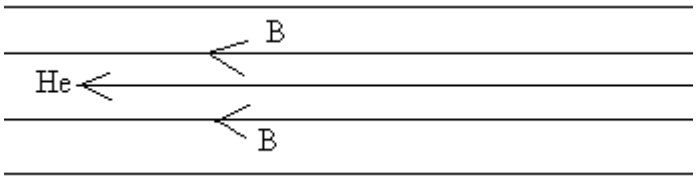
THE SCHOOL FOR EXCELLENCE
UNIT 4 PHYSICS 2007
COMPLIMENTARY WRITTEN EXAMINATION 2

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

QUESTION 1 Answer is A

QUESTIONS 2 & 3



Must show parallel (1 mark) and direction (1 mark) for Question 2.

QUESTION 4 Answer is B

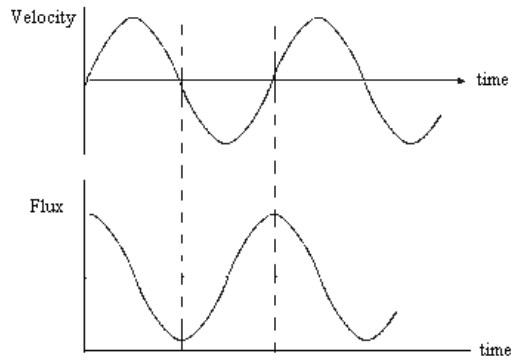
QUESTION 5

$$F_{RS} = nBIl \quad = 40 \times 80 \times 10^{-3} \times 1.5 \times 0.04 = 0.192\,N$$

QUESTION 6 Up

QUESTION 7 Zero (at all times).

QUESTION 8



QUESTION 9

Y to X. A south pole is induced at the top end of the solenoid caused by induced current flowing from Y to X.

QUESTION 10 Answer is A

QUESTION 11

$$current = \frac{power}{voltage} = \frac{40 \times 10^6}{500 \times 10^3} = 80A$$

QUESTION 12

$$P_{LOSS} = I^2 R = 80^2 \times 4 = 2.56 \times 10^4 W$$

$$Percentage\ loss = \frac{2.56 \times 10^4 \times 100}{40 \times 10^6} = 0.064\%$$

QUESTION 13

$$V_{DROP} = I \times R = 80 \times 4 = 320V$$

QUESTION 14

Power loss is proportional to current squared, therefore power loss is minimised by keeping current as low as possible. This is achieved by transmitting at a high voltage.

QUESTION 15 Step-up transformer.

QUESTION 16 96 V rms

QUESTION 17 B is positive.

QUESTION 18

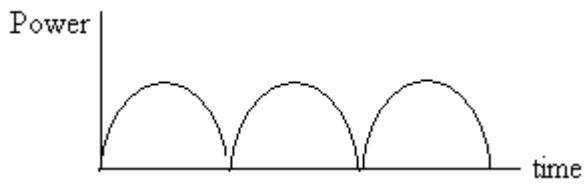
$$\Delta\Phi = BA = 0.40 \times 0.040 \times 0.050 = 8.0 \times 10^{-4}\ Wb$$

$$\Delta t = \frac{0.5}{4} = 0.125s$$

$$\xi = 100 \times \frac{8.0 \times 10^{-4}}{0.125} = 0.64\,V$$

QUESTION 19

The following represents the power output of the generator as it rotates. The brightness of the lamp is proportional to the power dissipation, hence the flicker.



AREA OF STUDY 2 – INTERACTIONS OF LIGHT AND MATTER

QUESTION 1 Answer is B

QUESTION 2 2.90×10^{-18} J

QUESTION 3 6.86×10^{-8} m

QUESTION 4 1.7 eV

QUESTION 5

KE = 2.72×10^{-19} J
v = 7.73×10^{5} m/s

QUESTION 6

Frequency increases.

∴ Energy of the incident light photons increases.
∴ Kinetic energy of the emitted photoelectrons increases.
∴ Stopping voltage increases in magnitude.

$V_o = h/q\ (f - f_o)$

QUESTION 7

1 mark for describing principle of superposition.
1 mark for describing constructive and destructive interference.
1 mark for relating interference patterns to light intensity.

QUESTION 8

The pattern will spread further across the screen.

QUESTION 9

1 mark for the wave model best explains this.

1 mark for explaining why wave model is better: Interference pattern (a wave phenomenon) will be observed.

1 mark for: Particle model would not predict the interference pattern, rather two zones where the electrons would strike the screen.

QUESTION 10

$P = nhc/\lambda t$

$\therefore n = Pt\lambda/hc = 3.92 \times 10^{21}$

QUESTION 11

$p = h/\lambda = 1.7 \times 10^{-27}$ kgm/s

QUESTION 12 1.02×10^{-34} m

QUESTION 13 1.62 x 10^{-10} m

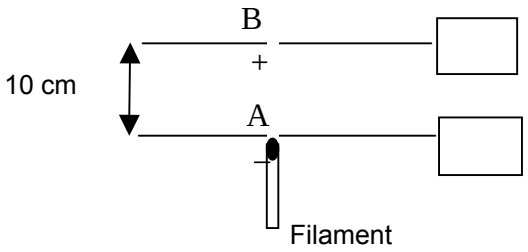
QUESTION 14

1 mark for: Diffraction of the electron can be observed after electrons pass through very thin slits (10^{-10} m).

1 mark for: Slits cannot be created thin enough for baseballs of such a small wavelength and even if we could its physical size would prevent it from passing through.

DETAILED STUDY 1 – SYNCHROTRON AND ITS APPLICATIONS

QUESTION 1



QUESTION 2

$$E = \frac{V}{d} = \frac{500}{0.1} = 5000\,V\ m^{-1}$$

QUESTION 3

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

$$v = \sqrt{\frac{2eV}{m}} = \sqrt{\frac{2 \times 1.6 \times 10^{-19} \times 500}{9.1 \times 10^{-31}}} = 1.3 \times 10^7\ ms^{-1}$$

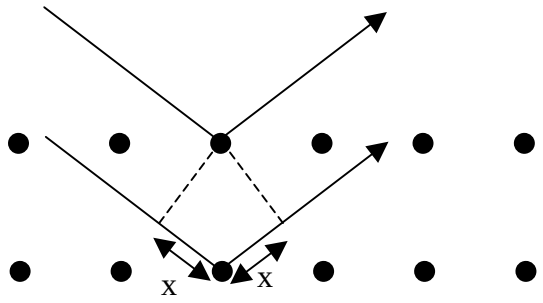
QUESTION 4 Answer is C

QUESTION 5

$$B = \frac{p}{er} = \frac{1 \times 10^{-18}}{1.6 \times 10^{-19} \times 34.4} = 0.18\,T$$

QUESTION 6 Answer is B

QUESTION 7
If path difference of rays incident on crystal planes is an integer multiple of wavelength (1 mark) constructive interference and therefore diffraction occurs (1 mark).



Path difference = 2x.

1 mark for diagram, 1 mark for indication of path difference between beams.

QUESTION 8

$$d = \frac{n\lambda}{2\sin\vartheta} == \frac{2\times 1.25\times 10^{-9}}{2\times\sin(32.5)} = 2.3\times 10^{-9}\, m$$

1 mark for $n = 2$, 1 mark for correct answer, 1 mark for correct unit.

QUESTION 9

Single crystal diffraction – provides more information.
Powder diffraction – able to use very small samples.

QUESTION 10 Answer is B

QUESTION 11 Answer is D

DETAILED STUDY 2 - PHOTONICS

QUESTION 1

LED A is violet.

LED A has a higher threshold voltage (3.0V) than LED B (2.0V). This implies that LED A will have a higher energy gap, hence emit a higher energy photon than LED B. A photon of violet light has a higher energy than a photon of orange light.

An alternative approach is to approximate the energy gap to the threshold potential and calculate the wavelength of the emitted photon ($\lambda = \frac{h\,c}{E_g}$).

This provides a wavelength of 414 nm for LED A

QUESTION 2 Answer is A & E

QUESTION 3

Select two of:

- Use a smaller diameter fibre to reduce the number of modes.
- Use a graded-index fibre.
- Use a single mode fibre.

QUESTION 4

$$E_{photon} = \frac{h\,c}{\lambda} = \frac{6.63\times10^{-34}\times\ 3\times10^{8}}{633\times10^{-9}} = 3.14\times10^{-19}\ J$$

QUESTION 5

Number of photons = $\frac{0.5\times10^{-3}}{3.14\times10^{-19}} = 1.6\times10^{15}$ (per second)

(Consequential question)

QUESTION 6

Three of the following:

- Higher bandwidth
- Low signal attenuation
- Lightweight fibres
- Immune to electrical interference
- Higher security

QUESTION 7

$$\theta_C = \frac{n_{cladding}}{n_{core}} = \frac{1.50}{1.52};\ \theta_C = 81^o$$

QUESTION 8

$$NA = \sqrt{n_{core}^2 - n_{cladding}^2} = \sqrt{1.52^2} - 1.5^2 = 0.246$$

QUESTION 9

$$NA = n_{ext} \sin\theta_a$$
$$\sin\theta_a = 0.246$$
$$\theta_a = 14.2^o$$

QUESTION 10
It is a collection of many thousands of individual optical fibres fused into an array. The order of the fibres must be maintained as each fibre forms a single pixel and the array forms the image.

QUESTION 11
Medical endoscope, monitoring machines and structures.

DETAILED STUDY 3 - SOUND

QUESTION 1 200 Hz

QUESTION 2 1.7 m

QUESTION 3 Answer is A

QUESTION 4 1.25 x 10^{-8} W/m^2

QUESTION 5

Mary: 53 dB
John: 41 dB

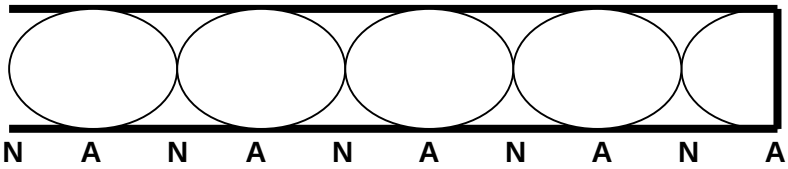
QUESTION 6 Answer is C

QUESTION 7 Answer is B

QUESTION 8 200 Hz

QUESTION 9

It has **one** open end (1 mark).



1 mark for correct number of nodes and antinodes.
1 mark for node at open end and antinode at closed end.

QUESTION 10

L = 2.25λ
f = 680 Hz
v = 340 m/s
λ = 340/680 = 0.5
L = 2.25 x 0.5 = **1.125m**

QUESTION 11

Maxine is correct. (1 mark).

The sound waves will diffract (bend) as they pass around a head (1 mark) and if the waves don't converge quickly, the ear further from the sound source may experience a "sound Shadow" of decreased intensity (1 mark).

This will be especially so for higher frequencies. Hence a person may detect that the ear experiencing the decrease in intensity is further from the source (1 mark). (Use Fig. 7 for a diagram).