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2022 VCAA Physics Examination Solutions

SECTION A

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

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

Q2 $f=\frac{1}{T}=\frac{1}{0.04}=25\,\text{Hz}$ D

Q4 4 cm from Q is 8 cm from $4Q$, Let E be the electric field of Q .: electric field of $4Q$ is $\frac{4E}{2^2}=E$. D

Q6 $(10+m)\times 2.0=10\times 3.0$, $m=5$ B

Q8 $k=\frac{40}{0.08}=500$, $\frac{1}{2}\times 500\times x^2=0.9$, $x=0.06$ m B

Q12 $\sin 45°=\frac{1.33}{n_{glass}}$, lowest $n_{glass}\approx 1.88$ D

Q13 $v=\frac{\lambda}{T}=\frac{1.2}{1.6}=0.75\,\text{m s}^{-1}$ A

Q17 $f=\frac{E}{h}=\frac{1.33\times 10^6}{4.14\times 10^{-15}}\approx 3.21\times 10^{20}\,\text{Hz}$ B

Q19 $\gamma=\frac{1}{\sqrt{1-\left(\frac{2.99}{3.00}\right)^2}}\approx 12.3$ C

SECTION B

Q1a From K to L so that the magnetic force on side KL is upward resulting in a clockwise torque (front view) on the loop.

Q1b From L to K because the right split ring is in contact with +.

Q1c $F=I\ell B$, $0.15=0.5\times 0.10\times I$, $I=3.0$ A

Q2a The satellite orbit will have the same centre as Earth for required condition $\vec{a}=\vec{g}$. The satellite (with a period of 24 hours) will appear to be stationary relative to an observer on Earth.

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

$r=\sqrt[3]{\frac{GMT^2}{4\pi^2}}\approx\sqrt[3]{\frac{6.67\times 10^{-11}\times 5.98\times 10^{24}\times 86400^2}{4\pi^2}}\approx 4.225\times 10^7$

Altitude $\approx 4.225\times 10^7-6.37\times 10^6\approx 3.59\times 10^7$ m

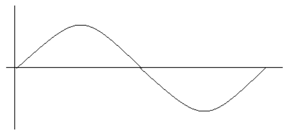
Q2c $v=\frac{2\pi r}{T}\approx\frac{2\pi\times 4.225\times 10^7}{86400}\approx 3.07\times 10^3\,\text{m s}^{-1}$

Q3a $\Delta E=qV\approx 1.6\times 10^{-19}\times 1500=2.4\times 10^{-16}$ J

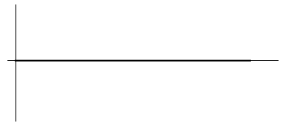
Q3b $\frac{1}{2}\times 4.80\times 10^{-27}\times v^2=2.4\times 10^{-16}$, $v\approx 3.16\times 10^5\,\text{m s}^{-1}$

Q3c $D=2r=\frac{2mv}{qB}\approx\frac{2\times 4.80\times 10^{-27}\times 3.16\times 10^5}{1.6\times 10^{-19}\times 0.10}\approx 0.19$ m

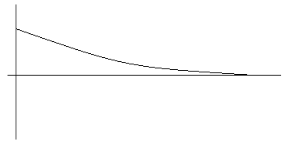
Q4a



A alternating



B no current



C clockwise

Q5a $P=VI=415\times 100=41500\text{ W}=41.5\,\text{kW}$

Q5b
$P_{\text{supplied}}=P_{output}-P_{loss}=41500-100^2\times 2.00=21500\text{ W}=21.5\,\text{kW}$
Will not be able to supply required power to the factory

Q5c Voltage output of step-up transformer $=415\times 10=4150$ V

Current at the output of transformer $=\frac{P}{V}=\frac{41500}{4150}=10$ A

$P_{\text{supplied}}=P_{output}-P_{loss}=41500-10^2\times 2.00=41300\text{ W}=41.3\,\text{kW}$

Q6a $\phi=BA$, $1.2\times 10^{-3}=B\times 0.060$, $B=0.020$ T

Q6b $T=\frac{1}{f}=\frac{1}{2.5}=0.40$ s, $\frac{1}{4}T=0.10$ s

$|\xi_{av}|=n\left|\frac{\Delta\phi}{\Delta t}\right|=200\times\left|\frac{0-1.2\times 10^{-3}}{0.1}\right|=2.4$ V

Q7ai $mg\sin\theta=2.0\times 9.8\times\sin 25°\approx 8.3$ N

Q7aii $a=\frac{F_{net}}{m}\approx\frac{8.3-F_f}{2.0}$, $F_f\approx 1.9$ N

Q7bi Conservation of momentum
$(2.0+2.0)\times v=2.0\times{}^{+}4.0+0$, $v={}^{+}2.0$, speed $=2.0\,\text{m s}^{-1}$

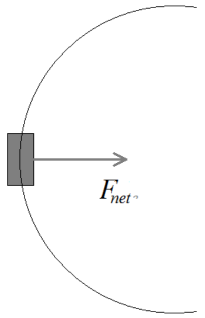
Q7bii Total kinetic energy after collision
$=\frac{1}{2}\times(2.0+2.0)\times 2.0^2=8.0$ J

Total kinetic energy before collision $=\frac{1}{2}\times 2.0\times 4.0^2=16$ J

Less kinetic energy after collision than before .: inelastic

Q8a $F_{net} = \frac{mv^2}{r} = \frac{800\times 40^2}{80} = 1.6\times 10^4\ \text{N}$

Q8b

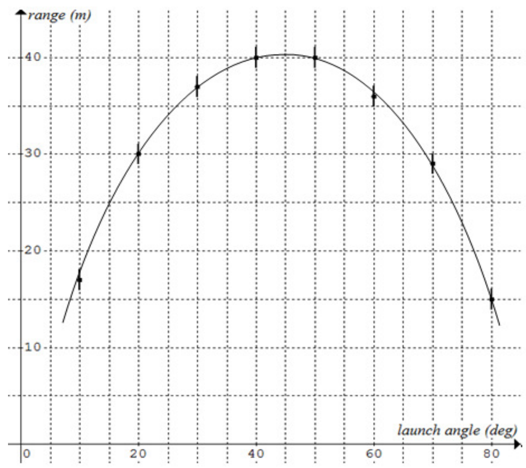


Q8c The net force (centripetal force in this case) is perpendicular to the direction of motion of the car, and it changes the direction of motion. The ground exerts this force on the car tyres due to friction between the ground and tyres.

Q9 Some mass of star changes to energy during nuclear reactions in the star. Its mass decreases by $\Delta m = \frac{E}{c^2}$ where E is the energy released.

Q10a Controlled variable: Mass of tennis ball
Dependent variable: Range R
Independent variable: Initial speed u or projection angle θ

Q10b



Q10c Maximum range $\approx 41\pm 1$ m at $\theta \approx 45°$ from graph

Q10di $R = \frac{25^2 \sin(2\times 30°)}{9.8} \approx 55\ \text{m}$

Q10dii The students were aware of air resistance. The data collected were for motion of the ball with air resistance. The difference between the maximum ranges obtained experimentally (41 m approx) and theoretically (55 m approx) was outside the margin of error/ ± 1 m, and it was too great to be ignored. It could only be explained by one of the effects of air resistance on the motion of the ball.

Q11 From the Earth observer's frame of reference, the half-lives of muons are dilated (lengthened, time dilation) whilst the distance between the muons and Earth's surface is the proper length.
From muons' frame of reference, the half-lives are proper times but the distance of the journey is shortened (length contraction).

Q12a The lasers at S_1 and S_2 are in phase. At C both lasers travelled the same distance (zero path difference), resulting in constructive interference (bright band). The dark band adjacent to the central bright band at C is caused by destructive interference of the lasers from the two slits due to the path difference being a half of the laser wavelength.

Q12b Waves (e.g. water waves, sound waves) interfere. Young's double-slit experiment demonstrates the interference of light like other physical waves and supports that light has a wave-like nature.

Q12c $\lambda = \frac{c}{f} = \frac{3.0\times 10^8}{6.00\times 10^{14}} = 5.0\times 10^{-7}\ \text{m}$

$\Delta x = \frac{\lambda L}{d} = \frac{5.0\times 10^{-7}\times 2.00}{0.10\times 10^{-3}} = 0.010\ \text{m}$

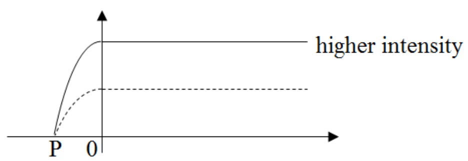
Q12d Since $v = f\lambda$, for constant frequency f, $\lambda \propto v$.
The refractive index of the liquid is higher .: the light speed is lower and thus the wavelength is shorter. Hence Δx is smaller.

Q13a Angle of incidence is $50.00°$
Snell's law: $1.335\sin\theta = 1.000\sin 50.00°$, $\theta \approx 35.017°$
$OX = 80.00\times \tan 35.017° \approx 56.05$ cm

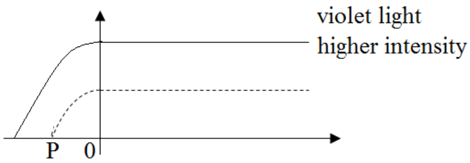
Q13b Violet end of the sunlight spectrum to the left of point X, green region of the spectrum at point X, and the red end of the spectrum to the right of point X.
Blue close to X left, green at X and orange close to X right

Q14a Stopping voltage, the minimum voltage required to completely stop the flow of electrons.

Q14b



Q14c



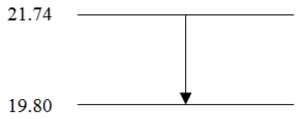
Q14d 3.4 eV

Q14e $h = \frac{3.4\times 1.6\times 10^{-19}}{8.1\times 10^{14}} \approx 6.7\times 10^{-34}\ \text{Js}$

Q14f The wave model cannot explain the existence of threshold frequency.

Q15a $\Delta E = \frac{hc}{\lambda} = \frac{4.14\times10^{-15}\times3.0\times10^{8}}{640\times10^{-9}} \approx 1.94\,\text{eV}$

Q15b



Q16a The wavelength of the light emitted by the sodium lamp must be comparable ($\geq$) to the width of each hole in the steel mesh for observable diffraction, i.e. $\lambda \geq w$.

Q16b $\lambda_{sodium} = 589\times10^{-9}$ m, $w_{window} \approx 1$.: $\lambda_{sodium} <<< w_{window}$
.: does not satisfy the condition stated in part a, thus no observable diffraction.

Q17a $E_k = \frac{1}{2}mv^2 = \frac{(mv)^2}{2m} = \frac{p^2}{2m}$.: $p = \sqrt{2mE_k}$

De Broglie $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mE_k}}$

$= \frac{6.63\times10^{-34}}{\sqrt{2\times9.1\times10^{-31}\times10.0\times10^{3}\times1.6\times10^{-19}}} \approx 1.23\times10^{-11}\,\text{m}$

$= 1.23\times10^{-2}\,\text{nm}$

Q17b From part a, $\lambda \propto \frac{1}{v}$ and $\lambda \propto \frac{1}{\sqrt{E_k}}$

When v is increased by a small amount, say 1%,

$\frac{\lambda_1}{\lambda_0} = \frac{v_0}{1.01v_0} \approx 0.99$.: $\lambda_1 \approx 0.99\lambda_0$, i.e. the de Broglie wavelength decreases by the same 1% approximately.

When E_k is increased by 1%, $\frac{\lambda_1}{\lambda_0} = \frac{\sqrt{E_k}}{\sqrt{1.01E_k}} \approx 0.995$

.: $\lambda_1 \approx 0.995\lambda_0$, i.e. the de Broglie wavelength decreases by 0.5% approximately.

For small increase in E_k de Broglie wavelength decreases by approximately half of the percentage increase in E_k .

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