THE SCHOOL FOR EXCELLENCE
UNIT 4 PHYSICS 2008
COMPLIMENTARY WRITTEN EXAMINATION 2

Errors and updates relating to this examination paper will be posted at www.tsfx.com.au/examupdates

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

QUESTION 1 Answer is E

QUESTION 2 Answer is E

(Note the field due to conductor Y is greater than the field from X)

QUESTION 3

$$velocity = \frac{540}{3.6} = 150\,ms^{-1}$$

$$emf = Blv = 6.0 \times 10^{-5} \times 25 \times 150 = 0.23V \qquad (0.225V)$$

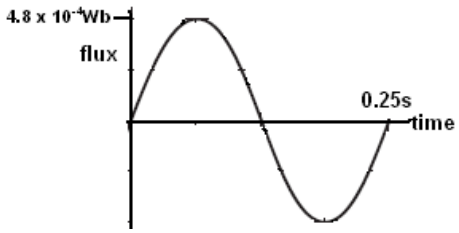
QUESTION 4

The right wing is positive.

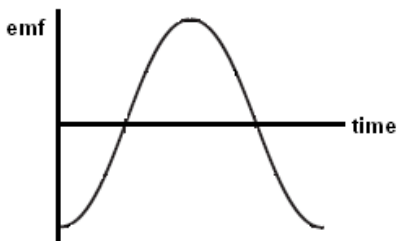
QUESTION 5

South pole COIL North pole

QUESTION 6



QUESTION 7



QUESTION 8

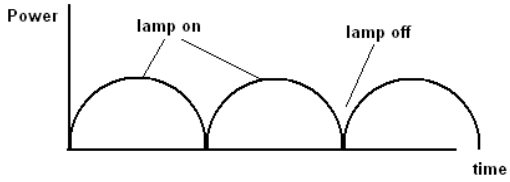
$$emf = \frac{n\Delta\phi}{t} = \frac{50 \times 0.2 \times 0.06 \times 0.04}{\frac{1}{16}} = 0.38V$$

QUESTION 9

X is positive.

QUESTION 10

The lamp turns on and off as the power supply oscillates.



QUESTION 11

There are two power peaks per cycle, and 4 cycles per second. Therefore the lamp flickers on 8 times per second (8 Hz).

QUESTION 12

$$V_{RMS} = \frac{V_{PEAK}}{\sqrt{2}} = \frac{4.8}{\sqrt{2}} = 3.4V$$

QUESTION 13

This is a step up transformer as indicated by the fact there are more secondary than primary coils.

QUESTION 14

$$\frac{n_p}{n_s} = \frac{V_p}{V_s}$$

$$\frac{200}{800} = \frac{24}{V_s}$$

$$V_s = 96V$$

QUESTION 15 Answer is B

In a real transformer some energy is lost as heat, therefore the output power must be less than the input.

QUESTION 16

The globe would barely glow at best. Iron is a magnetic metal whereas copper is not. Consequently the iron core enhances the strength of the electromagnet. It addition, the iron ring efficiently transfers the magnetic flux produced by the primary coils through the secondary (induction) coil. With the copper core, very little magnetic flux would pass through the secondary coil.

QUESTION 17

$P = V \times I = 1000 \times 100 = 1.0 \times 10^5 \ W$

QUESTION 18

$P_{LOSS} = I^2 R = 100^2 \times 2 = 2.0 \times 10^4 \ W$

QUESTION 19

$V_{DROP} = I_{LINE} \times R_{LINE} = 100 \times 2 = 200V$

$V_{FACTORY} = V_{SUPPLY} - V_{DROP} = 1000 - 200 = 800V$

QUESTION 20

Install a step up transformer at the wind generator and a step down transformer at the factory. This will reduce the line current and hence reduce the power loss.

$P_{LOSS} \propto I^2$

AREA OF STUDY 2 – INTERACTIONS OF LIGHT AND MATTER

QUESTION 1 Answer is D

LASER is the only light source that is both monochromatic and coherent.

QUESTION 2

$PD = n\lambda = 3 \times 580 \times 10^{-9} = 1.74 \times 10^{-6} m$

QUESTION 3 Answer is A, D

$\Delta x = \frac{\lambda L}{d}$, where d is the slit separation and x is the distance between maxima.

QUESTION 4 Answer is D

Both the metal of the electrode and the frequency of the light influence the stopping voltage. Therefore it is impossible to know if it is one or the other.

QUESTION 5

$$h = grad = \frac{rise}{run} = \frac{\Delta voltage}{\Delta frequency}$$

$$= \frac{V_1 - V_2}{\frac{c}{\lambda_1} - \frac{c}{\lambda_2}} = \frac{1.13 - 0.36}{\frac{3 \times 10^8}{384 \times 10^{-9}} - \frac{3 \times 10^8}{492 \times 10^{-9}}} = 4.5 \times 10^{-15} eVs$$

QUESTION 6

	Photons	**Electrons**
Wave	Young's double slit experiment	Orbiting atoms
Particle	Photoelectric effect	Gas discharge tube

QUESTION 7

$$p = \frac{h}{\lambda} = \frac{6.63\times10^{-34}}{4.90\times10^{-7}} = 1.35\times10^{-27}\,Ns$$

QUESTION 8

$$\lambda = \frac{h}{p} = \frac{6.63\times10^{-34}}{8.70\times10^{-27}} = 7.26\times10^{-11}\,m$$

QUESTION 9

$$E_k = \frac{1}{2}\frac{p^2}{m_e} = qV$$

$$V = \frac{1}{2}\frac{p^2}{m_e e} = \frac{1}{2}\frac{\left(8.7\times10^{-27}\right)^2}{9.1\times10^{-31}\times1.6\times10^{-19}} = 0.26\,V$$

QUESTION 10

Electrons.(1 mark). The de Broglie wavelength is much smaller than the object so no diffraction will occur(1 mark) and distort the image(1 mark).

QUESTION 11

6 spectral lines.

QUESTION 12

$$\lambda = \frac{hc}{E} = \frac{6.63\times10^{-34}\times3\times10^{8}}{10\times1.6\times10^{-19}} = 1.24\times10^{-7}\,m$$

DETAILED STUDY 1 – SYNCHROTRON AND ITS APPLICATIONS

QUESTION 1 Answer is C

$$E = \frac{V}{d} = \frac{100}{0.2} = 500V$$

QUESTION 2 Answer is B

$$E_K = qV = 1.6\times10^{-19}\times100 = 1.6\times10^{-17}\,J$$

QUESTION 3 Answer is A

The electrons need to spend the same amount of time in each tube. As the electrons are accelerating, they will travel furthering each subsequent tube over a set amount of time.

QUESTION 4 Answer is A

Booster ring comes before the storage ring.

QUESTION 5 Answer is D

$$r = \frac{mv}{qB} \Rightarrow r' = \frac{mv}{q(2B)} = \frac{1}{2}\frac{mv}{qB} = \frac{1}{2}r$$

QUESTION 6 Answer is C

Use Right Hand Rule, keep in mind that current is in the opposite direction to the electrons.

QUESTION 7 Answer is C

The radiation produced from a synchrotron undulator is brighter than the radiation from a bending magnet. All other options are not true.

QUESTION 8 Answer is C

$$sin\,\theta = \frac{n\lambda}{2d} = \frac{1\times0.105}{2\times0.350} = 0.15$$

$$\theta = sin^{-1}(0.15) = 8.6^o$$

QUESTION 9 Answer is B

$\sin\theta < 1,$

$$\frac{n\times0.105}{2\times0.350} < 1$$

$$n < 7$$

$$n = 6$$

QUESTION 10 Answer is B

The three peaks correspond to the 1,2,3 diffraction orders of a single atom spacing.

QUESTION 11 Answer is B

$2\theta = 25^o$

$\Rightarrow \theta = 12.5^o$

$$d = \frac{n\lambda}{2\sin\theta} = \frac{1\times 0.105}{2\sin(12.5)} = 0.25 = 0.3nm$$

QUESTION 12 Answer is D

Compton scattering is inelastic, both types of scattering occur between electrons and photons.

QUESTION 13 Answer is D

Diffuse scattering is caused by large temperatures.

DETAILED STUDY 2 - PHOTONICS

QUESTION 1 Answer is A

LEDs produce incoherent light.

QUESTION 2 Answer is C

$$\lambda = \frac{hc}{E_g} = \frac{4.14\times 10^{-15}\times 3.00\times 10^{8}}{2.24} = 554nm$$

QUESTION 3 Answer is A

Reduced energy gap produces photons of lower energy and lower frequency.

QUESTION 4 Answer is B

$$Frequency = \frac{1}{time} = \frac{1}{40\times 10^{-9}} = 25\,MHz$$

QUESTION 5 Answer is A

$$\frac{3.0\times 10^{8}}{1.5}\times 10^{-6} = 200\,m$$

QUESTION 6 Answer is C

$$E_{PHOTON} = \frac{hc}{\lambda} = \frac{6.63\times10^{-34}\times3\times10^{8}}{628\times10^{-9}} = 3.2\times10^{-19}\ J$$

$$Total\ Energy = P\times t = 1.0\times10^{-3}\times10^{-6} = 1.0\times10^{-9}\ J$$

Number of photons = $\frac{Total\ energy}{Photon\ energy} = \frac{1.0\times10^{-9}}{3.2\times10^{-19}} = 3.1\times10^{9}$

Spacing = $\frac{length\ of\ beam}{number\ of\ photons} = \frac{200}{3.1\times10^{9}} = 6.5\times10^{-8}\ m = 65nm$

QUESTION 7 Answer is B

Light of wavelength 1400nm has the lowest attenuation (signal loss)

QUESTION 8 Answer is B

Attenuation due to Rayleigh scattering is proportional to λ^{-4}, therefore attenuation increases as the wavelength decreases.

QUESTION 9 Answer is B

This reduces the critical angle which enables a greater range of angles to be totally internally reflected.

QUESTION 10 Answer is C

$$NA = n_{ext}\sin\theta_1 = \sqrt{n_{core}^2 - n_{cladding}^2} = \sqrt{1.48^2 - 1.46^2} = 0.244 = 14.03^o$$

QUESTION 11 Answer is B

Different wavelengths travel at different speeds in a given medium. Therefore, if a pulse is sent using a range of wavelengths, they will arrive at the end of the optical fibre at different times. This causes the pulse to spread out and limits transmission rates. The effect can be minimised by using a single or a narrow range of wavelengths.

QUESTION 12 Answer is A

$$\sin\theta_c = \frac{1.45}{1.50} = 0.933,\ \theta_c = 75^o\ ,\ angle\ illustrated = 90 - 75 = 15^o$$

QUESTION 13 Answer is A and D

The optical fibre relies on total internal reflection which requires the core to have the higher refractive index. As bending increases the incident angle increases beyond the critical angle resulting in some signal loss.

DETAILED STUDY 3 - SOUND

QUESTION 1 Answer is C

T = 0.005 s
λ = vT = 350 x 0.005 = 1.75 m

QUESTION 2 Answer is B

Speed is greater in water than in air, frequency is constant due to source; wavelength must be longer.

QUESTION 3 Answer is A

Doubling the intensity results in adding 3 DB to the sound level. Eight fans is three "doublings" of the intensity resulting in 9 dB more than the 12 dB for one fan.

QUESTION 4 Answer is D

John is 8 times the distance away. Subsequently the intensity is reduced by a factor of 64. 2×10^{-6} divided by 64 = 3.125×10^{-8}

QUESTION 5 Answer is A

The intensity (3.125×10^{-8}) converts to approximately 45 dB. Alternatively, the sound level at John must be 18 dB less than at Mary due to the intensity reduction factor of 64 which is six "halvings" and each halving results in 3 less dB.

QUESTION 6 Answer is C

The sound from the tuba has a lower frequency and longer wavelength and subsequently undergoes greater diffraction to be heard behind the building.

QUESTION 7 Answer is A

At a speed of 340 m/s the wavelength would be 5.3125 m. At any cooler temperature the speed would be less resulting in a decreased wavelength. The only option less than 5.3125 m is A.

QUESTION 8 Answer is B

Read directly from the graph; where the phone crosses the 30 dB line.

QUESTION 9 Answer is A

QUESTION 10 Answer is D

With the speed being constant the frequency is inversely proportional to the length of the pipe. If the fundamental frequency is on-quarter of that at the original length then the new length will be 4 times that of the original. 4 x 0.64 = 2.56 m

QUESTION 11 Answer is A

v = 2fL = 256 x 1.28 = 327.68 m/s

QUESTION 12 Answer is D

QUESTION 13 Answer is B