2024 VCAA Physics Examination Solutions

SECTION A

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

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

Q4 Work = area under graph $= \frac{1}{2} \times 40 \times 0.10 = \frac{1}{2} \times 0.05 v^2$ **C**

Q9 $\frac{r_{new}^2}{r_{old}^2} = \frac{F_{old}}{F_{new}} = \frac{1}{6}$, $r_{new}^2 = \frac{1}{6} \times d^2$, $r_{new} = \frac{1}{\sqrt{6}} d \approx 0.41d$ **B**

Q10 Same constant rate of change in magnetic flux for the first and third sections, greater constant rate of change for the middle section. **C**

Q15 $\gamma = \frac{1}{\sqrt{1-\left(\frac{v}{c}\right)^2}}$.: $v = c\sqrt{1-\frac{1}{\gamma^2}}$, when γ increases from 200 to 2000, it has a very small effect on v. $E = \gamma m_0 c^2$, when γ increases from 200 to 2000, it has a very large effect on the electron's total energy E **B**

Q18 $\Delta x \propto \frac{L}{d}$ **D**

SECTION B

Q1a $a = \frac{F_{net}}{m} = \frac{(9.2-1.2-1.4)\times 10^4}{(5.0+6.0)\times 10^5} = 6.0\times 10^{-2}$ ms^{-1}

Q1b $T - 1.4\times 10^4 = 6.0\times 10^5 \times 6.0\times 10^{-2}$, $T = 5.0\times 10^4$ N

Q2a Centripetal force $= mg\tan 33° = \frac{mv^2}{1.2\times 10^3}$, $v \approx 87$ m s^{-1}

Q2b The normal force is perpendicular to the track surface. It can be resolved into vertical and horizontal components. The horizontal component points towards the centre of the circular motion. It is the centripetal force on the car.

Q2c $\frac{r^3}{T^2} = \frac{GM}{4\pi^2} = \text{constant}$. When r is smaller, T is shorter.

Q3a Vertically: $s = {}^{-}h$, $a = {}^{-}9.8$, $u = {}^{+}48\sin 35°$, $t = 6.2$

${}^{-}h = 48\sin 35° \times 6.2 + \frac{1}{2} \times {}^{-}9.8 \times 6.2^2$, $h = 18$ m

Q3b Horizontally: $s = {}^{+}x$, $u = {}^{+}48\cos 35°$, $t = 6.2$

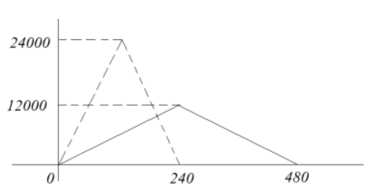
${}^{+}x = {}^{+}48\cos 35° \times 6.2$, $x \approx 2.4\times 10^2$ m

Q3c Air resistance is always opposite to motion $\vec{v}$. It opposes both vertical and horizontal components of $\vec{v}$. Thus it will reduce the altitude and the range of the golf ball.

Q4a Impulse = area under the graph

$= \frac{1}{2} \times 240 \times 10^{-3} \times 24000 = 2880$ Ns

Q4b



Q5a $\Delta\vec{p} = \vec{p}_f - \vec{p}_i = 0.63 \times \left({}^{+}10 - {}^{-}12\right) \approx {}^{+}14$, upwards 14 kg m s^{-1}

Q5b The collision is inelastic because the ball has a reduced speed immediately after collision. Hence its total energy at floor level just after collision is lower than that just before collision. The decrease in total energy changes to other forms of energy, e.g. heat and sound energy.

Q6a No, because force of gravity is far too weak.

$F_g = \frac{6.67\times 10^{-11} \times 4.50\times 10^5 \times 1.50\times 10^4}{500^2} \approx 1.8\times 10^{-6}$ N

Centripetal force required $= \frac{1.50\times 10^4 \times 0.436^2}{500} \approx 5.7$ N

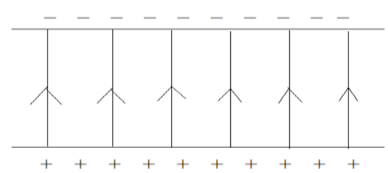
Q7a $\frac{mv^2}{r} = qvB$

$v = \frac{qBr}{m} = \frac{1.6\times 10^{-19} \times 5.00\times 10^{-3} \times 1.50\times 10^{-2}}{9.1\times 10^{-31}} \approx 1.32\times 10^7$ m s^{-1}

Q7b $qV_0 = \frac{1}{2}mv^2$, $V_0 = \frac{9.1\times 10^{-31} \times \left(1.32\times 10^7\right)^2}{2\times 1.6\times 10^{-19}} \approx 4.95\times 10^2$ V

Q7c The two particles have equal charge in magnitude, but $m_{proton} = 1.8\times 10^3 m_{electron}$.: a proton requires a much stronger magnetic field $\left(1.8\times 10^3 \times 5.00\,\text{mT}\right)$ to keep it in circular. A proton will travel straight ahead with little effect from the magnetic field.

Q8a



Q8b $E = \frac{V}{d} \approx \frac{1.20\times 10^9}{850} = 1.41\times 10^6$ V m^{-1}

Q8c Energy transferred

$= VIt = 1.20\times 10^9 \times 30.0\times 10^3 \times 60.0\times 10^{-6} \approx 2.16\times 10^9$ J

Q9a Side FG is parallel to the magnetic field, i.e. the single coil EFGH is horizontal as shown in the diagram provided.

Q9b Coil EFGH is vertical, i.e. side GH is directly above side EF. At this orientation the magnetic force on side GH is vertically down while the magnetic force on side EF is vertically up. The two forces are aligned resulting in zero torque of the coil.

Q9c Bring the two magnets closer together to provide a stronger magnetic field.

Q10a Slip rings provide contacts with the leads connected to the oscilloscope so that when the loop rotates the leads will not tangle around the rings.

Q10b $V_{peak-peak} \approx 8.0$ V, $f = \frac{1}{T} \approx \frac{1}{0.2} = 5$ Hz

Q10c By doubling the magnetic field using stronger magnets. By doubling the number of turns in the coil.

Q11a $\frac{N_s}{N_p} = \frac{V_s}{V_p}$, $N_s = \frac{V_s}{V_p} N_p = \frac{36}{230} \times 460 = 72$

Q11b $V_i I_i = V_o I_o$, $I_i = \frac{V_o}{V_i} I_o = \frac{36}{230} \times 0.80 \approx 0.13$ A

Q11c AC causes change in magnetic field and hence change in magnetic flux. The change in magnetic flux causes induced current in the secondary coil. Constant DC does not cause changing flux.

Q12a Maximum power output $= 5 \times 10 \times 600 = 30000$ W $= 30$ kW

Q12b Each string provides 10×20 V $= 200$ V .: $V_{max} = 200$ V,

$I_{max} = \frac{6000}{200} = 30$ A

Q12c The five strings are connected in parallel. $V_{max} = 200$ V

$I_{max} = 5 \times 30 = 150$ A

Q12d The inverter changes DC to AC for running appliances.

Q13a Time taken

$= \frac{\text{distance}}{\text{speed}} = \frac{9700 - 6500}{0.985 \times 3.0 \times 10^8} \approx 10.8 \times 10^{-6}\text{s} = 1.08\ \mu s$

Q13b No, because its life time is much shorter than the required travelling time.

Q13c $\gamma = \frac{1}{\sqrt{1 - \left(\frac{v}{c}\right)^2}} = \frac{1}{\sqrt{1 - 0.985^2}} \approx 5.80$

Q13d Mean half-life in the physicist frame of reference $= 2.20 \mu s \times 5.80 = 12.8 \mu s$

Q13e In the physicist frame of reference the mean half-life is dilated by a factor of 5.80 allowing muons enough time to reach the detector. In the muons frame of reference the distance from upper atmosphere to the detector is shortened due to length contraction allowing the muons to reach the detector during its life.

Q14a $E = mc^2 = 2 \times 9.1 \times 10^{-31} \times \left(3.0 \times 10^8\right)^2 \approx 1.64 \times 10^{-13}$ J

Q14b Before annihilation total momentum is approximately zero. After annihilation the total momentum of the two gamma ray photons must also be zero according to the law of conservation of momentum. The two gamma rays must travel in opposite directions to achieve this.

Q15a $p = \frac{\lambda}{h} = \frac{6.63 \times 10^{-34}}{2.00 \times 10^{-10}} \approx 3.32 \times 10^{-24}$ kg m s^{-1}

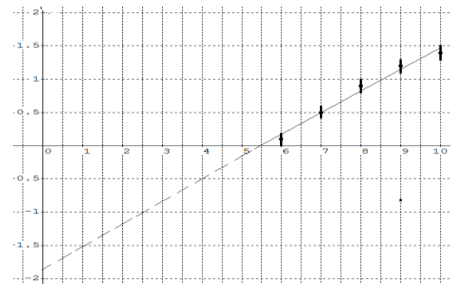
Q15b Max is correct because the de Broglie wavelength $\left(2.00 \times 10^{-10}\ \text{m}\right)$ is comparable to the inter-atomic spacing $\left(3.00 \times 10^{-10}\ \text{m}\right)$. Both have the same order of magnitude allowing the formation of a useful diffraction pattern.

Q15c Both X-ray and moving electrons exhibit wave behaviours. Their wavelengths are almost the same and the same material (the foil) is used for diffraction producing almost identical diffraction patterns.

Q15d $E = \frac{hc}{\lambda} = \frac{4.14 \times 10^{-15} \times 3.0 \times 10^8}{5.01 \times 10^{-11}} \approx 2.48$ eV

Q16a Controlled variable: metal plate
Dependent variable: stopping voltage
Independent variable: frequency of light (filter)

Q16b



Q16ci Use the points $\left(5.5 \times 10^{14}, 0\right)$ and $\left(10.0 \times 10^{14}, 1.5\right)$ to find the gradient which is h.

$h = \frac{1.5 - 0}{\left(10.0 - 5.5\right) \times 10^{14}} \approx 3.3 \times 10^{-15}$ eVs

Q16cii 5.5×10^{14} Hz

Q16ciii 1.8 eV

Q16d The photoelectrons have a range of kinetic energy depending on the frequency of light used. Higher frequency light produces higher kinetic energy photoelectrons.

Q16e The graph would have the same gradient but a different threshold frequency (or work function).

Q16f A blue filter produces photoelectrons with higher kinetic energy than a green filter produces. A higher voltage is required to reduce the photocurrent to zero .: P moves to the left.

Q16g With the same power output the number of blue light photons is less .: less photocurrent .: NM for blue is lower than NM for green.

Q16h Wave model predicts that any frequency of light can produce photoelectrons because light wave is continuous and the metal electrons can absorb the required amount of light energy for it to be emitted from the metal after a long enough exposure.

The particle model predicts that when a light particle (photon) hits an electron and is absorbed, the amount of energy (depending on frequency of the light) may/may not be enough for the electron to overcome the bonding energy keeping it within the metal. This explains the threshold frequency in the experimental data.

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