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2019 Trial Examination

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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 37 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

At a distance of x m from a 1.5 μC charge, the electric field has a magnitude of 50 N C^{-1}?

Which one of the following is closest to the magnitude of x?

A. 16 m

B. 270 m

C. 820 m

D. 6.7×10^{5} m

Question 2

Three positive charges and one negative charge are placed as shown in the diagram below. All the charges have the same magnitude. Point **P** is exactly halfway between the two left-hand charges.

Which one of the following best describes the direction of the electric field at point **P**?

A. Up

B. Right

C. Down

D. Left

SECTION A - continued

Question 3

The centres of two bodies are x m apart and they exert a force of 120 N on each other.

What force will they exert on each other if the mass of one of the bodies is tripled and the distance between their centres is doubled?

A. 80 N

B. 90 N

C. 180 N

D. 720 N

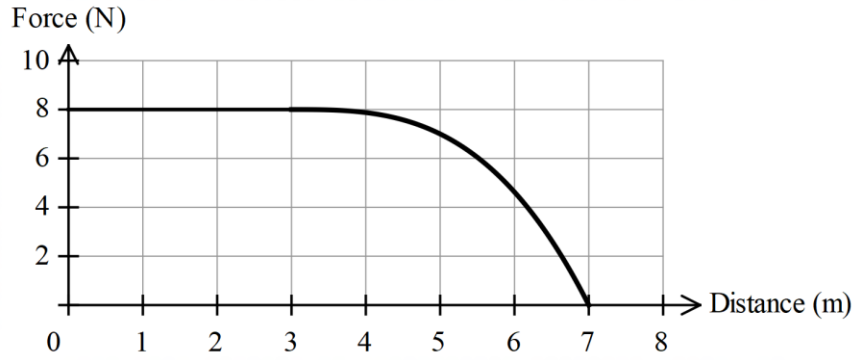
Question 4

An electron passing through a magnetic field is deflected to the east.

Which row of the table below could give the correct directions of the magnetic field and the velocity of the electron?

	Magnetic field direction	Electron velocity direction
A.	North	Into the page
B.	Down	South
C.	North	Out of the page
D.	Out of the page	North

Question 5



The graph above shows the force used by Chan as he pulled a trolley across a floor.
Which one of the following is closest to the amount of energy Chan used to pull the trolley?

A. 40 J

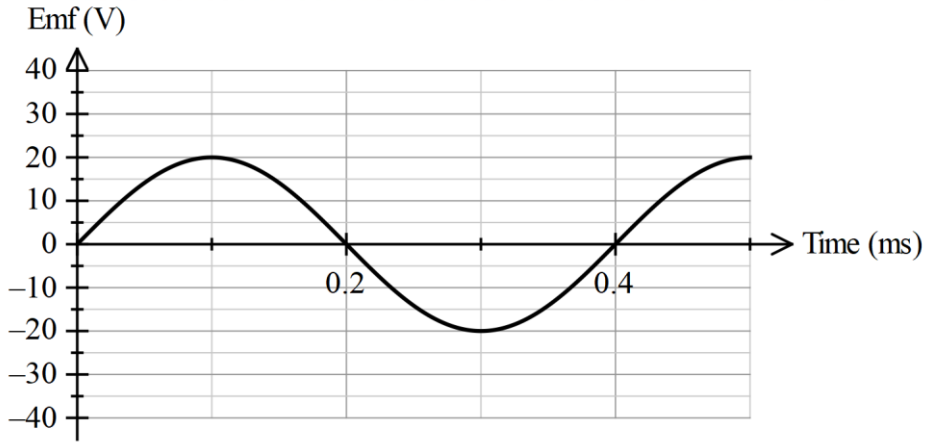
B. 44 J

C. 48 J

D. 56 J

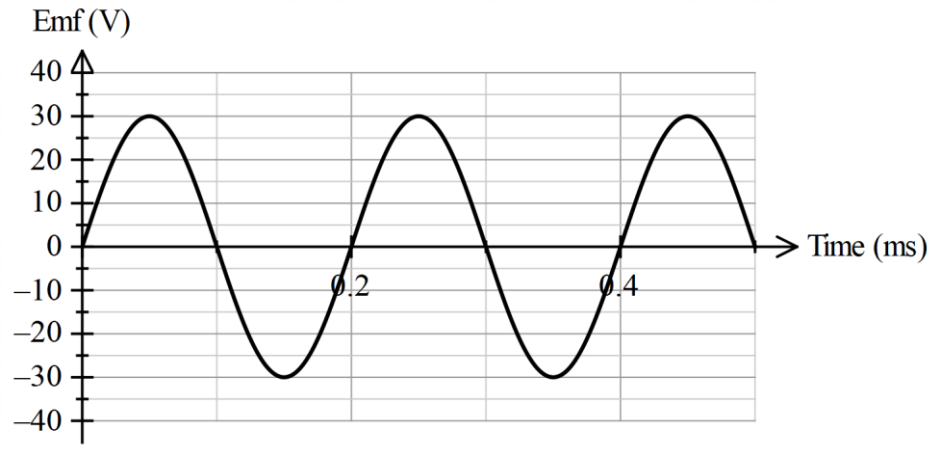
Question 6

In an experiment, Carla rotated a coil within a magnetic field. She obtained the following graph showing the emf between the ends of the coil plotted against time.



SECTION A – Question 6 - continued

She then modified the apparatus she was using, repeated the experiment and obtained the following graph of emf versus time.



Which one of the following describes the change or changes she could have made between the two experiments?

A. She increased the rate of rotation only.

B. She increased the magnitude of the magnetic field.

C. She increased the rate of rotation and increased the magnitude of the magnetic field.

D. She increased the rate of rotation and decreased the magnitude of the magnetic field.

Question 7

Electrical power is transmitted from an electrical generator to a city some distance from the generator. An engineer wants to decrease the power losses in the transmission wires.

Which one of the following is the best way to do this?

A. Increasing the resistance of the wires by using longer wires.

B. Decreasing the resistance of the wires by raising the wires higher above the ground.

C. Increasing the line voltage by using a step up transformer at the city end of the transmission wires.

D. Increasing the line voltage by using a step up transformer at the generator end of the transmission wires.

Question 8

In an experiment, several trials were conducted by rotating a loop within a magnetic field. The area of the loop and the rate of rotation were kept constant, the magnetic field was varied between each trial and the emf produced by the loop was measured for each trial.

Which one of the following best describes the independent variable or variables?

A. The magnetic field.

B. The emf.

C. The magnetic field and the emf.

D. The area of the loop and the rate of rotation.

Question 9

Ricardo is standing in a lift. The lift is travelling downwards but slowing down at a rate of $1.5\ \text{m s}^{-2}$. Which one of the following is closest to Ricardo's mass if his apparent weight is 836 N?

A. 101 kg

B. 85 kg

C. 74 kg

D. 57 kg

Question 10

How did Einstein resolve the seeming contradiction between his two postulates of special relativity?

A. He questioned Newton's assumptions that space and time are constant and uniform.

B. He dismissed the concept of a medium by which light propagated through space.

C. He proposed that events are simultaneous for all observers.

D. He did not do any practical experiments.

Question 11

Muons are produced about 15 km up in the atmosphere when cosmic rays interact with oxygen nuclei. Even though they move at very high speeds they are unstable and their average lives are so short that classical physics predicts that virtually none would reach the surface of the Earth. However, scientists have found that in fact significant numbers of muons do reach the surface of the Earth.

Which one of the following gives the best explanation for this phenomenon?

A. The distance travelled by the muons in their own frame of reference has been dilated.

B. The distance travelled by the muons in the scientists' frame of reference has been dilated.

C. The mean life of the muons in their own frame of reference has been dilated.

D. The mean life of the muons in the scientists' frame of reference has been dilated.

Question 12

A baseball pitcher throws a 150 g baseball at a speed of 27 m s^{-1} and the batter hits it directly back at the pitcher with an average force of 3150 N. The bat is in contact with the ball for 3.7 ms.

Which one of the following is closest to the speed of the ball after it has been hit?

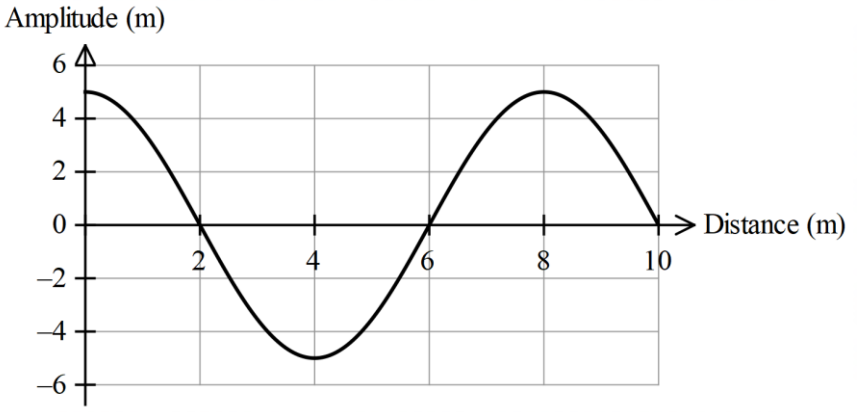
A. 12 m s^{-1}

B. 51 m s^{-1}

C. 28 m s^{-1}

D. 105 m s^{-1}

Question 13



The speed of the wave shown in the graph above is 10 m s^{-1}.
What is the frequency of the wave?

A. 1 Hz

B. 1.25 Hz

C. 2 Hz

D. 2.5 Hz

Question 14

A single slit diffraction experiment using light with a wavelength of 600 nm produced a diffraction pattern with a distance of 5 mm between adjacent bright bands. The screen on which the diffraction pattern was displayed was 3 m from the slit.
What was the width of the slit?

A. 4.2 μm

B. 25 μm

C. 0.12 mm

D. 0.36 mm

Question 15

A research scientist fired electrons at a crystal and a diffraction pattern was produced on a screen. The speed of the electrons was then changed and the scientist repeated the experiment while holding all other variables constant. She observed that the distance between dark bands in the pattern was smaller than in the first experiment.

The best explanation for this observation is that:

A. The speed of the electrons had increased which caused the wavelength to decrease.

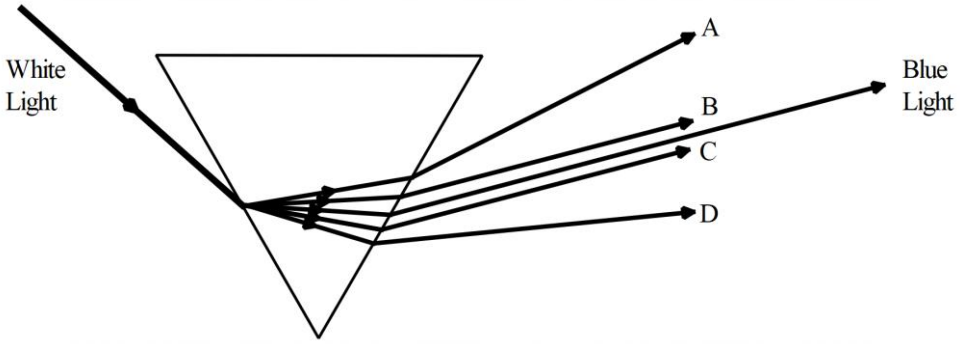
B. The speed of the electrons had increased which caused the wavelength to increase.

C. The speed of the electrons had decreased which caused the wavelength to decrease.

D. The speed of the electrons had decreased which caused the wavelength to increase.

Question 16

The diagram below shows a ray of white light incident on the left-hand side of a glass prism and the path of part of the blue component of the light through the prism and out the other side.



Which one of the rays A, B, C or D best represents the path of part of the red component of the light?

A. A

B. B

C. C

D. D

Question 17

Visible light has wavelengths that vary between about 400 nm and 800 nm.

Which one of the following wavelengths could be in the ultraviolet part of the electromagnetic spectrum?

A. 7.4×10^{-3} m

B. 6.2×10^{-6} m

C. 5.4×10^{-8} m

D. 3.2×10^{-11} m

Question 18

In an experiment on the photoelectric effect, the maximum photocurrent was found to be 25 mA and the stopping voltage was -2.1 V.

Some changes were made to the light source and when the experiment was repeated the maximum photocurrent was 35 mA and the stopping voltage was -1.6 V.

Which one of the following best describes the changes that were made to the light source?

A. The wavelength and the intensity were both decreased.

B. The wavelength was decreased and the intensity was increased.

C. The wavelength was increased and the intensity was decreased.

D. The wavelength and the intensity were both increased.

Question 19

An absorption spectrum consists of:

A. Coloured lines of wavelengths that have been emitted by a hot gas.

B. Coloured lines of wavelengths that have been absorbed and re-emitted by a gas.

C. A coloured spectrum with dark lines of wavelengths that have been absorbed by a gas.

D. A gas that has had some molecules absorbed by certain wavelengths of light.

Question 20

An LED produces light because:

A. It is heated to very high temperatures by an electric current.

B. Fast moving electrons are accelerated by magnetic fields.

C. Electrons in a gas in an excited state are stimulated to release energy.

D. Electrons in a semiconductor fall from the conduction band to the valence band.

END OF SECTION A

TURN OVER

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 (5 marks)

Figure 1 shows the electric field around two charges P and Q.

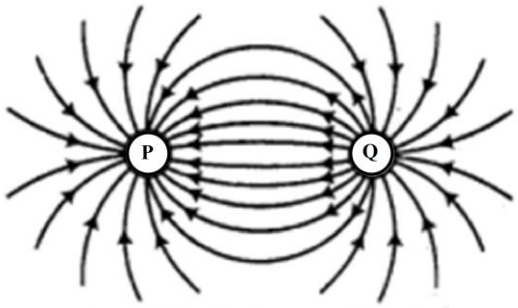


Figure 1

a. What are the polarities of the charges P and Q? Explain your answers.

Charge of P

Charge of Q

3 marks

b. Explain why Figure 1 could not represent the gravitational field around two masses.

2 marks

SECTION B - continued

Question 2 (5 marks)

A charged particle, R, passes from left to right through a magnetic field of magnitude 0.025 T as shown in Figure 2. The particle travels at a speed of 1.5×10^{5} m s^{-1} and the magnitude of the charge on R is 3.2×10^{-19} C.

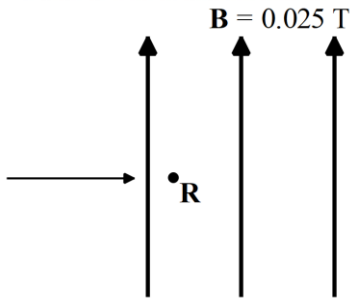


Figure 2

The path of R is curved out of the page as it passes through the magnetic field.

a. Does R have a positive or negative charge?

1 mark

The path of R has a radius of 12.5 cm.

b. What is the mass of R?

kg

2 marks

c. Explain why some electromagnetic radiation is produced from the particle.

2 marks

SECTION B – continued
TURN OVER

Question 3 (6 marks)

A spherical asteroid has a mass of 6.7×10^{20} kg and the gravitational field at the surface of the asteroid is 0.25 N kg^{-1}.

a. Calculate the radius of the asteroid.

m

3 marks

The distance between the centre of this asteroid and the centre of another 700 g asteroid is 2.6×10^{4} km.

b. What is the magnitude of the gravitational force that the first asteroid exerts on the second?

N

3 marks

SECTION B - continued

Question 4 (8 marks)

A planet with a mass of 3.12×10^{23} kg is in a circular orbit about a star. The planet has a centripetal acceleration of 0.551 m s^{-2} towards the star.

a. What is the magnitude of the force that the star exerts on the planet?

N

1 mark

b. What is the magnitude of the force the planet exerts on the star?

N

1 mark

The orbit of the planet has a radius of 7.56×10^{10} m.

c. What is the period of the orbit of the planet in Earth days (to the nearest day)?

days

3 marks

The star exerts a force F_Y and a force F_Z on two other planets, Y and Z respectively, that also orbit the star. Z has a mass that is 20 times that of Y and orbits the star at a radius that is 12 times the radius of the orbit of Y.

d. What is the value of the ratio $\frac{F_Y}{F_Z}$?

3 marks

SECTION B – continued
TURN OVER

Question 5 (5 marks)

Figure 3

The diagram on the left-hand side of Figure 3 shows a wire carrying a current of 1.8 A being held within a magnetic field of 0.25 T. The wire experiences a force of 0.18 N.

a. Find the direction of the force and the length of the wire that is within the magnetic field.

Direction

m

3 marks

In the diagram on the right-hand side of Figure 3 the wire remains in the same place and carries the same current, but the magnetic field has been turned so that its direction is from left to right.

b. Explain why there will now be no force on the wire.

2 marks

SECTION B - continued

Question 6 (12 marks)

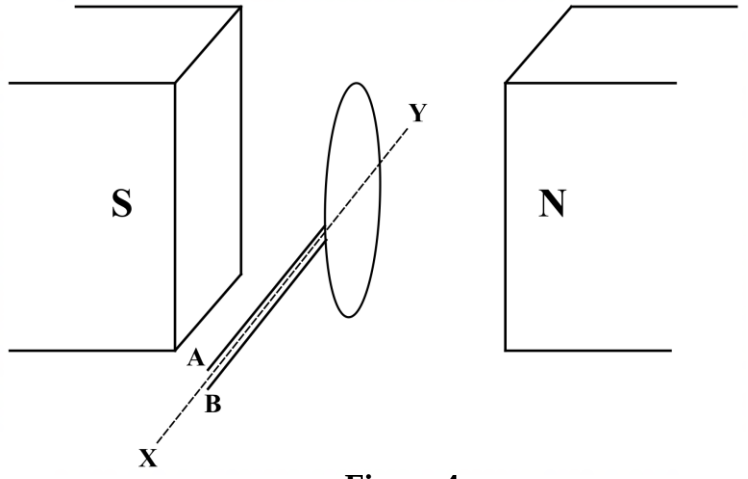


Figure 4

Figure 4 shows a coil made up of 20 turns that can be rotated about the axis XY. The magnetic field between the poles of the magnet has a magnitude of 0.73 T. In the position shown in Figure 4 the magnetic flux through the coil is 0.18 Wb. A and B are the ends of the coil.

a. What is the radius of the coil?

_____

_____

_____

_____

m

2 marks

The loop produces an average of 72 V when rotated through a quarter of a turn.

b. What is the frequency of rotation of the coil?

_____

_____

_____

_____

_____

Hz

3 marks

SECTION B – Question 6 – continued

TURN OVER

As viewed from X, the coil is rotated clockwise from its original position shown in Figure 4.

c. During the first half of its initial rotation what is the polarity of A? Explain your answer using Lenz's Law.

_____

_____

_____

_____

_____

3 marks

d. What is the orientation of the coil when the maximum emf is produced between A and B? Give a reason for your answer.

_____

_____

_____

_____

2 marks

The ends of the coil, A and B, could be connected to slip rings or a commutator in order to draw off the emf from the coil.

e. What difference does the means of connection make to the final output drawn from the coil?

_____

_____

_____

_____

2 marks

SECTION B - continued

Question 7 (6 marks)

A generator produces electrical power at an average rate of 2.88 MW with a peak-to-peak AC voltage of 6788 V.

a. Show that the RMS current produced by the generator is 1200 A.

2 marks

A transformer with 60 turns on the primary side is used to step down the current to 240 A before transmission of the power to a town some distance away.

b. How many turns are on the secondary side of the transformer?

turns

2 marks

The electrical engineers want to keep the power losses in the transmission wires to a maximum of 6% of the power produced by the generator.

c. Calculate the maximum total resistance of the transmission wires which will allow the engineers to meet their target.

Ω

2 marks

SECTION B – continued
TURN OVER

Question 8 (5 marks)

a. What is the Lorentz factor for a speed of 0.76*c* accurate to 3 significant figures?

_____

_____

1 mark

A spaceship is travelling at a speed where the Lorentz factor is 2.5 and passes a stationary observer who measures the spaceship as having a length of 140 m.

b. What is the length of the spaceship when it is at rest?

_____

_____

_____

_____

m

2 marks

c. What is the rest mass of the spaceship if its kinetic energy is 6.75×10^{24} J?

_____

_____

_____

_____

kg

2 marks

SECTION B - continued

Question 9 (7 marks)

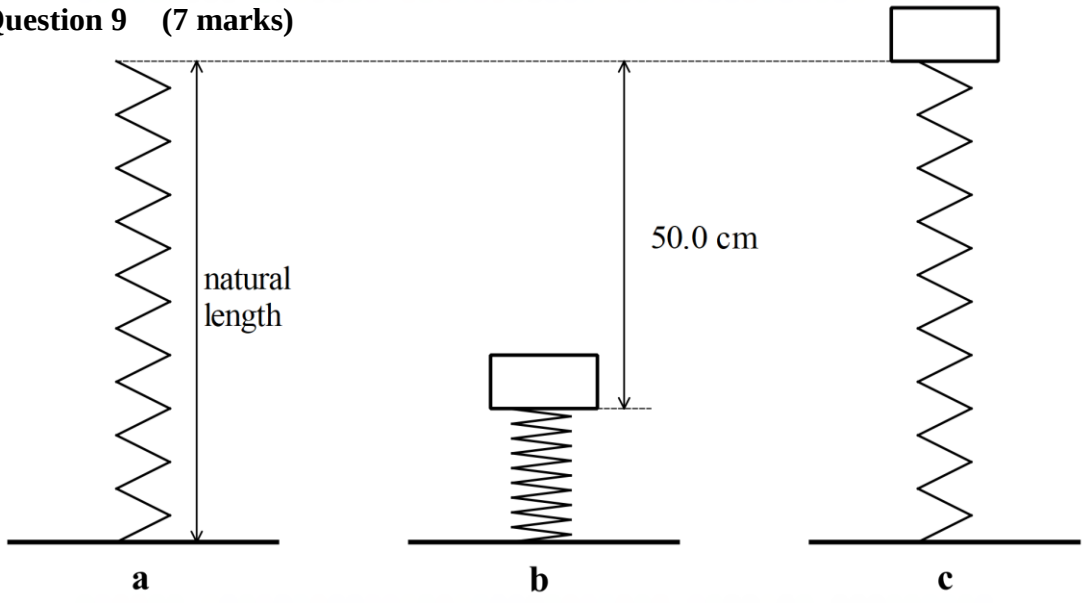


Figure 5

A spring is placed vertically on a hard surface, as shown in Figure 5a. The spring is compressed 50.0 cm and a metal block is placed on top of it, as shown in Figure 5b. The spring is then released and the spring expands to its original length before the metal block comes to rest momentarily, as shown in Figure 5c. The change in gravitational potential energy of the block between the positions shown in Figure 5b and Figure 5c is 24.5 J.

a. What is the mass of the steel block?

kg

2 marks

b. Show that the magnitude of the spring constant is 196 N m^{-1}.

2 marks

SECTION B – Question 9 – continued
TURN OVER

The acceleration of the block is zero at the point halfway between the lowest and highest points of its motion.

c. Show that the maximum kinetic energy of the block is 25% of the total energy of the block, assuming the gravitational potential energy of the block is zero at its lowest point.

_____

_____

_____

_____

_____

_____

3 marks

Question 10 (2 marks)

Nadi is swinging in a circular arc on a long rope that is tied to a branch of a tree. As he increases the amplitude of his swing he notices that he starts to feel faint, particularly at the bottom of the swing. His friend Rena notices that his face has started to go pale as his blood "drains" away from his head.

Explain why this happens to Nadi while he is swinging.

_____

_____

_____

_____

Question 11 (4 marks)

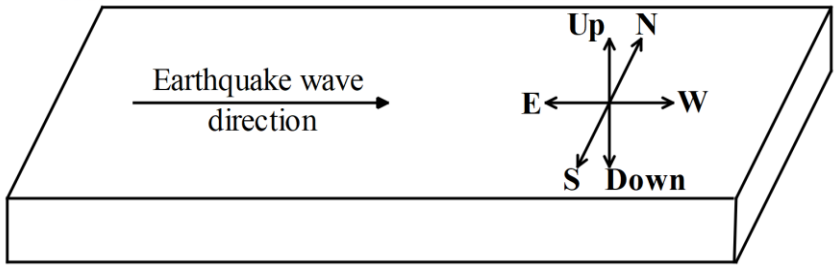


Figure 6

Figure 6 shows an earthquake shock wave moving from east to west through a section of the Earth's crust.

a. If the earthquake shock was a **transverse** wave, along which axis or axes would the earth move as the shock wave passed through it? Explain your answer.

_____

_____

_____

_____

2 marks

b. If the earthquake shock was a **longitudinal** wave, along which axis or axes would the earth move as the shock wave passed through it? Explain your answer.

_____

_____

_____

_____

2 marks

SECTION B – continued
TURN OVER

Question 12 (5 marks)

Carla stretches a string between two points 30.0 cm apart so that the speed of the waves along the string is 456 m s^{-1}. She then plays notes with the following frequencies on her cello.

190 Hz, 380 Hz, 760 Hz, 1140 Hz and 1520 Hz.

When answering both parts of this question give a detailed explanation of your answer including appropriate calculations.

a. Of the notes played by Carla which is the lowest frequency that could cause the string to resonate?

Hz

3 marks

b. Which one of the other frequencies played by Carla could cause the string to resonate?

Hz

2 marks

SECTION B - continued

Question 13 (4 marks)

Light with a frequency of 3.3×10^{15} Hz is shone through a 270 nm wide slit. The light is then replaced by light with a frequency of 1.2×10^{15} Hz.

Which frequency will be diffracted more significantly by the slit and why?

Question 14 (2 marks)

Some X-rays have the same diffraction pattern as charged particles with a momentum of 1.66×10^{-23} kg m s^{-1}.

What is the frequency of the X-rays?

Hz

SECTION B – continued
TURN OVER

Question 15 (8 marks)

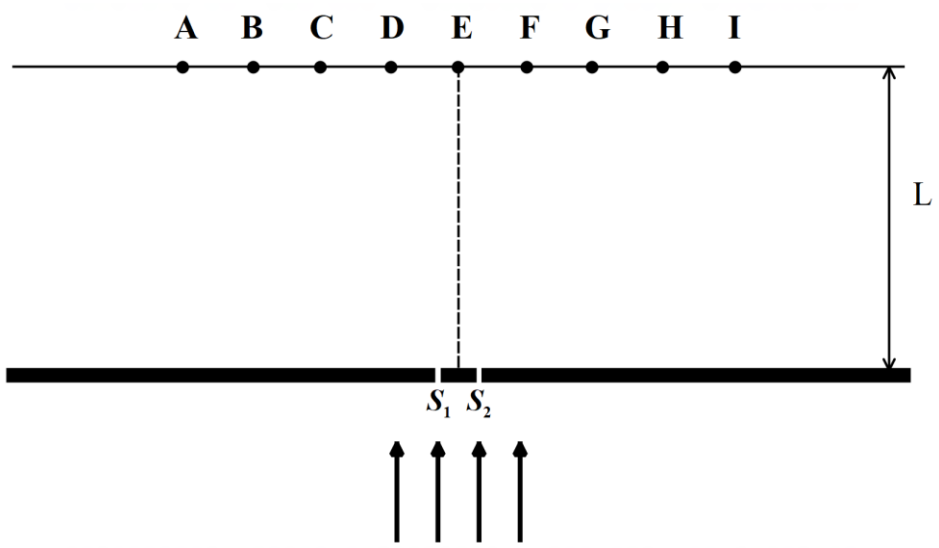


Figure 7

Light with a wavelength of 430 nm is shone through two slits and forms an interference pattern on a screen with bright lines at A, B, C, D, E, F, G, H and I, as shown in Figure 7.

a. For the bright line at A, explain why the path difference must be 1720 nm.

3 marks

The wavelength of the light was increased and the interference pattern shifted. The distance, L was kept the same but a change was made to the slit separation which restored the bright lines to their original positions.

b. What change was made to the slit separation? Explain your answer.

2 marks

SECTION B – Question 15 - continued

Consider a point P halfway between G and H. The path difference from the two slits to this point is now 1.275×10^{-6} m.

c. What is the wavelength of the light that is now being used, in nm?

_____

_____

_____

_____

_____

nm

3 marks

Question 16 (4 marks)

Figure 8 shows light coming from Medium 1 with a refractive index of 1.81 into Medium 2

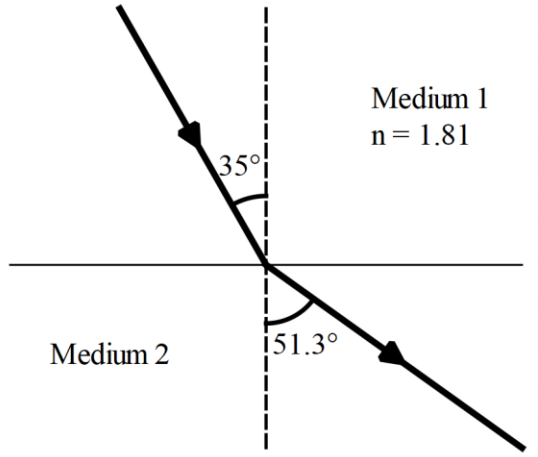


Figure 8

a. Show that the refractive index of Medium 2 is 1.33.

2 marks

b. Find the critical angle for total internal reflection for light passing from Medium 1 to Medium 2?

°

2 marks

SECTION B - continued

Question 17 (9 marks)

In a photoelectric experiment, Lisa shone light beams of varying frequencies on a metal plate and recorded the stopping voltages for the photoelectric current for each different frequency. She recorded the data in a table as shown below.

Light frequency ($\times 10^{14}$ Hz)	6.00	9.00	12.0
Stopping voltage (V)	0.48	1.73	2.96

Lisa used the stopping voltages to calculate the maximum kinetic energies of the photoelectrons in joule for each frequency and then displayed her results on a graph of maximum kinetic energy in joule versus frequency in hertz.

Figure 9

SECTION B – Question 17 – continued
TURN OVER

a. If Lisa used the voltmeter shown in Figure 9 to record the stopping voltages, what would be the extremes of the vertical error bars for the point with a frequency of 9.00×10^{14} Hz. Explain how you obtained your answer.

J to J

6 marks

b. How could Lisa use her graph to estimate the threshold frequency and the work function of the metal plate she used in her experiment?

3 marks

SECTION B - continued

Question 18 (6 marks)

In photoelectric experiments at the start of the 20th Century, the energy of photoelectrons was found to be dependent on the frequency of the light but independent of the intensity of the light.

a. Explain why these findings were a challenge to a wave model of light.

_____

_____

_____

_____

_____

2 marks

b. How did Einstein explain these findings in terms of a particle model of light?

_____

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4 marks

SECTION B – continued
TURN OVER

Question 19 (7 marks)

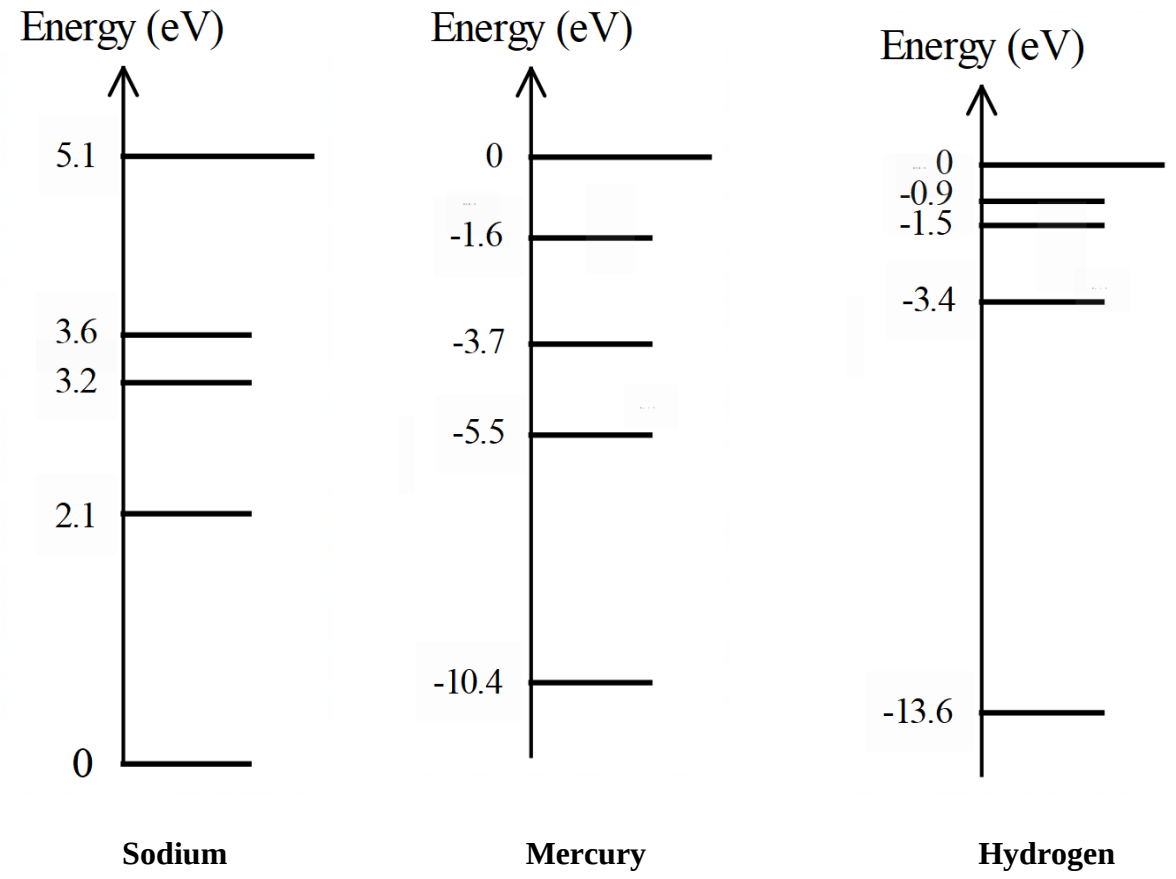

Figure 10

Figure 10 shows atomic energy level diagrams for sodium, mercury and hydrogen.

Three students, Raina, Alyssa and Karl were analysing the absorption spectrum obtained from a sample of hot gas to see if sodium, mercury and hydrogen were present in the sample. They found that there were two clear absorption lines with wavelengths of 185.4 nm and 496.8 nm.

a. Show that the energies (in eV) of the absorbed wavelengths were 2.5 eV and 6.7 eV.

_____

_____

_____

_____

2 marks

SECTION B – Question 19 - continued

Raina thought that these lines indicated that only one of the three elements were in the sample.
Alyssa thought they indicated that two of the three elements were present.
Karl thought that there was evidence that all three were present in the sample.

b. Which one of the students was correct? Clearly explain your answer using the energy level diagrams in Figure 10.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

5 marks

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	$v = \frac{\Delta s}{\Delta t};\ \ a = \frac{\Delta v}{\Delta t}$
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	$E = \frac{V}{d}$
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	$F = IlB$
radius of a charged particle in a magnetic field	$r = \frac{mv}{qB}$

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	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$
ideal transformer action	$\frac{V_1}{V_2} = \frac{N_1}{N_2} = \frac{I_2}{I_1}$
AC voltage and current	$V_{RMS} = \frac{1}{\sqrt{2}}V_{peak};\quad \mathrm{I}_{RMS} = \frac{1}{\sqrt{2}}I_{peak}$
electromagnetic induction	EMF: $\varepsilon = -N\frac{\Delta\phi}{\Delta t};\quad$ 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 light 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	$m_e = 9.1\times10^{-31} \text{ kg}$
magnitude of the charge of the electron	$e = 1.6\times10^{-19} \text{ C}$
Planck's constant	$h = 6.63\times10^{-34} \text{ J s}$; $h = 4.14\times10^{-15} \text{ eV s}$
speed of light in a vacuum	$c = 3.0\times10^{8} \text{ m s}^{-1}$
gravitational constant	$G = 6.67\times10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
mass of earth	$M_E = 5.98\times10^{24} \text{ kg}$
radius of Earth	$R_E = 6.37\times10^{6} \text{ m}$
Coulomb constant	$k = 8.99\times10^{9} \text{ N m}^2 \text{ C}^{-2}$

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