THE SCHOOL FOR EXCELLENCE (TSFX)

UNIT 4 PHYSICS 2009

WRITTEN EXAMINATION 2

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

QUESTION AND ANSWER BOOKLET

Structure of Booklet

Section		*Number of Questions*	*Number of Questions to be Answered*	*Number of Marks*	*Suggested Times (minutes)*
A	**Core Studies**				
	Electric Power	18	18	38	38
	Interactions of Light and Matter	14	14	26	26
B	**Detailed Studies**				
	1. Synchrotron **OR**	13	13	26	26
	2. Photonics **OR**	13	13	26	26
	3. Sound	13	13	26	26
				Total 90	Total 90

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SECTION A – CORE STUDIES

Instructions For Section A

Answer **all** questions for **both** Areas of Study in this section of the paper.

AREA OF STUDY 1 – ELECTRIC POWER

QUESTION 1
A current carrying conductor placed in a magnetic field experiences a force, the direction of the force depends on:

A. the direction of the current flow.
B. the direction of a switch.
C. the type of conductor used.
D. the strength of the magnet.

2 marks

QUESTION 2
On each opportunity, indicate the best response by circling your choice from the options in bold font.

The direction of the magnetic field around a current-carrying conductor
can be found using the right-hand ***grip / slap / push*** *rule.*
The magnitude of the field strength is
directly proportional to / proportional to the square of / inversely proportional to
the magnitude of the current.
The magnitude of the field strength is
directly proportional to / proportional to the square of / inversely proportional to
the radial distance from the conductor.

3 marks

QUESTION 3
In an AC motor, current enters the armature coils via:

A. carbon brushes and a split ring.
B. carbon brushes and slip rings.
C. springs pushing magnets.
D. springs pushing non-metallic brushes onto a split ring.

2 marks

The following information refers to Questions 4 to 7.

A rectangular loop PQRS made of a single wire passes at constant speed into and through a magnetic field (X) as indicated in Figures 1a, 1b and 1c below.

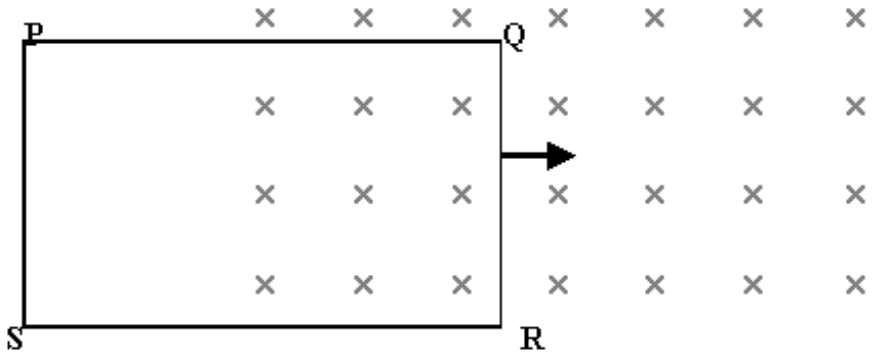


Fig 1a

Fig 1b

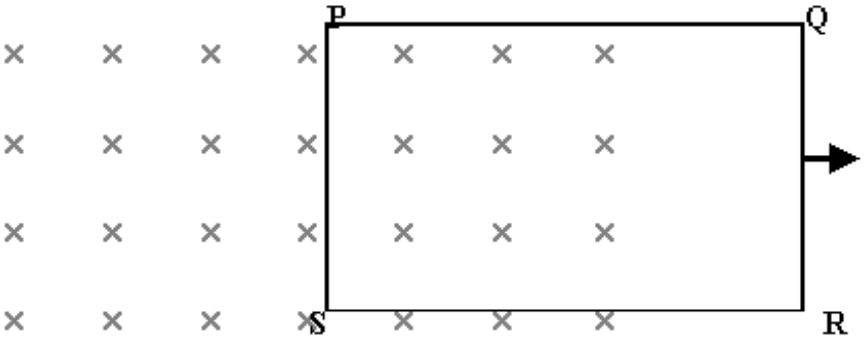


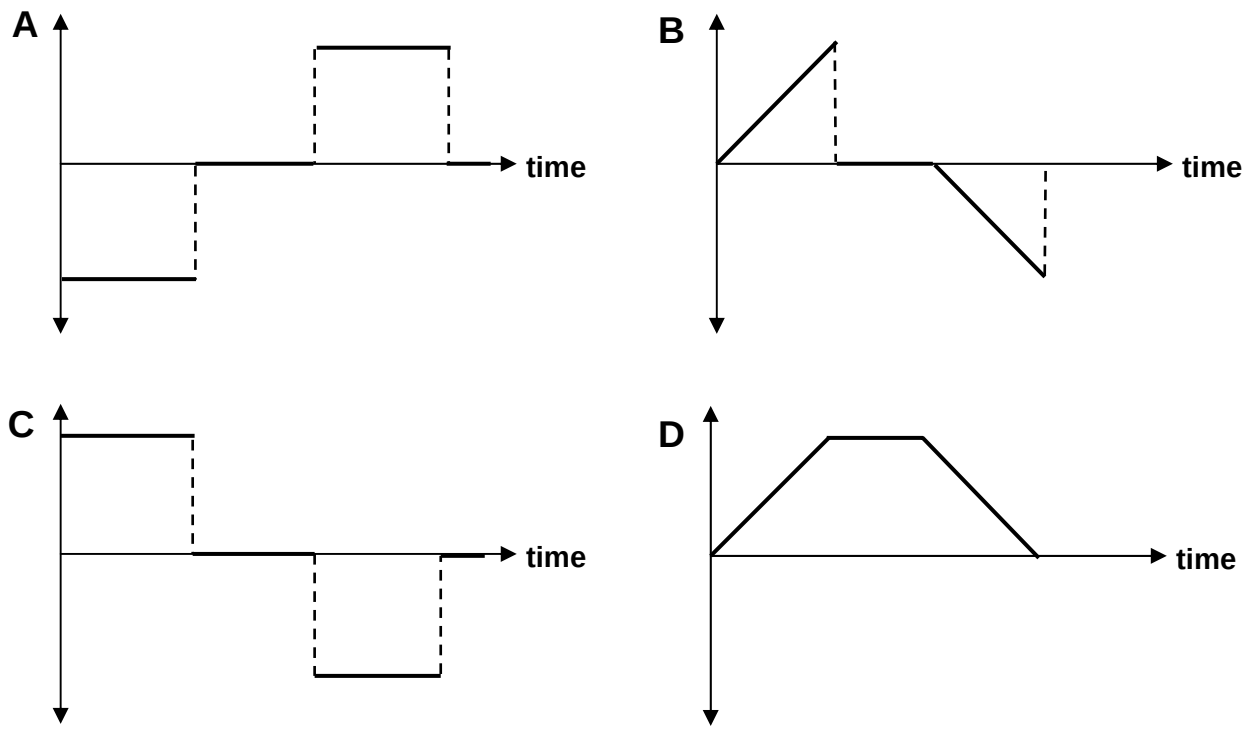
Fig 1c

QUESTION 4
What is the direction of the induced current in the loop in **Figure 1a**?
(Circle the correct response).

CLOCKWISE ***ANTICLOCKWISE***

1 mark

Questions 5 & 6 refer to the following graphs (A – D):



QUESTION 5
Which of the graphs best represents the variation in flux as the rectangular coil passes into, through and completely out of the magnetic field?

2 marks

QUESTION 6
If a clockwise current indicates a positive EMF then which of the graphs best represents the variation in induced EMF as the rectangular coil passes into, through and completely out of the magnetic field?

2 marks

Sides PQ and RS are 18 cm long and sides QR and PS are 10 cm long. The field in this region has field strength of 2.5 T and it takes 0.15 s for the entire loop to enter the field.

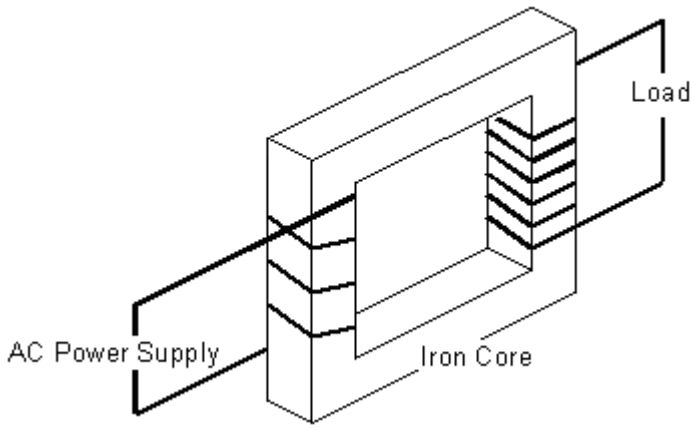
QUESTION 7
If the wire has a resistance of 4 Ω then what is the average current induced in the loop as it enters the field? (Answer in milliampere).

	mA

4 marks

The following information refers to Questions 8 to 11.

Two students; Jaq and Gille make a basic transformer from some wire and a square of iron. They plug it into 75 V (RMS) AC Power supply to see if it works, as illustrated below.



QUESTION 8
Is the transformer illustrated a **step-up** or a **step-down** transformer?

1 mark

QUESTION 9
Number of primary coils = 3.75
Number of secondary coils = 5.75

Assuming it is an "ideal" transformer, what is the secondary RMS voltage?

	V

2 marks

The transformer is used to provide power to a light globe with the filament having a resistance of 529 Ω

QUESTION 10
What is the power dissipated by the light globe?

	W

2 marks

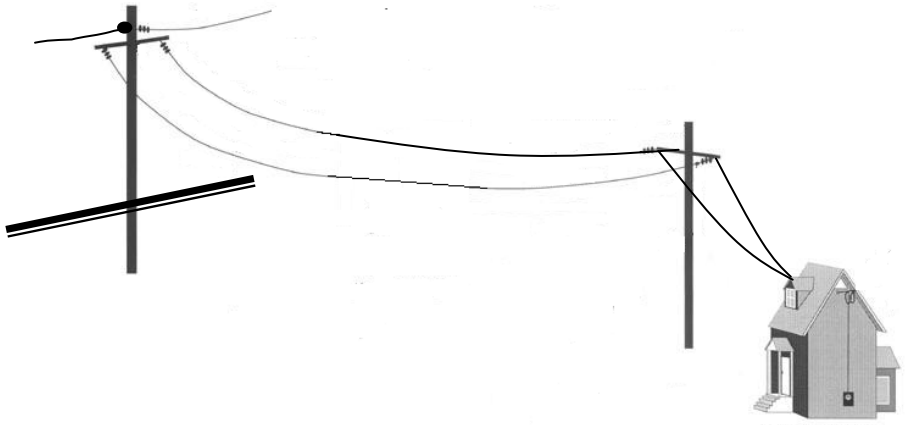
QUESTION 11
If the 'ideal' transformer was replaced with a 'real' transformer, which of the following would be true?

A. The secondary voltage would be less but the secondary current would remain the same.
B. The output power from the transformer would be less than the input power.
C. The frequency of the secondary coil would be less than the primary coil.
D. The secondary current would increase.

2 marks

The following information refers to Questions 12 to 16.

A cottage is connected to the 240 RMS Voltage provided from the roadway. The connections are very long and have a total resistance of 0.6 Ω. With every light and appliance ON in the cottage the total current being drawn is 15 A. At this stage, the people that live in the cottage are disappointed that their lights are not as bright as they should be.



QUESTION 12
How much power was lost in the connections between the roadway and the cottage with every light and appliance ON in the cottage?

	W

2 marks

QUESTION 13
How much power was actually being delivered to the cottage with every light and appliance ON in the cottage?

	W

2 marks

QUESTION 14
What was the voltage at the cottage with every light and appliance ON in the cottage?

	V

2 marks

QUESTION 15
Which of the following is the most realistic way for the cottage to receive more power when every light and all the appliances are on?

A. Decrease the resistance of the lights and appliances.
B. Decrease the resistance of the power connections between the roadway and the cottage.
C. Install a step-up transformer at the roadway power supply and a step-down transformer at the cottage.
D. Install a step-down transformer at the roadway power supply and a step-up transformer at the cottage.

2 marks

QUESTION 16
One of the people in the cottage says that they should install a step-down transformer at the roadway power supply and a step-up transformer at the cottage. Explain how this **will or will not** help the situation. Including a reference to power loss in your answer.

3 marks

QUESTION 17
Which of the following is the only **true** statement?

A. The magnetic field around a bar magnet is monopolar resulting from the aligning of many domains within the solenoid material of the magnet.
B. The magnetic field around a bar magnet is monopolar resulting from the aligning of many dipoles within the ferromagnetic material of the magnet.
C. The magnetic field around a bar magnet is dipolar resulting from the aligning of many domains within the solenoid material of the magnet.
D. The magnetic field around a bar magnet is dipolar resulting from the aligning of many domains within the ferromagnetic material of the magnet.

2 marks

QUESTION 18
Which of the following devices does not operate on the basis of an induced EMF?

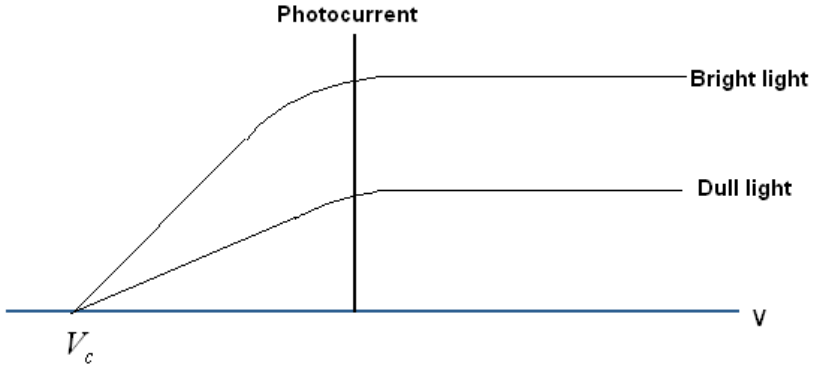
A. An alternator.
B. An AC generator.
C. A DC generator.
D. An electromagnet.

2 marks

End of Section on Electric Power

AREA OF STUDY 2 – INTERACTIONS OF LIGHT AND MATTER

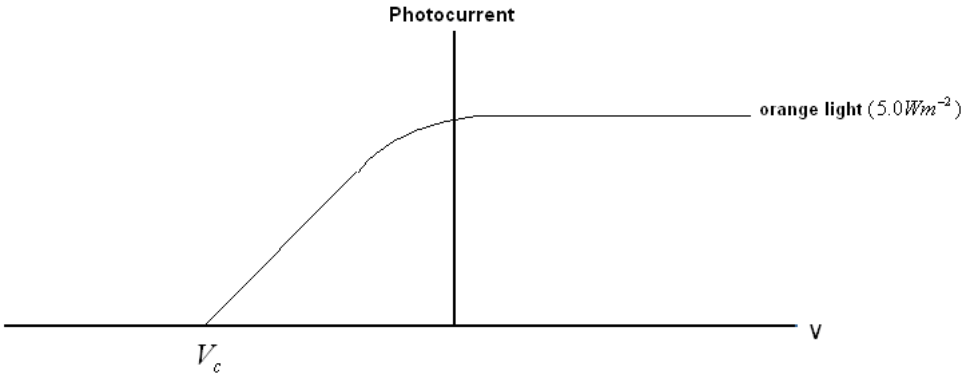
QUESTION 1
The following graph represents the results from an investigation of the photoelectric effect using monochromatic orange light on a metal surface. The stopping voltage for both bright and dull light was the same but the bright light source produced a greater photocurrent.



State whether these observations support the wave or particle model for light. Explain your reasoning.

3 marks

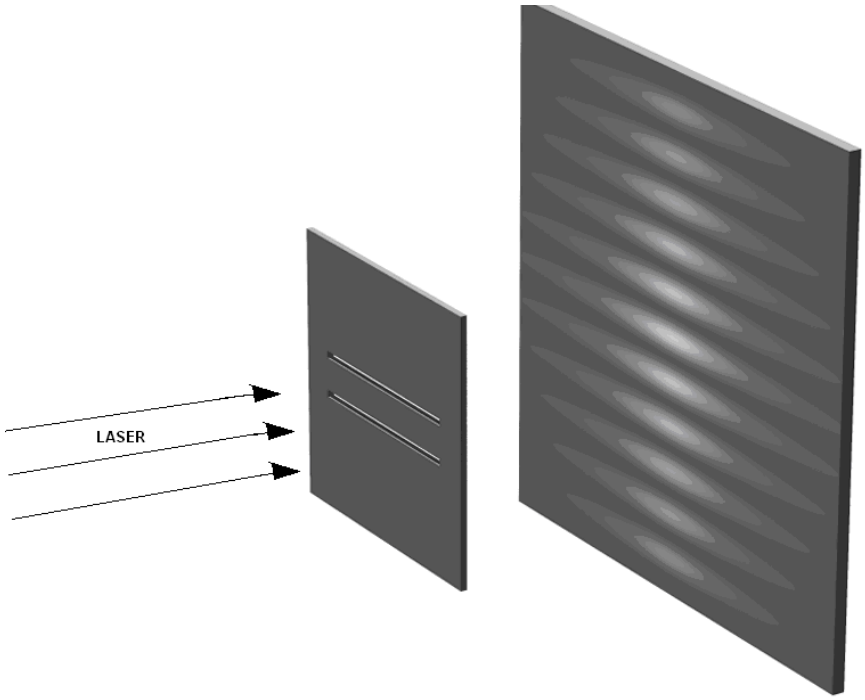
QUESTION 2
The graph below shows the photoelectric effect obtained with orange light of intensity $5.0 Wm^{-2}$. The incident light is then changed to violet, also of $5.0 Wm^{-2}$. On the set of axes below, draw the relationship that would be found between photocurrent and voltage for violet light.



2 marks

The following information refers to Questions 3 to 5.

In demonstrating Young's famous double slit experiment a student projected a red LASER onto two narrow slits and he observed a pattern of sequential light / dark zones on a screen.



Describe the effect on nodal spacing when each of the following changes are made:

QUESTION 3
The colour of the LASER is changed to yellow.

_____

_____

1 mark

QUESTION 4
The distance between the pair of slits is reduced.

_____

_____

1 mark

QUESTION 5
The screen is moved further from the slits.

_____

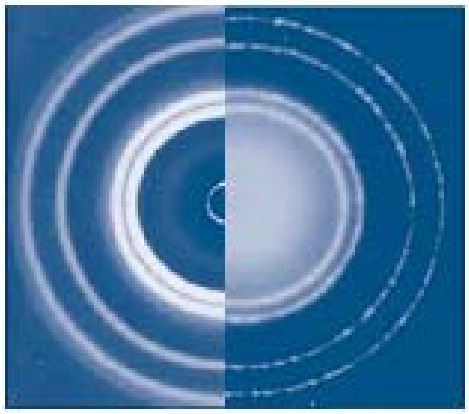
_____

1 mark

The following information refers to Questions 6 to 9.

To provide support for matter waves, Thomson fired a beam of electrons through a very thin metal foil onto a photographic plate. The pattern formed by the transmitted electrons was very similar to the diffraction pattern obtained when the exercise was repeated with a beam of X-rays.

The left hand side of the diagram is a diffraction pattern using 10 keV X-rays. On the right is the diffraction pattern obtained using electrons.



QUESTION 6
What is the frequency of the X-rays?

_____

_____

_____

2 marks

QUESTION 7
What is the momentum of an X-ray photon?

_____

_____

_____

2 marks

QUESTION 8
What is the wavelength of the electrons?

_____

_____

_____

2 marks

QUESTION 9
If the voltage accelerating the electrons was increased by a factor of 4, what is the effect on the wavelength of the electrons?

A. No change
B. Increased by a factor of 2.
C. Increased by a factor of four.
D. Decreased by a factor 2.
E. Decreased by a factor of four.

2 marks

The following information refers to Questions 10 to 13.

Electrons of 5.0 eV are fired through a gas Q and emerge with energies of 1.2, 1.8, 3.0 and 5.0 eV.

QUESTION 10
If the ground state is 0 V, what is the energy of the second excitation state?

2 marks

QUESTION 11
What is the maximum number of different wavelengths that could be emitted by the gas?

2 marks

QUESTION 12
A wavelength of about 380 nm is considered to be the upper limit for ultraviolet light. Suggest one electron transition that would emit a UV photon from gas Q. Support your reasoning with appropriate calculations.

2 marks

QUESTION 13
A spectroscope is used to observe the light emitted from the gas when the electrons are fired through it, and a number of coloured bands are observed which correspond to specific wavelengths being emitted. The spectroscope is also used to view the effect of shining white light through gas Q and a number of dark bands are observed. It was noted, however, that there are fewer dark bands than there are bright bands. Explain why fewer dark bands would be expected.

_____

_____

_____

_____

_____

_____

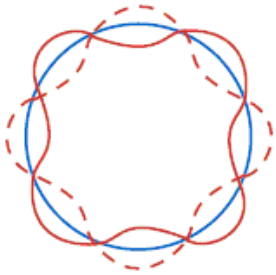
_____

_____

_____

3 marks

QUESTION 14
The following diagram represents the standing wave pattern of a valence electron after it had been excited by absorption of a photon.



What excitation state is represented by this diagram?

A. First
B. Second
C. Third
D. Fourth

1 mark

End of Section on Interactions of Light and Matter

SECTION B – DETAILED STUDIES

Instructions For Section B

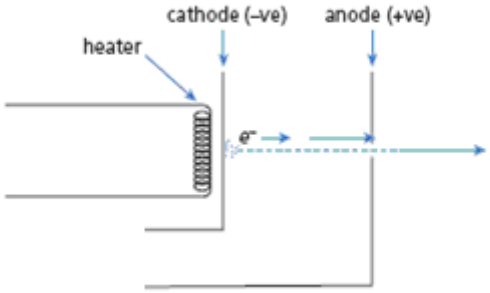
Choose one of the following **Detailed Studies**. Answer all the questions on the **Detailed Study** you have chosen.

DETAILED STUDY 1 – SYNCHROTRON AND ITS APPLICATIONS

Mass of electron is 9.11×10^{-31}kg
$c = 3.0 \times 10^{8}$ ms^{-1}
$e = 1.6 \times 10^{-19}$ C

The following information refers to Questions 1 to 3

An electron gun consists of a pair of parallel plates 20 cm apart with an applied potential difference of 12 kV. Electrons are emitted from the heated cathode and accelerate towards the anode.



QUESTION 1
The direction of the electric field between the plates is

A. to the left of the page.
B. to the right of the page.
C. into the page.
D. out of the page.

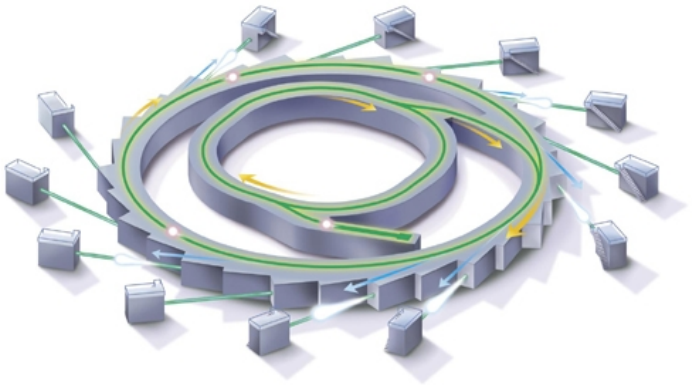
QUESTION 2
The velocity of the emitted electrons as they reach the anode is closest to (ignore the effect of relativity in this question)

A. 1.6×10^{6} ms^{-1}
B. 1.2×10^{7} ms^{-1}
C. 6.5×10^{7} ms^{-1}
D. 1.6×10^{8} ms^{-1}

QUESTION 3
If the spacing between the plates is halved, the final velocity of the electrons striking the anode will be

A. increased.
B. decreased.
C. the same as original spacing.

QUESTION 4
When a synchrotron storage ring is viewed from above the electrons travel in a clockwise direction.



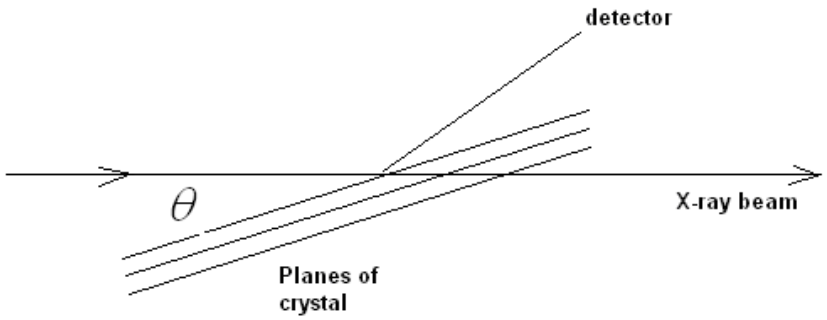
The magnetic fields in the bending magnets are directed

A. vertically upwards.
B. vertically downwards.
C. towards the centre of the ring.
D. away from the centre of the ring.

QUESTION 5
An electron enters a 0.80 T magnetic field at 2.9×10^{8} ms^{-1}. What is the radius of the electron's resulting circular motion? Ignore the effect of relativity in this question.

A. 2.1×10^{-4} m
B. 2.1×10^{-3} m
C. 0.68 m
D. 68 m

QUESTION 6
A crystal with 2.8 x 10^{-10} m atomic plane spacing is bombarded with X-rays of wavelength 0.15 nm, and a number of Bragg diffraction maxima are observed as the crystal is rotated.



The second of the observed maxima is obtained at a glancing angle of 35^{o}.
What is maximum number of intensity peaks (highest order maxima) to be observed as the crystal is rotated between 0 and 90^{o}?

A. 2
B. 3
C. 4
D. 5

QUESTION 7
With another crystal of different chemical composition, a first order Bragg diffraction maximum was observed at 12.5^{o} using X-rays of wavelength 0.15 nm What is the spacing between adjacent planes of ions?

A. 0.19 nm
B. 0.30 nm
C. 0.35 nm
D. 0.70 nm

QUESTION 8
In experiments involving Bragg diffraction, it is important to use X-ray photons with energies that cause them to

A. be scattered inelastically.
B. be scattered elastically without loss of energy.
C. overcome the work function of the irradiated material.
D. be absorbed by the material.

QUESTION 9
As electrons travel in a circular path in the storage ring of the synchrotron, the photon beam is produced

A. perpendicular to the electron beam and directed away from the centre of the storage ring.
B. perpendicular to the electron beam directed towards the centre of the storage ring.
C. along the direction of the path of the electron beam.
D. at a tangent to the path of the electron beam.

QUESTION 10
Select the **INCORRECT** statement from the following descriptions of undulator and wiggler characteristics.

A. Undulators are partially monochromatic, in that they produce a spectrum of synchrotron light that is enhanced at specific wavelengths.
B. An undulator consists of less powerful magnets than the wiggler that results in more divergent synchrotron light.
C. A wiggler consists of two rows of alternating magnetic poles which produces a more powerful beam of light than the undulator
D. Light from the wiggler can be much brighter than the bending magnets.

QUESTION 11
The nature of synchrotron light is

A. pulsed, polarized and collimated.
B. continuous, polarized and collimated.
C. pulsed, polarised and monochromatic.
D. continuous, non-polarised and coherent.

QUESTION 12
In the beamline, specific wavelengths can be selected from the synchrotron light by using

A. bending magnets.
B. collimating mirrors.
C. double crystal monochromator.
D. radiation attenuators.

QUESTION 13
The shield wall surrounding the storage ring is usually made of lead and concrete, and completely encloses the storage ring, except for the beamlines through which the radiation is guided. The function of the lead and concrete shielding is to

A. contain the heat generated by the massive input of electrical energy.
B. contain the radioactive isotopes generated by the high radiation source.
C. absorb high energy X-rays given off by the storage ring.
D. prevent people from walking into the electron beam.

End of Section on Synchrotron and its Applications

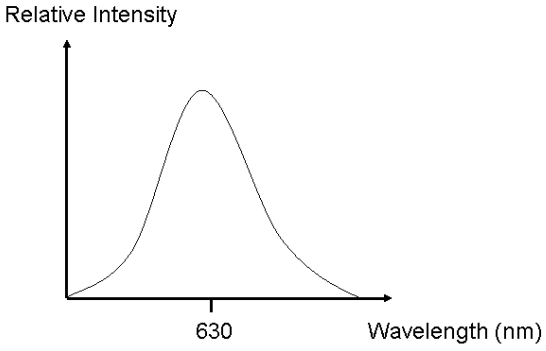
DETAILED STUDY 2 - PHOTONICS

The following information refers to Questions 1 and 2

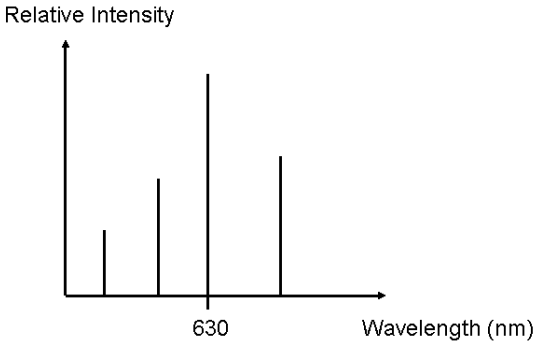
Red light of wavelength 630 nm, is produced by a LED.

QUESTION 1
Which of the following graphs best demonstrates the intensity spectrum of this red light?

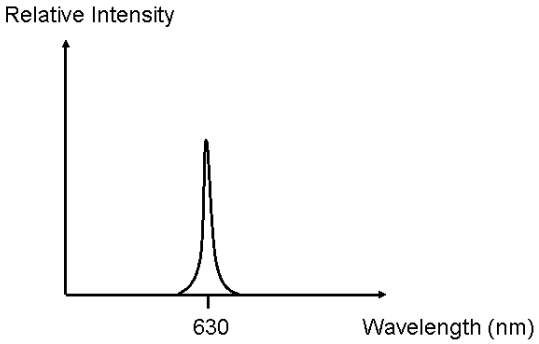
A.



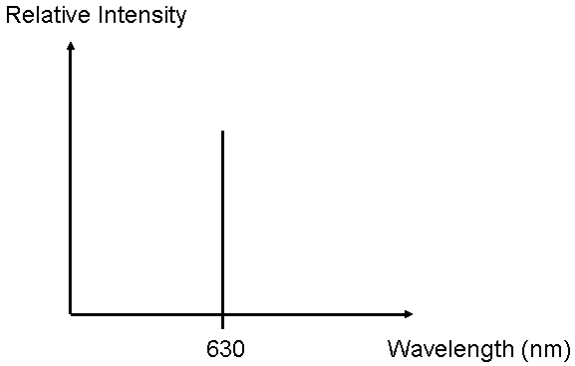
B.



C.



D.



QUESTION 2
Which one of the following best estimates the Band Gap energy for the LED?

A. 3×10^{-19} eV
B. 0.5 eV
C. 2 eV
D. 20 eV

QUESTION 3
Which of the following physical phenomena best describes how light is produced from the sun?

A. Fluorescence
B. Thermal radiation
C. Spontaneous emission
D. Stimulated emission

QUESTION 4
The waves in Figure 1 are a sample of electromagnetic waves that have originated from a light source.

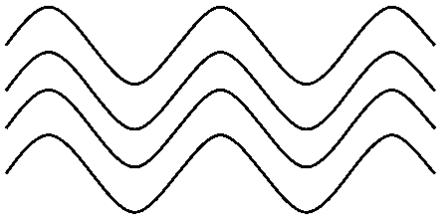


Figure 1

Which one of the following light sources would produce waves like those in Figure 1?

A. Candle
B. Incandescent globe
C. Sodium vapour lamp
D. Laser

The following information refers to Questions 5 and 6.

A step-index optic wave guide is constructed such that the core has a relative refractive index of 1.44 and the cladding has a relative refractive index of 1.41.

QUESTION 5
Which one of the following angles best estimates the critical angle for the optical fibre?

A. 12^{o}
B. 78^{o}
C. 90^{o}
D. The critical angle does not exist.

QUESTION 6
What is the numerical aperture for this optical fibre?

A. 0.030
B. 0.086
C. 0.17
D. 0.29

QUESTION 7
The light passing through a particular optical fibre appears in Figure 2.

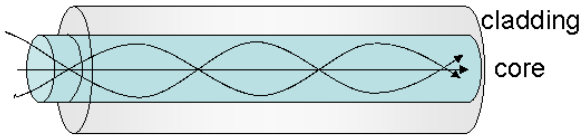


Figure 2

Which one of the following types of optical fibres best describes the one above?

A. Single mode step index fibre.
B. Multimode step index fibre.
C. Single mode graded index fibre.
D. Multimode graded index fibre**.**

QUESTION 8
Which one of the following statements best describes the reason for modal dispersion?

A. Different path lengths of different input signals.
B. Different wavelengths travel at different speeds.
C. Impurities in the fibre.
D. Loss of intensity inside the cladding.

QUESTION 9
An optical fibre of length 5 km has an input signal power of 80 mW and an output signal power of 30 mW. Which one of the following best estimates the attenuation of this fibre?

A. 6 mW km^{-1}
B. 10 mW km^{-1}
C. 16 mW km^{-1}
D. 22 mW km^{-1}

QUESTION 10
The graph in Figure 3 represents the total attenuation with wavelength for a particular optical fibre.

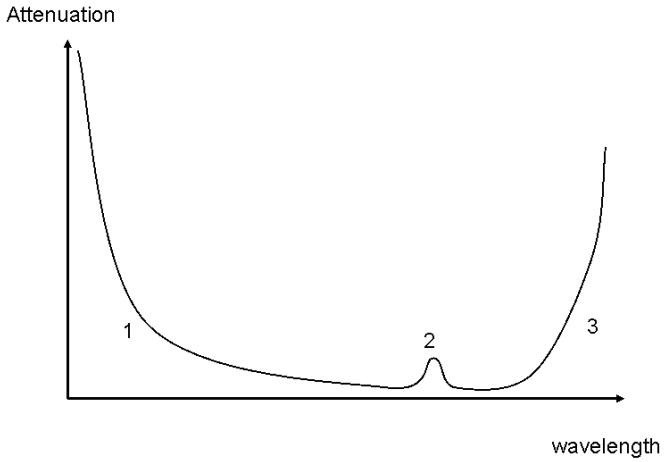


Figure 3

Which one of the following options best accounts for the large signal loss in regions **1, 2 and 3** in Figure 3?

	1	2	3
A	Rayleigh scattering	Absorption by resonance	Absorption by impurities
B	Absorption by resonance	Absorption by impurities	Rayleigh scattering
C	Rayleigh scattering	Absorption by impurities	Absorption by resonance
D	Absorption by impurities	Absorption by resonance	Rayleigh scattering

QUESTION 11
Which one of the following statements best describes the purpose of optical modulation of the fibre-optic telecommunications system?

A. To add a light signal to the electrical signal.
B. To remove a light signal from the electrical signal.
C. To convert the signal from analogue to digital.
D. To convert the signal from digital to analogue.

QUESTION 12
Fibre optic imaging allows images to be received from places difficult to get to. This is enabled by

A. an optical cable with a large diameter.
B. high intensity light through the cable.
C. a series of coherent optical cables.
D. many wavelengths passing through the cable.

QUESTION 13
The acceptance angle is best described as

A. the angle between the core and the cladding.
B. the maximum angle light can enter an optical cable and still be internally reflected.
C. the minimum angle at which the light is internally reflected.
D. the maximum angle the fibre can bend and still propagate light.

End of Section on Photonics

DETAILED STUDY 3 - SOUND

The schematic diagram below in Figure 1 shows a particular microphone.

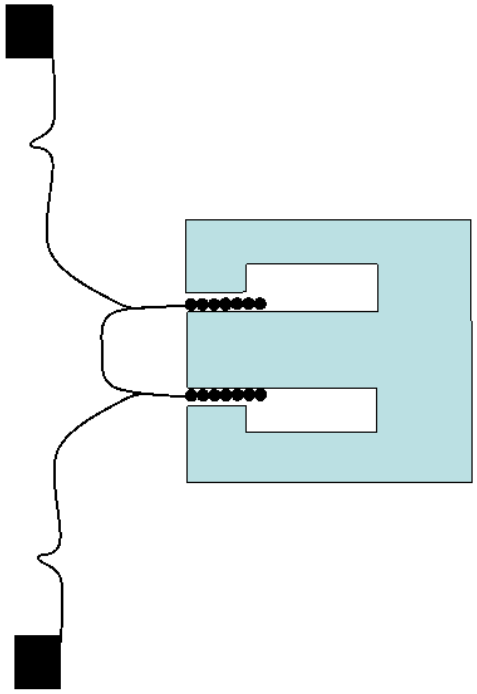
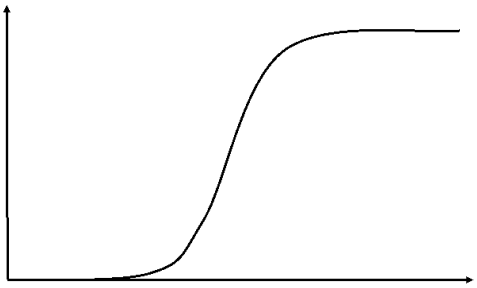


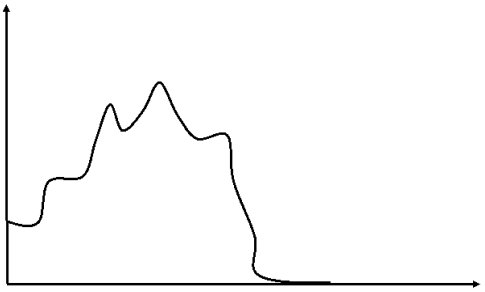
Figure 1

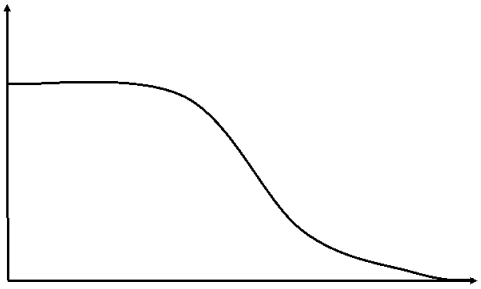
QUESTION 1
Which of the following names best suits this type of microphone?

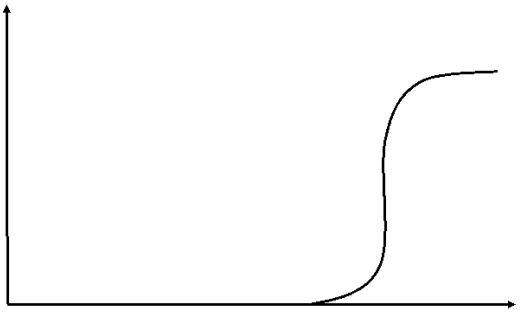
A. Dynamic
B. Crystal
C. Electret-Condenser
D. Velocity

QUESTION 2
Jo wishes to buy a new high fidelity sub-woofer for her Hi-Fi system. Below are four frequency response curves across the range of audible sounds for the speakers she looked at. Which speaker best suits her needs?

A.


B.


C.


D.


QUESTION 3
In a sound experiment, Paul was blindfolded and placed in the centre of the school oval. His classmates were positioned at various points around Paul and one at a time, played a variety of instruments. Paul was then asked to point where each sound came from. It was found that Paul was able to identify the direction of the high frequency sounds with high accuracy, but not the low frequency sounds. Which of the following statements best describes this result?

A. High frequency sounds diffract more.
B. High frequency sounds diffract less.
C. High frequency sounds reflect more.
D. High frequency sounds reflect less.

QUESTION 4
In which of the following ways does a baffle increase the fidelity of a speaker?

A. Reduce diffraction of created sound waves.
B. Reduce the movement of the cone.
C. Reduce interference of created sound waves.
D. Increase movement of cone.

The following information refers to Questions 5 to 8.

A loudspeaker on a tall pole is situated at the edge of a sporting field. Two students, Jenny and Kim, are in the field with sound detection devices. Jenny measures the sound intensity level to be 45 dB.

QUESTION 5
Which of the following best estimates the sound intensity as measured by Jenny?

A. 3.16×10^{-8} Wm^{-2}
B. 3.16×10^{4} Wm^{-2}
C. 3.16×10^{16} Wm^{-2}
D. 1.0×10^{33} Wm^{-2}

QUESTION 6
If Jenny is 3 m from the speaker and Kim is 6 m away, what is the ratio of Jenny's sound intensity to Kim's sound intensity?

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

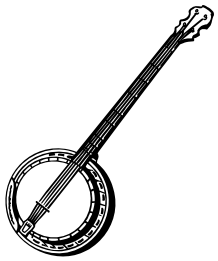
QUESTION 7
Kim now moves to the edge of the field and records a sound intensity of 1×10^{-9} Wm^{-2}.
Which of the following sound intensity levels does this correspond to?

A. 0.3 dB
B. 3 dB
C. 30 dB
D. 300 dB

QUESTION 8
Jenny now moves around the field until her sound intensity is **half** her original sound intensity. Which of the following is Jenny's new sound intensity *level* reading?

A. 27.5 dB
B. 42 dB
C. 45 dB
D. 90 dB

QUESTION 9
A banjo has a string of length 60 cm and has a fundamental frequency of 300 Hz. Which of the following speeds best represents the speed of the wave passing through the string?



A. 180 ms^{-1}
B. 360 ms^{-1}
C. 18000 ms^{-1}
D. 36000 ms^{-1}

QUESTION 10
A clarinet can be modelled as a pipe closed at one end. Which of the following is true for the fifth harmonic with respect to the fundamental frequency, f_o?

A. $\frac{1}{5} f_o$
B. $4 f_o$
C. $5 f_o$
D. $7 f_o$

QUESTION 11
Which one of the following statements best describes a longitudinal wave?

A. Particles move parallel in the direction of propagation.
B. Particles oscillate parallel in the direction of propagation.
C. Particles move perpendicular to the direction of propagation.
D. Particles oscillate perpendicular to the direction of propagation.

QUESTION 12
Two students are investigating the sound intensity level of the sound generated from a signal generator over a range of frequencies. Both students notice that even though the sound intensity level meter measures 50 dB at both 50 Hz and 1000 Hz, the higher frequency sounds louder. Which of the following statements provides the best explanation?

A. 50 Hz is below the threshold of hearing.
B. Higher frequency sounds diffract less.
C. The student's hearing is subject to their ears response to different frequencies.
D. The sound is more likely to destructively interfere at lower frequencies.

QUESTION 13
Resonance occurs when

A. the wave is too big.
B. the force creating the wave has the same frequency as the wave.
C. the waves constructively interfere.
D. an object breaks.

End of Section on Sound

THE SCHOOL FOR EXCELLENCE
UNIT 4 PHYSICS 2009
COMPLIMENTARY WRITTEN EXAMINATION 2

SECTION A – CORE STUDIES
AREA OF STUDY 1 – ELECTRIC POWER

QUESTION 1 A

QUESTION 2

The direction of the magnetic field around a current-carrying conductor can be found using the right-hand **grip** rule. The magnitude of the field strength **increases with** an increase in the magnitude of the current. The magnitude of the field **decreases with** an increase in the radial distance from the conductor.

QUESTION 3 B

QUESTION 4 Anticlockwise

QUESTION 5 D

QUESTION 6 A

QUESTION 7

$$\xi_{ave} = -n\frac{\Delta\phi}{\Delta t}$$

$\Delta\Phi = \Delta(BA) = 2.5 \times 0.18 \times 0.10 = 0.045$ Wb [1 mark]

$\Delta t = 0.15$ s

$$\xi_{ave} = -1 \times \frac{0.045}{0.15} = 0.3\,V$$ [1 mark]

$$I = \frac{\xi}{R} = \frac{0.3}{4}[1\ mark] = 0.075\ A$$ **= 75 mA** [1 mark]

QUESTION 8

"Step-up": based on the number of loops on each side of the transformer.

QUESTION 9 115 V_{RMS}

QUESTION 10. 25 W

QUESTION 11 B

QUESTION 12

$P_{loss}=I^2R = 15^2 \times 0.6 =$ **135 W**

QUESTION 13.

$P_{delivered} = P_{supplied} – P_{loss} = VI – 135 = 3600 – 135 =$ **3465 W**

QUESTION 14

$V_{cottage} = 240 – V_{drop\ across\ connecting\ wires} = 240 – IR = 240 – (15 \times 0.6)$
$=240 – 9 =$ **231 V**

QUESTION 15 C

It is unlikely that the appliances could be easily changed to draw less power but appropriately placed transformers will help. (see Q16)

QUESTION 16

It will not help. It will make the situation worse. A step-up transformer at the roadway and then a step-down transformer at the cottage will transfer the power at a higher voltage and lesser current (P = VI) decreasing power loss ($P_{loss} = I^2R$).

QUESTION 17 D

QUESTION 18 D

AREA OF STUDY 2 – INTERACTIONS OF LIGHT AND MATTER

QUESTION 1

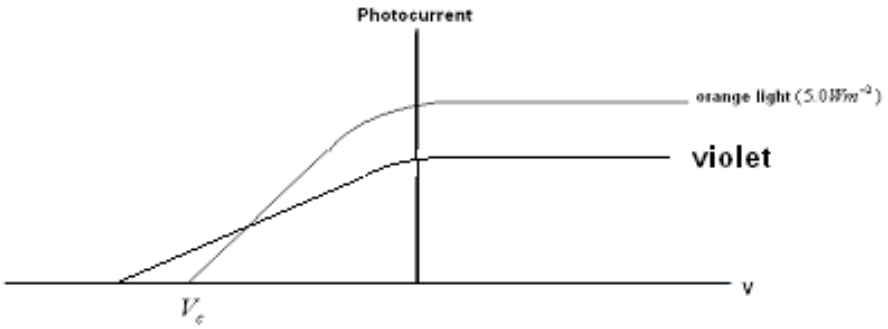
This observation supports the particle model, in which bright light is considered to have more particles but of the same energy value as dull light (1 mark). Therefore, photoelectrons from both sources have the same energy, hence same stopping voltage. Bright light has more particles, therefore emits more photoelectrons and produces higher photocurrents (1 mark).

The wave model would suggest bright light would transfer more energy to the photoelectrons which would require a greater stopping voltage (1 mark).

QUESTION 2

Two important features:

1. Violet has a greater stopping voltage (1 mark).
2. Violet has a lower photocurrent (violet photons have more energy than orange, therefore less violet photons are needed to transfer 5W) (1 mark).



QUESTION 3

Nodal spacing is reduced ($nodal\ spacing \propto \lambda$).

QUESTION 4

Nodal spacing increases ($nodal\ spacing \propto \frac{1}{d}$).

QUESTION 5

Nodal spacing increases ($nodal\ spacing \propto L$).

QUESTION 6

$$f = \frac{E}{h} = \frac{10000}{4.14 \times 10^{-15}} = 2.4 \times 10^{18}\ Hz$$

QUESTION 7

$$P = \frac{hf}{c} = \frac{6.63\times10^{-34}\times2.4\times10^{18}}{3\times10^{8}} = 5.3\times10^{-24}\ kgms^{-1}$$

QUESTION 8

The diffraction pattern provides evidence that the wavelength of the X-rays is the same as the electrons:

$$\lambda = \frac{hc}{E} = \frac{4.14\times10^{-15}\times3\times10^{8}}{10000} = 1.24\times10^{-10}\,m$$

QUESTION 9

Increasing the voltage by a factor of 4 gives the electrons 4 times as much kinetic energy. This doubles the velocity of the electrons. Matter wavelength $\propto \frac{1}{v}$, therefore the wavelength is halved.

QUESTION 10

As the energy level increases the energy difference between transitions decreases 3.8 eV.

QUESTION 11

Electrons can be ejected (ionisation) with 1.8 eV of kinetic energy**.**

QUESTION 12

Two possible answers. Both 3.8 ev and 5.0 eV photons are in the UV region.

The transition from n = 4 to n = 1 will release the greatest energy photon.

$$\lambda = \frac{hc}{E} = \frac{4.14\times10^{-15}\times3\times10^{8}}{5.0} = 2.48\times10^{-7} = 248nm$$

The transition from n = 3 to n = 1 will release 3.8 eV, also in the UV region:

$$\lambda = \frac{hc}{E} = \frac{4.14\times10^{-15}\times3\times10^{8}}{3.8} = 3.29\times10^{-7} = 327nm$$

QUESTION 13

The dark bands correspond to absorbed photons which have raised electrons to particular excitation states. The bright bands correspond to energies emitted when the electron de-excites. Unlike photon absorption which is a single process, dropping to a lower energy level can occur with multiple steps, hence releasing more energy values eg. dropping from n = 3 to n=2 does not have a corresponding absorption component.

QUESTION 14 C

Circumference is 4λ, therefore n=4, which corresponds to the third excitation state

DETAILED STUDY 1 – SYNCHROTRON AND ITS APPLICATIONS

QUESTION 1 A

The direction of the field is the direction of force that would act on a positive charge.

QUESTION 2 C

$$eV = \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{2eV}{m}} = \sqrt{\frac{2 \times 1.6 \times 10^{-19} \times 12000}{9.1 \times 10^{-31}}} \quad = 6.5 \text{ x } 10^7 \text{ ms}^{-1}$$

QUESTION 3 C

QUESTION 4 B

Found using the right hand slap rule. Don't forget that current is in the opposite direction to electron flow.

QUESTION 5 B

$$r = \frac{mv}{qB} = \frac{9.1 \times 10^{-31} \times 2.9 \times 10^{8}}{1.6 \times 10^{-19} \times 0.8} \quad = \quad 2.1 \times 10^{-3}\ m$$

QUESTION 6 B

QUESTION 7 C

$$d = \frac{\lambda}{2\sin\theta} = 0.35 \text{ nm}$$

QUESTION 8 B

QUESTION 9 D

QUESTION 10 B

QUESTION 11 A

QUESTION 12 C

QUESTION 13 C

DETAILED STUDY 2 - PHOTONICS

QUESTION 1 C

Light from and LED is not monochromatic but has a small spread in wavelength.

QUESTION 2 C

$$E_g = \frac{hc}{\lambda} = \frac{4.14\times10^{-15}\times3\times10^{8}}{630\times10^{-9}} = 2eV$$

QUESTION 3 B

QUESTION 4 D

Only a laser will produce coherent light.

QUESTION 5 B

$$\sin\vartheta = \frac{n_{cladding}}{n_{core}} = \frac{1.41}{1.44}$$

$$\theta = 78^{o}$$

QUESTION 6 D

$$NA = \sqrt{n_{core}{}^{2} - n_{cladding}{}^{2}} = 0.29$$

QUESTION 7 D

The refractive index of the core fibre gradually decreases radially from the centre of the fibre causing a gradual bending of light back towards the centre of the core fibre, rather than the light sharply undergoing internal reflection.

QUESTION 8 A

QUESTION 9 B

$$attenuation = \frac{80-30}{5} = 10\ mW\ km^{-1}$$

QUESTION 10 C

QUESTION 11 A

QUESTION 12 C

QUESTION 13 B

DETAILED STUDY 3 - SOUND

QUESTION 1 A

QUESTION 2 C

The sub-woofer should be responsive to the low frequencies. A high fidelity would require a relatively flat curve.

QUESTION 3 B

Diffraction is proportional to the wavelength/width, therefore the higher the frequency, the smaller the wavelength and the less likely the waves will diffract.

QUESTION 4 C

QUESTION 5 A

$$45 = 10\log\frac{I}{I_o}$$

$$4.5 = \log\frac{I}{10^{-12}}$$

$$I = 3.16\times10^{-8}\,Wm^{-2}$$

QUESTION 6 D

$$I = \frac{P}{r^2}$$

$$I_j = \frac{P}{r^2}, I_k = \frac{P}{(2r)^2} = \frac{I_j}{4}$$

$$4:1$$

QUESTION 7 C

$$dB = 10\log\frac{1\times10^{-9}}{1\times10^{-12}} = 30dB$$

QUESTION 8 B

Half intensity corresponds to -3dB so Jenny's new sound intensity level is 42 dB.

QUESTION 9 B

$$\lambda = 2\times0.6$$

$$v = f\lambda = 300\times2\times0.6 = 360\ ms^{-1}$$

QUESTION 10 C

QUESTION 11 B

QUESTION 12 C

QUESTION 13 B