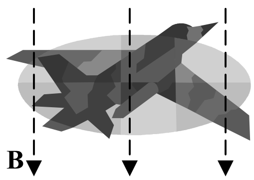
2006 Physics Trial Exam 2 Solutions

Area of study 1 – Electric power

Q1 The Earth's magnetic field at the North Pole is almost vertically downward.



The charges in the plane move forwards with the plane in the magnetic field. The positive charges experience a magnetic force to the left and the electrons to the right. Hence the right wing tip becomes negatively charged.

Q2 Always the right wing tip is negatively charged at the North Pole.

Q3 The compass north pole points in the same direction as the magnetic field line at the location of the compass, i.e. Q.

Q4 $F = nBIL = 20(0.50)(2.0)(0.10) = 2.0$ N.

Q5 The magnetic forces on the four sides of the loop all point inwards and tend to squash the loop.

Q6 $\phi = BA = 0.5(0.15 \times 0.10) = 7.5 \times 10^{-3}$ wb

Q7 The magnetic flux (to the right, seen from the front) decreases from its maximum value. To oppose the decrease the induced current must flow anticlockwise (viewed from the right) according to Lenz's law.

Q8 The magnetic flux (to the right, seen from the front) decreases from its maximum value. To oppose the decrease the induced current must flow anticlockwise (viewed from the right) according to Lenz's law.

Q9 $\Delta\phi = \phi_f - \phi_i = {}^{-}7.5 \times 10^{-3} - {}^{+}7.5 \times 10^{-3} = {}^{-}1.5 \times 10^{-2}$ wb.

Period $T = \dfrac{1}{f} = \dfrac{1}{2} = 0.50$ s, $\therefore \Delta t = \dfrac{0.50}{2} = 0.25$ s.

$$|\xi_{av}| = n\frac{|\Delta\phi|}{\Delta t} = 20 \times \frac{1.5 \times 10^{-2}}{0.25} = 1.2 \text{ v}$$

Q10 A, B. There are more turns in the secondary coil, $\therefore$ it is a step-up transformer. The core must be a ferromagnetic substance and copper is not.

Q11 $N_P = \dfrac{V_P}{V_S} \times N_S = \dfrac{48}{240} \times 400 = 80$.

Q12 $I = \dfrac{P}{V} = \dfrac{60}{48} = 1.25$ A.

Q13 Decreasing current flows from A to B in the primary coil generating a decreasing downward magnetic field inside the primary coil. Through the core this decreasing magnetic field gives rise to a decreasing upward magnetic flux in the secondary coil. A secondary coil current is induced and flows from Q to P according to Lenz's law. Hence Q is at higher potential.

Q14 C. Constant voltage at the primary coil does not give rise to changing magnetic flux in the secondary coil. Hence zero induced emf.

Q15 $V_{pp} = 17.0$, $V_p = 8.50$, $\therefore V_{rms} = \dfrac{V_p}{\sqrt{2}} = 6.01$ kv.

$\therefore I_{rms} = \dfrac{P}{V_{rms}} = \dfrac{250k}{6.01k} = 41.6$ A.

Q16 Voltage drop in the transmission line:
$V_{drop} = I_{rms}R = 41.6 \times 1.60 = 66.6$ v (rms)
$= 188$ v (pp) $= 0.188$ kv (pp).
Input voltage $= 17.0 - 0.188 = 16.8$ kv (pp).

Q17 Power lost in the transmission line:
$P_{loss} = I_{rms}^2 R = 41.6^2 \times 1.60 = 2.77 \times 10^3$ w $= 2.77$ kw.
Max. power delivered $= 250 - 2.77 = 247$ kw.

Q18 Number of hours per week $= 12 \times 7 = 84$.
Energy lost $= P_{loss} \times \Delta t = 2.77 \times 84 = 233$ kwh.
Cost $= 0.25 \times 233 = \$58.15$.

Area of study 2 – Interactions of light and matter

Q1 Mainly two bright bands appear on the screen directly opposite the slits. Possibly they overlap depending on the size and separation of the slits.

Q2 Each bright band is caused by the diffraction of the laser through the slit directly in front and opposite to the bright band. There is no interference pattern appeared on the screen because the two laser sources are incoherent, i.e. light emissions from the two sources are in random phase.

Q3 A beam of light of constant intensity directed at a surface has a constant number of photons hitting the surface per unit time. Thus a constant number of photoelectrons are produced in a unit time. Hence the current approaches a constant value with increasing accelerating voltage.

Q4 The number of photons per unit time hitting a surface is directly proportional to the intensity of the light used. A high intensity beam of light will have more photons hitting the surface, more photoelectrons emitted, and thus higher photoelectric current.

Q5 As the photons penetrate into the metal they lose energy in collisions with the particles of the metal before they are absorbed. Thus the photoelectrons emitted have a range of kinetic energy values even though photons of the same energy (i.e. the same frequency) are directed at the metal. Photoelectrons with low kinetic energy can be stopped by a low retarding voltage. As the retarding voltage increases more photoelectrons can be stopped and thus the photoelectric current decreases.

Q6 If the frequency of light is constant, the photon energy remains constant irrespective of intensity. The photoelectrons emitted have the same range of kinetic energy for different light intensities, $\therefore$ the same maximum kinetic energy. Hence the stopping voltage is the same for different light intensities.

Q7 Max $E_K = qV = 1\text{ e} \times 1.8\text{ v} = 1.8\text{ ev}$

or $= 1.6 \times 10^{-19}\text{ C} \times 1.8\text{ v} = 2.9 \times 10^{-19}\text{ J}$.

Q8 D.

Q9 X-rays: $\lambda = \dfrac{c}{f} = \dfrac{3.0 \times 10^{8}}{1.0 \times 10^{18}} = 3.0 \times 10^{-10}$ m.

To produce the same diffraction pattern, the de Broglie wavelength of electron must be the same:

$\lambda = \dfrac{h}{p}$,

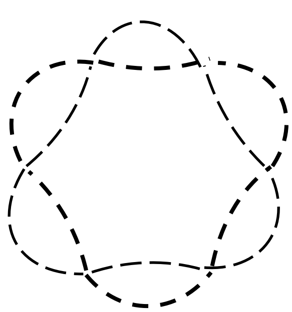
$$E_K = \frac{p^2}{2m} = \frac{1}{2m}\left(\frac{h}{\lambda}\right)^2 = \frac{1}{2(9.1 \times 10^{-31})}\left(\frac{6.63 \times 10^{-34}}{3.0 \times 10^{-10}}\right)^2$$

$= 2.7 \times 10^{-18}$ J.

Q10 Yes.

Since $\lambda = \dfrac{h}{p}$, particles with the same momentum have the same de Broglie wavelength, $\therefore$ same diffraction pattern.

Q11



Q12 Photon energy $E = 13.6 - 1.5 = 12.1$ ev.

$$\lambda = \frac{hc}{E} = \frac{(4.14 \times 10^{-15})(3.0 \times 10^{8})}{12.1} = 1.03 \times 10^{-7}\text{ m} = 103\text{ nm}.$$

Detailed study 3 − Sound

Q1 $\lambda = \dfrac{2}{3}$ of the length of the wire $= \dfrac{2}{3} \times 0.75 = 0.50$ m.

Q2 Speed $v = f\lambda = 150 \times 0.50 = 75\text{ ms}^{-1}$.

Q3 λ of sound wave in air $= \dfrac{v}{f} = \dfrac{333}{150} = 2.22$ m.

$L = n\left(\dfrac{\lambda}{2}\right) = 1.11$, 2.22 or 3.33 m for $n = 1$, 2 or 3. B, D or F.

Q4 Since the medium is the same,
$\therefore$ the speed is the same 75 ms^{-1}.

Q5 Distance of fighter jet from Q $= \sqrt{300^2 + 520^2} = 600$ m.
This distance is twice the distance of the jet from P, $\therefore$ the sound intensity at Q is $\dfrac{1}{4}$ of the sound intensity at P. $\therefore$ the sound level at Q is 6 dB lower than at P. $\therefore 102 - 6 = 96$ dB.

Q6 Sound intensity at P $= 10^{\frac{L}{10} - 12} = 10^{\frac{102}{10} - 12} = 0.0158\text{ wm}^{-2}$.
$P = I \times A = I \times 4\pi R^2 = 0.0158 \times 4\pi(300^2) = 17900\text{ w} = 17.9\text{ kw}$.

Q7 A: Velocity microphone. The air movement caused by sound waves moves the metallic ribbon in the magnetic field. Electromagnetic induction produces a varying emf (electrical signal) in the ribbon
B: Crystal microphone. Sound waves send the diaphragm into vibration. The two sides of the piezoelectric crystal become oppositely charged and a varying emf (signal) is produced when it is deflected by the vibrating diaphragm.

Q8 The frequency response range is not wide enough: The system does not respond well to very low and very high frequencies.
The system does not have a 'flat' enough frequency response: Some frequencies are much louder than others by as much as 20 dB. A good system gives just the right amount (usually within ± 3 dB) of each frequency.

Q9 Every loudspeaker has its own natural frequencies of vibrations. It resonates when driven by signals of matching frequencies. Thus some frequencies are louder than others.

Q10 $\Delta L = L_{2k} - L_{200} = 30 - 35 = -5$ dB.

$\therefore \dfrac{I_{2k}}{I_{200}} = 10^{\frac{\Delta L}{10}} = 10^{\frac{-5}{10}} = 0.32$.

Q11 Low frequency (long wavelength) sound diffracts to a greater extent than high frequency sound and $\therefore$ low frequency sound tends to reflect more from the corner walls to the listener.

Please inform physicsline@itute.com re conceptual, mathematical and/or typing errors