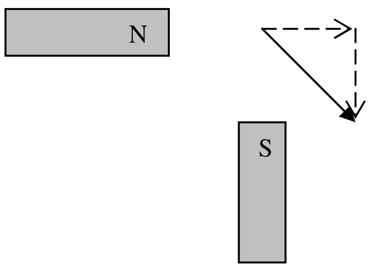
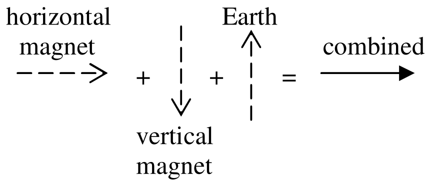
2011 VCAA Physics Exam 2 Solutions

Area of study 1 – Electric power

Q1

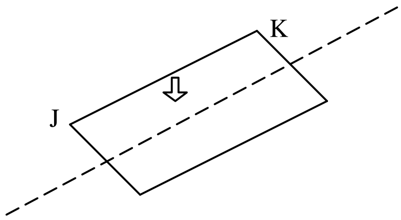


Q2



Q3 Reverses the current direction every half-turn, makes the torque on the rectangular loop to stay in the same direction every half-turn, so that the rectangular loop keeps on rotating in the same direction. The loop will oscillate without the commutator.

Q4



Q5 $F = nBIL = 50\times 0.30\times 6.0\times 0.050 = 4.5$ N

Q6 AC is changed to DC with the split-ring commutator. A

Q7 The polarity of each end of the coil will alternate between + and – every ½ turn without the commutator. The commutator ensures the same current flow direction every ½ turn and thus the same polarity at each end of the coil.

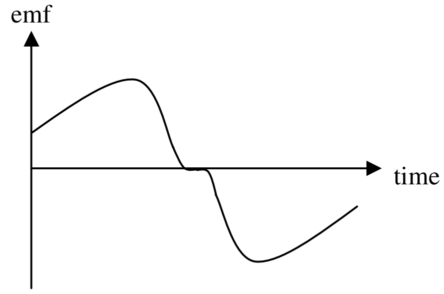
Q8 $\phi = BA\cos\theta = 2.0\times 0.020\times \cos 45° \approx 0.03$ Wb B

Q9 The sign of the average emf cannot be determined from the given information.

$$|\xi_{av}| = n\left|\frac{\Delta\phi}{\Delta t}\right| = 50\times\frac{2.0\times 0.020}{0.15} \approx 13 \text{ V}$$

Q10 As the magnet moves closer to the loop the magnet field through the loop increases, .: the magnetic flux to the left through the loop increases and thus induces an emf. As the magnet leaves the loop the magnetic flux to the left decreases and induces an emf.

Q11 The following sketch is an approximation without the knowledge of the size of the magnet and the loop.



Q12 The N-pole of the magnet is on the left. As the magnet moves away from the loop, the magnetic flux to the left decreases, Lenz's law says that the induced current in the loop must generate its own magnetic field to oppose the decrease, i.e. more magnetic field to the left, .: the induce current flows anticlockwise when viewed from the left.

Q13 $P = VI = 50000\times 15 = 750000$ W

Q14 For the same power lower voltage means higher current through the transmission lines. Since $power\ loss = I^2R$, .: higher current causes higher power loss in the lines.

Q15 $power\ loss = I^2R$, $9000 = 15^2R$, $R = 40\,\Omega$

Q16 $\frac{I_s}{I_p} = \frac{V_p}{V_s} = \frac{49400}{250} \approx 198$

Q17 $peak\ current = 30\sqrt{2} \approx 42.4$ A,

$F_{peak} = BI_{peak}L \approx 1.0\times 10^{-4}\times 42.4\times 1 = 4.24\times 10^{-3}$ N B

Q18 For A: $P = VI = 12\times 2 = 24$ W

For B: $P = VI = 12\times 3 = 36$ B

Area of study 2 – Interactions of light and matter

Q1 $S_2P - S_1P = \frac{3}{2}\lambda = \frac{3}{2}\times 560 = 840$ nm

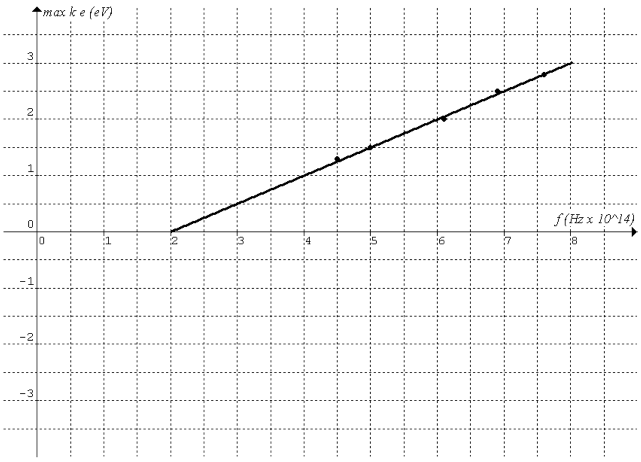
Q2 Increased spacing

Q3 Increased spacing

Q4 In Young's experiment an interference pattern was produced when light passed through the two slits. Interference is one of the properties of waves. This led to his conclusion about the wave-like nature of light.

Q5 The voltage used is a retarding voltage and it slows down the photoelectrons which have a range of kinetic energy. Those with the lowest kinetic energy will be first prevented from moving across the photocell and thus the ammeter reading drops. Eventually the voltage is high enough to stop all electrons to give zero ammeter reading.

Q6 The given stopping voltages equal to the maximum kinetic energies in eV numerically.



Q7 *Planck's constant* = *gradient* $= \frac{3}{6\times10^{14}} = 5\times10^{-15}$ eV s

Q8 *Threshold frequency* $= 2\times10^{14}$ Hz,

$\therefore$ *longest wavelength* $= \frac{c}{f} = \frac{3\times10^{8}}{2\times10^{14}} = 1.5\times10^{-6} = 1500\times10^{-9}$ m

$\therefore$ 1500 nm

Q9 Light has particle-like nature. The intensity of light is related to the number of particles (photons) in the beam of light, and the energy carried by each photon is related to the frequency of the light.

Q10 $E = \frac{hc}{\lambda} = \frac{(4.14\times10^{-15})(3.0\times10^{8})}{0.20\times10^{-9}} \approx 6210$ eV

Q11 Same pattern and spacing $\rightarrow$ same wavelength for the X-ray beam and the beam of electrons, 0.20 nm
$\therefore$ momentum of each electron:

$p = \frac{h}{\lambda} = \frac{6.63\times10^{-34}}{0.20\times10^{-9}} \approx 3.315\times10^{-24}$ kg ms^{-1}

$E_k = \frac{p^2}{2m} = \frac{(3.315\times10^{-24})^2}{2\times9.1\times10^{-31}} \approx 6.04\times10^{-18}$ J ≈ 38 eV

Q12 The electrons have wave-like nature and this nature is characterised by $\lambda = \frac{h}{p}$ which has the same value as the wavelength of the X-rays.

Q13 0.7, 1.9, 2.6, 10.2, 12.1, 12.8 eV

Detailed study 1 – Synchrotron and its applications

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

Q1 C

Q2 $eV = \frac{1}{2}mv^2$, $\therefore V = \frac{mv^2}{2e} = \frac{(9.1\times10^{-31})(2.65\times10^{7})^2}{2(1.6\times10^{-19})} = 2000$

Injector at Y must be positive to accelerate the electrons. A

Q3 $B = \frac{mv}{re} = \frac{(9.1\times10^{-31})(1.3\times10^{6})}{(0.35)(1.6\times10^{-19})} \approx 2.1\times10^{-5}$ B

Q4 The magnetic field does no work on the electrons. C

Q5 Rate of change of direction is acceleration. B

Q6 B

Q7 D

Q8 $E = \frac{hc}{\lambda} = \frac{(4.14\times10^{-15})(3.0\times10^{8})}{0.14\times10^{-9}} \approx 8900$ eV D

Q9 $d = \frac{n\lambda}{2\sin\theta} = 1\left(\frac{0.140\times10^{-9}}{2\sin15°}\right) \approx 0.27\times10^{-9}$ m B

Q10 $\sin\theta = \frac{n\lambda}{2d} = 2\left(\frac{0.140\times10^{-9}}{2\times0.27\times10^{-9}}\right)$, $\therefore\ \theta \approx 31°$

$\sin\theta = \frac{n\lambda}{2d} = 3\left(\frac{0.140\times10^{-9}}{2\times0.27\times10^{-9}}\right)$, $\therefore\ \theta \approx 51°$ C

Q11 $E = \frac{hc}{\lambda} = \frac{(4.14\times10^{-15})(3.0\times10^{8})}{0.081\times10^{-9}} \approx 15300$ eV

$E = \frac{hc}{\lambda} = \frac{(4.14\times10^{-15})(3.0\times10^{8})}{0.063\times10^{-9}} \approx 19700$ eV C

Q12 After undergoing Compton scattering, the X-ray beam loses energy.

Since $\lambda = \frac{hc}{E}$, lower energy $\rightarrow$ longer wavelength. D

Detailed study 2 – Photonics

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

Q1 C

Q2 C

Q3 $E = \frac{hc}{\lambda} = \frac{(4.14\times10^{-15})(3.0\times10^{8})}{620\times10^{-9}} \approx 2.0\ \text{eV}$ D

Q4 C

Q5 $V_{LED} = 2.2\ \text{V}$, .: $V_R = 3.0 - 2.2 = 0.8\ \text{V}$
.: $I = \frac{V}{R} = \frac{0.8}{100} = 0.008$ A, i.e. 8 mA C

Q6 Each LED in the series requires 2.2 V to operate but the supply voltage is only 3.0 V. Neither will operate. D

Q7 B

Q8 $\theta = \sin^{-1}\left(\frac{1.36}{1.42}\right) \approx 73°$

Q9 Snell's: $n_{air}\sin\theta_{air} = n_{core}\sin\theta_{core}$
$\sin\alpha = 1.48\sin(90° - 63°)$, $\sin\alpha = 1.48\sin 27°$, $\alpha \approx 42°$ D

Q10 B

Q11 B

Q12 $0.5^3 P = 2.0$, .: $P = 16\ \mu\text{W}$ C

Detailed study 3 – Sound

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

Q1 A

Q2 $L = 10\times\log_{10}\left(\frac{1.1\times10^{-4}}{10^{-12}}\right) \approx 80\ \text{dB}$ C

Q3 Point Y is at half of the distance of point X from the source, .: the sound intensity is 4 times that at X (inverse square law).
$I = 4\times1.1\times10^{-4} = 4.4\times10^{-4}\ \text{W m}^{-2}$ D

Q4 The sound at 3000 Hz and 40 dB is slightly above the 40 phon loudness curve. D

Q5 At 100 Hz on the 20 phon loudness curve, the sound level is about 50 dB. C

Q6 Open end is a pressure node. B

Q7 $\lambda = 4\times1.1 = 4.4$, $v = f\lambda = 90\times4.4 = 396\ \text{ms}^{-1}$ D

Q8 B

Q9 Option B (wide source) is more directional (i.e. less diffracted) than Option A. A

Q10 D

Q11 A

Q12 C

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

