critical angle between water and air.

2 marks

o

Question 14 (8 marks)

Brett is investigating double slit interference. He uses a 600 nm wavelength laser and a double slit slide to conduct a similar experiment to Young's double slit investigation. He obtains a pattern as shown in Figure 14, where C refers to the central band.

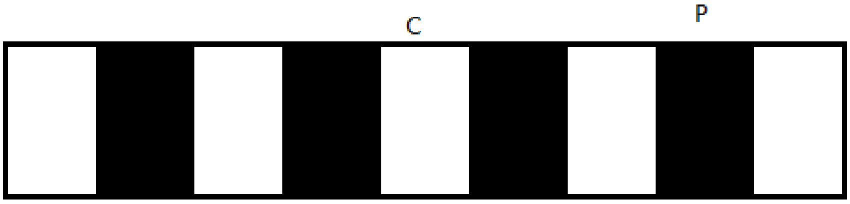

Figure 14

a. With reference to interference, explain why the central band is bright and not dark.

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3 marks

b. Brett uses a laser with a different wavelength and notices the second dark band labelled P is replaced with the fourth bright band. Find the wavelength of the new laser.

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2 marks

nm

c. Explain how the double slip experiment supports the wave-like nature of light instead of the particle nature of it.

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3 marks

Question 15 (5 marks)

A group of students are studying the photoelectric effect by directing a light source on a photocell and measuring the output voltage and current. The threshold frequency of the photoelectric material is 3.4×10^{14} Hz

a. Calculate the maximum wavelength that would cause photoelectric emission.

nm

2 mark

b. What would be the maximum kinetic energy of an emitted electron if the frequency of the incident ray is 4.2×10^{14} Hz. Give your answer in J and eV.

J

eV

3 marks

Question 16 (4 marks)

A group of students are experimenting with diffraction patterns by directing a beam of photons with an energy of 5 eV on a circular aperture and noting the patterns produced on a screen behind the aperture.

a. Calculate the wavelength of the incident photons.

nm

2 marks

b. The group replaces the beam of photons with a beam of electrons of the same energy and note that the produced pattern has different spacing to that of the photons. Explain why

2 marks

Question 17 (2 marks)

A simplified version of the energy diagram of an element is shown in Figure 15.

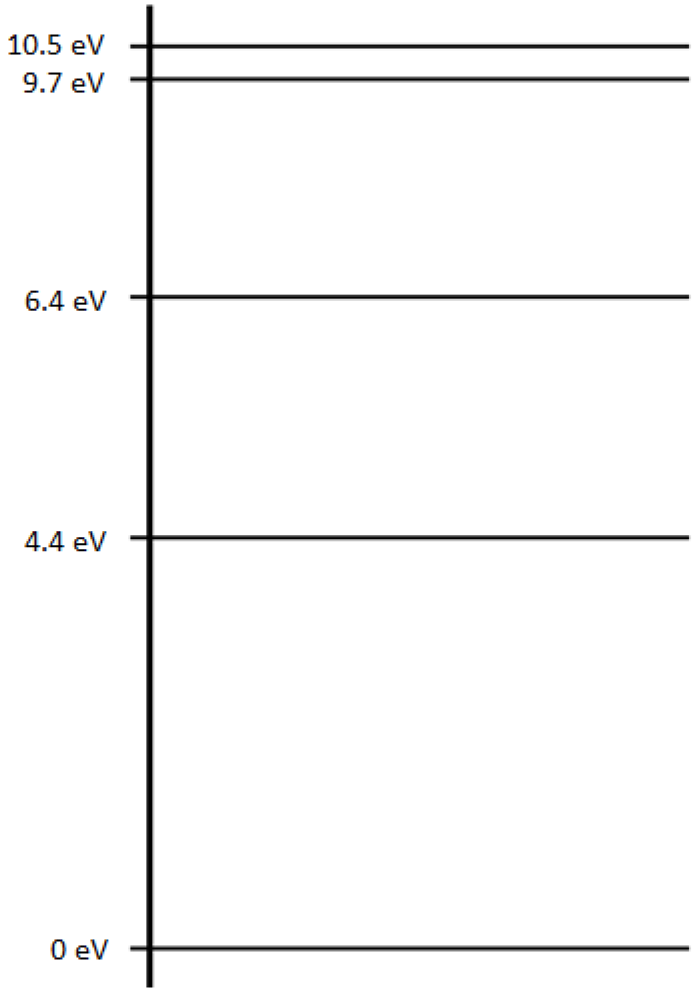

Figure 15

What would be the frequency of the emission spectrum if an electron returns from the 9.7 eV to the 4.4 eV energy levels?

____

____

____

2 marks

Hz

END OF QUESTION AND ANSWER BOOK

Multiple Choice Answer Sheet

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

Physics formulas

Motion and related energy transformation

velocity, acceleration	$v = \frac{\Delta s}{\Delta t}; \quad a = \frac{\Delta v}{\Delta t}$
equations for constant acceleration	$v = u + at$ $s = ut + \frac{1}{2}at^2$ $s = vt - \frac{1}{2}at^2$ $v^2 = u^2 + 2as$ $s = \frac{1}{2}(v+u)t$
Newton's second law	$\Sigma F = ma$
circular motion	$a = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2}$
Hooke's law	$F = -k\Delta x$
elastic potential energy	$\frac{1}{2}k(\Delta x)^2$
gravitational potential energy near the surface of Earth	$mg\Delta h$
kinetic energy	$\frac{1}{2}mv^2$
Newton's law of universal gravitation	$F = G\frac{M_1 M_2}{r^2}$
gravitational field	$g = G\frac{M}{r^2}$
impulse	$F\Delta t$
momentum	mv
Lorentz factor	$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$
time dilation	$t = t_0\gamma$
length contraction	$L = \frac{L_0}{\gamma}$
rest energy	$E_{rest} = mc^2$
relativistic total energy	$E_{total} = \gamma mc^2$

relativistic kinetic energy	$E_k = (\gamma - 1)mc^2$

Fields and application of field concepts

electric field between charged plates	$E = \dfrac{V}{d}$
energy transformations of charges in an electric field	$\dfrac{1}{2}mv^2 = qV$
field of a point charge	$E = \dfrac{kq}{r^2}$
force on an electric charge	$F = qE$
Coulomb's law	$F = \dfrac{kq_1q_2}{r^2}$
magnetic force on a moving charge	$F = qvB$
magnetic force on a current	$F = IlB$
radius of a charged particle in a magnetic field	$r = \dfrac{mv}{qB}$

Generation and transmission of electricity

voltage; power	$V = RI;\ \ P = VI = I^2R$
resistors in series	$R_T = R_1 + R_2$
resistors in parallel	$\dfrac{1}{R_T} = \dfrac{1}{R_1} + \dfrac{1}{R_2}$
ideal transformer action	$\dfrac{V_1}{V_2} = \dfrac{N_1}{N_2} = \dfrac{I_2}{I_1}$
AC voltage and current	$V_{RMS} = \dfrac{1}{\sqrt{2}}V_{peak};\quad \mathrm{I}_{RMS} = \dfrac{1}{\sqrt{2}}I_{peak}$
electromagnetic induction	EMF: $\varepsilon = -N\dfrac{\Delta\phi}{\Delta t};\quad$ flux: $\phi = BA$
transmission losses	$V_{drop} = I_{line}R_{line};\quad P_{loss} = I_{line}^2R_{line}$

Wave concepts

wave equation	$v = f\lambda$
constructive interference	path difference $= n\lambda$
destructive interference	path difference $= \left(n - \frac{1}{2}\right)\lambda$
fringe spacing	$\Delta x = \frac{\lambda L}{d}$
Snell's law	$n_1 \sin\theta_1 = n_2 \sin\theta_2$
refractive index and wave speed	$n_1 v_1 = n_2 v_2$

The nature of life and matter

photoelectric effect	$E_{k_{\max}} = hf - W$
photon energy	$E = hf$
photon momentum	$p = \frac{h}{\lambda}$
de Broglie wavelength	$\lambda = \frac{h}{p}$
Heisenberg's uncertainty principle	$\Delta p_x \Delta x \geq \frac{h}{4\pi}$

Data

acceleration due to gravity at Earth's surface	$g = 9.8 \text{ m s}^{-2}$
mass of the electron	$m_e = 9.1 \times 10^{-31}$ kg
magnitude of the charge of the electron	$e = 1.6 \times 10^{-19}$ C
Planck's constant	$h = 6.63 \times 10^{-34}$ J s; $h = 4.14 \times 10^{-15}$ eV s
speed of light in a vacuum	$c = 3.0 \times 10^{8} \text{ m s}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
mass of earth	$M_E = 5.98 \times 10^{24}$ kg
radius of Earth	$R_E = 6.37 \times 10^{6}$ m
Coulomb constant	$k = 8.99 \times 10^{9} \text{ N m}^2 \text{ C}^{-2}$

Prefixes/Units

$\text{p} = \text{ pico} = 10^{-12}$	$n = \text{ nano} = 10^{-9}$	$\mu = \text{ micro} = 10^{-6}$	$m = \text{ milli} = 10^{-3}$
$k = \text{ kilo} = 10^{3}$	$M = \text{ mega} = 10^{6}$	$G = \text{ giga} = 10^{9}$	$t = \text{ tonne} = 10^{3}\text{ kg}$