2023 VCAA Physics Examination Solutions

SECTION A

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

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

Q2 Force is directly proportional to Q and inversely proportional to the square of separation d. **C**

Q3 $g=\frac{GM}{R^2}$, $\frac{g}{2}=\frac{GM}{\left(\sqrt{2}R\right)^2}$ **C**

Q4 Estimated area $=$ average force $\times \Delta t \approx 100\times 0.05 = 5$ N s **B**

Q5 The globe turns on when there is a change in flux. **A**

Q6 $\phi = BA = 0.2\times\pi\times 0.05^2 \approx 0.0016$ Wb **A**

Q7 $V_{peak\ peak} = 20\times 6 = 120$ $f=\frac{1}{T}=\frac{1}{0.01\times 4}=25$ **D**

Q9 $\tan^{-1}\left(\frac{v^2}{gr}\right)=\tan^{-1}\left(\frac{11^2}{9.8\times 25}\right)\approx 26°$ **C**

Q10 $k=\frac{40\times 10^3}{8.0\times 10^{-3}}=5.0\times 10^6$ N m **D**

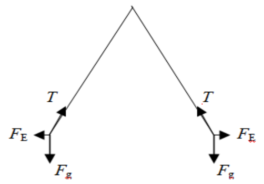
Q11 Area under the graph from 4.0 mm to 8.0 mm

$=\frac{1}{2}(20+40)\times 10^3\times 4\times 10^{-3}=120$ **B**

Q19 $f=\frac{c}{\lambda}=\frac{3.0\times 10^8}{650\times 10^{-9}}\approx 4.6\times 10^{14}$ Hz **B**

SECTION B

Q1a



Q1b $T\cos 30° = 0.004\times 9.8$, $T=4.5\times 10^{-2}$ N

Q1c $F_E = T\sin 30° \approx 2.3\times 10^{-2}$ N

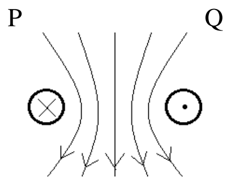
Q2a $\frac{g}{3.72}=\frac{\left(3390\times 10^3\right)^2}{\left(9390\times 10^3\right)^2}$, $g\approx 0.484854\approx 0.48$ N kg^{-1}

Q2b $g=\frac{GM}{r^2}$ and $\frac{r^3}{T^2}=\frac{GM}{4\pi^2}$

.: period $T=\sqrt{\frac{4\pi^2 r^3}{GM}}=2\pi\sqrt{\frac{r}{g}}\approx 2\pi\sqrt{\frac{9390\times 10^3}{0.48}}\approx 2.8\times 10^4$ s

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

Q3a



Q3b Refer to the diagram above the magnetic field on Q (current out of the page) is downward, which exerts a force on Q to the right. If P exerts a force on Q to the right, then Q exerts a force on P to the left according to Newton's third law .: they repel.

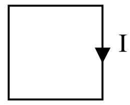
Q4a $\frac{N_p}{N_s}=\frac{V_p}{V_s}=\frac{240}{12}=20$

Q4b $P_p = P_s$, $240\times I_p = 20\times 6$ W .: $I_p = 0.5$ A

Q4c The working of a transformer is based on electromagnetic induction which requires a changing magnetic field produced by the primary coil. This can be achieved by an AC as the input current. A constant DC produces a constant magnetic field.

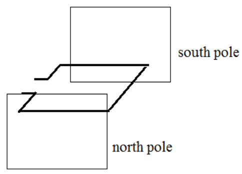
Q5a Average EMF $=\frac{\Delta\phi}{\Delta t}=\frac{0.30\times 0.040^2}{0.50}=9.6\times 10^{-4}$ V

Q5b



Q6a Assuming the magnetic field is uniform in the region between the north pole and the south pole, and it is parallel to the axle of the loop, the magnetic flux through the loop is constant at zero. There is no change in the magnetic flux while the loop is rotating. Therefore the rotation will not generate an EMF.

Q6b



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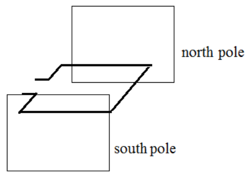


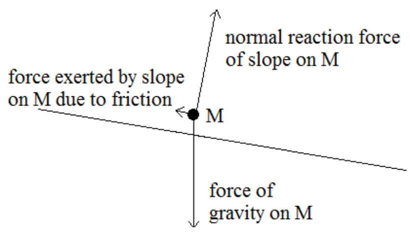
Q7a $P_{loss}=I^2R$, $20\times 10^6 = 700^2 R$, $R\approx 41\ \Omega$

Q7b No. $V_{drop}=700\times 41 = 28700$ V

.: voltage available $500\times 10^3 - 28700 = 471.3\times 10^3 < 480\times 10^3$ V

Q7c Lower transmission voltage $\rightarrow$ higher transmission line current for the same power at A $\rightarrow$ higher voltage drop in the transmission lines $\rightarrow$ lower voltage at B

Q8a



Q8b $F_{friction} = 65\times 9.8\sin 5° \approx 56$ N

Q8c Consider as a collision between M and Earth. All the momentum of M is transferred to Earth. Most of the kinetic energy is also transferred to Earth, but some kinetic energy is transformed to sound and heat energy.

Q9a Time from A to B: $s=1.8$, $a=-9.8$, $v=0$

Use $s=vt-\frac{1}{2}at^2$.: $t\approx 0.6061$, total time $=2\times t\approx 1.2$ s itute.com

Q9b Speed at C $\approx \frac{\frac{1}{4}\times 2\pi \times 1.8}{0.6061} \approx 4.7$ m s^{-1}

Q9c Horizontally: $t = \frac{12}{24} = 0.50$ s

Vertically: $u = 0$, $a = -9.8$, $t = 0.50$, $s = ut + \frac{1}{2}at^2 \approx -1.225$ m

Over the net by $2\times 1.8 - 1.225 - 0.90 = 1.475 \approx 1.5$ m

Q10a $\frac{1}{\sqrt{1-\left(\frac{v}{c}\right)^2}} = 2.00$, $1-\left(\frac{v}{c}\right)^2 = 0.25$, $\frac{v}{c} = \sqrt{0.75}$, $v \approx 0.866c$

Q10b Contracted length $L = \frac{L_0}{\gamma} = \frac{4.80}{2.00} = 2.40$ km

Q10c

$E_K = (\gamma - 1)mc^2 = 1.00\times 1.67\times 10^{-27}\times \left(3.0\times 10^8\right)^2 \approx 1.5\times 10^{-10}$ J

Q11a $f = \frac{v}{\lambda} = \frac{393}{2\times 0.75} = 262$ Hz

Q11b Two travelling waves in opposite directions are generated when the string is plucked. Repeated reflections of the two waves at both fixed ends superpose on each other (interfere with each other) creating a standing wave.

Q12a $\theta_c = \sin^{-1}\left(\frac{1}{1.52}\right) \approx 41.1°$

Q12b Angle of incidence at side AC is $45° > \theta_c$

.: total internal reflection occurs

Q13a Path diff. $S_1P_2 - S_2P_2 = 2\lambda = 2\times 510\times 10^{-9} = 1.02\times 10^{-6}$ m

Q13b Band spacing $\Delta x \propto \lambda$, red laser has a longer wavelength

.: the spacing increases

Q13c When waves (examples: longitudinal sound waves or transverse surface water waves) cross each other, constructive and destructive superposition of the two waves occurs, thus forming a pattern called an interference pattern. Formation of interference pattern is a characteristic of coherent waves. The bright and dark bands in Young's double slit experiment form an interference pattern, indicating that light has wave-like nature. If light is considered having particle-like nature, two bright bands are expected to appear on the screen directly in front of the slits.

Q14a $\lambda = \frac{h}{mv} = \frac{6.63\times 10^{-34}}{1.67\times 10^{-27}\times v} = 3.02\times 10^{-10}$, $v \approx 1.31\times 10^3$ m s^{-1}

Q14b The de Broglie wavelength of the neutrons and the interatomic spacing have the same order of magnitude, thus the two are comparable and a diffraction pattern is expected.

Q14c Same de Broglie wavelength $\rightarrow$ same momentum. Since $m_e v_e = m_n v_n$.: electron speed is higher when its mass is smaller.

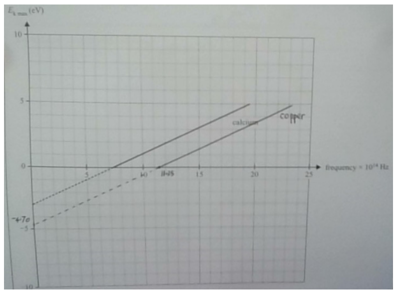
Q15a Read from graph, 3 eV

Q15b $\frac{hc}{\lambda} = \text{work function}$,

$\lambda = \frac{hc}{\text{work function}} \approx \frac{4.14\times 10^{-15}\times 3.0\times 10^8}{3} \approx 4.1\times 10^{-7}$ m

Q15c Threshold frequency

$= \frac{\text{work function}}{h} \approx \frac{4.70}{4.14\times 10^{-15}} \approx 11.35\times 10^{14}$ Hz



Q15d Photon frequency $\approx \frac{3.0\times 10^8}{380\times 10^{-9}} \approx 7.9\times 10^{14}$ Hz which is lower than the threshold frequency .: no ejected photoelectrons

Q16a $E = \frac{hc}{\lambda} = \frac{4.14\times 10^{-15}\times 3.0\times 10^8}{436.6\times 10^{-9}} \approx 2.84$ eV

Q16b The photon energy in part a corresponds to the transition of from $n = 4$ (7.73 eV) to $n = 2$ (4.89 eV).

Diagram is not shown here.

Q16c $n = 3$ (6.70 eV) to $n = 1$ (0 eV), photon energy = 6.7 eV

$n = 3$ (6.70 eV) to $n = 2$ (4.89 eV), photon energy = 1.8 eV

$n = 2$ (4.89 eV) to $n = 1$ (0 eV), photon energy = 4.9 eV

Q17a $v = \sqrt{2V_0 \frac{e}{m}}$

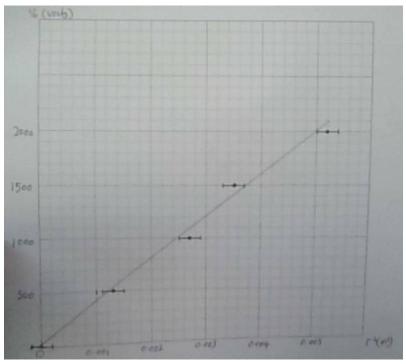
Q17b Magnetic force on the moving charge is perpendicular to the direction of its motion, i.e. its velocity vector. The effect is to cause the charge to change its direction (its acceleration is $\perp$ to its velocity, condition for circular motion) and move in a circular arc.

Q17c $\frac{mv^2}{r} = evB$ or $\frac{e}{m} = \frac{v}{rB}$

Q17d independent V_0, dependent r, controlled B

Q17e Missing values of r^2 are 0.0027, 0.0035, 0.0052

Q17f



Q17g Use points *on the line*: $\frac{2000-500}{0.0050-0.0012} \approx 3.95\times 10^5$ V m^{-2}

Q17 h $V_0 = \frac{eB^2}{2m}r^2$ where $\frac{eB^2}{2m} = 3.95\times 10^5$ and $B = 2$ mT

.: $\frac{e}{m} \approx 2\times 10^{11}$ C kg^{-1}

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