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2017 VCAA Physics Examination Solutions

SECTION A

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

11	12	13	14	15	16	17	18	19	20
B	C	B	D	A	B	D	D	A	A

Q2 $F = qE = (9.6\times10^{-19})(10^{4}) = 9.6\times10^{-15}$ N B

Q3 $V = Ed = (1000)(5.0\times10^{-3}) = 5.0\,\text{V}$ A

Q4 $\dfrac{N_{\text{primary}}}{N_{\text{secondary}}} = \dfrac{240}{12} = \dfrac{20}{1}$ D

Q5 $P_{\text{av}} = V_{\text{RMS}} I_{\text{RMS}}$, $I_{\text{RMS}} = \dfrac{P_{\text{av}}}{V_{\text{RMS}}} = \dfrac{48}{12} = 4$

$I_{\text{peak}} = 4\sqrt{2} \approx 5.7$ C

Q7 $a = \dfrac{F}{m} = \dfrac{4.0}{2.0} = 2.0\ \text{m s}^{-2}$ C

Q8 $\text{Impulse} = (4.0)(5.0) = 20\ \text{N s}$ C

Q9 $v = u + at = (2.0)(10) = 20\ \text{m s}^{-1}$ C

Q11 $m = \dfrac{E}{c^2} = \dfrac{3.8\times10^{26}}{(3.0\times10^{8})^2} \approx 4.2\times10^{9}\ \text{kg}$ B

Q12 $k = \dfrac{200}{0.50} = 400\ \text{N m}^{-1}$ C

Q13 $E_{\text{k}} = \dfrac{1}{2}(200)(0.50) = 50\ \text{J}$ B

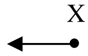
Q18 Bob's measurements should be recorded as 9.4 ± 0.3 mA, i.e. with 2 significant figures.
Jan's measurements are 9.28 ± 0.08 mA, i.e. with 3 significant figures.
.: Jan's are more accurate than Bob's.
Both sets are measured to the second decimal place,
.: they have the same precision. D

Q20 Random errors are caused by unknown and unpredictable changes in the experiment. Systematic errors usually come from the measuring instruments or wrongful use of the instruments by the experimenter.

A

SECTION B

Q1a



Q2a $F = \dfrac{(9.0\times10^{9})(1.6\times10^{-19})^2}{(53\times10^{-12})^2} \approx 8.2\times10^{-8}\ \text{N}$

Q2b $F = \dfrac{mv^2}{r}$

$.:\ v = \sqrt{\dfrac{Fr}{m}} = \sqrt{\dfrac{(8.2\times10^{-8})(53\times10^{-12})}{9.1\times10^{-31}}} \approx 2.2\times10^{6}\ \text{m s}^{-1}$

Q3a $F = nBIL = 10(0.50)\left(\dfrac{9.0}{6.0}\right)(0.12) = 0.90\,\text{N}$, direction D

Q3b Side KL is parallel to the uniform magnetic field.
$.:\ F = nBIL\sin\theta = nBIL\sin 0° = 0\,\text{N}$

Q4a $g = \dfrac{GM}{r^2} = \dfrac{(6.67\times10^{-11})(1.3\times10^{22})}{(1.2\times10^{6})^2} \approx 0.60\ \text{N kg}^{-1}$ (or m s^{-2})

Q4b $a = g$, $\dfrac{4\pi^2 r}{T^2} = \dfrac{GM}{r^2}$

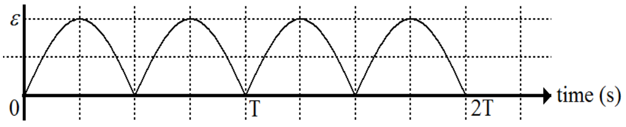
$T = 2\pi\sqrt{\dfrac{r^3}{GM}} = 2\pi\sqrt{\dfrac{(1.8\times10^{7})^3}{(6.67\times10^{-11})(1.3\times10^{22})}} \approx 5.2\times10^{5}\ \text{s}$

Q4c $a = g$, $\dfrac{v^2}{r} = \dfrac{GM}{r^2}$, the speed $v = \sqrt{\dfrac{GM}{r}}$ is independent of the mass of the spacecraft. Melissa is correct.

Q5a $B = \dfrac{\phi}{A} = \dfrac{0.20}{0.30\times0.40} \approx 1.7\,\text{T}$

Q5b $|\,\varepsilon_{\text{av}}| = n\left|\dfrac{\Delta\phi}{\Delta t}\right| = 10\times\dfrac{0.20}{\frac{1}{4}\times\frac{1}{4}} = 32\ \text{V}$

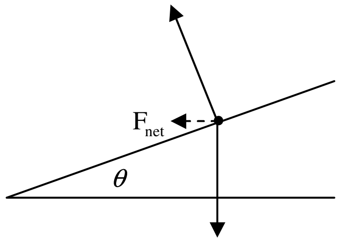
Q5c



Q6a $P_{\text{loss}} = I^2R = 200^2\times3.0 = 120\,000\ \text{W} = 120\,\text{kW}$

Q6b When the voltage is halved to 250 kV, the transmission line current will be doubled, .: power loss is 4 times that at 500 kV.

Q7a



Q7b $\frac{v^2}{r} = g\tan\theta$, $\theta = \tan^{-1}\left(\frac{v^2}{gr}\right) = \tan^{-1}\left(\frac{10^2}{9.8\times 20}\right) \approx 27°$

Q8a $\frac{v^2}{r} = g$, $v = \sqrt{gr} = \sqrt{9.8\times 6.4} \approx 7.9\ \text{m s}^{-1}$

Q8b $\frac{1}{2}mv_Q{}^2 = \frac{1}{2}mv_P{}^2 + mgh_P$, $\frac{1}{2}v_Q{}^2 = \frac{1}{2}\times 4.0^2 + 9.8\times 5.0$

$v_Q \approx 11\ \text{m s}^{-1}$

Q9a Time taken: $t = \frac{26}{20\cos 30°} \approx 1.501\,\text{s}$

Vertical displacement:

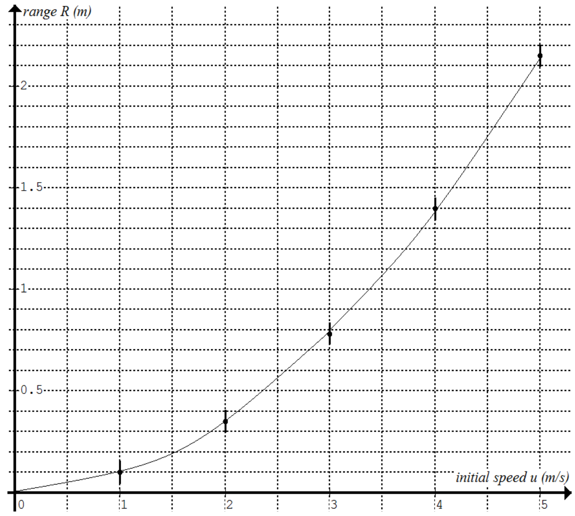
$s = ut + \frac{1}{2}at^2 \approx (20\sin 30°)(1.501) + \frac{1}{2}(-9.8)(1.501^2) \approx 4.0\ \text{m}$

.: height $\approx 4.0\,\text{m}$

Q9b

Classification	Variable
controlled	firing angle θ
dependent	range R
independent	firing speed u

Q9c



Q10 $\sqrt{1-\left(\frac{v}{c}\right)^2} = \frac{L}{L_0} = \frac{1}{3}$, .: $1-\left(\frac{v}{c}\right)^2 = \frac{1}{9}$, $\left(\frac{v}{c}\right)^2 = \frac{8}{9}$,

$v = \sqrt{\frac{8}{9}}\,c \approx 0.9428c$

Q11a $T = \frac{9.14\times 10^{-5}}{0.99875c} \approx 3.05\times 10^{-13}\ \text{s}$

Q11b $L = \frac{L_0}{\gamma} = \frac{9.14\times 10^{-5}}{20} = 4.57\times 10^{-6}\,\text{m}$

Q11c $T = \gamma T_0$, .: the lifetime of the fast moving particles will be dilated (longer) when observed by the stationary scientists, .: more particles will pass through the end of the range before they decay, .: the scientist would observe more particles at the end of the range.

Q12 Momentum conservation: $(4.0+2.0)v = 4.0\times 5.0 + 2.0\times 2.0$

.: $v = 4.0\ \text{m s}^{-1}$

Before: $E_k = \frac{1}{2}(4.0)(5.0^2) + \frac{1}{2}(2.0)(2.0^2) = 54\,\text{J}$

After: $E_k = \frac{1}{2}(6.0)(4.0^2) = 48\ \text{J}$

There is a loss of kinetic energy after the collision, .: the collision is inelastic.

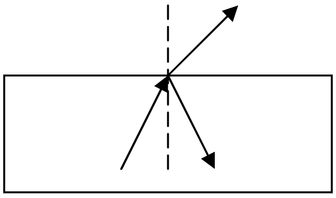
Q13a $\frac{1}{2}k(\Delta x)^2 = mg(\Delta x)$, $\Delta x = \frac{2mg}{k} = \frac{2(2.00)(9.8)}{20.0} = 1.96\ \text{m}$

Q13b

Assume zero gravitational potential energy at the lowest point.
The total energy remains the same during the fall from rest.
At the highest point, the gravitational potential energy only is the total energy. As the mass falls, its gravitational potential energy decreases whilst its kinetic energy and the elastic potential energy increase. After passing through the midpoint (in this case) of its fall, gravitational potential energy continues to decrease towards zero, kinetic energy starts to decrease towards zero, and elastic potential energy continues to increase to its maximum value (total energy), at the lowest point.

Q14a $\theta = \sin^{-1}\left(\frac{1.00}{1.44}\right) \approx 44.0°$

Q14b



Q14c The observer says she cannot see the laser because no laser is transmitted from the glucose into the air due to the total internal reflection of the laser.

Q15a $\lambda = \frac{v}{f} = \frac{340}{680} = 0.50\ \text{m}$

Q15b When both loudspeakers are connected in phase, interference of the sound waves from the two loudspeakers sets in forming a pattern of alternating loud and soft sound across the row of students. Elli is wrong to say the students will hear a similar sound and Sam is right. At the loud spots the amplitude of the wave is about double that with one loudspeaker, .: the intensity will be four times that with one loudspeaker, .: Elli is also wrong about the intensity of the sound.

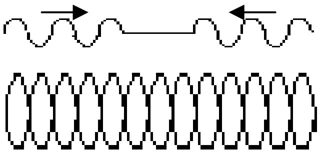
Q15c Student 2 hears loud sound because the path difference equals a wavelength approximately. Student 5 hears soft sound because the path difference equals a half of a wavelength approximately.
At the location of student 2, path difference

$= \sqrt{24^2 + 5.0^2} - \sqrt{24^2 + 1.0^2} \approx 0.49\,\text{m}$

Q16a $\lambda = 2\times 4.0 = 8.0$ m

Q16b $\lambda = 4.0$, $f = \frac{v}{\lambda} = \frac{240}{4.0} = 60$ Hz

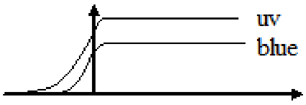
Q16c A standing wave on a string is a pattern of constructive and destructive interference of two travelling waves of the same frequency moving in opposite directions. Constructive interference occurs when the two waves arriving at certain spot in phase, resulting in an oscillation with greater amplitude. Destructive interference occurs when the two waves arriving at certain spot out of phase by a half of a cycle, resulting in an oscillation with diminished amplitude.



Q17a $E_{\text{K max}} = hf - hf_o$, $qV_o = hf - hf_o$,

$$V_o = \frac{(6.63\times10^{-34})(6.25\times10^{14} - 5.50\times10^{14})}{1.6\times10^{-19}} \approx 0.31\ \text{V}$$

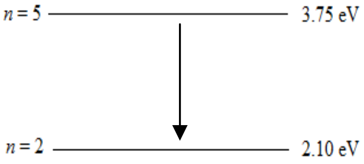
Q17b



Q17c There is a minimum light frequency for photoelectrons to be released for a particular metal receiving the light. The wave model suggests that the photoelectrons can be emitted at any light frequency. The emission of electrons only depends on the duration that the metal is exposed to the light and the light intensity.

There is a maximum value of the kinetic energy of the photoelectrons depending on the frequency of light used. It is not affected by the light intensity. The wave model suggests that the photoelectrons can be of any kinetic energy depending on the duration that the metal is exposed to the light and the light intensity.

Q18a



Q18b $\lambda = \frac{hc}{E} = \frac{(4.14\times10^{-15})(3.0\times10^{8})}{3.75} \approx 3.31\times10^{-7}\ \text{m} = 331\ \text{nm}$

Q18c An atom has quantised states means that an electron in the atom can only have discrete energy levels. The appearance of a spectral line is due to the emission of photons of the same energy $E = \frac{hc}{\lambda}$ when electrons transit from the same level to another same level. The difference in energy between the two levels corresponds to the energy of the spectral line. There is no energy difference of 2.5 eV among the quantised states of a sodium atom.

Q19 Current understanding of light and matter supports what Mary said. The current view suggests that matter has dual nature, i.e. under certain conditions it has particle behaviour, and under other conditions it behaves like a wave. In some situations it shows both behaviours at the same time. The diffraction pattern of the electrons demonstrates their wave nature.
Roger does not know the dual nature of matter. He was right in saying that light diffracts because of the wave nature of light.

The wave nature of matter was confirmed by the experiment performed by Davisson and Germer. They observed the formation of diffraction patterns when the surface of a piece of nickel was bombarded with electrons.

A few years before them, W. H. and W. L. Bragg (father and son) developed the theory and technique of X-ray diffraction by crystals, the basis for X-ray crystallography. This shows the wave nature of electromagnetic radiation, like light and X-rays.

Please inform mathline@itute.com re conceptual and/or mathematical errors.