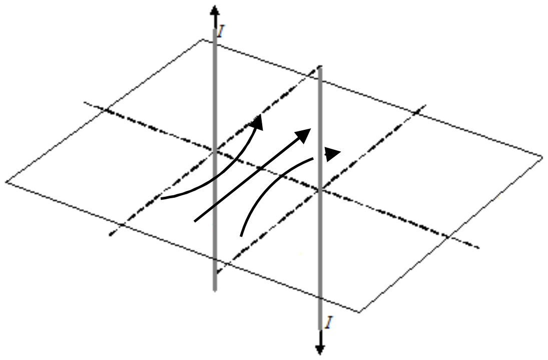
2012 Physics Trial Exam 2 Solutions

Area of study 1 – Electric power

Q1a



Q1b The magnetic field of conductor B is directed to the north at the location of conductor A, .: the magnetic force on conductor A is to the west. [D]

Q1c The magnetic field is zero midway between the two conductors. Magnetic force on A is to the east and the magnetic force on B to the west.

Q2a In one second the sliding conductor moves 0.50 m.
$\Delta\Phi = B\Delta A = 0.80(0.25\times 0.50) = 0.10$ wb

Q2b $|emf| = \frac{|\Delta\Phi|}{\Delta t} = \frac{0.10}{1.0} = 0.10\text{ V}$

Q2c $I = \frac{V}{R} = \frac{0.10}{5.0} = 0.020\text{ A} = 20\text{ mA}$
To oppose the increase in upward magnetic flux, the induced current in the sliding conductor produces a downward magnetic field inside the rectangular loop. The direction of the induced current must be to the south to achieve this.

Q2d The required force equals but opposes the magnetic force on the sliding conductor.
$F = BIL = 0.80\times 0.020\times 0.25 = 0.0040\text{ N}$

Q2e $P = VI = 0.10\times 0.020 = 0.0020\text{ W}$
OR $P = Fv = 0.0040\times 0.50 = 0.0020\text{ W}$

Q3a [B]

Q3b [A]

Q3c The amplitude increases whilst the period decreases.

Q4a The pair of magnetic forces on the upper and lower sections of the coil provides zero torque on the coil, .: the coil remains stationary.

Q4b Initially the pair of magnetic forces on the upper and lower sections of the coil provides a clockwise torque on the coil. It makes the coil to rotate clockwise with increasing speed. As the coil turns the torque decreases to zero and becomes an anticlockwise torque after a quarter of the turn. It slows the coil to a stop after making half of the turn and starts to reverse the direction. This is repeated every half turn causing the coil to oscillate.

Q5a *Total resistance of the copper wires (transmission cables)* $= 0.0060\times 100 = 0.60\ \Omega$
Voltage drop in the copper wires $= 0.60\times 4.0 = 2.4\text{ V}$
Voltage across the light globe $= 12 - 2.4 = 9.6\text{ V}$

Q5b *Power loss* $= I^2R = 4.0^2\times 0.60 = 9.6\text{ W}$

Q5c The power pack is initially set at constant 12 V dc. The working of a transformer is based on the principle that voltage is induced by changing magnetic flux. If the input voltage of the transformer is constant, the output voltage is zero. .: the light globe is off.
Switch the power pack to 12 V ac.

Q5d $V_{peak} = \sqrt{2}\times 12 \approx 17\text{ V}$

Q5e Step-up transformer: $\frac{I_p}{I_s} = \frac{N_s}{N_p}$, $\frac{I_p}{2.35} = \frac{200}{100}$, $I_p = 4.70\text{ A}$
Power output of power pack $= VI = 12\times 4.70 \approx 56.4\text{ W}$
Power loss in cables $= I^2R = 2.35^2\times 0.60 \approx 3.3\text{ W}$
Power dissipated in light globe $= 56.4 - 3.3 \approx 53\text{ W}$

Area of study 2 – Interactions of light and matter

Q1a The torch light is incoherent, .: there is no interference pattern formed. [C]

Q1b The two patches of light merge to form a single wider patch on the screen.

Q1c The laser beam is coherent enough to form an interference pattern on the screen. [B]

Q1d A diffraction pattern is formed on the screen. [D]

Q2a The minimum retarding voltage (in volts) required to stop the photoelectric current completely gives the maximum kinetic energy (in eV) of the photoelectrons.
.: *Planck's constant = gradient of the line*
$= \frac{4-0}{(17-7)\times 10^{14}} = 4\times 10^{-15}\text{ eV s}$

Q2b *Work function* $= hf_0 \approx 4\times 10^{-15}\times 7\times 10^{14} = 2.8\text{ eV}$

Q2c $\max E_k = hf - w \approx 4\times10^{-15}\times1.2\times10^{15} - 2.8 = 2\text{ eV}$

$2\times1.6\times10^{-19} = 3.2\times10^{-19}\text{ J}$

Q2d In a photoelectric effect experiment, photoelectrons will be emitted if the light directed at the metal is above certain frequency. This frequency is called the threshold frequency of the metal. Below the threshold frequency the photon energy is too low to cause the emission of electrons.

Q2e $\max E_k = hf - w = hf - hf_0$,

$qV = h(f - f_0) = 4\times10^{-15}\left(1.2\times10^{15} - 9.0\times10^{14}\right)$,

$V = 1.2\text{ V}$

Q2f A beam of monochromatic light consists of photons of the same energy given by $E = hf$ where *f* is the frequency of the light used. When the photons hit the target metal, some are absorbed and others are scattered (Compton scattering) by the free electrons in the metal before they are absorbed. If the absorbed photon energy is high enough, the emitted electrons (photoelectrons) will have a range of kinetic energy with $\max E_k = hf - w$, where *w* is the work function of the metal. For a particular metal, $\max E_k$ depends on the frequency *f* of the light and not on the intensity. .: the minimum retarding voltage required to stop the photocurrent completely only depends on *f*. Intensity of the light beam is related to the number of photons in the beam. It affects only the number of electrons emitted.

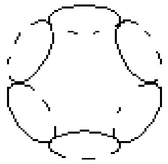
Q3a $E_k = qV = \left(1.6\times10^{-19}\right)(100) = 1.6\times10^{-17}\text{ J}$

$$\lambda = \frac{h}{\sqrt{2mE_k}} = \frac{6.63\times10^{-34}}{\sqrt{2\left(9.1\times10^{-31}\right)\left(1.6\times10^{-17}\right)}} \approx 1.2\times10^{-10}\text{ m}$$

Q3b $E = \dfrac{hc}{\lambda} = \dfrac{\left(6.63\times10^{-34}\right)\left(3.0\times10^{8}\right)}{1.2\times10^{-10}} \approx 1.7\times10^{-15}\text{ J}$

Q3c [C]

Q4a



Q4b *Photon energy* $= 13.6 - 1.5 = 12.1\text{ eV}$

$$\lambda = \frac{hc}{E} = \frac{\left(4.14\times10^{-15}\right)\left(3.0\times10^{8}\right)}{12.1} = 1.03\times10^{-7}\text{ m} = 103\text{ nm}$$

Q4c *Minimum photon energy required* $\approx 13.6\text{ eV}$

.: *minimum photon frequency*

$$f = \frac{E}{h} = \frac{13.6}{4.14\times10^{-15}} \approx 3.29\times10^{15}\text{ Hz}$$

Detailed study 3 – Sound

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

Q1 The lengths of longer pipes are 2 times and 3 times the length of the shortest pipe. When the shortest pipe resonates at the lowest frequency (fundamental frequency) the longer pipes will also resonate at the same frequency.

$f = \dfrac{v}{2L} = \dfrac{336}{2\times0.50} = 336\text{ Hz}$ [B]

Q2 [C]

Q3 [B]

Q4 $\lambda = 4\text{ m}$, $f = \dfrac{v}{\lambda} = \dfrac{336}{4} = 84\text{ Hz}$ [C]

Q5 $T = \dfrac{1}{f} = \dfrac{1}{84} \approx 0.012\text{ s}$ [B]

Q6 The wavelengths of standing waves that can be formed between the walls are 12 m, 6 m, 4 m, 3 m, etc. When the frequency is halved, the wavelength is 8 m and does not fit in between the walls. [D]

Q7 $I = 10^{\frac{L}{10}-12} = 10^{\frac{85}{10}-12} \approx 3\times10^{-4}$ [D]

Q8 30 m is about 4 times 8.0 m, .: the intensity at 30 m will drop to $\dfrac{1}{16}$ of the intensity at 8.0 m.

$\dfrac{1}{16} = \left(\dfrac{1}{2}\right)^4$, .: sound level will drop by about $4\times3 = 12\text{ dB}$

$85 - 12 = 73\text{ dB}$ [B]

Q9 When the intensity is doubled, the sound level increases by 3 dB. $85 + 3 = 88\text{ dB}$ [A]

Q10 $\lambda = \dfrac{v}{f} = \dfrac{336}{800} = 0.42\text{ m}$

Between the two loudspeakers the pressure nodes are

$\dfrac{\lambda}{2} = \dfrac{0.42}{2} = 0.21\text{ m}$

Number of $\dfrac{\lambda}{2}$ between the loudspeakers $= \dfrac{1.1}{0.21} \approx 5.2$, i.e. 5,

.: number of pressure nodal lines is 6. [B]

Q11 For the sound wave to diffract to the same extent the ratio $\dfrac{\lambda}{w}$ needs to be about the same for the 3 loudspeakers. Longer wavelength sounds (lower frequency) need longer diameter loudspeaker. [B]

Q12 Reflection from the walls. [B]

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