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‘2017 Examination Package’ - Trial Examination 6 of 9

STUDENT NUMBER

										Letter
Figures										
Words										

PHYSICS

Units 3 & 4 – Written examination

(TSSM's 2013 trial exam updated for the current study design)

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

QUESTION & ANSWER BOOK

Structure of Book

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

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, and rulers, up to 4 pages (A4) of prewritten notes and an approved calculator.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out or liquid/tape.

Materials supplied

- Question and answer book of 32 pages (including a 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.
- Write your answers in the spaces provided.

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

SECTION A – Multiple Choice

Instructions for Section A

Answer **all** questions in pencil on the answer sheet provided for multiple choice questions.
Choose the response that is **correct** and that **best answers** the question.
A correct answer **scores** 1; an incorrect answer scores 0.
Marks will not be deducted for incorrect answers.
Unless 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

An electron gun has an accelerating voltage of 4000 V between two metal plates. The force on an electron between these plates is $2\ \ 10^{-15}$ N.
Which of the following is the best estimate for the distance between the plates?

A. 3.2 mm
B. 13.2 cm
C. 3.2 cm
D. 32 cm

Question 2

The force on a dust particle having charge equal to 8×10^{-19} when plates are separated by distance of 2 cm and have a potential difference of 5 kV is

A. 2×10^{-13} N
B. 3 N
C. 5 N
D. 20 N

The following information applies to Questions 3 & 4

An electron travelling east enters a magnetic field of magnitude 30 mT deflects south and moves in a circular path of radius 25 mm.

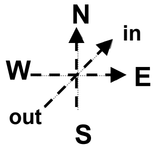
Question 3

Which of the following is the best estimate for the velocity of the electron as it enters the field?

A. 13.2×10^{8} m s^{-1}
B. 1.32×10^{8} m s^{-1}
C. 1.3×10^{-9} m s^{-1}
D. 1.3 m s^{-1}

SECTION A – continued

Question 4
Referring to the directions below, which of the following is the direction of the magnetic field required for the deflection?



A. North
B. West
C. Into the "page"
D. Out of the "page"

Question 5
A current-carrying wire in a magnetic field is subject to a magnetic force. If the current in the wire is doubled, what happens to the magnetic force acting on the wire?

A. It is quartered.
B. It is halved.
C. It is unchanged.
D. It is doubled.

The following information applies to Question 6 – 8

A graph of an input voltage signal is shown in Figure 1.

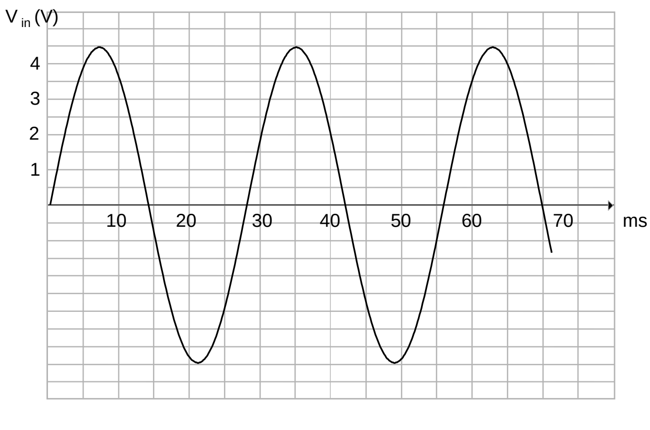


Figure 1

Question 6
Which of the following is the best estimate for the frequency of the input signal?

A. 50 Hz
B. 14 Hz
C. 29 Hz
D. 36 Hz

SECTION A – continued
TURN OVER

Question 7
Which of the following is the best estimate for the V_{RMS} of the input signal?

A. 4.5 V
B. 9 V
C. 3.2 V
D. 6.4 V

Question 8
The input voltage is connected to a transformer with 200 primary turns and 1500 secondary turns.
Which of the following is the best estimate for the expected for V_{peak} of the output voltage?

A. 34 V
B. 0.6 V
C. 4.5 V
D. 400 V

Question 9
A circular loop of wire is stationary in a magnetic field. The sides are then pushed together to change the shape and reduce the area within the loop, as shown in Figure 2.

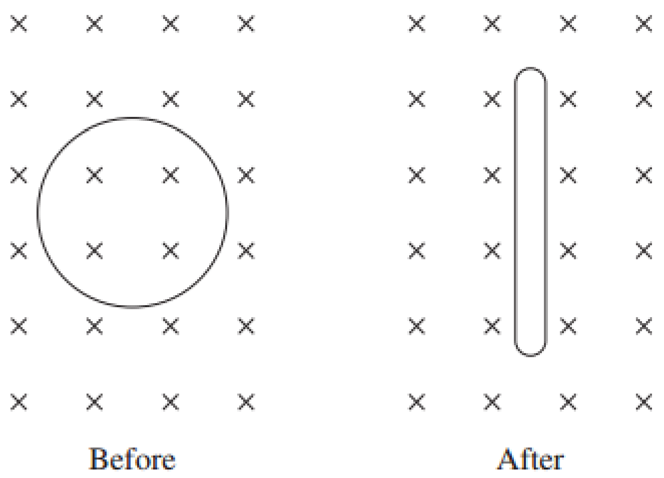


Figure 2

As the loop is compressed, a current is induced. Which row of the table shows the direction of the current and explains why it is induced?

A	Clockwise	Change in magnetic flux
B	Anticlockwise	Change in magnetic flux
C	Clockwise	Change in magnetic field strength
D	Anticlockwise	Change in magnetic field strength

SECTION A – continued

Question 10
Given the information in the table below:

Orbital period of the Moon around Earth	2.36×10^{6} s
Mean orbital radius of the Moon	3.83×10^{8} m
Mass of Earth	6.0×10^{24} kg
Mass of the Moon	7.35×10^{22} kg

What is the centripetal force experienced by the Moon due to Earth's influence?

A. $\mathbf{2 \times 10^{20}}$ N
B. $\mathbf{1.6 \times 10^{22}}$ N
C. $\mathbf{4.7 \times 10^{26}}$ N
D. $\mathbf{7.6 \times 10^{28}}$ N

Question 11
A projectile was launched from the ground with a velocity of 23 m s^{-1}. It had a range of 70 metres and was in the air for 3.5 seconds. At what angle to the horizontal was it launched?

A. 30°
B. 40°
C. 50°
D. 60°

Question 12
Which of the following best describes a key property of an inertial reference frame?

A. It is stationary.
B. It is travelling in the same direction as the rotation of the earth.
C. No observer in the frame can detect acceleration of the frame.
D. It is travelling close to the speed of light.

Question 13
Einstein's postulates for his special theory of relativity were that the laws of physics were the same in all inertial reference frames and that the speed of light was constant for all.
Prior to Einstein, which of the following was considered to be true about the speed of light?

A. Light travels significantly slower, but at a constant speed for all observers.
B. Speed of light is relative to a medium known as the luminiferous aether.
C. Speed of light is infinite everywhere.
D. Speed of light is relative to the age of the universe.

SECTION A – continued
TURN OVER

Question 14
A source of frequency 680 Hz is used for a loudspeaker. Take $v = 340 \text{ m s}^{-1}$.
Which of the following is the best estimate for the wavelength of source?

A. 2.0 m
B. 0.5 m
C. 340 m
D. 1.5 mm

Question 15
Compared to a laser source, synchrotron radiation is:

A. Less intense.
A. Wider spectrum.
B. Highly divergent.
C. Narrow spectrum.

Question 16
Coherent light, like that used in a laser, is best characterised by:

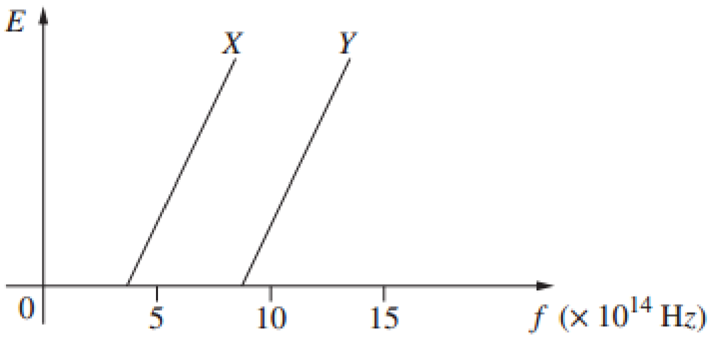
A. High divergence.
B. Photons that are in phase.
C. Photons out of phase.
D. Wide spectrum of discrete wavelengths.

Question 17
Which of the following best explains the production of light by an LED?

A. Spontaneous fall of electrons from conduction to valence bands.
B. Stimulated fall of from valence to conduction bands.
C. Spontaneous fall of electrons between conduction bands.
D. Spontaneous fall from low to high energy levels.

SECTION A – continued

Question 18
The graph shows the maximum kinetic energy (E) with which photoelectrons are emitted as a function of frequency (f) for two different metals X and Y.



The metals are illuminated with light of wavelength 450 nm. What would be the effect of doubling the intensity of this light without changing the wavelength?

A. For metal X, the number of photoelectrons emitted would not change but the maximum kinetic energy would increase.
B. For metal X, the number of photoelectrons emitted would increase but the maximum kinetic energy would remain unchanged.
C. For both metals X and Y, the number of photoelectrons emitted would not change but the maximum kinetic energy would increase.
D. For both metals X and Y, the number of photoelectrons emitted would increase but the maximum kinetic energy would remain unchanged

Question 19
What is Heisenberg's uncertainty principle?

A. We cannot simultaneously know both the exact position, and the velocity of a subatomic particle.
B. We can never know exactly how atoms behave.
C. The mass of an electron cannot be known with any certainty.
D. All possible theories of the atom can only be approximately correct.

Question 20
An investigation is designed to determine the size of the generated current when the strength of a magnet is varied. Which is the independent variable for this investigation?

A. Speed of the magnet.
B. Strength of the magnet.
C. Size of the generated current.
D. Distance between the coil and the magnet.

END OF SECTION A
TURN OVER

SECTION B – Short answer

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 full answer in the box.
If an answer box has a unit provided in it, give your answer in that unit.
In questions where more than one mark is available, appropriate working **must** be shown.
Unless 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 (6 marks)

An electron sits between two charged, parallel pates 10.0 cm apart. The electric field strength between the plates is 2.5×10^3 N C$^{-1.}$

a. What is the potential difference across the plates? 2 marks

V

b. What is the magnitude of the electric force experienced by the electron? 2 marks

N

c. What is the acceleration experienced by the electron? 2 marks

m s^{-2}

SECTION B – continued

Question 2 (4 marks)

Figure 1 shows the initial path of an electron with a velocity of 5.0×10^5 m s^{-1}, fired into a uniform magnetic field with a field strength of 4.0T. The magnetic field is at right angles to the direction of the electron and extends significantly in all directions.

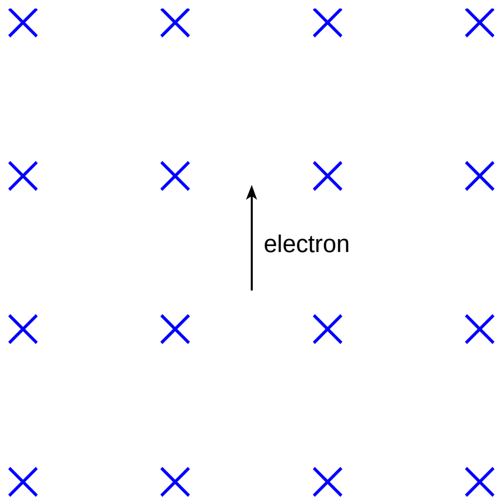


Figure 1

a. Add a labelled arrow to the show the direction of the force on the electron. 1 mark

b. Draw the subsequent path of the electron. 1 mark

c. What is the radius of curvature of its path? 2 marks

m

Question 3 (3 marks)
A solenoid is connected to a DC supply, as shown in Figure 1. You may ignore any magnetic field associated with the straight wires near the supply. The direction of the current in the solenoid is indicated by an arrow.

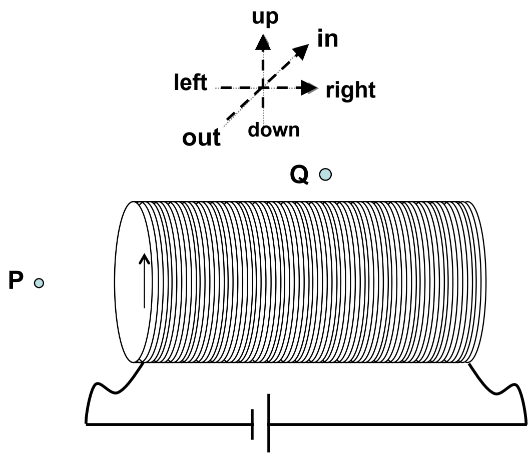


Figure 1

a. State the direction of the magnetic field at Point P. 1 mark

A secondary circuit is now connected, with a wire at Q carrying current of 0.3 A out of the page. A 3 cm section of wire experiences a magnetic field of 0.12 T.

b. State the size direction of the magnetic force experienced by the wire at Point Q. 2 marks

Size: N	Direction:

SECTION B – continued

Question 4 (7 marks)
A simplified DC motor is constructed and shown in Figure 2.

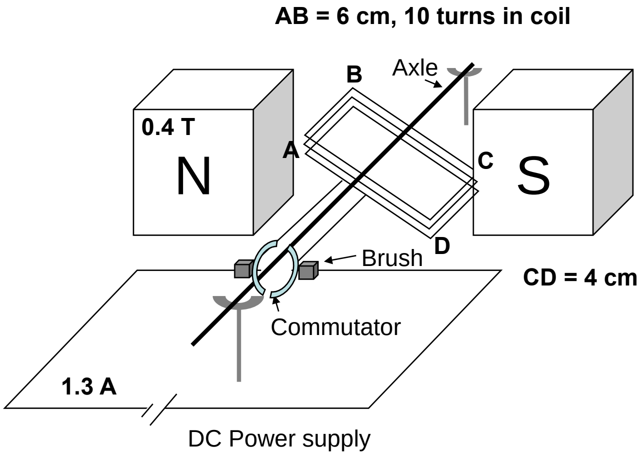


Figure 2

a. Which of the following best describes the initial movement of side AB in the motor as the current is switched on? 2 marks

- **A.** Up
- **B.** Down
- **C.** No movement
- **D.** Oscillation about starting position

b. Calculate the size of the force on side AB. 2 marks

N

c. Explain the purpose of a commutator in a correctly constructed DC motor. 3 marks

SECTION B – continued
TURN OVER

Question 5 (9 marks)
A new 400 V RMS generator supplies power to a factory via transmission lines. There is a 1:5 transformer to step up voltage to the lines, which have a combined resistance of 3 Ω. The factory has an effective resistance of 17 Ω. The system is outlined in Figure 3.

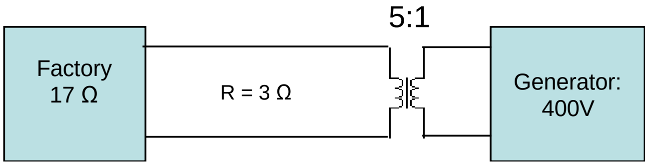


Figure 3

a. Calculate the power lost in the cables. 2 marks

kW

b. State the voltage drop across the load. 2 marks

V

c. Determine the power produced at the generator site. 2 marks

W

SECTION B – Question 5 - continued

d. Explain the effect on the voltage across the load is its resistance drops to 10 Ω. 3 marks

Question 6 (3 marks)

Two copper rings are arranged so their centres align vertically. Current is switched on and flows clockwise (as viewed from above) in the lower ring (additional DC supply is not shown). Figure 4 shows a perspective view of the rings.

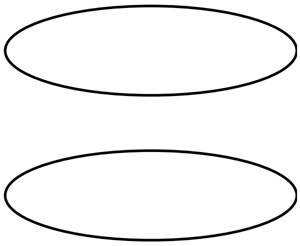


Figure 4

Explain the effect on the upper ring. 3 marks

SECTION B – Question 6 - continued
TURN OVER

Question 7 (4 marks)
A simple generator is shown in Figure 5. Clockwise rotation of the coil from its present position yields clockwise current from A to B.

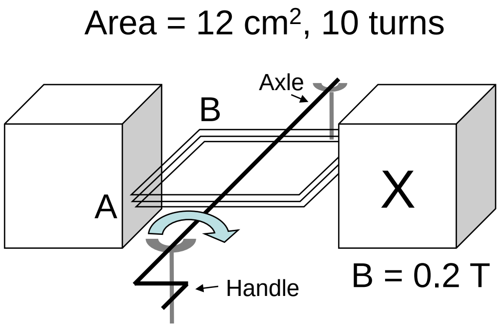


Figure 5

a. State the polarity of magnet X. 2 marks

The coil now rotates to a vertical position.

b. Calculate the flux through the coil. 2 marks

mWb

SECTION B – continued

Question 8 (7 marks)
A communications satellite is launched by the residents of Zephia, a small delightfully arranged planet in a distant solar system.
The satellite is to be geostationary about Zephia.
The mass of Zephia is 4.0×10^{23} kg and it rotates on its own axis in 16 hrs.
The radius of Zephia is 4.2×10^{6} m.

a. Determine the altitude of the satellite from the surface of the planet. 3 marks

km

b. Determine the orbital speed of the satellite. 2 marks

m s^{-1}

c. Calculated the gravitational field strength at the altitude of the satellite. 2 marks

N kg^{-1}

SECTION B – continued
TURN OVER

Question 9 (7 marks)
Graeme is pushing three boxes along the floor, as shown in Figure 7. He exerts a force of 140 N on Box A. Sliding friction forces, equal to 20% of the weight of each box, resist motion. The boxes stay in contact with each other as Graeme pushes them along.

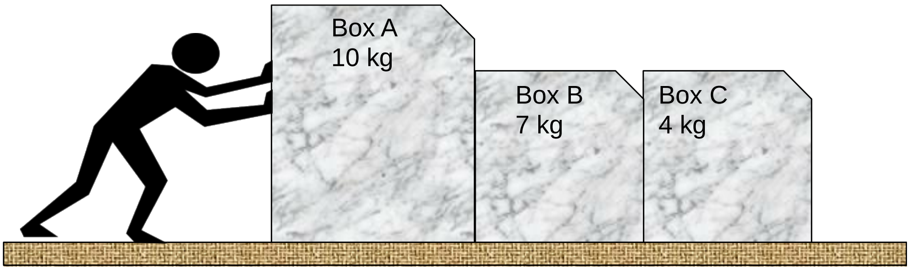


Figure 7

a. Determine the acceleration of the boxes. 2 marks

m s^{-2}

b. Determine the speed of the boxes after Graeme moves them through 4 m. 2 marks

m s^{-1}

c. Find the force of Box B on Box A ($F_{\text{B on A}}$) 3 marks

N

SECTION B – continued

Question 10 (4 marks)
A car is moving at 35 m s^{-1} through a dip that is part of a vertical circle, as shown in Figure 8. An occupant in the car with a mass of 75 kg feels like they are 5 times heavier than usual.

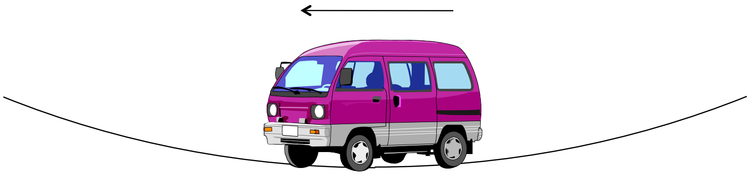


Figure 8

a. Determine the size and direction of the net force acting on the occupant. 2 marks

N	Direction:

b. Determine the radius of the vertical curve that the vehicle is travelling on. 2 marks

m

SECTION B – continued
TURN OVER

Question 11 (6 marks)
A projectile is launched at an angle of 30^{o} and reaches a maximum height of 12 m, as shown in Figure 9.

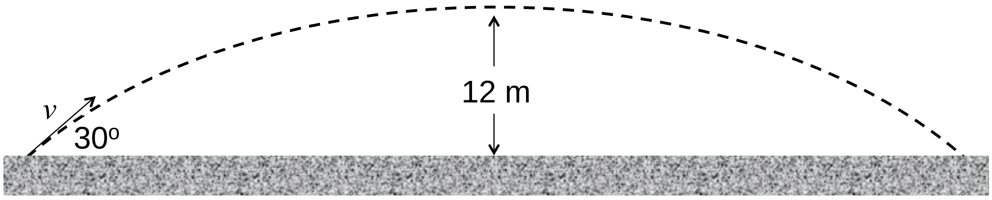


Figure 9

a. Determine the total time of flight for the projectile. 2 marks

s

b. Determine the magnitude of the launch velocity. 2 marks

m s^{-1}

c. Determine the range of the projectile. 2 marks

m

SECTION B – continued

Question 12 (4 marks)
A mass hangs from a spring at rest, 12 cm beyond the natural length of the spring, as shown in **Figure 10**. The mass is then lifted 12 cm and then released.

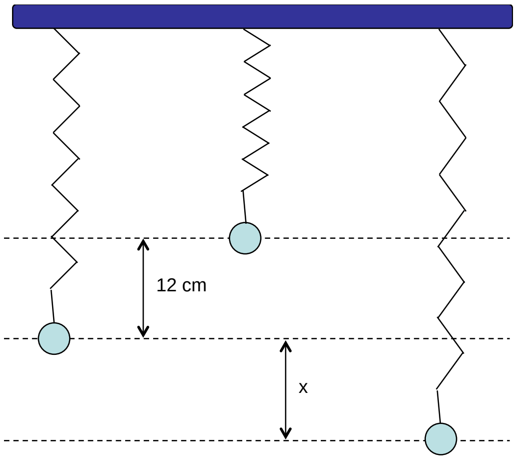


Figure 10

Determine the furthest distance below the rest position (x cm) that the spring would reach.

m

SECTION B – continued
TURN OVER

Question 13 (5 marks)
A 10 kg block is released from rest down an icy slope from a vertical height of *h* above the ground, as shown in Figure 11. At ground level, it collides with a stationary 5 kg block in a sticky collision and then comes to rest in 0.3 m due to a rough surface and combined friction force of 20 N. Note, when the collision takes place, the surface is still icy and can be considered frictionless until the objects are moving as one.

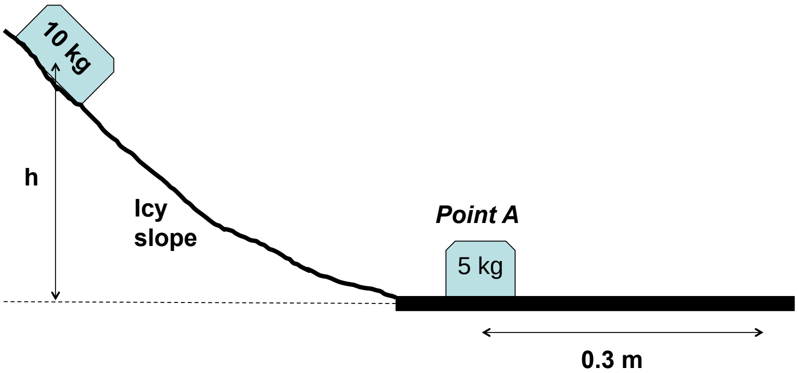


Figure 11

a. Calculate the work done on the blocks as they come to rest. 2 marks

J

b. Determine the height, *h*, from which the 10 kg is released. 3 marks

m

SECTION B – continued

Question 14 (8 marks)
A muon has a lifetime of 2×10^{-6} s in its rest frame. It is created 100 km above the earth and moves towards it at a speed of 2.97×10^{8} m s^{-1}.

a. How long would an observer on Earth see the lifetime of a muon? 3 marks

ms

b. At what altitude does it decay? 3 marks

km

c. According to the muon, how far did it travel in its brief life? 2 marks

m

SECTION B – continued
TURN OVER

Question 15 (5 marks)
A ray of white light traveling inside of a diamond strikes the diamond-air interface with an incident angle of 24^{o} as shown in Figure 12. In a diamond the index of refraction is 2.410 for red light, but for blue light it is 2.450.

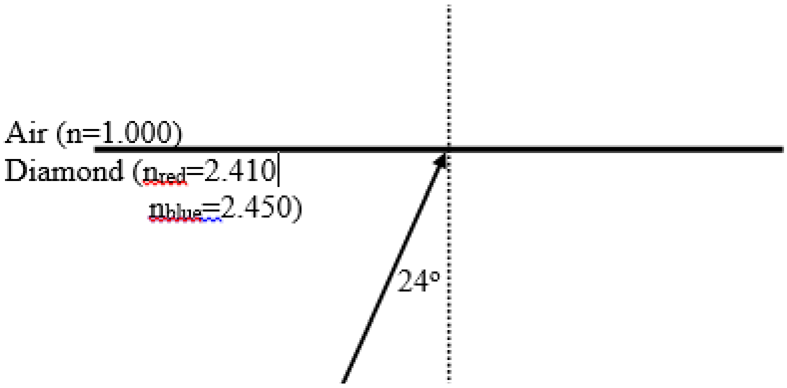


Figure 12

a. Although the incident ray appears white describe what the light exiting the diamond would look like 2 marks

___

___

___

b. On Figure 12 draw the refracted rays showing the angles of refraction. 3 marks

SECTION B – continued

Question 16 (6 marks)
A horn is a both ends open pipe. If the third harmonic has a frequency of 698 Hz, and sound has a speed of 295 m s^{-1} inside the pipe.

a. What is the wavelength of the sound in the horn? 2 marks

m

b. What is the length of the standing wave in the horn? 2 marks

m

c. What is the next higher frequency it can generate? 2 marks

Hz

SECTION B – continued
TURN OVER

Question 17 (10 marks)
Students are investigating the photoelectric effect. They use light of frequency 8×10^{14} Hz to eject electrons from a sodium source within a photocell. The sodium has a work function of 2.18 eV.

a. List the independent, dependent and control variables within this experiment. 3 marks

Independent:

Dependent:

Controlled:

b. State an appropriate aim for this experiment 2 marks

c. Calculate the maximum kinetic energy (in J) if the ejected electrons. 2 marks

J

SECTION B – Question 17 - continued

Students discussing the operation of the photocell make the following statement:

"If the intensity of the light source is increased, but the frequency held constant, the stopping voltage of the photoelectrons should remain constant."

d. Discuss whether you agree with this statement, referring to the model for light that can best be used to explain the result. 3 marks

Question 18 (4 marks)
A two-slit interference pattern is generated using a 40 mW laser source and pair of narrow slits, with the resulting pattern captured on a projection screen and shown in Figure 1.
C is the central band, X a dark band on the pattern.

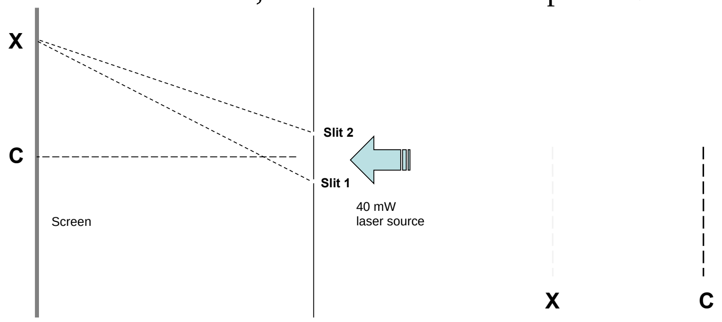


Figure 1

a. Explain why a dark band at X can form, despite only two slits being used. Refer the appropriate model for light to explain your answer. 2 marks

Ross estimates the path difference between each slit and Point X to be 1483 nm

b. Calculate the wavelength of the laser source. 2 marks

nm

SECTION B – continued

Question 19 (4 marks)
A beam of X-rays of wavelength 0.14 nm is incident on a crystal, producing a diffraction pattern shown in Figure 2.

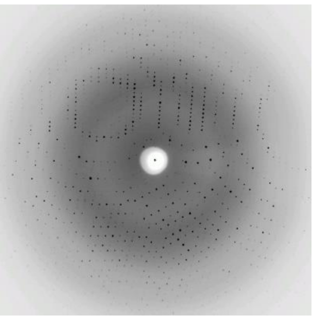


Figure 2

a. Determine the momentum of a single X-ray photon. 1 mark

Ns

b. Calculate the accelerating voltage required for an electron beam that could generate the same shaped diffraction pattern as the X-rays. 3 marks

V

SECTION B – continued
TURN OVER

Question 20 (4 marks)
An energy level for an element is shown in Figure 3.

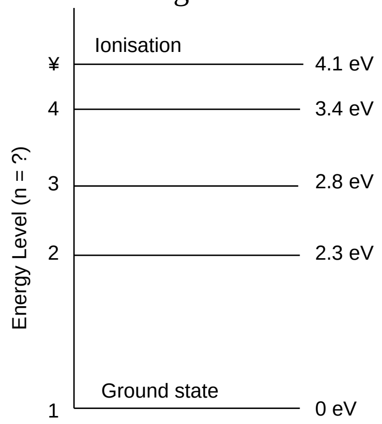


Figure 3

A photon of wavelength 2070 nm is emitted as an electron within an atom transitions between energy states.

a. State the energy level change that has been observed. 2 marks

Initial state:	Final state:

b. Describe how *electrons modelled as existing as standing waves* can be used to explain the nature of the energy levels within the atom. 2 marks

END OF QUESTION AND ANSWER BOOK

Data Sheet

1	Velocity, acceleration	$v = \frac{\Delta x}{\Delta t}$ $a = \frac{\Delta v}{\Delta t}$
2	Equations for constant acceleration	$v = u + at$ $x = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$ $x = \frac{1}{2}(u+v)t$
3	Newton's second law	$F = ma$
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	$\frac{1}{2}kx^2$
7	Gravitational potential energy near the surface of the earth	mgh
8	Kinetic energy	$\frac{1}{2}mv^2$
9	Lorentz factor	$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$
10	Time dilation	$t = t_0 \gamma$
11	Length contraction	$L = L_0 / \gamma$
12	Relativistic mass	$m = m_0 \gamma$
13	Newton's law of universal gravitation	$F = \frac{GM_1 M_2}{r^2}$
14	Gravitational field	$g = \frac{GM}{r^2}$
15	Transformer action	$\frac{V_1}{V_2} = \frac{N_1}{N_2}$
16	AC voltage and current	$V_{\text{RMS}} = \frac{1}{\sqrt{2}}V_{\text{peak}}$ $I_{\text{RMS}} = \frac{1}{\sqrt{2}}I_{\text{peak}}$
17	Voltage, power	$V = IR$, $P = VI$
18	magnetic force	$F = IlB$

19	electromagnetic induction	emf : $\varepsilon = -N\dfrac{\Delta\phi}{\Delta t}$ flux : $\phi = BA$
20	transmission losses	$V_{\text{drop}} = I_{\text{line}}R_{\text{line}}$ $P_{\text{loss}} = I_{\text{line}}^2 R_{\text{line}}$
21	Snell's Law	$n_1 \sin i = n_2 \sin r$
22	photoelectric effect	$E_{\text{k max}} = hf - W$
23	photon energy	$E = hf$
24	photon momentum	$p = \dfrac{h}{\lambda}$
25	de Broglie wavelength	$\lambda = \dfrac{h}{p}$
26	Planck's constant	$h = 6.63\times10^{-34}$ J s $h = 4.14\times10^{-15}$ eV s
27	Universal gravitational constant	G = 6.67 × 10^{-11} N m^2 kg^{-2}
28	Mass of Earth	M_E = 5.98 × 10^{24} kg
29	Radius of Earth	R_E = 6.37 × 10^6 m
30	Mass of the electron	m_e = 9.1 × 10^{-31} kg
31	Charge on the electron	q = -1.6 × 10^{-19} C
32	Speed of light	c = 3.0 × 10^8 m s^{-1}
33	energy transformations for electrons in an electron gun (<100 keV)	$\frac{1}{2}mv^2 = eV$
34	radius of electron beam	$r = \dfrac{p}{qB}$
35	force applied to an electron beam	$F = qvB$
36	electric field between charged plates	$E = \dfrac{V}{d}$

Prefix/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}

t = tonne = 10^{3} kg

SECTION A MULTIPLE CHOICE ANSWER SHEET

Answers – Circle ONE of A-D for each of the 11 multiple choice questions.

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