2015 Physics Trial Exam Solutions

SECTION A – Core studies

Area of study – Motion in one and two dimensions

Q1a $\text{Weight} = mg = 1.9\times10^{6}\times10 = 1.9\times10^{7}$ N

Q1b $\text{Speed} = \dfrac{\text{distance}}{\text{time taken}} = \dfrac{2\pi\times60}{30\times60} \approx 0.21\ \text{m s}^{-1}$

Q1c $\text{Net force} = ma = m\dfrac{v^2}{r} = 65\times\dfrac{0.21^2}{60} \approx 0.45$ N

Q1d $^{-}1.3\times10^{4}\times10 + \vec{R} = 1.3\times10^{4}\times\dfrac{^{-}0.21^2}{60}$

.: the reaction force $\vec{R} \approx {}^{+}1.3\times10^{5}$ N , 1.3×10^{5} N upwards

Q1e $^{-}1.3\times10^{4}\times10 + \vec{R} = 1.3\times10^{4}\times\dfrac{^{+}0.21^2}{60}$

.: the reaction force $\vec{R} \approx {}^{+}1.3\times10^{5}$ N , 1.3×10^{5} N upwards

Q2a Force = 66 N

Q2b Area under the F-x graph ≈ 34 J

Q2c $\dfrac{1}{2}\times1.0\times v^2 \approx 34$, $v \approx 8.2\ \text{m s}^{-1}$

Q2d $1.0\times a = 5.0$, $a = 5.0\ \text{m s}^{-2}$

Q2e To the north $v = 8.0\ \text{m s}^{-1}$

To the east $v = u + at = 0 + 5.0\times5.0 = 25\ \text{m s}^{-1}$

$\tan\theta = \dfrac{25}{8}$, $\theta \approx 72°$, direction of motion is N72°E

Q2f

$\text{Displacement to the east} = ut + \dfrac{1}{2}at^2 = 0 + \dfrac{1}{2}\times5.0\times5.0^2 = 62.5$ m

ΔE_k = work done by the crosswind $= 5.0\times62.5 \approx 310$ J

Q3a $a = \dfrac{v^2 - u^2}{2s} = \dfrac{2.5^2 - 0}{2\times5.0} = 0.625 \approx 0.63\ \text{m s}^{-2}$

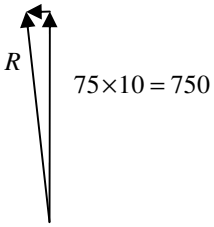
Q3b Driving force $= ma \approx 4\times3000\times0.625 = 7.5\times10^{3}$ N

Q3c Force of friction = driving force $= 7.5\times10^{3}$ N

Q3d Tension $= ma = 3000\times0.625 \approx 1.9\times10^{3}$ N

Q3e

$75\times0.625 = 46.875$



$R = \sqrt{750^2 + 47^2} \approx 751$ N

Q3f

$\text{Average power} = \dfrac{\Delta E}{\Delta t} = \dfrac{\frac{1}{2}mv^2}{\Delta t}$

$= \dfrac{\frac{1}{2}\times12000\times2.5^2}{8.0} \approx 3.8\times10^{3}$ W or 3.8 kW

Q4a $\dfrac{(\text{orbital radius of Pluto around Sun})^3}{(\text{orbital radius of Earth around Sun})^3} = \dfrac{T_P{}^2}{T_E{}^2}$

$\dfrac{\text{orbital radius of Pluto around Sun}}{\text{orbital radius of Earth around Sun}} = \sqrt[3]{\dfrac{248^2}{1^2}} \approx 39.5$

Q4b $r \approx 39.5\times1.5\times10^{11} \approx 5.9\times10^{12}$ m

Q4c

$\dfrac{\text{the weight on Earth}}{\text{the weight on Pluto}} = \dfrac{\frac{GM_E}{r_E{}^2}}{\frac{GM_P}{r_P{}^2}} = \dfrac{M_E}{M_P}\left(\dfrac{r_P}{r_E}\right)^2 \approx \dfrac{455}{1}\left(\dfrac{2}{11}\right)^2 \approx 15$

Q5a $\Delta p = mv - mu = 75\times50 - 0 = 3750\ \text{kg m s}^{-1}$

Q5b Apparent weight = drag force = weight $= 75\times10 = 750$ N

Q5c $F_{\text{av.drag}}\Delta t = \Delta p$, $F_{\text{av.drag}} = \dfrac{\Delta p}{\Delta t} = \dfrac{3750}{25} = 150$ N

Area of study – Electronics and photonics

Q6a $I_1 = 3 \times 22.5 = 67.5 \text{ mA}$

Q6b Voltage across $R_1 = 9.0 \text{ V}$, $\therefore V_Y = 2.0 + 9.0 = 11.0 \text{ V}$

Q6c Total current from Y to X = 67.5 + 22.5 = 90.0 mA

$$R_{\text{effective}} = \frac{V}{I} = \frac{9.0}{90.0 \times 10^{-3}} = 100 \,\Omega$$

Q7a Circuit A: $R = \dfrac{9.0 - 2 \times 3.2}{20 \times 10^{-3}} = 130 \,\Omega$

Circuit B: $R = \dfrac{9.0 - 3.2}{40 \times 10^{-3}} = 145 \,\Omega$

Q7b Heat dissipated in the resistor in Circuit A

$= I^2R = \left(20 \times 10^{-3}\right)^2 \times 130 = 0.052 \text{ W}$

Heat dissipated in the resistor in Circuit B

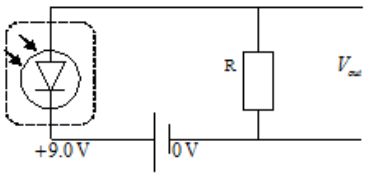
$= I^2R = \left(40 \times 10^{-3}\right)^2 \times 145 = 0.232 \text{ W}$

$\therefore$ A is more efficient than B

Q8a 0 V

Q8b $V = IR = 10 \times 10^{-6} \times 5 \times 10^{3} = 0.05 \text{ V}$

Q8c



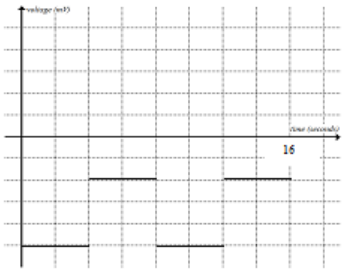
Q8d Voltage across the photodiode = 9.0 – 0.05 = 8.95 V

Q8e $I \times 5 \times 10^{3} = 10 \times 10^{-3}$, $I = 2 \times 10^{-6}$ A

$\therefore$ light intensity $< 0.2 \times 10^{3} = 200$ lux

Q8f $|\, gain \,| = \dfrac{1}{50 \times 10^{-3}} = 20$

Q8g



Area of study – Electric power

Q9a Magnetic south pole

Q9b $F = BIL = \left(4.0 \times 10^{-5}\right)(200)(12) = 0.096 \text{ N}$

Q9c D

Q10a $\left|V_{\text{AB}}\right| = n\left|\dfrac{\Delta\phi}{\Delta t}\right| = 20 \times \dfrac{1.50 \times 0.15^2}{1.5} = 0.45 \text{ V}$

Q10b $\left|V_{\text{AB}}\right| = 0.45 \text{ V}$ is constant from $t = 0$ to $t = 1.5 \text{ s}$

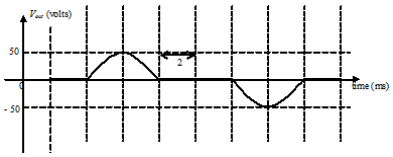
Q10c The induced current opposes the decreasing flux by producing its magnetic field into the page inside the coil. The direction of the induced current has to be clockwise (right-hand grip rule) to achieve this. $\therefore$ B is positive and A negative.

Q10d $P = \dfrac{V^2}{R} = \dfrac{0.45^2}{1.2} \approx 0.17 \text{ W}$

Q10e Magnetic flux (into the page) decreases when the coil rotates about the axis in either direction. The induced current flows in the clockwise direction according to Lenz's law.

Q10f Assuming the magnetic field is perfectly perpendicular to the plane of the coil, the magnetic force on each side of the coil acts in the plane of the coil and $\therefore$ has no torque about the axis of rotation. Hence there is no rotational motion of the coil.

Q11a



Q11b Changing input voltage at the primary coil causes changing magnetic field in the ferromagnetic rod and thus changing magnetic flux in the secondary coil. The output voltage in the secondary coil according to Faraday's law is given by induced emf $\xi = -n \times$ rate of change of ϕ.

Q12a House: $V_{\text{rms}} = \dfrac{340}{\sqrt{2}} \approx 240 \text{ V}$ Shed 2: 240 V

Q12b House: 240 V

Shed 2: $240 - 10.0 \times 1.0 - 5.0 \times 0.6 = 227 \text{ V}$

Q12c Total power loss $= 10.0^2 \times 1.0 + 5.0^2 \times 0.6 = 115 \text{ W}$

Q12d Shed 1: $V = 240 - 10.0 \times 1.0 = 230 \text{ V}$,

$P = VI = 230 \times 5.0 = 1150 \text{ W}$

Q13a (i) The same current in both wires. (ii) The current in the active wire is greater than that in the neutral wire.

Q13b When the current in the active wire is greater than that in the neutral wire, there is a net current through the centre of the ferromagnetic core. This change in the net current (from zero) causes a change in the magnetic field in the core and hence a change in the magnetic flux through the insulated coil. The induced current in the insulated coil triggers the disconnection of the active and neutral wires.

Area of study – Interactions of light and matter

Q14a $\text{Difference} = \frac{3}{2}\lambda = \frac{3}{2}\times 690\times 10^{-9} \approx 1.0\times 10^{-6}$ m

Q14b Spacing between bands is given by $\Delta x = \frac{L\lambda}{d}$. The bands will be closer together when blue light (shorter wavelength) is used.

Q14c An interference pattern will not be possible because the lights from the two slits are no longer coherent. Instead, two patches of light appear on the screen, one from each slit.

Q15a A photon is completely absorbed by an electron in the metal. The electron gains enough energy to 'escape' from the metal. This process is called the photoelectric effect. Sometimes some energy of the photon is transferred to the electron and the photon scatters off the electron with a longer wavelength. This is known as the Compton Effect.

Q15b

$$\text{Work function} = \frac{4.14\times 10^{-15}\times 3.0\times 10^{8}}{250\times 10^{-9}} - 2.7 \approx 2.3\,\text{eV}\ (2.268)$$

Q15c

$$\text{Threshold frequency } f = \frac{\text{work function}}{h} = \frac{2.268}{4.14\times 10^{-15}} \approx 5.48\times 10^{14}\ \text{Hz}$$

Q15d As the photons enter the metal they lose energy before they are absorbed due to the Compton Effect. Thus the electrons absorbing these lower energy photons will have a range of kinetic energy when they are emitted.

Q16a $\lambda = \frac{h}{p} = \frac{6.63\times 10^{-34}}{9.0\times 10^{-27}} \approx 7.4\times 10^{-8} = 74\,\text{nm}$

Q16b

$$\lambda = \frac{h}{\sqrt{2mE}} = \frac{6.63\times 10^{-34}}{\sqrt{2\times 9.1\times 10^{-31}\times 1.6\times 10^{-17}}} \approx 1.2\times 10^{-10} = 0.12\,\text{nm}$$

Q16c Since the extent of diffraction is proportional to wavelength, there will be less diffraction for the beam of electrons because of its shorter wavelength.

Q17a Atoms present in the photosphere of the Sun absorb certain frequencies of the sunlight passing through. These missing frequencies appear as dark lines in the visible spectrum of sunlight.

Q17b $E = \frac{hc}{\lambda} = \frac{4.14\times 10^{-15}\times 3.0\times 10^{8}}{656.28\times 10^{-9}} \approx 1.89\,\text{eV}$

This amount of energy corresponds to the transition of electron from level $n = 2$ to level $n = 3$ in a hydrogen atom.

SECTION B

Detailed study 3 – Sound

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

Q1 $f = \frac{1}{T} = \frac{1}{4\times 10^{-3}} = 250\,\text{Hz}$ C

Q2 $\lambda = \frac{v}{f} = \frac{340}{250} \approx 1.4\,\text{m}$ B

Q3 The speed of sound depends on the medium and its temperature. D

Q4 Assuming the graph shows maximum variation of the air pressure, the best choice is C. C

Q5 $\frac{I_B}{I_C} = 10^{\frac{\Delta L}{10}} = 10^{\frac{5.8}{10}} \approx 3.8$ B

Q6 Doubling the output of the source will double the intensities measured by Betty and Cathy, but the ratio $\frac{I_B}{I_C}$ remains the same. A

Q7 Both sound waves have the same wavelength, hence the same frequency. C

Q8 For open pipe the frequency of the first overtone is 2 times its fundamental frequency. For closed pipe the frequency of the first overtone is 3 times its fundamental frequency. B

Q9 C

Q10 B

Q11 Low frequency sound diffracts more, hits the walls and reflects from the walls to the person. The person receives the direct and reflected sounds. B

Q12 Type A responds to a narrow range. Type B responds to a wide range but not equally well. D

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

