Neap:

Trial Examination 2008

VCE Physics Unit 4

Written Examination

Question and Answer Booklet

Reading time: 15 minutes
Writing time: 1 hour 30 minutes

Student's Name: ______________________________

Teacher's Name: ______________________________

Structure of Booklet

Section	Number of questions	Number of questions to be answered	Number of marks
A Core – Areas of study			
1. Electric power	16	16	39
2. Interactions of light and matter	13	13	25
B Detailed studies			
1. Synchrotron and its applications **OR**	13	13	26
2. Photonics **OR**	13	13	26
3. Sound	13	13	26
			Total 90

Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, up to two pages (one A4 sheet) of pre-written notes (typed or handwritten) and one scientific calculator. Students are NOT permitted to bring into the examination room: blank pieces of paper and/or white out liquid/tape.

Materials supplied

Question and answer booklet of 26 pages with a detachable data sheet in the centrefold.

Instructions

Detach the data sheet from the centre of this booklet during reading time.

Write your **name** and your **teacher's name** in the space provided on this page.

Answer all questions in the spaces provided.

Always show your working where space is provided because marks may be awarded for this working.

Where an answer box has a unit printed in it, give your answer in that unit.

All written responses must be in English.

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

Students are advised that this is a trial examination only and cannot in any way guarantee the content or the format of the 2008 VCE Physics Unit 4 Written Examination.

SECTION A – CORE

Instructions for Section A

Answer **all** questions **for both** Areas of study in this section of the paper.
For all questions which require a numerical answer you must show all working.
You should take the value of g to be 10 m s^{-2}.

Area of study 1 – Electric power (39 marks)

Figure 1 shows a solenoid used to produce a magnetic field. *X* is a point above the coil of wire, *Y* is a point inside the coil and *Z* is a point at the right-hand end of the coil.

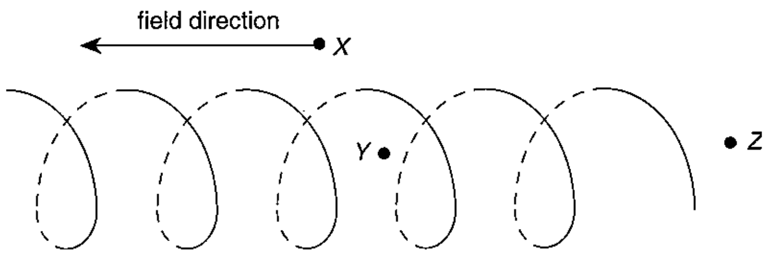


Figure 1

The direction of the field at point *X* is shown in Figure 1 and is from right to left.

Question 1

Using arrows on Figure 1 to clearly show the direction of the current in the coil required to produce the field direction at *X* described above.

2 marks

Question 2

Which of the following options best describes the direction of the field at point *Y* and the magnitude of the field at point *Y* compared with point *X*?

A. The field at *Y* is to the right and is larger in magnitude than the field at *X*.
B. The field at *Y* is to the left and is larger in magnitude than the field at *X*.
C. The field at *Y* is to the right and is smaller in magnitude than the field at *X*.
D. The field at *Y* is to the left and is smaller in magnitude than the field at *X*.
E. The field at *Y* is to the right and is equal in magnitude to the field at *X*.
F. The field at *Y* is to the left and is equal in magnitude to the field at *X*

2 marks

Question 3

State two modifications that could be made to the solenoid in order to increase the magnitude of the field at point *Z*, whilst maintaining the same field direction.

Modification 1: ______________________________

Modification 2: ______________________________

2 marks

As part of a science project, Hannah and Molly are designing an electric motor to operate the fan in a model hair dryer.
They use a rectangular coil of wire, *ABCD*, consisting of 20 turns with dimensions 3.0 cm by 2.0 cm.
They place the coil between magnetic poles in a uniform field of strength 0.1 T. The coil is connected to a 6.0 V battery.
Figure 2 shows the initial arrangement of the components of the motor, and a key used to describe direction in Questions 4–6.

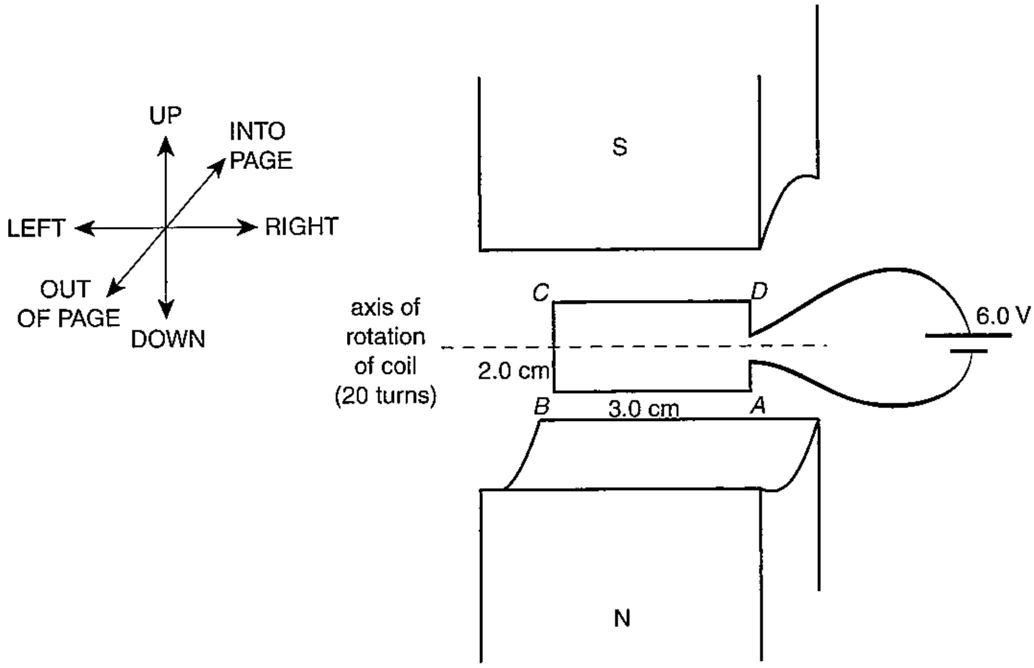


Figure 2

The total resistance of the coil and connecting wires is equal to 60 Ω.

Question 4

Calculate the magnitude of the force on the side *AB* when the coil is in the orientation shown in Figure 2.

N

3 marks

Question 5

Use the key in Figure 2 to describe the direction of the force on the side *AB*. Give an explanation for your answer.

Direction of force:

3 marks

Question 6

When Molly and Hannah switch on the motor, it does not operate as expected. Explain what will happen to the coil when it is switched on and why this occurs.

3 marks

Molly and Hannah decide to experiment further with their coil of wire and magnet. They place the coil of wire between the magnets once again, but this time the battery is removed from the circuit. This is shown in Figure 3.

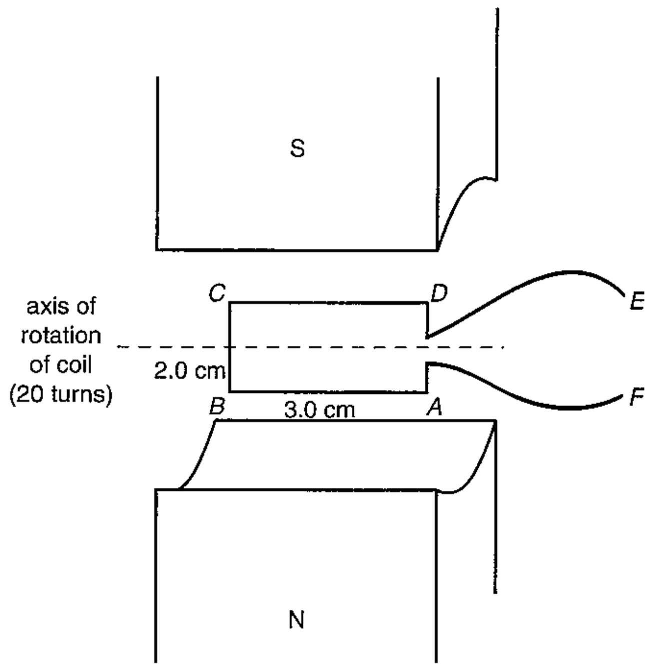


Figure 3

The field strength is still 0.1 T, and the coil still consists of 20 turns.

Question 7

Calculate the flux passing through the coil *ABCD* when it is in the orientation shown in Figure 3.

Wb

2 marks

Molly rotates the coil through 90° so that side *AB* moves out of the page and *CD* moves into the page, until the coil is in the horizontal position.

Question 8

If an average emf of 2.0 mV is recorded between points *E* and *F* as the coil is rotated, calculate the time it took to rotate the coil.

s

3 marks

Question 9

Molly predicts that while the coil is rotated through 90° the current in the coil flows in the direction *ABCD*, whilst Hannah insists that it will flow in the direction *DCBA*. Who is correct? Explain your answer in terms of Lenz's law.

3 marks

The coil is now continuously rotated within the magnetic field. A graph of emf versus time is shown in Figure 4.

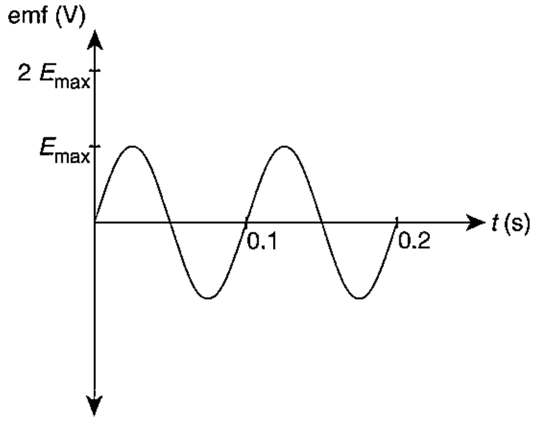


Figure 4

Question 10

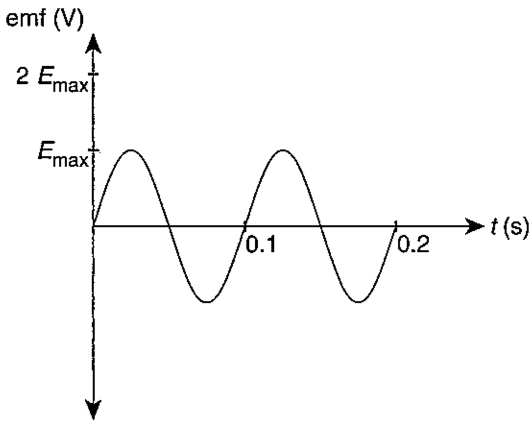
What is the frequency of rotation required to produce the output shown in Figure 4?

Hz

2 marks

Question 11

The frequency of rotation calculated in Question 10 is now **halved** and the field strength of the magnets is **doubled**. On the copy of Figure 4 below, sketch the output of the coil once these changes have been made.



2 marks

At a remote gold mine in outback Australia, a 20 000 W, 240 V RMS AC generator is used to provide power for light and machinery that operates on 240 V RMS AC inside the mine. To reduce the risk of fire, the generator is located above the ground and cables run down into the mine to supply the electricity where it is required.

The arrangement at the mine is shown in Figure 5.

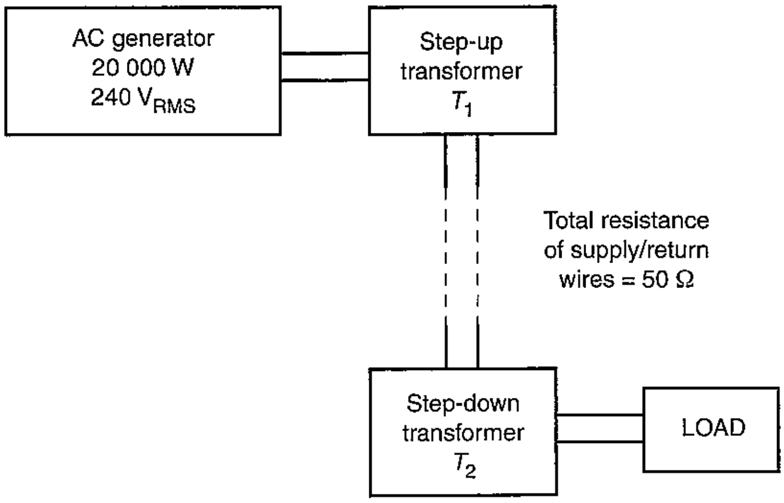


Figure 5

The total resistance of the transmission supply/return wires between the two transformers is 50 Ω. The step-up transformer T_1 has 100 turns in its primary coil and an output voltage of 3.6 kV_{RMS}.

Question 12

Calculate the peak-to-peak output voltage of transformer T_1.

V

2 marks

Question 13

Explain why the system includes both step-up and step-down transformers, rather than simply connecting the generator to the load via the supply/return wires.

____

____

____

____

3 mark

Question 14

Calculate the number of turns in the secondary coil of the step-up transformer T_1.

turns

2 marks

Question 15

Calculate the voltage delivered to the **input** of the step-down transformer T_2.

V

3 marks

The generator breaks down and one of the miners suggests using a bank of 10×24 V batteries as the input to the transformer T_1 in place of the generator.

Question 16

What would happen if the generator was replaced with batteries? Give the reason for your answer.

____

____

____

____

2 marks

END OF AREA OF STUDY 1

Area of study 2 – Interactions of light and matter (25 marks)

Figure 1 shows a green laser beam of wavelength 532 nm being used to investigate aspects of Young's double slit interference experiment. The green laser beam goes through the double slits and projects onto the screen. The point M is on the perpendicular bisector of the screen. The point P is the first minima.

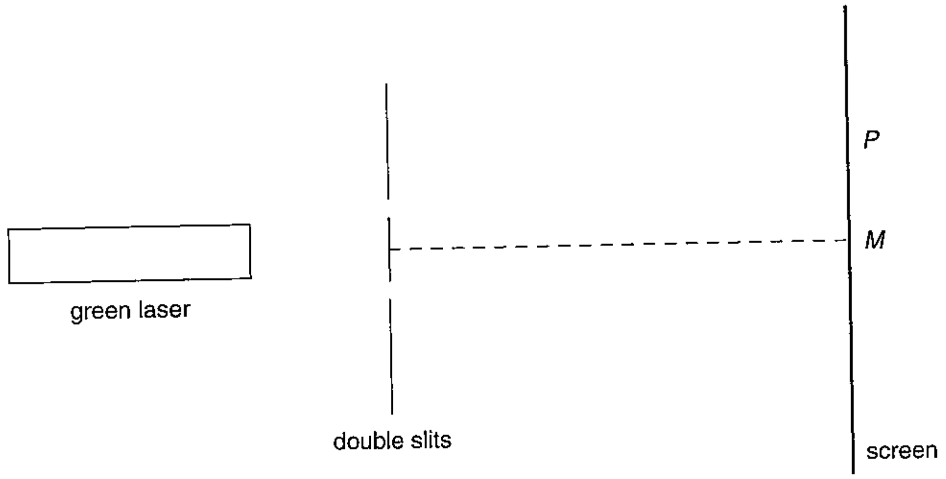
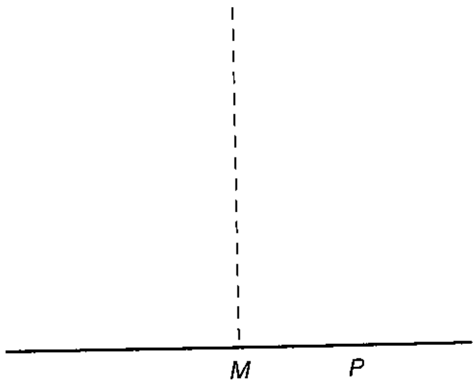


Figure 1

Question 1

Sketch the intensity pattern seen on the screen on the diagram below.



2 marks

Question 2

Calculate the path difference for the point P.

nm

2 marks

The green laser light is now replaced with a red laser light.

TEVPHYU4_QA_08.FM

Question 3

Explain what happens to the interference pattern as seen on the screen.

2 marks

Question 4

Explain what Young's double slit interference experiment demonstrates about the nature of light.

2 marks

An experiment on the photoelectric effect is undertaken. Physics students shine red light of wavelength 620 nm and blue light of wavelength 440 nm onto a metal surface. This is done using two different intensities. The students measure the current created by the photoemitted electrons. The metal has a work function of 2.2 eV. The data collected by the students is shown in Table 1.

Intensity	620 nm	440 nm
1	0.0 μA	6.0 μA
2	0.0 μA	12.0 μA

Table 1

Question 5

Explain why the red light does not give any current but the blue light does.

2 marks

Question 6

Explain why doubling the intensity of the blue light doubles the current.

2 marks

Question 7

Calculate the threshold frequency for this metal.

Hz

2 marks

Orange light has frequency of 5.2×10^{14} Hz. The speed of light is 3.0×10^{8} m s^{-1}.

Question 8

Calculate the wavelength of the orange light.

m

1 mark

Question 9

Calculate the photon momentum of a single photon of orange light.

kg m s^{-1}

2 marks

Figure 2 shows the energy level diagram for the first three energy states of a hydrogen atom.

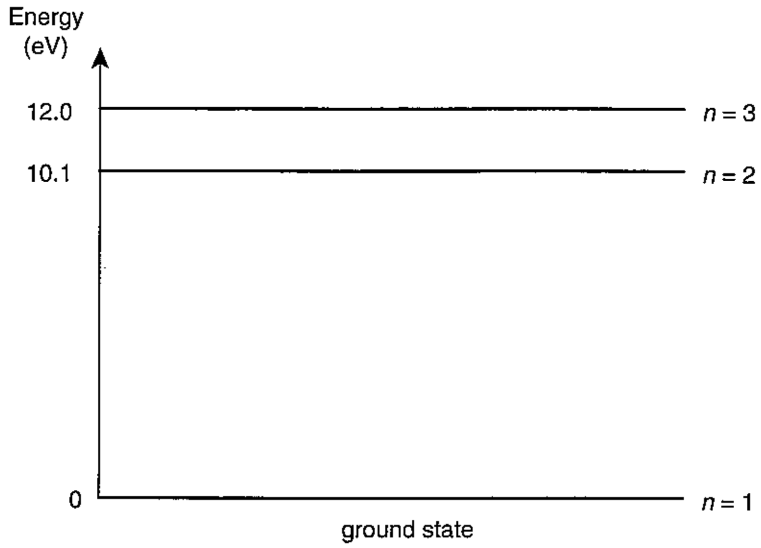


Figure 2

An electron sitting in the $n = 3$ state falls down to the $n = 2$ state.

Question 10

Calculate the wavelength of the photon associated with this transition.

m

2 marks

An experiment is conducted to investigate the wave-like nature of electrons. The electrons are accelerated until they have reached a speed of 3.2×10^7 m s^{-1}.

Question 11

Calculate the momentum of one electron.

kg m s^{-1}

2 marks

Question 12

Calculate the de Broglie wavelength of the electron.

| m |

2 marks

Question 13

Explain why it is difficult to observe the wave-like nature of a 1500 kg car moving down the highway at a speed of 100 km h^{-1}.

2 marks

END OF AREA OF STUDY 2

SECTION B – DETAILED STUDIES

Instructions for Section B

Choose **one** of the following **Detailed studies**. Answer **all** the questions on the Detailed study you have chosen. You should take the value of g to be 10 m s^{-2}.

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.

Choose the response that is **correct** for the question.

A correct answer scores 2, 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.

Detailed study 1 – Synchrotron (26 marks)

A simple particle accelerator for electrons can be constructed by creating a potential difference across a cathode and an anode in an evacuated glass tube as shown in Figure 1.

The charge of an electron is 1.6×10^{-19} C and its mass is 9.1×10^{-31} kg.

Figure 1

When a potential difference of 10 kV is applied to the tube, electrons accelerate across the evacuated chamber from the cathode to the anode.

Question 1

If it starts at rest at the cathode, the kinetic energy of an electron at the anode is closest to

A. 10 eV
B. 100 eV
C. 1000 eV
D. 1×10^4 eV

A magnetic field is applied across part of the tube as shown in Figure 2.

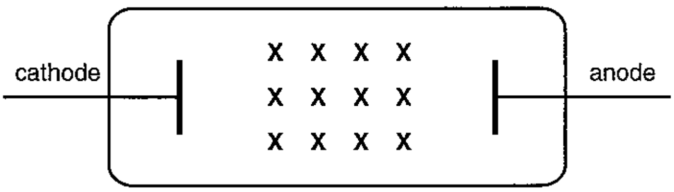


Figure 2

Question 2

Which one of the following best describes the direction of the force applied by the magnetic field to the electrons as they travel from the cathode to the anode through the magnetic field?

A. Up
B. Down
C. Into the page
D. Out of the page

Question 3

If the voltage was increased form 10 kV to 40 kV the magnitude of the magnetic force acting on an electron as it travels from the cathode to the anode through the magnetic field would change by a factor of

A. 0.25
B. 0.50
C. 2.00
D. 4.00

Figure 3 shows a schematic view of the new Australian synchrotron as seen from the top. Various areas of interest have been labelled.

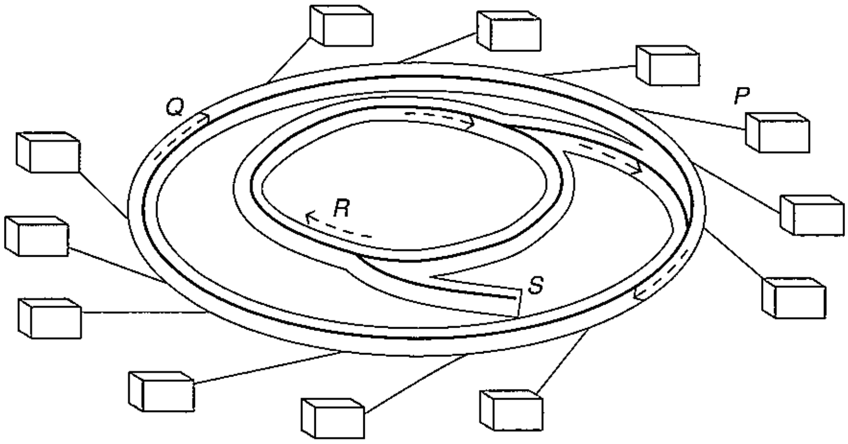


Figure 3

The synchrotron includes an electron linear accelerator (linac), a booster ring, a storage ring, and various beamlines that are used for different experiments.

Question 4

P and *Q* respectively represent the

A. beamline and booster ring.
B. linac and storage ring.
C. booster ring and linac.
D. beamline and storage ring.

Question 5

R and *S* respectively represent the

A. booster ring and beamline.
B. linac and storage ring.
C. booster ring and linac.
D. beamline and storage ring.

Question 6

The function of the booster ring in the synchrotron is

A. to accelerate the electrons up to orbit speed.
B. to maintain the electrons at a certain speed in their circular orbits.
C. to accelerate the electrons from rest.
D. to do experiments with the electron beam.

Question 7

The function of the storage ring in the synchrotron is to

A. to accelerate the electrons up to orbit speed.
B. to maintain the electrons at a certain speed in their circular orbits.
C. to accelerate the electrons from rest.
D. to do experiments with the electron beam.

When describing characteristics of synchrotron radiation, the following terms are often used: **brightness** and **divergence**.

Question 8

The **brightness** of synchrotron radiation is best described as

A. the range of wavelengths created by the emitted light.
B. the spread of the beam.
C. the brightness of the radiation compared with the sun.
D. the concentration of emitted light.

Question 9

The **divergence** of synchrotron radiation is best described as

A. the range of wavelengths created by the emitted light.
B. the spread of the beam.
C. the brightness of the radiation compared with the sun.
D. the concentration of emitted light.

A crystal is examined in a synchrotron using X-rays. The incident X-ray is of wavelength 7.8×10^{-10} m and the scattered X-ray is of wavelength 9.4×10^{-10} m.

Question 10

The energy of the incident photon is

A. 1.59 eV
B. 7.80 eV
C. 1.59 keV
D. 7.80 keV

Question 11

The amount of energy lost in this collision is

A. 0.31 eV
B. 2.71 eV
C. 27.1 eV
D. 271 eV

Question 12

The extra energy has gone into

A. the kinetic energy of an electron in the lattice.
B. heat and sound.
C. the creation of another photon.
D. none of the above.

Scattering experiments in a synchrotron using X-ray radiation beams can be understood using different models of light.

Question 13

Which one of the following forms of scattering provides evidence supporting the particle nature of light?

A. Thomson scattering
B. Diffuse scattering
C. Compton scattering
D. None of the above

END OF DETAILED STUDY 1

Detailed study 2 – Photonics (26 marks)

A TV remote control uses an indium phosphate (InP) LED that emits infrared light. The band gap energy for this LED is 1.33 eV.

Question 1

1.33 eV is equivalent in energy to

A. 7.1×10^{-28} J

B. 2.1×10^{-19} J

C. 8.3×10^{18} J

D. 2.5×10^{28} J

Question 2

The wavelength of the infrared light emitted by the LED is equal to

A. 1.5×10^{-25} m

B. 1.0×10^{-15} m

C. 9.3×10^{-7} m

D. 1.7×10^{-6} m

Question 3

Compared with the infrared LED, an orange LED would have

A. a higher band gap energy and produce light of a longer wavelength.
B. a lower band gap energy and produce light of a longer wavelength.
C. a higher band gap energy and produce light of a shorter wavelength.
D. a lower band gap energy and produce light of a shorter wavelength.

Question 4

Electrical insulators do not conduct electricity because they have

A. a large band gap energy.
B. a small band gap energy.
C. zero band gap energy.
D. a variable band gap energy.

Question 5

Which one or more of the following statements describes the light produced by all lasers?

A. It is monochromatic.
B. It is all of the same wavelength
C. It is coherent.
D. It is fluorescent.

Question 6

In the production of laser light, the term **stimulated emission** refers to the process in which

A. the photons stimulated all come from the same atom so are all identical.
B. mirrors reflect photons back and forth, stimulating them to be emitted from the laser.
C. electricity is used to stimulate atoms into higher energy states.
D. a photon released by one atom stimulates other atoms to release identical photons in phase.

A company manufactures an optic fibre has a core with a refractive index of 1.47 and a cladding with refractive index 1.39, as shown in Figure 1.

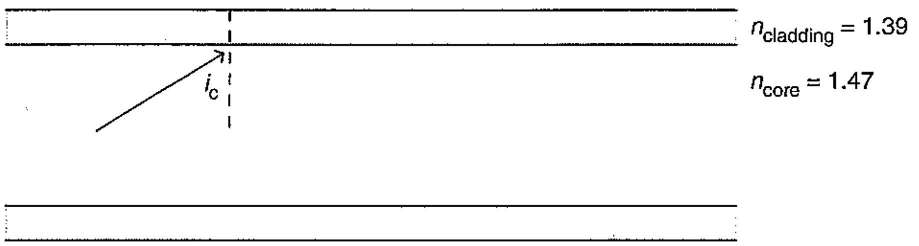


Figure 1

Question 7

The critical angle i_c for this optical fibre is equal to

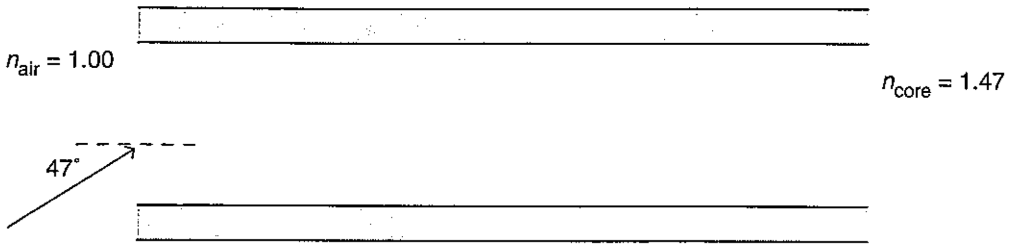
A. 5°
B. 43°
C. 46°
D. 71°

Question 8

In order to increase the critical angle for the optic fibre, the manufacturer could

A. increase n_{core} to a value greater than 1.47 while keeping $n_{cladding}$ the same.
B. increase $n_{cladding}$ so that it is closer to (but not greater than) n_{core}.
C. make $n_{cladding}$ greater than n_{core}.
D. make $n_{cladding}$ equal to n_{core}.

A **different** optic fibre has an acceptance angle α of 47° and a core refractive index of 1.47.



Question 9

The critical angle i_c for this optical fibre is equal to

A. 29.8°
B. 42.9°
C. 60.2°
D. 68.5°

Question 10

The term **attenuation** of an optic fibre refers to

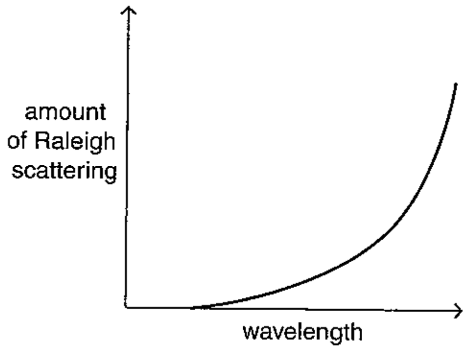
A. the amount of power loss in the optic fibre.
B. the amount of energy transmitted by the optic fibre.
C. the range of wavelengths that can be transmitted by the optic fibre.
D. the speed at which a signal is transmitted by the optic fibre.

Raleigh scattering is caused by particles in the fibre which are smaller than the wavelength of the light being transmitted.

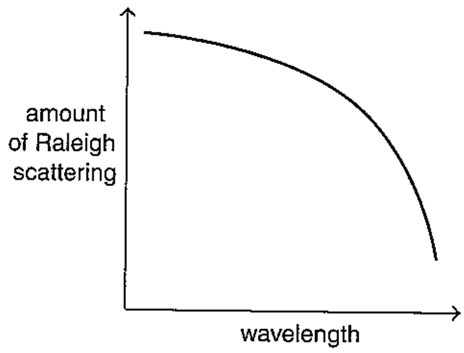
Question 11

Which of the following graphs best represents how the amount of Raleigh scattering varies with the wavelength of light transmitted?

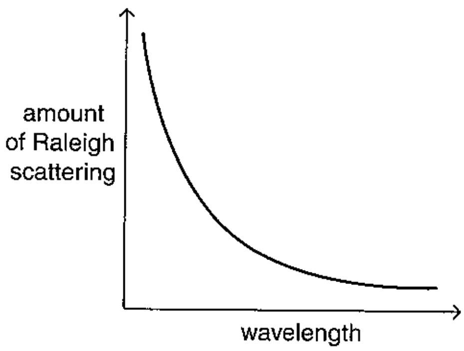
A.



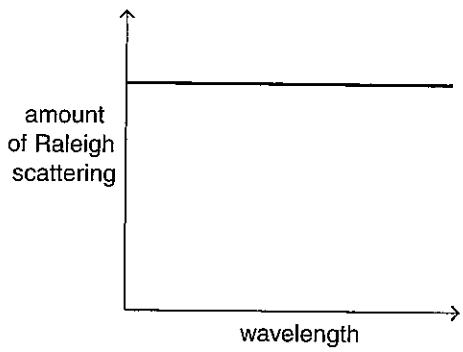
B.



C.



D.



Question 12

When compared with multimode step-index optic fibre, multimode graded-index fibre has

A. more modal dispersion so is more suitable for short distances.
B. less modal dispersion so is more suitable for short distances.
C. more modal dispersion so is more suitable for long distances.
D. less modal dispersion so is more suitable for long distances.

Optic fibres are often used in structures such as bridges to detect small movements. A diagram of such a system is shown in Figure 2.

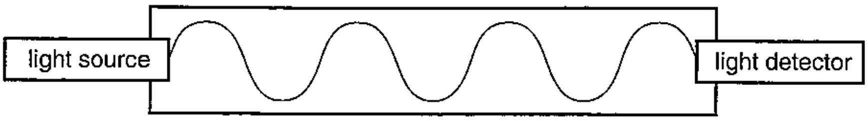


Figure 2

Question 13

The system operates because if the bridge bends too much

A. the optic fibre straightens out, resulting in less total internal reflection within the fibre and a decrease in the intensity of the light reaching the detector.

B. the optic fibre bends more, resulting in more total internal reflection within the fibre and an increase in the intensity of the light reaching the detector.

C. the optic fibre straightens out, resulting in more total internal reflection within the fibre and a decrease in the intensity of the light reaching the detector.

D. the optic fibre bends more, resulting in less total internal reflection within the fibre and a decrease in the intensity of the light reaching the detector.

END OF DETAILED STUDY 2

Detailed study 3 – Sound (26 marks)

Figure 1 shows a magnified dust particle in front of a loudspeaker.

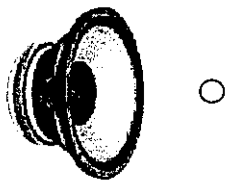


Figure 1

Question 1

What happens to the dust particle when a sound is produced by the loudspeaker?

A. The dust particle moves to the right.
B. The dust particle stays exactly where it is.
C. The dust particle oscillates back and forth in a horizontal direction.
D. The dust particle oscillates back and forth in a vertical direction.

Question 2

What does this observation demonstrate about the nature of sound waves?

A. They are transverse.
B. They are longitudinal.
C. They are a form of electromagnetic radiation.
D. They travel at the speed of light.

Figure 2 shows a musical instrument, a xylophone, modelled as a pipe that is open at both ends.

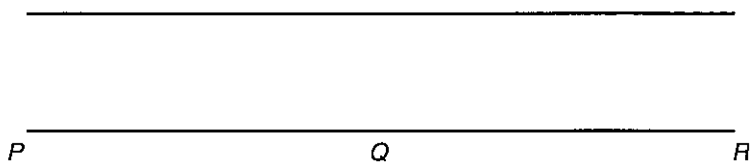


Figure 2

A note creating the first harmonic is played in the xylophone pipe.

Question 3

At point *P* you would expect to find

A. a pressure node.
B. a pressure antinode.
C. zero pressure.
D. none of the above.

Question 4

At point Q you would expect to find

A. a pressure node.
B. a pressure antinode.
C. atmospheric pressure.
D. none of the above.

The speed of sound in the concert hall is 340 m s^{-1} and the first harmonic is a note of frequency 680 Hz.

Question 5

The length of the pipe is

A. 0.25 m
B. 0.50 m
C. 1.0 m
D. 2.0 m

Question 6

The frequency of the second harmonic for this xylophone is

A. 170 Hz
B. 340 Hz
C. 680 Hz
D. 1360 Hz

Question 7

Xylophones create their musical notes by the principle of resonance, which means

A. a travelling wave is set up in the air in the pipe.
B. echoes are set up in the pipe.
C. a transverse electromagnetic wave is set up in the pipe.
D. a standing wave is set up in the air in the pipe.

One type of microphone used to capture sound waves and turn them into electrical signals is a dynamic microphone.

Question 8

The best explanation as to how the air pressure variations cause electrical signals in a dynamic microphone is

A. compressing the diaphragm causes a change in its electrical resistance.
B. compressing the crystal creates electricity.
C. an induced current is created due to the movement of a magnet within a coil of wire.
D. a current is produced by the change in capacitance.

Figure 3 shows two students, Jasmeet and Jasmine, outside a hall. Inside the hall, a band is playing music. Sound on a double bass of frequency 165 Hz is being created simultaneously with sound from a flute of frequency 3300 Hz. The speed of sound in the hall is 330 m s^{-1}. The width of the open doorway is 2.0 m.

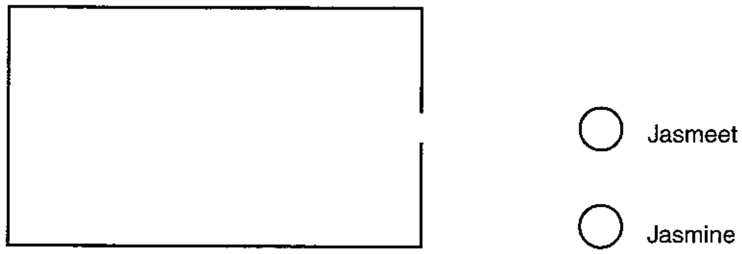


Figure 3

Question 9

The wavelength of the double bass note is

A. 1.0 m
B. 2.0 m
C. 4.0 m
D. 165 m

2 marks

Question 10

The wavelength of the flute note is

A. 0.01 m
B. 0.10 m
C. 1.0 m
D. 2.0 m

2 marks

Question 11

Which one of the following best describes what Jasmeet would hear?

A. Both the double bass note and the flute note.
B. Only the double bass note, not the flute note.
C. Only the flute note, not the double bass note.
D. Neither note.

2 marks

Question 12

Which one of the following best describes what Jasmine would hear?

A. Both the double bass note and the flute note.
B. Only the double bass note, not the flute note.
C. Only the flute note, not the double bass note.
D. Neither note.

2 marks

Question 13

The best explanation for what Jasmeet and Jasmine hear is that the sound coming through the door

A. undergoes refraction.
B. undergoes diffraction.
C. undergoes constructive interference.
D. undergoes destructive interference.

2 marks

END OF QUESTION AND ANSWER BOOKLET

Detailed study 2 – Photonics

22	band gap energy	$E = \frac{hc}{\lambda}$
23	Snell's law	$n_1 \sin i = n_2 \sin r$

Detailed study 3 – Sound

24	speed, frequency and wavelength	$v = f\lambda$
25	intensity and levels	sound intensity level (in dB) $= 10\log_{10}\left(\frac{I}{I_0}\right)$ where $I_0 = 1.0 \times 10^{-12}$ W m^{-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

END OF DATA SHEET

Physics Unit 4 Data Sheet

1	photoelectric effect	$E_{k_{max}} = hf - W$
2	photon energy	$E = hf$
3	photon momentum	$p = \frac{h}{\lambda}$
4	de Broglie wavelength	$\lambda = \frac{h}{p}$
5	resistors in series	$R_T = R_1 + R_2$
6	resistors in parallel	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$
7	magnetic force	$F = IlB$
8	electromagnetic induction	emf: $\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$ flux: $\Phi = BA$
9	transformer action	$\frac{V_1}{V_2} = \frac{N_1}{N_2}$
10	AC voltage and current	$V_{RMS} = \frac{1}{\sqrt{2}}V_{peak}$ $I_{RMS} = \frac{1}{\sqrt{2}}I_{peak}$
11	voltage; power	$V = RI$ $P = VI$
12	transmission losses	$V_{drop} = I_{line}R_{line}$ $P_{loss} = I_{line}^2R_{line}$
13	mass of the electron	$m_e = 9.1 \times 10^{-31}$ kg
14	charge on the electron	$e = -1.6 \times 10^{-19}$C
15	Planck's constant	$h = 6.63 \times 10^{-34}$ J s $h = 4.14 \times 10^{-15}$ eV s
16	speed of light	$c = 3.0 \times 10^8$ m s^{-1}

Detailed study 1 – Synchrotron and its applications

17	energy transformations for electrons in an electron gun (< 100 keV)	$\frac{1}{2}mv^2 = eV$
18	radius of an electron beam	$r = \frac{p}{eB}$
19	force applied to an electron beam	$F = evB$
20	Bragg's law	$n\lambda = 2d\sin\theta$
21	electric field between charged plates	$E = \frac{V}{d}$