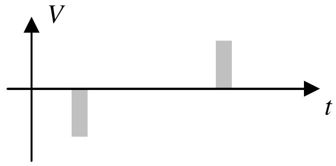
2011 Physics Trial Exam 2 Solutions

Area of study 1 – Electric power

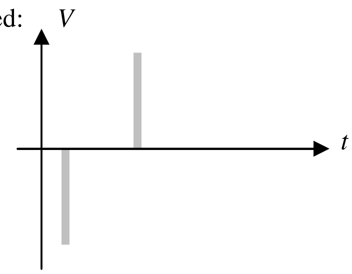
Q1 Magnetic flux increases as the bar magnet enters the gap. It remains constant while the magnet moves across the gap. It decreases as the magnet leaves the gap. .: A

Q2 $\xi = -\frac{\Delta\phi}{\Delta t}$.: B

Q3 Original speed:

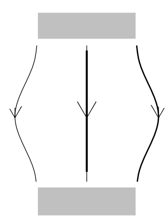


Twice the original speed:

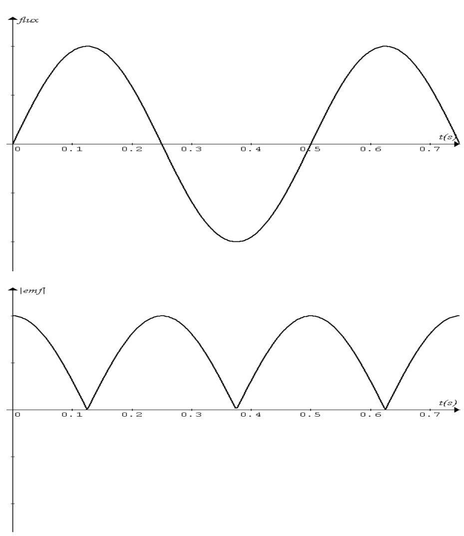


Q4 Work and thus a force is required to induce emf. .: B

Q5

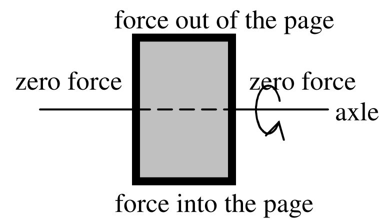


Q6 $T = \frac{1}{f} = \frac{1}{2} = 0.5$ s



Q7 $\left|\xi_{av}\right| = n\left|\frac{\Delta\phi}{\Delta t}\right| = 5\times 0.15 = 0.75$ V

Q8



Rotate anticlockwise about the axle (view from the right side).

Q9 $F = nBIL$

$0.0025 = 20\times B\times 0.25\times 0.010$, $B = 0.050$ tesla

Q10 A

Q11 When the switch changes from off to on, the downward magnetic flux through the secondary coil increases and a current is induced in the coil. According to Lenz's law, the induced current flows in the direction such that its magnetic field opposes the original increase in magnetic flux, i.e. from Y to X through the resistor. .: the potential at X is lower than 0 (negative).

When the switch changes from on to off, the downward magnetic flux through the secondary coil decreases and induces a current (in the coil) whose magnetic field opposes the original decrease in magnetic flux, i.e. from X to Y through the resistor. .: the potential at X is positive.

Q12 $I = \frac{P}{V} = \frac{20}{240} \approx 0.0833$ A, $V_{drop} = IR = 0.0833\times 1.5 \approx 0.13$ V

The voltage drop is too small to affect the florescent light.

Q13 $R_{heater} = \frac{V^2}{P} = \frac{240^2}{2500} = 23.04\,\Omega$,

$I = \frac{V}{R_{total}} = \frac{240}{1.5+23.04} \approx 9.78$ A

$V_{heater} = IR_{heater} \approx 9.78\times 23.04 \approx 225$ V rms

Q14 $P_{loss} = I^2R \approx 9.78^2\times 1.5 \approx 143$ W

$P_{supply} = VI = 240\times 9.78 \approx 2347$ W

Percentage loss $= \frac{143}{2347}\times 100\% \approx 6\%$

Q15 Require power loss to be 1% ($\frac{1}{100}$) of the original value.

Since $P_{loss} \propto I^2$, .: $I = \frac{I_o}{10}$ where I_o is the original current.

.: $\frac{N_s}{N_p} = \frac{I_p}{I_s} = \frac{I_o}{\frac{I_o}{10}} = 10$

Q16 $\frac{V_s}{V_p} = \frac{N_s}{N_p} = 10$, $V_s = 10 \times V_p = 10 \times 240 = 2400$ V rms

Q17 $V_{peak-peak} = 2400 \times 2\sqrt{2} \approx 6800$ V

Area of study 2 – Interactions of light and matter

Q1 D

Q2 B, D

Q3 The number of photons in the beam is constant for a particular light intensity. Thus the number of electrons emitted is also constant. At certain accelerating voltage or higher, the same number of photoelectrons move across the photocell. Hence the photocell current is constant.

Q4 Electrons in a metal require different amount of energy to get out of the metal. .: they escape with a range of kinetic energy. Higher retarding voltage will stop electrons with higher kinetic energy moving across the photocell. Hence the photocell current decreases with increasing retarding voltage.

Q5 Max. $E_k = qV_o = (1.6\times10^{-19})(0.75) = 1.2\times10^{-19}$ J

Q6 Max. $E_k = hf - w$, $0.75 = (4.14\times10^{-15})f - 2.28$

$f \approx 7.3\times10^{14}$ Hz

Q7 Electrons, like light, have a wave nature. C

Q8 Less diffraction results in a higher image resolution. C

Q9 Excitation of an atomic electron to a higher energy state in the atom can occur when a photon (light) interacts with an atom and the photon energy is not sufficient to knock the electron out altogether as in the photoelectric effect. In this process the photon also disappears (is absorbed), and all its energy is given to the atom, as oppose to a photon in the Compton effect transferring some momentum and energy to an atom.

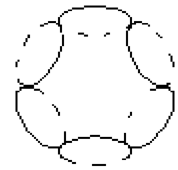
Q10 13.6 eV

Q11 Photon energy $= 13.6 - 0.85 = 12.75$ eV

$$\lambda = \frac{hc}{E} = \frac{(4.14\times10^{-15})(3.0\times10^{8})}{12.75} = 9.74\times10^{-8}\text{ m} = 97.4\text{ nm}$$

Q12 $p = \frac{E}{c} = \frac{12.75\times1.60\times10^{-19}}{3.0\times10^{8}} = 6.8\times10^{-27}$ kg ms^{-1}

Q13 According to de Broglie, a particle of mass *m* moving with speed *v* would have a wavelength of $\lambda = \frac{h}{mv}$. Each electron orbit in an atom is actually a circular standing wave and .: must consist a whole number of wavelengths. This explains the discrete energy levels in Bohr's model of a hydrogen atom.



Detailed study 3 – Sound

1	2	3	4	5	6	7	8	9	10	11	12
C	D	C	A	C	B	B	C	C	B	B	A

Q1 Sound wave in the air: $\lambda = \frac{v}{f} = \frac{336}{168} = 2.0$ m

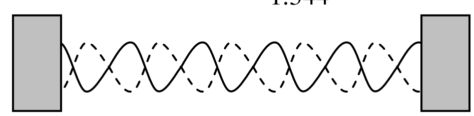
Vibration of the rod: $\lambda = 4\times0.50 = 2.0$ m C

Q2 Third harmonic: $f = 3\times168 = 504$ Hz D

Q3 $f = \frac{1}{T} = \frac{1}{4.0\times10^{-3}} = 250$ Hz C

Q4 $\lambda = vT = 336\times4.0\times10^{-3} = 1.344$ m A

Q5 Number of wavelengths $= \frac{6.72}{1.344} = 5$ C



Q6 $E = IA\Delta t = 0.050\times1.5\times15 = 1.125$ J B

Q7 $I \propto \frac{1}{r^2}$, .: $\frac{I_f}{I_i} = \frac{r_i^2}{r_f^2}$,

$I_f = \left(\frac{r_i}{r_f}\right)^2 I_i = \left(\frac{12}{8}\right)^2 \times 0.050 = 0.1125$ W m^{-2} B

Q8 When the distance is halved, $I = 4\times0.050 = 0.20$ W m^{-2}

$L = 10\times\log_{10}\frac{0.20}{10^{-12}} \approx 113$ dB C

Q9 $PS_2 - PS_1 = \frac{1}{2}\lambda = \frac{1}{2}\times\frac{v}{f} = \frac{1}{2}\times\frac{336}{1000} = 0.168$ m C

Q10 B

Q11 B

Q12 High frequency (short wavelength λ) sound is more directional because diffraction is proportional to the ratio $\frac{\lambda}{w}$ where *w* is the diameter of the loudspeaker. Using different-diameter loudspeakers will provide the same spread (diffraction) of sound waves of different frequency ranges. A

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

