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2009 Physics Trial Exam 2 Solutions

Area of study 1 – Electric power

Q1 Uniform inside the solenoid to the west.

Q2 $F = nBIL = 5\left(1.0\times10^{-2}\right)\left(1.2\right)\left(1.5\times10^{-2}\right) = 9.0\times10^{-4}$ N

Q3 F

Q4 Front view description: The cylindrical armature rotates anticlockwise at increasing speed. After turning 90° it starts to slow down. It comes to a stop momentarily after turning a further 90°. Immediately it starts to turn clockwise at increasing speed, slows down and comes to a stop momentarily at the original position. The whole process repeats itself if there are no air resistance and friction.

Q5 Replace the slip rings with a split-ring commutator. The split-ring commutator reverses the current direction every 180° turn so that the direction of the torque on the armature remains the same and the motor rotates in the same direction at increasing speed. For a practical motor, air resistance and friction limit the maximum speed of rotation.

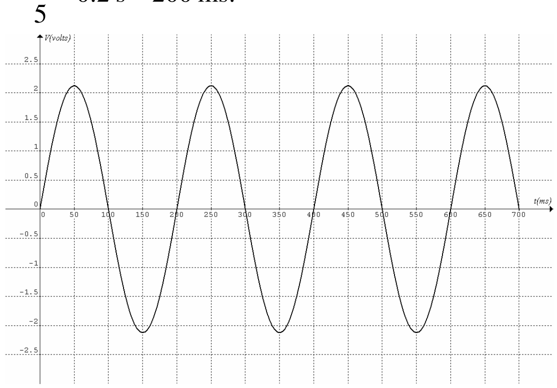
Q6 In all four cases the change in magnetic flux is zero and no current is induced in the rectangular loop. Hence there is no magnetic force on the loop and it falls under gravity only at constant acceleration.

Q7 $\left|\xi_{av}\right| = n\left|\frac{\Delta\phi}{\Delta t}\right|$, $0.80 = 100\left|\frac{\Delta\phi}{\Delta t}\right|$, $\left|\frac{\Delta\phi}{\Delta t}\right| = 0.0080$ Wb s^{-1}.

Q8 At that moment the flux (N to S) through the rectangular coil is at its maximum, and it starts to decrease irrespective of the direction of rotation. According to Lenz's law, the induced current in the coil flows from P to Q so that its magnetic field (N to S) opposes the original decrease in magnetic flux, i.e. makes up for the original decrease in magnetic flux.

Q9 $V_{rms} = 1.5$ V, $\therefore V_{peak} = 1.5\sqrt{2} = 2.1$ V. $f = 5$ Hz,

$T = \frac{1}{f} = \frac{1}{5} = 0.2\text{ s} = 200\text{ ms}$.



Q10 $P = \frac{V^2}{R} = \frac{1.5^2}{4.5} = 0.5$ W.

Q11 B

Q12 Input peak voltage $= \frac{1.8}{2} = 0.90$ V.

Output peak voltage $= \frac{50}{200}\times0.90 = 0.225$ V

RMS $V_{OUT} = \frac{0.225}{\sqrt{2}} \approx 0.16$ V.

Q13 $I = \frac{P}{V} = \frac{120\times10^3}{300} = 400$ A.

$P_{loss} = I^2R = 400^2\times0.40 = 64000 = 6.4\times10^4$ W.

Q14 $V_{drop} = IR = 400\times0.40 = 160$ V.

$V_{supply} = 300 - 160 = 140$ V.

Q15 Increase the voltage for transmission at the power station with a step-up transformer. This reduces the current and hence the power loss in the transmission cables. At the small town the voltage is reduced to 240 V with a step-down transformer.

Area of study 2 – Interactions of light and matter

Q1 To ensure the lights from S_1 and S_2 are coherent enough for interference pattern to form on the viewing screen.

Q2 Point P is on the third dark fringe from the central bright fringe.

$\therefore PS_1 - PS_2 = 2\frac{1}{2}\lambda = \frac{5}{2}\times\frac{c}{f} = \frac{5}{2}\times\frac{3.0\times10^8}{6.0\times10^{14}} = 1.3\times10^{-6}$ m.

Q3 C and D.

Q4 Wave theory predicts that both the number of photoelectrons and their maximum kinetic energy increase as the intensity of the light source increases.

Q5 For constant intensity, the maximum kinetic energy of the photoelectrons increases as the frequency increases, but the number of photoelectrons emitted remains the same.

Q6 Photon energy $E = \frac{hc}{\lambda} = \frac{\left(4.14\times10^{-15}\right)\left(3.0\times10^8\right)}{6.0\times10^{-7}} = 2.07$ eV.

This amount is less than the work function 2.28 eV. Hence no emission of electrons from the lithium surface.

Q7 B

Q8 Matching scattering patterns imply that the de Broglie wavelength of the electrons is the same as the X-ray wavelength, i.e. 0.13 nm.

Q9 $\lambda = \frac{h}{\sqrt{2mE}} = \frac{h}{\sqrt{2mqV}}$.

$\therefore V = \frac{h^2}{2mq\lambda^2} = \frac{\left(6.63\times10^{-34}\right)^2}{2\left(9.11\times10^{-31}\right)\left(1.60\times10^{-19}\right)\left(0.13\times10^{-9}\right)^2} = 89\text{ V}.$

Q10 The dark lines in the sun’s spectrum are due to absorption by atoms and molecules in the cooler outer atmosphere of the sun, as well as by atoms and molecules in the earth’s atmosphere.

Q11 $E = \frac{hc}{\lambda} = \frac{\left(6.63\times10^{-34}\right)\left(3.0\times10^{8}\right)}{480\times10^{-9}} \approx 4.1\text{ J}$

Q12 The dark lines indicate that atoms have discrete energy levels. The discrete amounts can be explained by considering electron as a standing wave. Only certain standing wave patterns around the nucleus (i.e. integral multiple of a wavelength) can be sustained, and each pattern corresponds to a particular amount of energy. When an electron (a standing wave) changes from its ground state pattern to a higher energy pattern, the atom absorbs an amount of energy that corresponds to a dark line in the sun’s spectrum.

Detailed study 3 – Sound

1	2	3	4	5	6	7	8	9	10	11	12	13
B	B	D	C	C	C	A	C	A	C	A	B	B

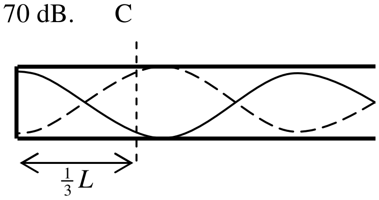
Q1 Read from graph, $\lambda = 2.0$ m. $\therefore T = \frac{\lambda}{v} = \frac{2.0}{338} \approx 5.9$ ms. B

Q2 A quarter of a period later, the pattern moves to the right by a quarter of a wavelength. B

Q3 All particles between $x = 3$ and $x = 4$ move away from the source (to the right) to create a rarefaction at $x = 3$ and a compression at $x = 4$. D

Q4 At 10 m away the sound intensity is a quarter of its original value, and the level drops by 6 dB to 75 dB. At 20 m away the sound intensity is a quarter of its value at 10 m, and the level drops by another 6 dB to 69 dB. Hence at 15 m the level is closest to 70 dB. C

Q5



C

Q6 $f = 5\left(\frac{v}{4L}\right)$, $845 = 5\left(\frac{338}{4L}\right)$, $L = 0.5$. C

Q7 A

Q8 C

Q9 A

Q10 C

Q11 If both loudspeakers have the same diameter w, the woofer (producing longer wavelength sounds) causes sound waves to diffract (spread out) more than the tweeter (producing shorter wavelength sounds) does because the extent of diffraction depends on the ratio $\frac{\lambda}{w}$. To ensure sound waves from both loudspeakers to diffract to the same extent, the diameter of the tweeter must be smaller than that of the woofer. A

Q12 Both X and Y have the same sound intensity level of 60 dB, but they are on different equal-loudness (phon) curves. B

Q13 X is on the equal-loudness curve that passes through 1000 Hz 40 dB. $\therefore$ the phon level of X is 40. B

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

