2020 VCAA Physics Examination Solutions

SECTION A

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

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

Q1 Impossible pattern! **A**

Q2 $g = \frac{(6.67\times10^{-11})(1.5\times10^{23})}{(2.6\times10^{6})^2} \approx 1.5 \text{ m s}^{-2}$ **B**

Q3 **C**

Q4 $r = \frac{mv}{qB}$, $r \propto v$

The radius is halved when the speed is halved. **B**

Q5 $\phi = BA = 0.03\times(1.0\times10^{-3}) = 3.0\times10^{-5}$ wb **B**

Q6 $|\xi_{av}| = \left|\frac{\Delta\phi}{\Delta t}\right| = \frac{(3.5\times10^{-4})(0.05)}{0.20} \approx 8.8\times10^{-5}$ V **C**

Q7 Constant input .: output 0V **A**

Q8 Net force is towards the centre of the circular path. **D**

Q9 Both blocks have the same acceleration a , Net force on the 5kg and 10kg blocks are $5a$ and $10a$ newtons respectively. **C**

Q10 $W = 250\times20 = 5000$ J **A**

Q11 Direction of momentum changes continuously. **D**

Q12 $\gamma = \frac{1}{\sqrt{1-\left(\frac{2.50}{3.0}\right)^2}} \approx 1.81$ **A**

Q13 $P = (6.6\times10^{9})c^2 \approx 6.0\times10^{26}$ W **C**

Q14 **B**

Q15 Increasing amplitude $\rightarrow$ increasing intensity $\rightarrow$ more photons

$E = hf = \frac{hc}{\lambda}$ **D**

Q16 **D**

Q17 **C**

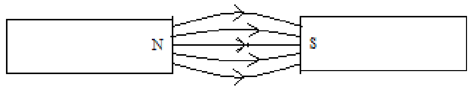
Q18 **D**

Q19 **A**

Q20 $E_{k,\max} = \frac{hc}{\lambda} - W$ **B**

SECTION B

Q1



Q2

Field type	Only monopoles	Only dipoles	Both
gravitation	∨		
magnetism		∨	
electricity			∨

Q3a $qv_0B = qE$, $v_0 = \frac{E}{B}$

Q3b $v_0 = \frac{E}{B} = \frac{500\times10^3}{0.25} = 2.0\times10^6 \text{ m s}^{-1}$

Q3ci Point Z

Q3cii Magnetic force on a moving charge $\propto v$

.: higher speed gives rise to a stronger downward magnetic force than the upward electric force .: net force is downwards

Q4a Radius $= 6.37\times10^6 + 600\times10^3 = 6.97\times10^6$ m

Q4b $g = \frac{GM}{r^2} = \frac{4\pi^2 r}{T^2}$

$T = \sqrt{\frac{4\pi^2 r^3}{GM}} = \sqrt{\frac{4\pi^2(6.97\times10^6)^3}{(6.67\times10^{-11})(5.98\times10^{24})}} \approx 5.79\times10^3$ s

Q4c The ICON satellite is in free fall and its acceleration is due to gravity g only, which is perpendicular to the satellite's motion .: no work is done by gravity on the satellite and the satellite moves at constant speed and maintains a stable circular orbit. If propulsion is used, work is done on the satellite and its speed increases and it moves to a higher orbit.

Q4d Change in gravitational potential energy

$= mass \times area\ under\ graph$

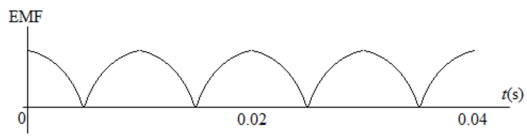
$= 288\times\left(\frac{1}{2}(9.80+8.20)\times600\times10^3\right) \approx 1.56\times10^9$ J

Q5a Anticlockwise

Q5b Time for a quarter turn $= \frac{1}{4}\times\frac{1}{50} = 0.005$ s

Average EMF $= \left|\frac{\Delta\phi}{\Delta t}\right| = \frac{(0.2\times10^{-3})(0.050\times0.035)}{0.005} = 7.0\times10^{-5}$ V

Q5c Initially, zero flux, maximum EMF



Q5d Pick any two of the following modifications: Use stronger magnets, increase the number of turns in the wire loop, rotate the loop faster, increase the dimensions of the loop

Q6a Area of the coil decreases, magnetic flux decreases.

Q6b A change in magnetic flux induces EMF in the coil, $|\xi| = \left|\frac{\Delta\phi}{\Delta t}\right|$.
Since the loop is closed by the ammeter, the induced EMF drives a current in the coil through the ammeter and thus a current is registered. To oppose the decrease in magnetic flux (i.e. to increase the flux in the direction of the uniform magnetic field) the induced current flows in the clockwise direction according to Lenz's Law.

Q6c The action of the student generates an alternating current in the coil. The area of the coil, hence the flux through the coil increases and then decreases. The induced current flows anticlockwise and then clockwise, generating magnetic field against and then in the direction of the uniform magnetic field.

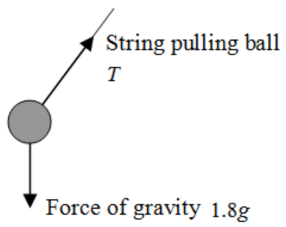
Q7a $V_{peak} = \sqrt{2} \times 12 \approx 17$ V

Q7b $\frac{N_p}{N_s} = \frac{240}{12} = 20$

Q7c $P_{av} = V_{RMS} I_{RMS}$

$I_{RMS,p} = \frac{P_{av}}{V_{RMS,p}} = \frac{0.90}{240} = 0.00375 \text{ A} = 3.75 \text{ mA}$

Q8a



Q8b Radius $= 0.75 \sin 25° \approx 0.3170$ m
Vertically: $T\cos 25° = 1.8g$
Horizontally: Centripetal force $= F_{net} = T \sin 25°$

$\frac{F_{net}}{1.8g} = \tan 25°$, $\frac{1.8 \times \frac{v^2}{0.3170}}{1.8 \times 9.8} = \tan 25°$, $v \approx 1.2$ m s^{-1}

Q9a $\frac{1}{2}mv^2 = \frac{1}{2}kx^2$, $v = \sqrt{\frac{k}{m}}x = \sqrt{\frac{1250}{0.20}} \times 0.15 \approx 12$ m s^{-1}

Q9b Conservation of energy: Kinetic energy after fallen 2.5 m
$= \frac{1}{2} \times 0.20 \times v^2 = \frac{1}{2} \times 0.20 \times 12^2 + 0.20 \times 9.8 \times 2.5 = 19.3$
.: $v \approx 14$ m s^{-1}

Q10a Conservation of momentum: $1200v + 2200 \times 6.5 = 1200 \times 10$
$v \approx -1.92$.: speed of the car is 1.92 m s^{-1} to the left.

Q10b It is an example of inelastic collision because the total kinetic energy is less after collision.

$E_{before} = \frac{1}{2} \times 1200 \times 10^2 = 60000$ J

$E_{after} = \frac{1}{2} \times 1200 \times 1.92^2 + \frac{1}{2} \times 2200 \times 6.5^2 \approx 48679$ J

Q10ci Impulse = change in momentum
$F_{av} \times (40 \times 10^{-3}) = 2200 \times 6.5$
$F_{av} \approx 3.58 \times 10^5$ N = 358 kN to the right

Q10cii $F_{av} \times (40 \times 10^{-3}) = 1200 \times (-1.92 - 10)$
$F_{av} \approx 3.58 \times 10^5$ N = 358 kN to the left

Q11a Time measured by observers on Earth $\approx \frac{8.61}{0.800} \approx 10.76$ years

Time measured by astronaut $\approx \frac{10.76}{1.67} \approx 6.44$ years

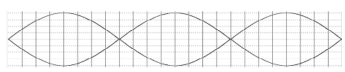
Q11b Trip time measured by the astronaut is a proper time because the events (departure and arrival) occur at the same position (spaceship window).

Q12a Coherent light waves from the two slits arriving at point P in phase (crest + crest, trough + trough) result in constructive interference, thus a bright fringe is formed. This is possible because the path difference $SP_1 - SP_2$ is a multiple (4 times in this case) of the wavelength.

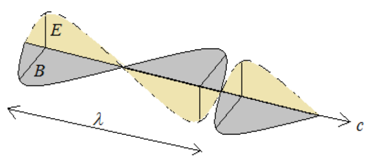
Q12b $\Delta x = \frac{1.26 \times 10^{-2}}{4} = \frac{\lambda \times 2.00}{4.0 \times 10^{-4}}$, $\lambda = 6.3 \times 10^{-7}$ m = 630 nm

Q13a $v = f\lambda = 250 \times 1.6 = 400$ m s^{-1}

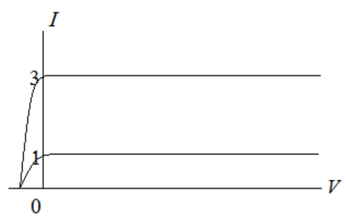
Q13b



Q14



Q15a



Q15b Stopping voltage

Q15c The retarding voltage is high enough to stop all photoelectrons from reaching the negative collecting electrode.

Q16a Single crystal or powder pattern?

$E_k = \frac{1}{2}\left(9.1\times10^{-31}\right)\left(1.72\times10^{5}\right)^2 \approx 1.346\times10^{-20}\ \text{J} \approx 0.084\ \text{eV}$

Ex16b Electron $p = \left(9.1\times10^{-31}\right)\left(1.72\times10^{5}\right) \approx 1.5652\times10^{-25}$ kg ms^{-1}

De Broglie wavelength = X-ray wavelength for the same spacing

.: the same $p = \frac{h}{\lambda}$.: X-ray photon

$E = \frac{hc}{\lambda} = pc = \left(1.5652\times10^{-25}\right)\left(3.0\times10^{8}\right) \approx 4.7\times10^{-17}\ \text{J} \approx 293\ \text{eV}$

Q17a 668 nm

Q17b $f = \frac{c}{\lambda} = \frac{3.0\times10^{8}}{588\times10^{-9}} \approx 5.1\times10^{14}$ Hz

Q17c Electrons in a helium atom exist at well defined energy levels. When an electron transits from a level to a lower energy level it emits a photon of energy equal to the difference in energy between the two levels, resulting in a spectral line. Many such transitions are possible and hence many spectral lines are present in the spectrum.

Q18a $24 = i\left(R + r\right)$, $i = \frac{24}{R + r}$, $P_{globe} = i^2 R = \frac{576R}{\left(R + r\right)}$

P_{globe} decreases as r increases. Hence brightness decreases.

Q18b Dependent: Current in cables

Independent: Resistance of cables

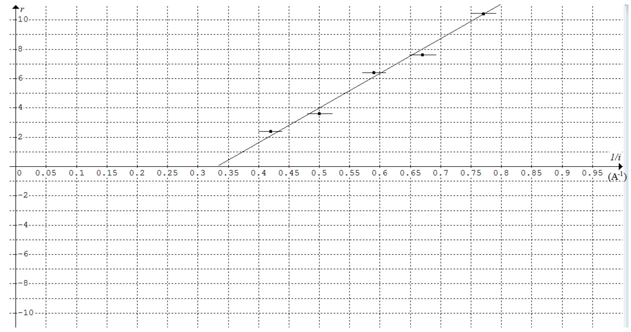
Current depends on resistance, as resistance r increases, current i decreases.

Q18c $24 = i\left(R + r\right)$.: $r = \frac{24}{i} - R$

Q18d

r	$\frac{1}{i}$
2.4	0.42
3.6	0.50
6.4	0.59
7.6	0.67
10.4	0.77

Q18e



Q18f $r = \frac{24}{i} - R$, horizontal axis intercept: $r = 0$ and $\frac{1}{i} \approx 0.33$

.: $R \approx 0.33\times24 \approx 7.9\ \Omega$

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