2018 VCAA Physics Examination Solutions

SECTION A

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

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

Q1 $F = BIL = 4.0\times10^{-4}$ N **B**

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

Q4 $E = \frac{kq}{r^2} \approx 2.0\times10^3$ V m^{-1} **D**

Q5 $\sqrt{(200-180)^2 + (240-210)^2} \approx 36.1$ N **C**

Q6 $a = \frac{-20}{3.0-0.50} = -8.0$ m s^{-2} , $F = ma = -8000$ N **C**

Q7 Distance from the centre is $3R$, i.e. 3 times the original,
∴ $g = \frac{1}{3^2}\times 9.76 \approx 1.08$ N kg^{-1} **A**

Q8 Conservation of momentum $15v = 10\times6.0$, $v = 4.0$ m s^{-1} **C**

Q9 Total kinetic energy is less after collision than before. **B**

Q11 The sound will have increased amplitude (louder) as well.

Q14 $E_k = (\gamma-1)mc^2 > \frac{1}{2}mv^2$ **B**

Q18 We do not need to measure a quantity if its true value is already there. **A**

SECTION B

Q1a $E = \frac{10\text{ k}}{0.20} = 50\text{ k} = 50000$ V m^{-1}

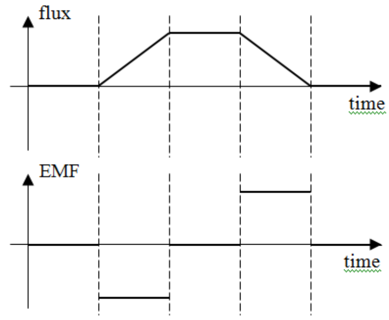
Q1b $E_K = qV = 1.6\times10^{-19}\times10000 = 1.6\times10^{-15}$ J

$\frac{1}{2}\times1.7\times10^{-27}v^2 = 1.6\times10^{-15}$, $v \approx 1.4\times10^6$ m s^{-1}

Q1c $r = \frac{mv}{qB} = \frac{(1.7\times10^{-27})(1.0\times10^6)}{(1.6\times10^{-19})(2.0\times10^{-2})} \approx 0.53$ m

Q2a $|\varepsilon_{av}| = n\left|\frac{\Delta\phi}{\Delta t}\right| = 10\times\frac{(2.0\times10^{-2})(1.6\times10^{-3})}{0.50} = 6.4\times10^{-4}$ V

Q2b

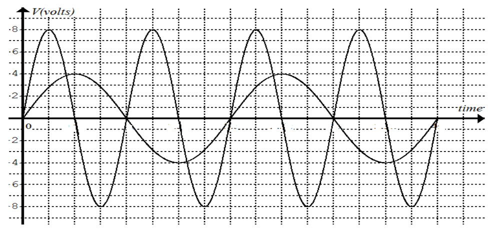


Q3a C (clockwise). Current flows from H to G, magnetic field direction is from left to right, magnetic force on HG is downward causing the coil to rotate clockwise.

Q3b Current always flows in the direction from H to G. The coil speeds up its clockwise rotation in the first ¼ turn. After the first ¼ turn the magnetic force on HG is still downward but the turning effect (torque) on the coil is anticlockwise. It slows down its clockwise rotation and the coil comes to a stop at the end of the second ¼ turn. The turning effect is still anticlockwise causing the coil to start rotating anticlockwise. Overall the coil oscillates every ½ turn if there is no friction.

Q4a $V_{\text{BATT}} = V_{\text{RMS}} = \frac{4}{\sqrt{2}} \approx 2.83$ V

Q4b



Q5a Current in light globe $= 3.0\times4 = 12$ A RMS
Power $= VI = 4.0\times12 = 48$ W

Q5b Voltage drop in the transmission lines
$= IR = 3.0\times8.0 = 24$ V RMS
Voltage of power supply $= 24 + 4.0 = 28$ V RMS

Q5c Power loss $= I^2R = 3.0^2\times8.0 = 72$ W

Q5d Current in light globe $= 12$ A RMS
Current in transmission lines $= \frac{12}{8} = 1.5$ A RMS

Power loss $= 1.5^2\times8.0 = 18$ W, i.e. $\frac{1}{4}$ of 72 W because the current in the transmission lines is halved.

Q5e High voltages for transmission reduce the transmission currents, ∴ (1) power losses and (2) voltage drops are reduced.

Q6a Conservation of energy: $\frac{1}{2}k\times 0.50^2 = 2.0\times 9.8\times 2.5$
$k = 392\text{ N m}^{-1}$

Q6b $a = 0\text{ m s}^{-2}$ when the net force is zero and the ball is at its maximum speed.

Q6c Net force is zero. $392x - 2.0\times 9.8 = 0$
compression $x = 0.05\text{ m}$

Q7a Horizontal distance $= 3.0\times 0.40 = 1.2$ m

Q7b Vertically: $s = \frac{1}{2}\times 10\times 0.40^2 = 0.80$, height $= 0.80$ m

Q7c Horizontally: 3.0, vertically: $at = 10\times 0.40 = 4.0$
Speed $= \sqrt{3.0^2 + 4.0^2} = 5.0\text{ m s}^{-1}$

Q8a $a = \frac{40}{5.0} = 8.0\text{ m s}^{-2}$, $F_{\text{on B by A}} = 1.0\times 8.0 = 8.0\text{ N}$

Q8b Newton's third law: $F_{\text{on A by B}} = -F_{\text{on B by A}}$, 8.0 N to the left

Q9a $F = mg = 1500\times 3 = 4500\text{ N}$

Q9b The average field strength ≈ 6.9
Change in potential energy
$=$ area under graph $\times$ mass $\approx 6.9\times 1.0\times 1500 \approx 1.04\times 10^4$ J

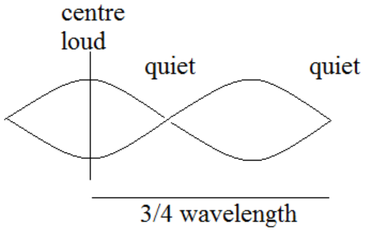
Q9c $\frac{4\pi^2 r}{T^2} = \frac{GM}{r^2}$, $T = 2\pi\sqrt{\frac{r^3}{GM}} \approx 3.06\times 10^5$ s

Q10a $\frac{v^2}{r} = g$, $r = \frac{v^2}{g} \approx 3.31\times 10^3$ m

Q10b Zero gravity experience means apparent weight is zero, i.e. zero reaction force on the passenger. This occurs when the passenger is in free fall, $a = g \approx 9.8\text{ m s}^{-2}$ at low altitude (8000 m).

Q11a $\lambda = \frac{v}{f} = 1.0$ m

Q11b Distance $= \frac{3}{4}\lambda \approx 0.75$ m



Q12a $f = \frac{c}{\lambda} \approx 5.31\times 10^{14}$ Hz

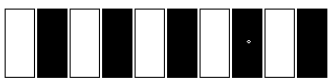
Q12b $\theta_c = \sin^{-1}\left(\frac{1.45}{1.67}\right) \approx 60.3°$

Q12c $v = \frac{c}{n_{\text{core}}} \approx \frac{3.0\times 10^8}{1.67} \approx 1.80\times 10^8\text{ m s}^{-1}$

Q13a Photon energy $= \frac{hc}{\lambda} \approx 3.261\times 10^{-19}$ J
Number of photons $\approx \frac{5.03\times 10^{-3}}{3.261\times 10^{-19}} \approx 1.54\times 10^{16}$

Q13b At point C there is zero difference between CS_1 and CS_2, constructive interference occurs at and around C.

Q13c $CS_1 - CS_2 = 2.14\times 10^{-6}\text{ m} = \frac{2.14\times 10^{-6}}{610\times 10^{-9}}\lambda \approx 3.5\lambda$
.: fourth dark band on the right of C.



Q14 No, the velocity may not be constant because the spaceship may not be travelling in a straight line, e.g. it is in circular motion.

Q15 $t = t_0\gamma$, $\gamma = \frac{t}{t_0} = 8$
$E_K = (\gamma - 1)mc^2 = (8-1)\times 10\,000\times (3.0\times 10^8)^2 \approx 6.3\times 10^{21}$ J

Q16 The observed time interval of 20 h is a dilated time interval.
$t_0 = \frac{t}{\gamma} = \frac{20}{1.41} \approx 14.2$ h

Q17ai Kym

Q17aii Sai might say that brighter light carries higher energy for the electrons to absorb, and waiting longer allows the electrons to absorb enough energy to be emitted.

Q17b Planck's constant = gradient $\approx \frac{2.8}{5\times 10^{14}} \approx 5.6\times 10^{-15}$ eV s

Q17c $E_K = hf - w$, threshold frequency $\approx 7\times 10^{14}$ Hz
.: $0 = 5.6\times 10^{-15}\times 7\times 10^{14} - w$, $w \approx 3.9$ eV

Q18a The electrons and the X-rays must have the same wavelength to produce the same pattern.

$$\lambda = \frac{hc}{E} = \frac{(4.14\times10^{-15})(3.0\times10^{8})}{8000} \approx 1.55\times10^{-10}\text{ m} = 0.155\text{ nm}$$

Q18b Electron momentum $= \frac{h}{\lambda}$

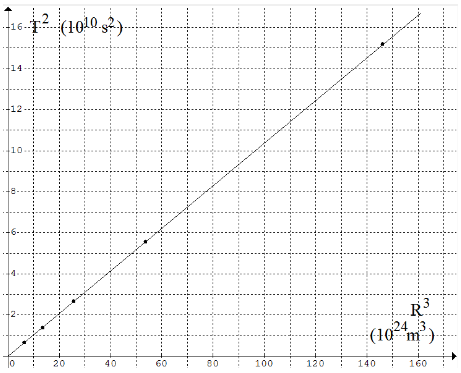
$$= \frac{6.63\times10^{-34}}{1.55\times10^{-10}} \approx 4.28\times10^{-24}\text{ kg m s}^{-1}$$

$$E_K = \frac{p^2}{2m} \approx \frac{(4.28\times10^{-24})^2}{2(9.1\times10^{-31})} \approx 1.0\times10^{-17}\text{ J}$$

Q19a red

Q19b The electron in a hydrogen atom has discrete energy according to which energy level (ground or excited states) it is in. The discrete energies can be explained using de Broglie's idea of matter wave. An energy level must correspond to a whole number of wavelengths. When the electron moves to a lower energy level, a photon is emitted with energy which is the difference between the two levels, hence the discrete spectral lines.

Q20a



Q20b Gradient $= \frac{15.2\times10^{10}}{146\times10^{24}} \approx 1.04\times10^{-15}\text{ s}^2\text{ m}^{-3}$

Q20c $\frac{T^2}{R^3} = \frac{4\pi^2}{GM}$, $1.04\times10^{-15} = \frac{4\pi^2}{6.67\times10^{-11}M}$, $M \approx 5.7\times10^{26}$ kg

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