TSSM
Creating VCE Success

2023 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	18	18	110
			Total 130

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners and rulers
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.
- No calculator is permitted in this examination.

Materials supplied

- Question and answer book of 38 pages.

Instructions

- Print your name in the space provided on the top of this page.
- All written responses must be in English.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic communication 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 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 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 image shown in Figure 1 could show which type of field?

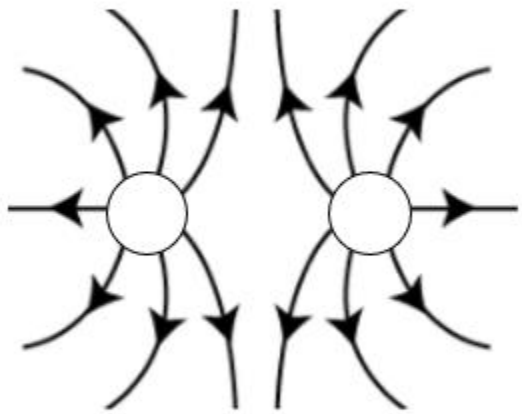


Figure 1.

A. Electric field around two positive charges
B. Electric field around a negative and positive charge
C. Gravitational field around two masses
D. Magnetic field around two current carrying conductors

Question 2

An unknown planet (mass of 1.30×10^{22} kg) has a moon (mass of 1.55×10^{21} kg). The distance between the centre of the planet and the moon is 600 km. What would be the force of attraction between the planet and the moon?

A. 6.98×10^{10} N
B. 9.33×10^{20} N
C. 1.87×10^{21} N
D. 3.73×10^{21} N

SECTION A- continued

Use the following information to answer questions 3-4.

An electric field is produced between 1000 V charged plates placed 8 cm apart as shown in Figure 2.

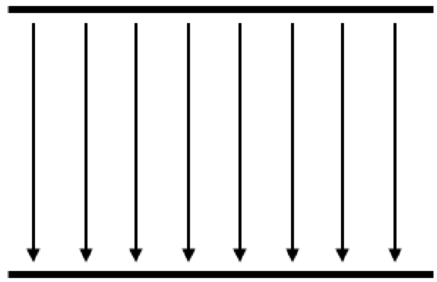


Figure 2.

Question 3

Which plate is positively charged?

A. Top plate.
B. Bottom plate.
C. They are both positive.
D. Cannot be determined.

Question 4

What is the strength of the electric field?

A. 1.05×10^{-4} N C^{-1}
B. 3.45×10^{4} N C^{-1}
C. 1.25×10^{4} N C^{-1}
D. 6.78×10^{-4} N C^{-1}

Question 5

A transformer is used to step down the 40 kV voltage from high voltage transmission lines to the 13 kV voltage used in street powerlines. The ratio of number of turns in the primary to secondary coil of the transformer is closest to:

A. $2:1$
B. $3:1$
C. $1:4$
D. $2:4$

SECTION A- continued
TURN OVER

Use the following information to answer questions 6-7.

A DC motor is set up as shown in Figure 3. The coil has dimensions 10 cm x 5 cm and a current of 1.5 A runs through the coil. The magnetic field has a strength of 0.4 T.

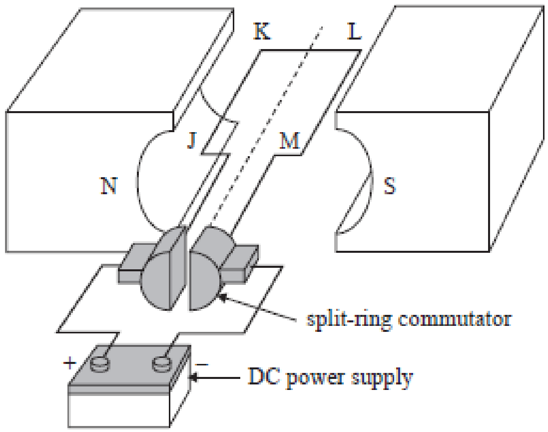


Figure 3.

Question 6

What is the force on side JK?

A. 0.06 N up
B. 0.06 N down
C. 0.03 N up
D. 0.03 N down

Question 7

How could the rotation speed of the motor be increased?

A. Increase the resistance of the wires.
B. Decrease the length CD.
C. Have two north poles facing each other.
D. Increase the number of turns in the coil.

Question 8

Two friends, Sarah and Jessica, are jumping off a 5 m cliff into some water below. Sarah takes a run up and launches herself with a speed of 7 m s^{-1} horizontally. Jessica decides to step off the cliff, with zero speed in the horizontal direction. Ignoring the effects of air resistance, who will hit the water first?

A. Sarah
B. Jessica
C. They will both hit at the same time.
D. Whoever has the greatest mass will hit the water first.

SECTION A- continued

Use the following information to answer questions 9-10.

Two forces are applied to two boxes from either end as shown in Figure 4.

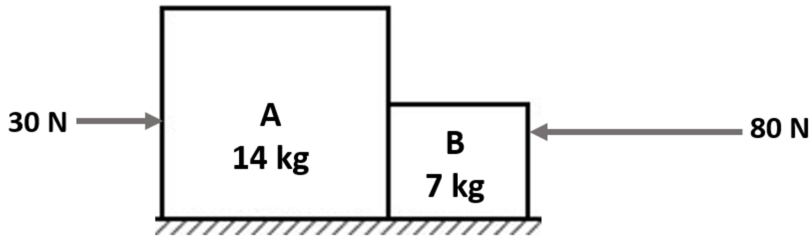


Figure 4.

Question 9

The magnitude of the acceleration of the boxes is closest to:

A. 1.4 m s^{-2}

B. 2.1 m s^{-2}

C. 2.4 m s^{-2}

D. 3.6 m s^{-2}

Question 10

What would be the total amount of work done in moving the boxes 3 m?

A. 4 J

B. 50 J

C. 150 J

D. 330 J

Question 11

The Sun has a power output of 3.80×10^{26} W. How much mass does the Sun lose each second?

A. 1.28×10^{2} kg

B. 6.98×10^{3} kg

C. 1.03×10^{9} kg

D. 4.22×10^{9} kg

Question 12

A car of total mass 800 kg is travelling over a hump in the road. The hump has a radius of curvature of 20 m. What is the maximum speed with which the car can travel over the hump without losing contact with the road?

A. 8 m s^{-1}

B. 14 m s^{-1}

C. 27 m s^{-1}

D. 56 m s^{-1}

SECTION A- continued
TURN OVER

Question 13
Two students are standing on the side of the road watching F1 racing cars go past. Which of these options best describes the pitch of the sound emitted by the cars as the cars move towards the students?
A. It is higher compared to when the cars are moving away from them.
B. It is lower compared to when the cars are moving away from them.
C. It is the same as when the cars are moving away from them.
D. It increases, then decreases.

Question 14
The wave in Figure 5 shows the motion of a particle in a transverse wave over time.

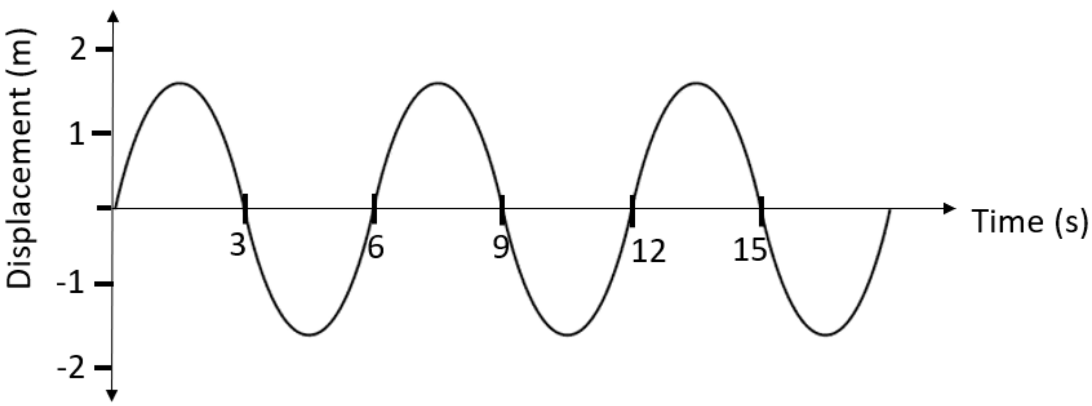


Figure 5.

Which of the following is the closest to the amplitude and frequency of the wave, respectively?
A. 1.50 m, 3.00 Hz
B. 1.50 m, 0.17 Hz
C. 3.00 m, 0.17 Hz
D. 3.00 m, 6.00 Hz

Question 15
Water waves diffract around a rock sticking out of the water. A large boat goes past, producing waves that are closer together than the waves naturally produced in the water. How will these waves diffract differently compared to the waves with a shorter wavelength?
A. They will diffract more.
B. They will diffract less.
C. They will have the same diffraction pattern.
D. The diffraction depends on the speed through the water.

SECTION A- continued

Question 16

An electron is moving at a speed of 8.6×10^{6} m s^{-1}. What is the associated de Broglie wavelength of this electron?

A. 4.8×10^{-22} m

B. 7.7×10^{-41} m

C. 8.5×10^{-11} m

D. Electrons do not have a wavelength.

Question 17

Heisenberg's uncertainty principle can be used to explain electron diffraction through a single slit. Which explanation below is most correct?

A. Widening the slit ***increases*** the uncertainty in the position which ***decreases*** the uncertainty in momentum which ***decreases*** the diffraction pattern.

B. Widening the slit ***decreases*** the uncertainty in the position which ***increases*** the uncertainty in momentum which ***increases*** the diffraction pattern.

C. Widening the slit ***increases*** the uncertainty in the position which ***increases*** the uncertainty in momentum which ***decreases*** the diffraction pattern.

D. Widening the slit ***decreases*** the uncertainty in the position which ***decreases*** the uncertainty in momentum which ***increases*** the diffraction pattern.

Question 18

Which source of light would produce light that could be described as coherent and monochromatic?

A. Hot objects

B. LEDs

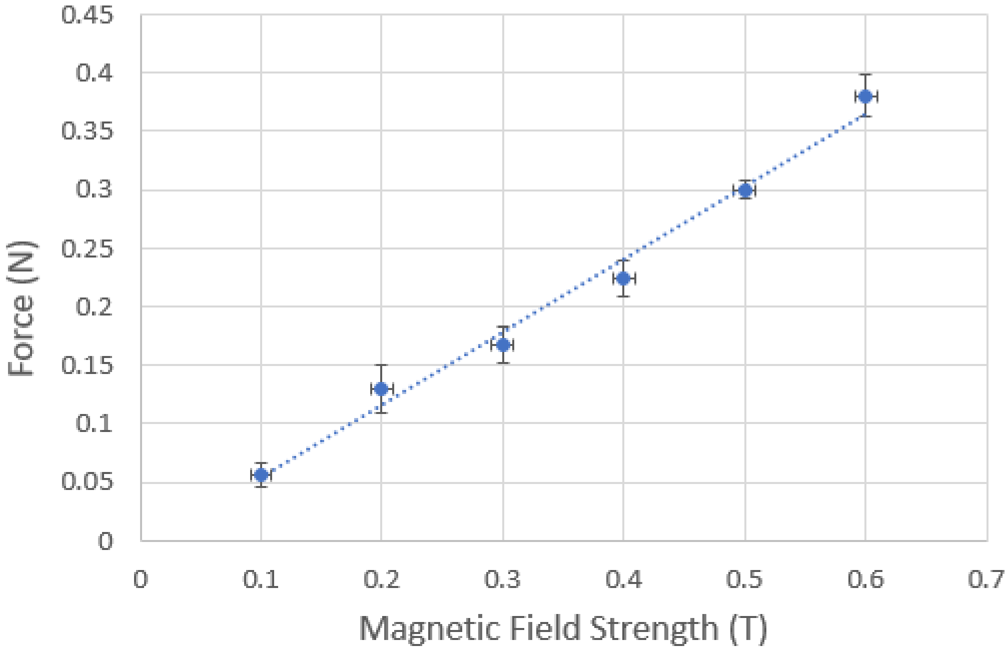
C. An incandescent globe

D. A laser

SECTION A- continued
TURN OVER

Use the following information to answer questions 19-20.

Students conduct an experiment to measure the force applied to a conducting wire inside a magnetic field. They obtain the following graph.



Question 19

Which option correctly identifies the variables of this experiment?

	Independent variable	Dependent variable	Controlled variable
A.	Magnetic field strength	Length of wire	Current
B.	Force	Magnetic field strength	Area of wire
C.	Force	Magnetic field strength	Length of wire
D.	Magnetic field strength	Force	Current

Question 20

Have the students drawn a suitable trendline?

A. Yes, because it goes through the first and last point.

B. Yes, because it goes through all uncertainty bars.

C. No, because it doesn't go through all of the points.

D. No, because it doesn't go through the first and last point.

END OF SECTION A

SECTION B - Short-answer questions

Instructions for Section B

Answer **all** questions in the spaces provided.
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 m s^{-2}.

Question 1 (3 marks)

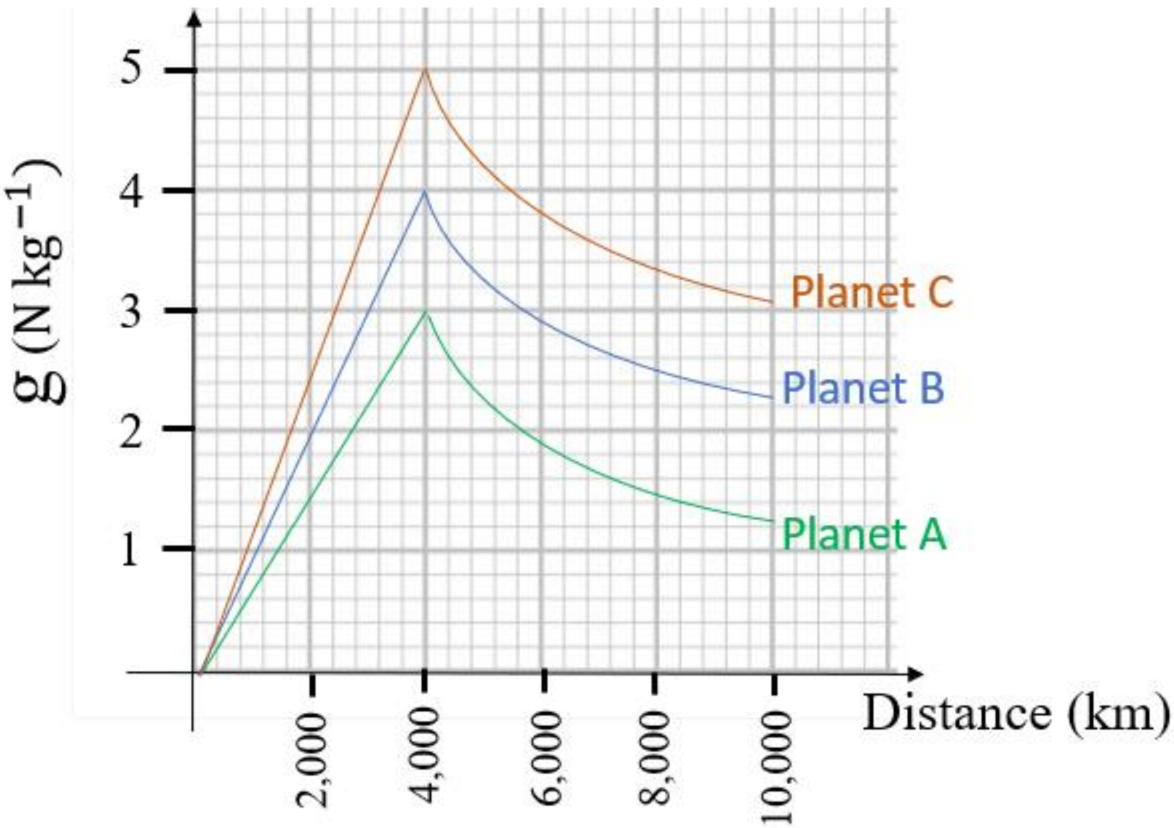
Complete the table by placing a tick in the box where the option applies to each type of field.

	Gravitational field	**Electric field around a point mass**	**Magnetic field around a bar magnet**
Can be attractive or repulsive			
Can exist as dipoles or monopoles			
Static			
Uniform			

SECTION B –continued
TURN OVER

Question 2 (9 marks)

The graph below shows the value for 'g' at various distances from the centre of 3 unknown planets.



a. Which planet has the greatest mass? Justify your response with an appropriate equation.

2 marks

SECTION B – Question 2 – continued

b. Calculate the change in gravitational potential energy for an 800 kg satellite in orbit around planet A, moving from a distance of 2 000 km to 4 000 km above the surface of the planet.

J

2 marks

c. Calculate the mass of planet A. Give your answer to 3 significant figures.

kg

3 marks

d. Calculate the period of orbit for the 800 kg satellite in orbit around planet A at a distance of 1000 km above the surface.

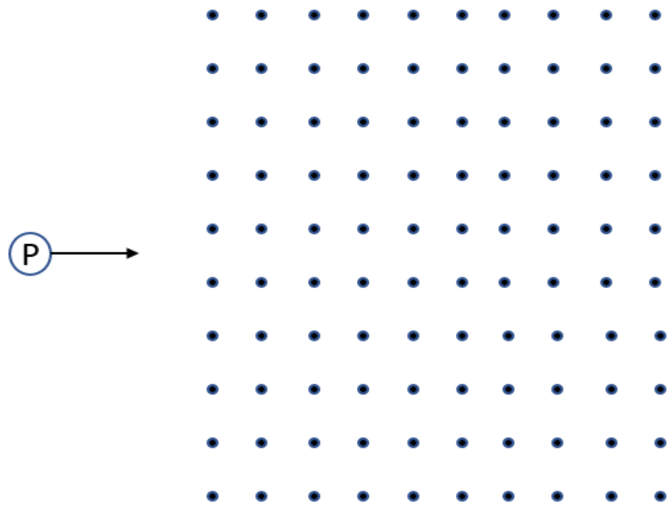
s

2 marks

SECTION B – continued
TURN OVER

Question 3 (5 marks)

A proton (mass 1.67×10^{-27} kg) enters a uniform magnetic field of strength 0.05 T as shown in Figure 6.



Not to scale

Figure 6.

The proton follows a circular path with a radius of 60 cm.

a. Show that the velocity with which the proton entered the field is equal to 2.87×10^6 m s^{-1}.

1 mark

b. On Figure 6, draw the path that the proton will follow, labelling the direction of the force at three difference locations inside the magnetic field. The path does not need to be drawn to scale.

2 marks

SECTION B – Question 3 – continued

c. Calculate the size of the force acting on the proton.

N

2 marks

Question 4 (4 marks)

An alpha particle has a charge of 3.2×10^{-19} C. You can consider this particle a point charge.

a. Calculate the strength of the electric field at a distance of 20 μm away.

$\mathrm{N\ C^{-1}}$

2 marks

b. A proton is placed at this point 20 μm away from the alpha particle. Calculate the magnitude of the force on the proton from the alpha particle.

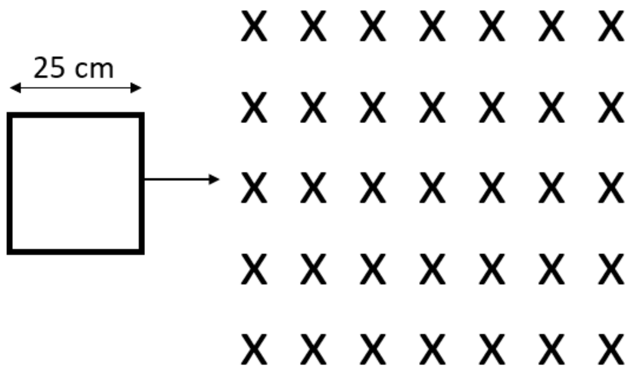
N

2 marks

SECTION B –continued
TURN OVER

Question 5 (7 marks)

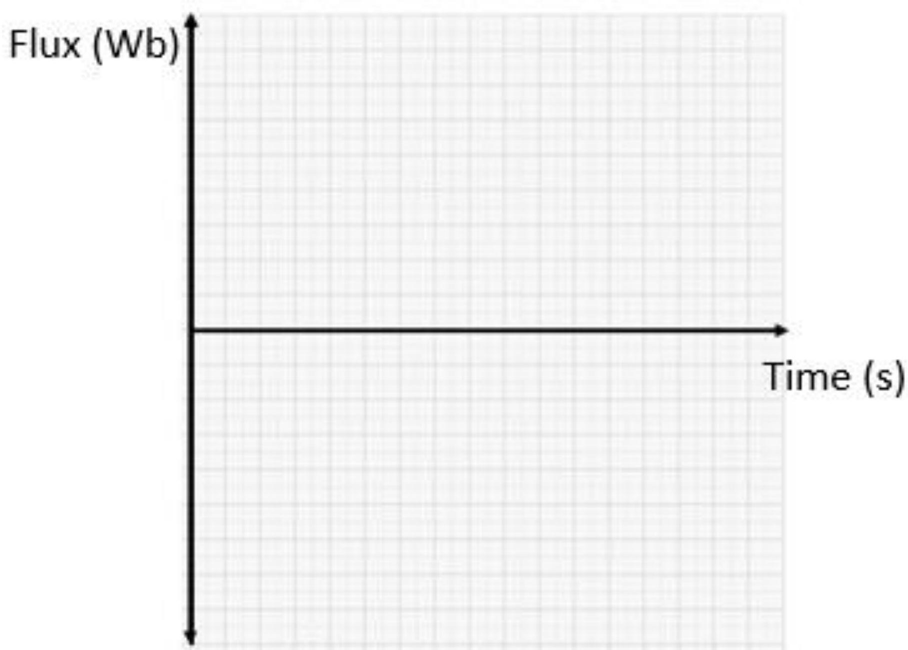
A square coil moves all the way through a magnetic field (of strength 2.0×10^{-3} T) and out the other side at a constant speed of 0.5 m s^{-1} as shown in Figure 7 below.



Not to scale

Figure 7.

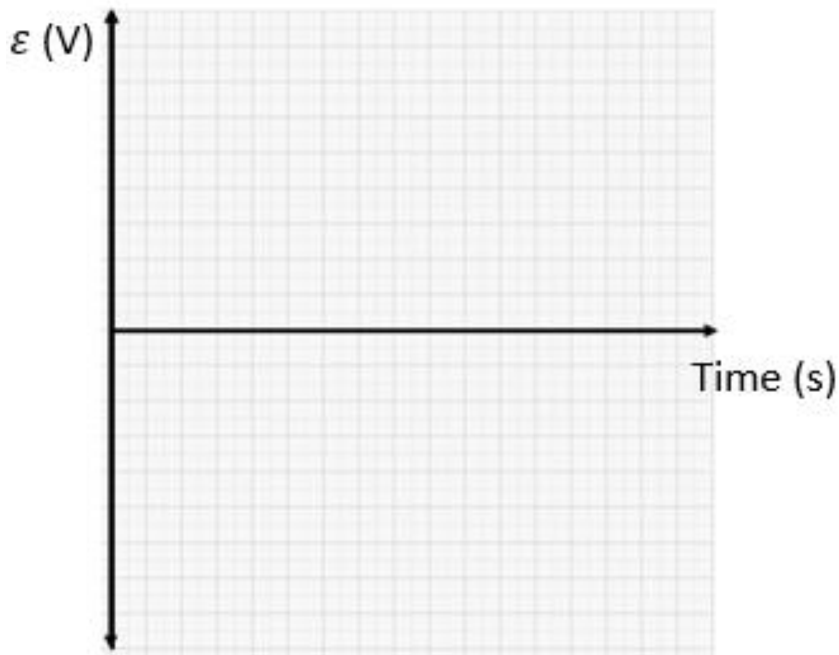
a. Draw a flux time graph for the flux through the coil as it moves all the way through the magnetic field. Include a scale on the y axis (no scale is required on the x axis).



2 marks

SECTION B – Question 5 – continued

b. Draw an EMF time graph for the induced EMF in the coil as it moves all the way through the magnetic field. Include a scale on the y axis (no scale is required on the x axis).



2 marks

c. In which direction will the induced EMF be as the coil enters the field? Justify your response.

___

___

___

___

3 marks

SECTION B –continued
TURN OVER

Question 6 (6 marks)
An electricity substation converts high voltage electricity 20 kV to a lower voltage 200 V for transmission along electrical cables in the street.

a. Explain why electricity is transmitted at such high voltages from the point at which it is generated to the substation.

2 marks

b. The current in the wires in the street is 10 A. Calculate the current in the wires before reaching the substation.

A

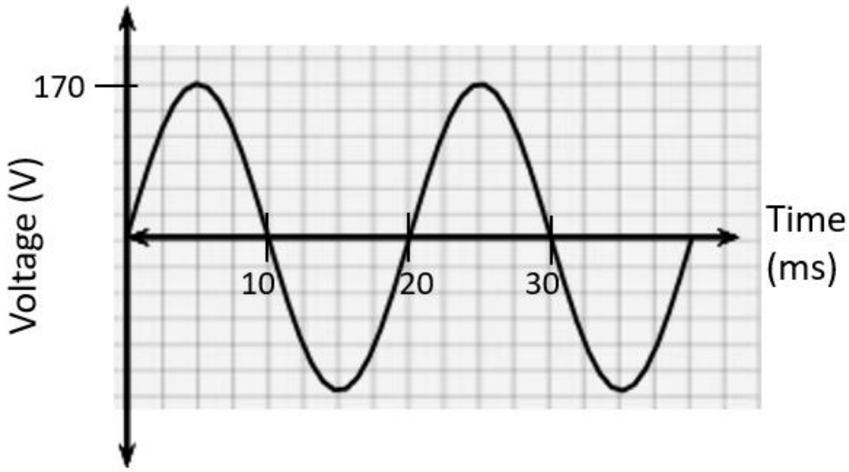
2 marks

c. Many devices in the home use DC electricity. Explain why the preferred option for electricity distribution in the form of AC.

2 marks

SECTION B –continued

Question 7 (7 marks)
The following graph shows AC voltages produced as a result of the uniform rotation of a loop in a constant magnetic field.



a. Calculate the frequency of rotation of the loop.

____

____

____

____

| Hz |

2 marks

b. Calculate the RMS voltage and explain what this term means.

____

____

____

____

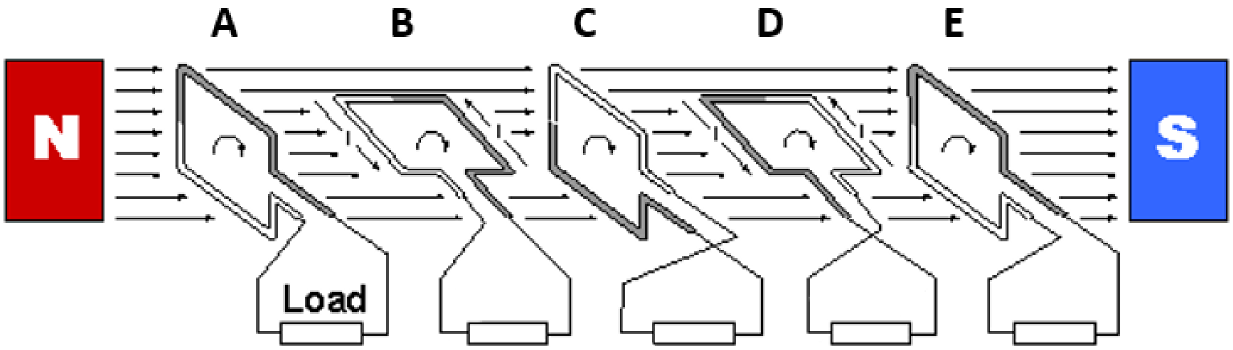
____

| V |

2 marks

SECTION B – Question 7 - continued
TURN OVER

c. The coil rotation is shown as different times in the image below.



Explain in which location there is peak voltage being produced. Give reasons for your answer.

3 marks

SECTION B –continued

Question 8 (5 marks)

A rock is fired out of a volcano at 46 m s^{-1} at an angle of 35 ° above the horizontal as shown in Figure 8.

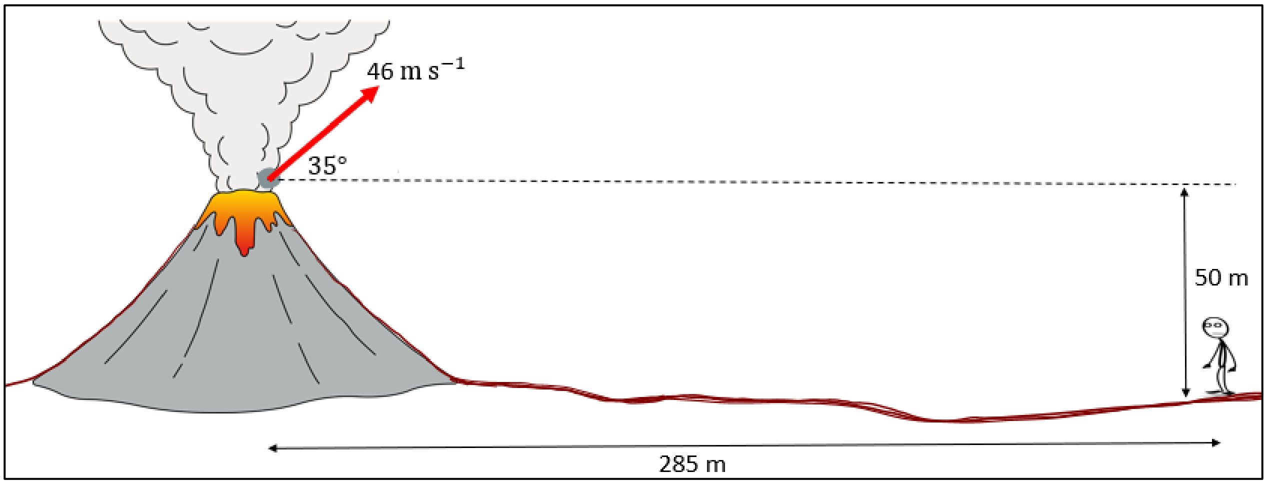


Figure 8.

a. Jimmy is standing 285 m away from the volcano. Ignoring air resistance, will the rock hit Jimmy? Show your working.

3 marks

SECTION B – Question 8 – continued
TURN OVER

b. Describe how the result to part (a) would differ if air resistance was not ignored (no calculations are required).

2 marks

Question 9 (5 marks)

A 900 kg car is travelling around a circular track as shown in Figure 9. It is travelling at a constant speed of 150 km/hr.

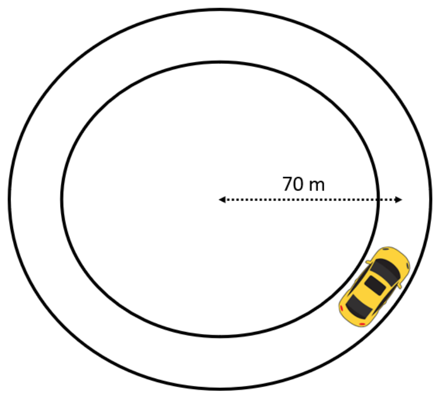


Figure 9.

a. Calculate the frictional force required to keep the car moving in the circular path.

N

2 marks

SECTION B – Question 9 – continued

The race director decides that this design is a little dangerous and decides to bank the track at an angle of 10° above the horizontal as shown in Figure 10.

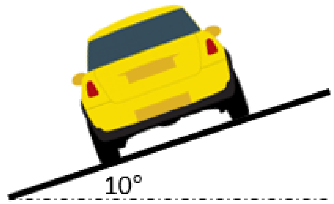


Figure 10.

b. Draw and label the forces acting on the car as well as the net force (draw this with a dotted arrow).

1 mark

c. Explain how banking the track makes the race safer for the drivers.

2 marks

SECTION B – continued
TURN OVER

Question 10 (6 marks)

Muons are particles produced when cosmic rays collide with the Earth's upper atmosphere. Travelling at 0.988c, the muons have a half-life of 2.0×10^{-6} s and a rest mass of 1.88×10^{-28} kg.

a. Calculate the the half-life of the muons as observed by scientists on Earth.

s

2 marks

b. Calculate the relativistic kinetic energy of these muons travelling at this speed.

J

2 marks

c. If the muons were able to emit light as they travelled, would the scientist on Earth observe the light emitted by the muons moving towards them as faster than, slower than or the same speed as the speed of light (c)? Circle and justify your response.

Faster than c **Slower than c** **The same speed as c**

2 marks

SECTION B –continued

Question 11 (4 marks)
A 300 g ball is placed onto a spring. The spring is compressed downwards by 4 cm and then released, launching the ball straight into the air.

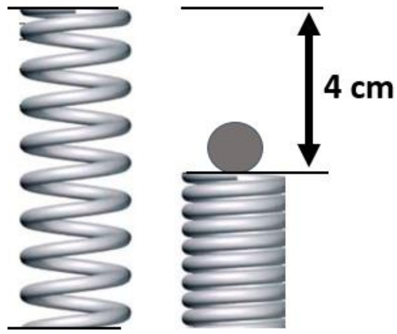
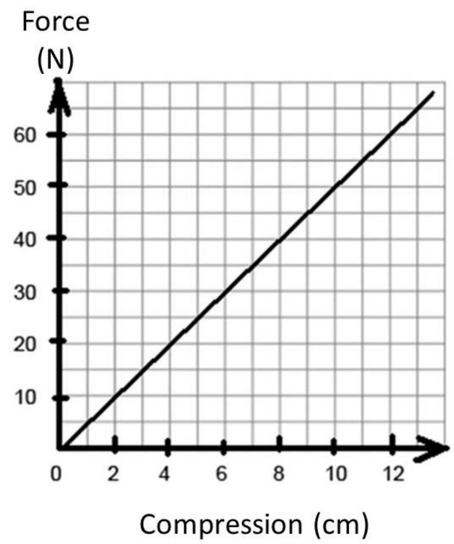


Figure 11.

The spring has the compression characteristics shown in the graph below.



a. Calculate the spring constant, *k*.

____

____

____

$N\ m^{-1}$

1 mark

SECTION B – Question 11 – continued
TURN OVER

b. The ball is compressed by 4 cm and then released. It shoots straight up in the air. Calculate the maximum height to which the ball reaches above it starting (compressed) position.

m

3 marks

Question 12 (7 marks)

The following wave shows the air pressure due to a sound wave at an increasing distance away from a speaker. Assume the sound waves travel at 340 m s^{-1}.

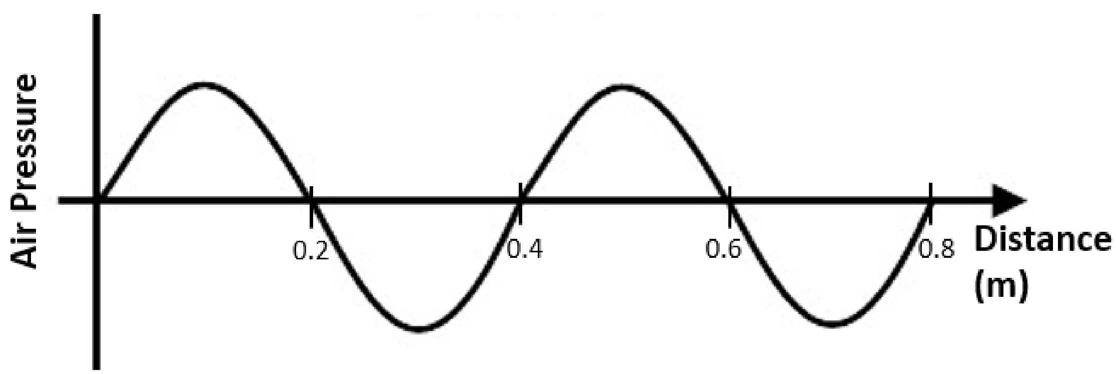


Figure 12.

a. What type of wave is a sound wave? Circle the correct response.

Transverse **Longitudinal** **Electromagnetic**

1 mark

SECTION B –Question 12 - continued

b. Calculate the frequency of the sound wave above. Show your working.

Hz

2 marks

A second speaker is placed 0.8 m next to the first speaker at the far end of the room as shown in Figure 13. It produces an identical sound to the first speaker.

Not to scale

Figure 13.

c. Students walk across the room from point A to point B and notice that the volume of the sound appears to change in different locations. Explain the reason for this observation.

2 marks

SECTION B – Question 12 - continued
TURN OVER

d. Students stand at point X which is equal distance from both speakers. They walk towards point A and stop at the second quiet region. How much closer to speaker 1 are they compared to speaker 2?

m

2 marks

Question 13 (4 marks)

A student is conducting a double-slit experiment using a green laser ($\lambda = 550$ nm). The laser is incident on two slits that are 8.9×10^{-5} m apart. They produce an interference pattern with adjacent bright bands 1.0 cm apart.

a. Calculate the distance between the double slits and the screen where the interference pattern is observed.

m

2 marks

SECTION B –Question 13 - continued

b. The students find the separation between bright bands hard to measure and wish to make the bright bands further apart. Stanley says that they should use a double-slit filter in which the slits are closer together, while Jovan says they should use a double-slit filter in which the slits are further apart. Who is correct? Justify your response.

2 marks

Question 14 (7 marks)

The diagram below shows the electromagnetic spectrum which consists of light waves of varying frequency as shown in Figure 14.

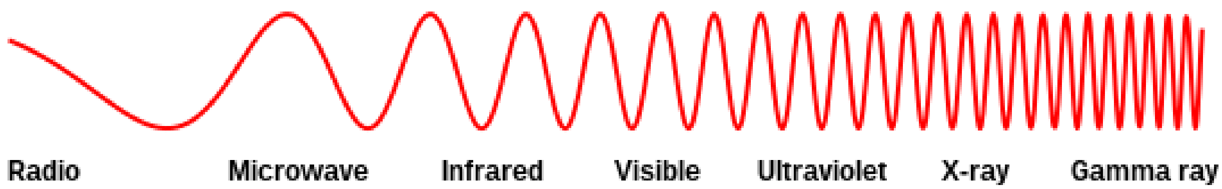


Figure 14.

a. Identify the section that has the highest energy.

1 mark

b. Seyara says that the higher frequency waves should travel at a greater velocity because velocity is proportional to frequency as per the equation $\mathbf{v = f\lambda}$. Dhimanya says this is not true, they all travel at the same speeds. Who is correct? Justify your response.

2 marks

SECTION B – Question 14 – continued

TURN OVER

c. Light has certain observable properties. For each property, give a description of what this term means.

i. Diffraction

1 mark

ii. Superposition

1 mark

iii. Refraction

1 mark

iv. Dispersion

1 mark

SECTION B – continued

Question 15 (8 marks)

Figure 15 below shows photoemission of electrons from a metal surface when exposed to incident light.

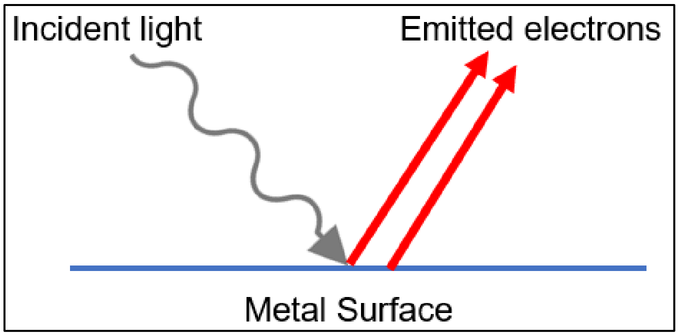


Figure 15.

a. The intensity of the incoming incident light is reduced. What effect would this have on the:

i. Number of emitted electrons per second? Justify your response.

2 marks

ii. Average velocity of the emitted electrons? Justify your response.

2 marks

SECTION B – Question 15 – continued

TURN OVER

The intensity of the incoming light is returned to its initial level. The wavelength of the incoming incidence light is then decreased. What effect would this have on the:

i. Number of emitted electrons per second? Justify your response.

2 marks

ii. Average velocity of the emitted electrons? Justify your response.

2 marks

Question 16 (6 marks)

Figure 16 below shows the spectrum produced when white light was shone through a sample of hydrogen gas. The black bands show an absence of colour.

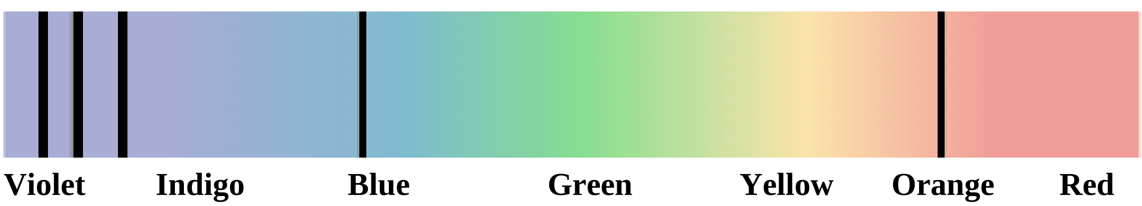


Figure 16.

a. Explain the presence of the black bands in this spectrum.

2 marks

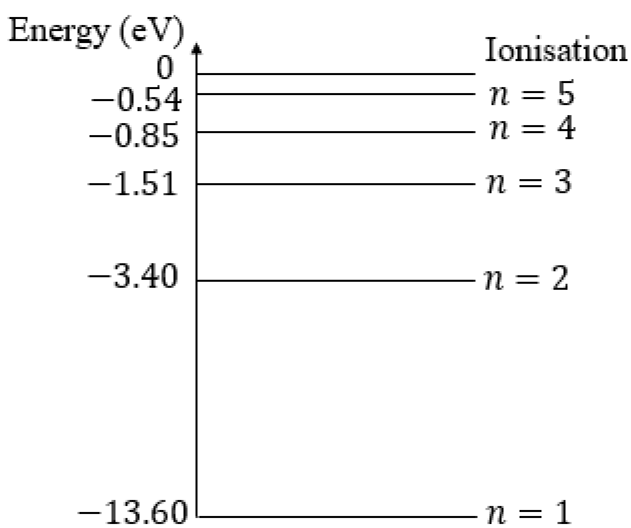
SECTION B – Question 16 – continued

b. The black band in the blue region corresponds to a wavelength of 434 nm. Calculate the energy associated with this photon of light.

J

2 marks

c. Draw an arrow to show the energy transition that would occur to produce this dark band in the blue region.



2 marks

SECTION B – continued
TURN OVER

Question 17 (6 marks)

X-rays of wavelength 4.2 nm are emitted from an X-ray source.

a. Calculate the momentum of these X-rays.

kg m s^{-1}

2 marks

b. The X-rays are incident on a single narrow gap. Explain why a gap width of 0.4 nm would produce a diffraction pattern but a width of 56 nm would not.

2 marks

c. The X-rays are replaced by a stream of electrons which produces the same diffraction pattern as the X-rays. At what speed are the electrons travelling at?

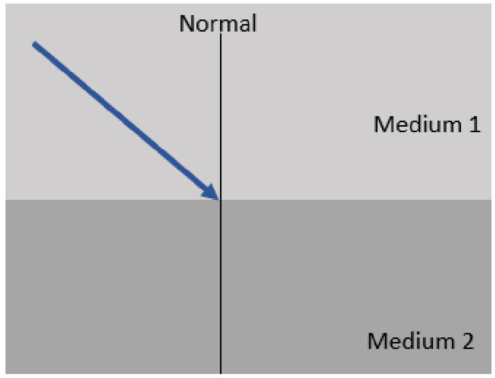
m s^{-1}

2 marks

SECTION B – continued

Question 18 (11 marks)

Students set up the following experiment. An incident light beam in medium 1 (n=1.5) was shone into medium 2. They measured the angle of refraction for various angles of incidences.



They collected the data as follows:

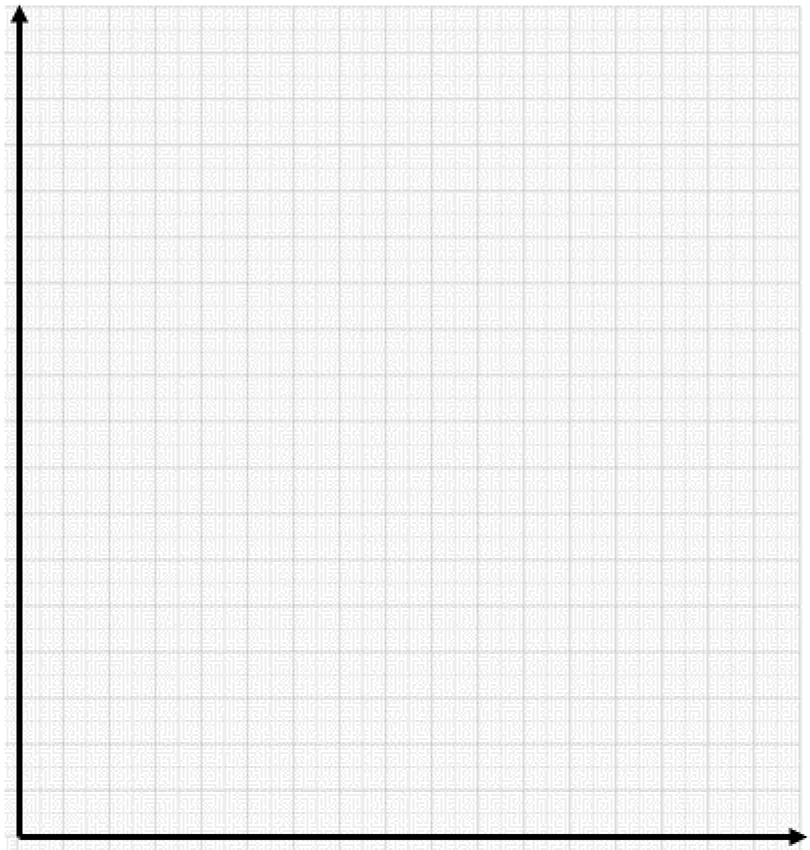
i	**r**	**sin(i)**	**sin(r)**
35	41	0.57	0.66
40	51	0.64	0.78
45	59	0.71	0.86
50	66	0.77	0.91
55	80	0.82	0.98
60	-	0.87	-

a. Explain why there is no angle of refraction for an angle of incidence of 60 degrees.

2 marks

SECTION B – Question 18 - continued
TURN OVER

b. Graph sin(*i*) against sin(*r*). Include a straight line of best fit.



4 marks

c. Use the graph to calculate the refractive index of material 2 to 3 significant figures.

2 marks

SECTION B – Question 18 – continued

d. The protractor has a scale that increases by increments of 1°. Determine the uncertainty from the protractor.

1 mark

e. The true ***n*** value for the second material is known to be 1.10. Comment on the accuracy of their data using appropriate calculations.

2 marks

END OF QUESTION AND ANSWER BOOK

Formula Sheet

Motion and related energy transformations

velocity; acceleration	$v = \frac{\Delta s}{\Delta t}$; $a = \frac{\Delta v}{\Delta t}$
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	$t = t_o\gamma$
length contraction	$L = \frac{L_o}{\gamma}$
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	$E = \frac{V}{d}$
energy transformations of charges in an electric field	$\frac{1}{2}mv^2 = qV$
field of a point charge	$E = \frac{kq}{r^2}$
force on an electric charge	$F = qE$
Coulomb's law	$F = \frac{kq_1q_2}{r^2}$
magnetic force on a moving charge	$F = qvB$
magnetic force on a current carrying conductor	$F = nIlB$
radius of a charged particle in a magnetic field	$r = \frac{mv}{qB}$

Generation and transmission of electricity

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

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 light and matter

photoelectric effect	$E_{k\,max} = hf - \phi$
photon energy	$E = hf$
photon momentum	$p = \frac{h}{\lambda}$
de Broglie wavelength	$\lambda = \frac{h}{p}$

Data

acceleration due to gravity at Earth's surface	$g = 9.8$ 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	$c = 3.0 \times 10^{8}$ m s^{-1}
universal gravitational constant	$G = 6.67 \times 10^{-11}$ N m^2 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	$k = 8.99 \times 10^{9}$ N m^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}	t = tonne = 10^{3} kg