2007 Physics Trial Exam 2 Solutions

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Area of study 1 – Electric power

Q1 The force on WX and the force on YZ are equal in magnitude but opposite in direction. The net force is zero. G

Q2 Doubling WX and doubling WZ do not affect the magnetic force on WX. Doubling B and doubling I will increase the magnetic force by a factor of $2 \times 2 = 4$. C

Q3 Period $T = 20\text{ ms} = 0.020\text{ s}$, $f = \frac{1}{T} = \frac{1}{0.020} = 50\text{ Hz}$

Q4 Perpendicular B

Q5 $\xi_{av} = -n\frac{\Delta\phi}{\Delta t} = -50 \times \frac{1.0\times10^{-4}}{5.0\times10^{-3}} = -1.0\text{ v}$

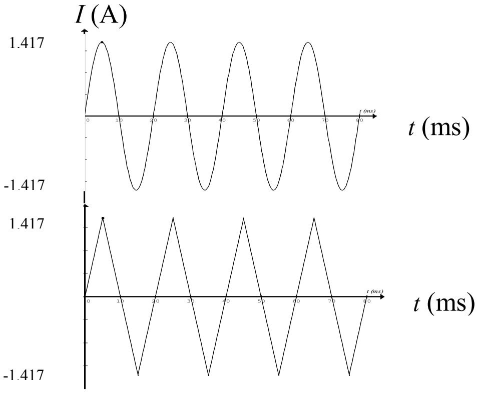
Q6 At $t = 5.0$ ms, the magnetic flux ϕ is at its peak and the induced emf is zero v.

Q7 The current is from Y to X through the light globe.

Q8 Just before that particular moment there is an increase in magnetic field (clockwise viewed in front of the page) in the soft iron core. This results in increasing magnetic flux through the windings around the soft iron core and gives rise to an induced current in the windings. Lenz's law states that the induced current flows in such a direction (from Y to X through the light globe) so that the magnetic field generated by the induced current opposes the increase in the magnetic field through the windings.

Q9 Just before that particular moment, the induced current flows from Y to X through the light globe and is decreasing. Just after that particular moment, the induced current flows from X to Y through the light globe and is increasing. At that particular moment, the induced current is zero.

Q10



Note: $I_p = \frac{V_p}{R} = \frac{17}{12} \approx 1.417$

Q11 $P_{av} = \frac{(V_{rms})^2}{R}$, $V_{rms} = \sqrt{P_{av}R} = \sqrt{8.0\times12} = 9.8$ volts

Q12 $\frac{N_S}{N_P} = \frac{V_S}{V_P} = \frac{12}{240} = 0.05$

Q13 $P = V_S I_S$, $I_S = \frac{P}{V_S} = \frac{25}{12}$ A

$\frac{I_P}{I_S} = \frac{V_S}{V_P}$, $I_P = \frac{V_S}{V_P}I_S = 0.05\times\frac{25}{12} = \frac{5}{48} \approx 0.10$ A

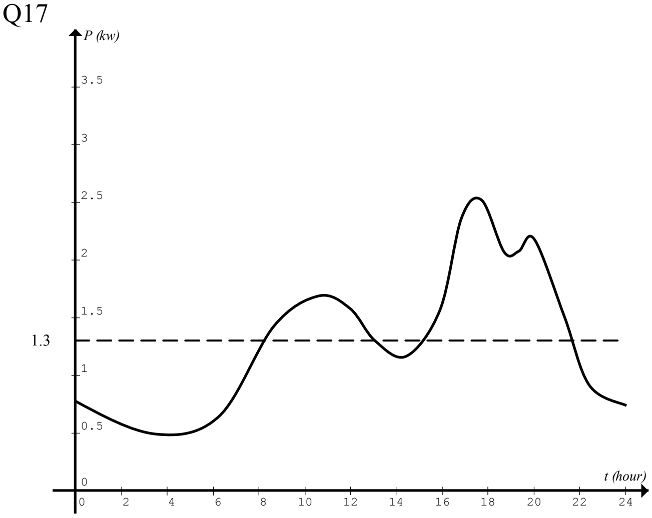
Q14 Each light globe draws $\frac{5}{48}$ A in the cord, n globes connected in parallel draw $\frac{5}{48}n$ A.

$\therefore \frac{5}{48}n \le 15$, $n \le 144$.

Q15 Voltage drop $V = IR = 15\times0.50 = 7.5$ v
Input voltage at primary $= 240 - 7.5 = 232.5$ v

Q16 Power delivered to light globe = output power of transformer = input power of transformer
$= V_P I_P = 232.5\times15 = 3490$ w

Q17



Estimated average power (dotted line) in the 24-hour period ≈ 1.3 kw
Energy usage in the 24-hour period
$= P\Delta t = 1.3\times24 = 31.2$ kwh
Cost $= 0.13\times31.2 = \$4.06$.

Area of study 2 – Interactions of light and matter

Q1 The atoms in the filament of an incandescent light globe are excited by heating. They releases their excess energy in the form of short wave trains of light. The light from the light globe is the sum of a great many such wave trains emitted in random phase to each other and therefore is incoherent.

Q2 A, C and D

Q3 P is the second dark band from the central bright band. It is caused by destructive interference of light waves from S_1 and S_2. Destructive interference occurs when the two sources are out of phase by half wavelength. This is possible when the path difference $PS_2 - PS_1 = n\left(\frac{\lambda}{2}\right)$ for odd n.

For the second dark band, $PS_2 - PS_1 = 3\left(\frac{\lambda}{2}\right) = 3\left(\frac{450}{2}\right) = 675$ nm

Q4 The bright and dark bands become wider and the pattern spreads out wider. The bright bands change from blue to red.

Q5 To ensure the light waves from S_1 and S_2 are coherent.

Q6 Sun light in the red region of its spectrum diffracts more than the other colours because the extent of diffraction depends on the ratio $\frac{\lambda}{w}$, where λ is the wavelength and w the size of the particles in the air. Therefore red light has a relatively higher penetrating ability through the smoke filled air whilst the other colours are scattered in all directions. Hence the sun appears red.

Q7 For no emission of photoelectrons,

photon energy < work function, i.e. $\frac{hc}{\lambda} < w$,

$\lambda > \frac{hc}{w} = \frac{(4.14\times10^{-15})(3.0\times10^{8})}{2.3}$, $\therefore \lambda > 540$ nm.

A and C

Q8 X-rays: $\lambda = \frac{c}{f} = \frac{3.0\times10^{8}}{1.0\times10^{18}} = 3.0\times10^{-10}$ m

To produce the same diffraction pattern, the electrons must have the same wavelength.

Electrons: $p = mv = \frac{h}{\lambda}$,

$v = \frac{h}{m\lambda} = \frac{6.63\times10^{-34}}{(9.1\times10^{-31})(3.0\times10^{-10})} = 2.4\times10^{6}$ ms^{-1}.

Q9 C

Q10 The range of energy of red light: from

$\frac{(4.14\times10^{-15})(3.0\times10^{8})}{750\times10^{-9}} = 1.66$ eV to

$\frac{(4.14\times10^{-15})(3.0\times10^{8})}{630\times10^{-9}} = 1.97$ eV.

Transition from n = 3 to n = 2, $E = 3.4 - 1.5 = 1.9$ eV. C

Q11 Louis de Broglie proposed that electrons have a wave nature. Each electron orbit in an atom is a circular standing wave that closes on itself. If the wavelength of a wave does not close on itself, destructive interference causes the wave to die out quickly. Thus, the only waves that persist are those for which the circumference of the orbit contains a whole number of wavelengths. De Broglie's idea gave an explanation for the quantised energy levels of hydrogen.

Detailed study 3 − Sound

Q1 $\lambda \approx 1.0$ m, $f = \frac{v}{\lambda} \approx \frac{340}{1.0} = 340$ m

Q2 To create a compression to the left of P, the particles at P must displace to the left. C

Q3 C

Q4 $\Delta L = 95 - 52 = 43$ dB, $\frac{I_P}{I_Q} = 10^{\frac{\Delta L}{10}} = 10^{\frac{43}{10}} = 2.0\times10^{4}$.

Q5 The sound source is not a point source. The sound source consists of two loudspeakers in phase and interference of the sound waves exists.

Q6 $\lambda = \frac{v}{f} = \frac{340}{580} = 0.5862$ m, X is $\frac{3}{4}\lambda$ from the wall,

distance $= \frac{3}{4}\lambda = \frac{3}{4}\times0.5862 = 0.44$ m.

Q7 B, C and D

Q8

Device	Operation
Electret-condenser microphone	E
Crystal microphone	E
Velocity microphone	EM
Dynamic microphone	EM
Dynamic loudspeaker	EM

Q9 When baffles and enclosure are removed, the sound from the back of the loudspeaker cone cancels the sound from the front of the cone because of destructive interference. The enclosure has a lower resonant frequency than that of the loudspeaker. This effectively lowers the low cutoff frequency and thus increases the frequency range of the system. The frequency range is smaller without the enclosure.

Q10

Sound	Loudness (phon)
X	100
Y	50
Z	25

Q11 Microphone C is the best because it responds equally well to all frequencies in the musical range.

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

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