2010 VCAA Physics Exam 1 Solutions

Area of study 1 – Motion in one and two dimensions

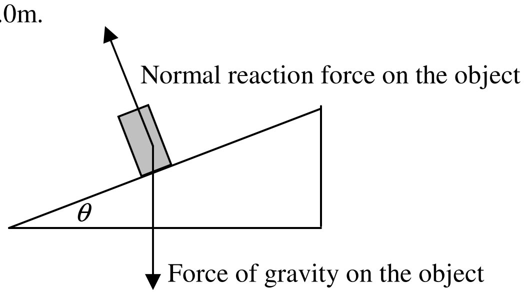
Q1 $F_{net} = \frac{mv^2}{r}$, $11200 = \frac{700v^2}{50}$, $v = 28.3$ ms^{-1}

Q2 $a = \frac{F_{net}}{m} = \frac{11200}{700} = 16$ ms^{-2} towards the centre of the circular corner.

Q3 Net force on the two blocks $(m_1 + m_2)$
$= m_2 g = 0.10 \times 10 = 1.0$ N
$a = \frac{F_{net}}{m} = \frac{1.0}{0.40 + 0.10} = 2.0$ ms^{-2} to the left.

Q4 Force pulling block $m_1 = m_1 a = 0.40 \times 2.0 = 0.80$ N
Change in kinetic energy of block m_1 = work done by pulling force $= Fs = 0.80 \times 1.0 = 0.80$ J
The block starts from rest, .: its kinetic energy is 0.80 J after it has travelled 1.0m.

Q5



Q6 $v = \sqrt{gr \tan \theta}$, $10 = \sqrt{10 \times 100 \tan \theta}$, $\tan \theta = 0.1$, $\theta = 5.71°$

Q7 Conservation of energy: $mgh = \frac{1}{2}mv^2$,
$v = \sqrt{2gh} = \sqrt{2 \times 10 \times 20} = 20$ ms^{-1}

Q8 Rebecca's statement is correct because each rider is attracted by the force of gravity of the earth, mg N, where m is the mass of a rider.

Q9 $a = g$ for the riders to feel no weight, $\frac{v^2}{r} = g$,
$v = \sqrt{gr} = \sqrt{10 \times 10} = 10$ ms^{-1}. At higher speed the riders will feel some weight due to the reaction of the restraints.

Q10 Projectile motion:
Vertical component, $u = 0$, $s = {}^{-}200$, $a = {}^{-}10$, t?
$s = ut + \frac{1}{2}at^2$, $t = \sqrt{40}$
Horizontal component, $u = {}^{+}10$, $t = \sqrt{40}$, $s = ut = {}^{+}63.2$,
$d = 63.2$ m

Q11 Conservation of energy: Total energy at 200 m above the ground = total energy at ground level. Take the ground as the level of zero gravitational potential energy.
$\frac{1}{2}m \times 10.0^2 + m \times 10 \times 200 = \frac{1}{2}mv^2 + 0$, $v = \sqrt{4100} = 64.0$ ms^{-1}

Q12 $I = F_{av}\Delta t$, $F_{av} = \frac{I}{\Delta t} = \frac{1.70}{0.0080} = 212.5$ N

Q13 $F = kx$, $k = \frac{F}{x} = \frac{mg}{x} = \frac{2.0 \times 10}{0.40} = 50$ Nm^{-1}

Q14 Take the lowest level (bottom of 2.0-kg mass) in Figure 5b as the level of zero gravitational potential energy.
Total energy in Figure 5a $= mgh = 2.0 \times 10 \times 0.40 = 8.0$ J
Total energy in Figure 5b $= \frac{1}{2}kx^2 = \frac{1}{2} \times 50 \times 0.40^2 = 4.0$ J
Difference $= 8.0 - 4.0 = 4.0$ J

Q15 Graph A: The same total kinetic energy before and after collision because it is an elastic collision. During collision some kinetic energy is changed to elastic potential energy and back to kinetic energy.

Q16 Graph B: The total momentum remains constant before, during and after the collision because there is zero external net force on the system.

Q17 Graph B: The total momentum remains constant before, during and after the collision because there is zero external net force on the system, irrespective to the type (elastic or inelastic) of collision taking place.

Q18
Weight $= mg = m\frac{GM}{r^2} = (3.04 \times 10^5) \times \frac{(6.67 \times 10^{-11})(5.98 \times 10^{24})}{(6.72 \times 10^6)^2}$
$= 2.69 \times 10^6$ N

Q19 The ISS is in free fall, $a = g$, $\frac{4\pi^2 r}{T^2} = \frac{GM}{r^2}$,
$T = \sqrt{\frac{4\pi^2 r^3}{GM}} = \sqrt{\frac{4\pi^2 (6.72 \times 10^6)^3}{(6.67 \times 10^{-11})(5.98 \times 10^{24})}} = 5.48 \times 10^3$ s

Q20 The period will be the same because $T = \sqrt{\frac{4\pi^2 r^3}{GM}}$ is independent of the mass of ISS.

Area of study 2 – Electronics and photonics

Q1 Diode voltage $= 1.0$ V, resistor voltage $= 6.0 - 1.0 = 5.0$ V, ammeter current = current through the 500-ohm resistor $= \frac{5.0}{500} = 0.010\text{ A} = 10\text{ mA}$

Q2 Diode voltage $= 1.0$ V,
500-ohm resistor voltage $= 6.0 - 1.0 = 5.0$ V,
ammeter current = current through the 500-ohm resistor $= \frac{5.0}{500} = 0.010\text{ A} = 10\text{ mA}$

Q3 Total resistance of A and B in parallel $= \frac{1}{\frac{1}{2.0} + \frac{1}{2.0}} = 1.0\ \Omega$

The 0.50-ohm resistor, A and B in parallel, and the remaining 0.50-ohm resistor form a voltage divider. The voltage across the parallel resistors $= \frac{1.0}{0.50 + 1.0 + 0.50} \times 24 = 12$ V.

.: $V_{globeA} = V_{globeB} = 12$ V

Q4 Total resistance $= 2.0\ \Omega$, $I = \frac{V}{R} = \frac{24}{2.0} = 12$ A

Q5 Percentage efficiency

$= \frac{P_{out}}{P_{in}} \times 100\% = \frac{50 \times 10^{-3}}{10 \times (10 \times 10^{-3})} \times 100\% = 50\%$

Q6 From graph, 10 lux $\rightarrow 10^4\ \Omega$.

Voltage divider: $\frac{R}{R_{LDR}} = \frac{V_R}{V_{OUT}}$, $\frac{R}{10^4} = \frac{8}{4}$, $R = 2 \times 10^4\ \Omega$

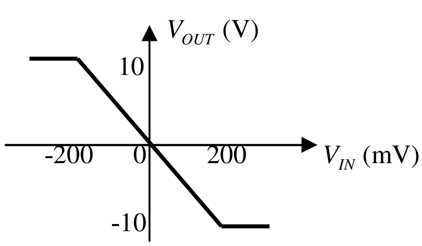
Q7 As sunset approaches, the daylight gets less bright, the LDR resistance increases, and the value of V_{OUT} increases. This is because $V_{OUT} = \frac{R_{LDR}}{R + R_{LDR}} \times 12 = \frac{1}{\frac{R}{R_{LDR}} + 1} \times 12$, and $\frac{1}{\frac{R}{R_{LDR}} + 1}$ increases as R_{LDR} increases.

Q8 Since $V_{OUT} = \frac{R_{LDR}}{R + R_{LDR}} \times 12 = \frac{1}{\frac{R}{R_{LDR}} + 1} \times 12$, by **decreasing *R*** the 4 V threshold can also be reached in brighter daylight (lower R_{LDR}).

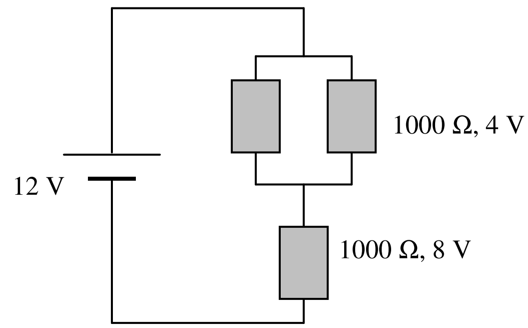
Q9 At $t = 5$ ms, $V_{IN} = 200$ mV, $V_{OUT} = -10$ V,

voltage gain $= \frac{-10}{200 \times 10^{-3}} = -50$

Q10



Q11



Detailed study 1 – Einstein's special relativity

1	2	3	4	5	6	7	8	9	10	11	12
C	A	C	B	A	B	A	A	B	B	A	A

Q1 Time taken = distance/speed $= \frac{1000}{3.0 \times 10^8} = 3.3 \times 10^{-6}$ s. C

Q2 Length is contracted when it is measured from a moving frame. $L = L_o\sqrt{1 - \frac{v^2}{c^2}} = 1.00 \times \sqrt{1 - 0.9^2} = 0.44$ km A

Q3 Vicky and Susanna are at the same location when Susanna sends simultaneous flashes of light. .: Vicky also sees the flashes of light sent simultaneously by Susanna. C

Q4 B

Q5 Carriage A is an inertial frame. A

Q6
Distance $=$ speed $\times$ time
$= 0.85 \times (3.0 \times 10^8) \times (784 \times 10^{-6}) = 199920\text{ m} \approx 200\text{ km}$ B

Q7 The robot measures the proper time
$t_0 = \frac{t}{\gamma} = 784 \times \sqrt{1 - 0.85^2} = 413$ microseconds. A

Q8 Motion is relative. A

Q9 B

Q10 $E_{total} = mc^2$, $m = \frac{E_{total}}{c^2} = \frac{3.38 \times 10^{-11}}{(3.0 \times 10^8)^2} = 3.76 \times 10^{-28}$ kg

Mass of a single muon $= \frac{3.76 \times 10^{-28}}{2} = 1.88 \times 10^{-28}$ kg B

Q11 $E_k + E_{rest} = mc^2$, $E_k + m_o c^2 = m_o \gamma c^2$,

$E_k = m_o \gamma c^2 - m_o c^2 = (\gamma - 1) m_o c^2$

$7.714 \times 10^{-10} = (\gamma - 1)(6.64424 \times 10^{-27})(3.0 \times 10^8)^2$

$\therefore \gamma = \frac{1}{\sqrt{1 - \left(\frac{v}{c}\right)^2}} = 2.29$, $\frac{v}{c} = 0.90$, $v = 0.90c$ A

Q12 A

Detailed study 2 – Materials and their use in structures

1	2	3	4	5	6	7	8	9	10	11	12
D	B	C	C	C	B	D	A	C	D	D	B

Q1 Tensile stress increases the separation between the atoms in the direction of the applied stress. D

Q2 Shear stress causes the layers of atoms to slide over each other in the direction of the applied stress. B

Q3 Young's modulus = gradient of the linear section

$= \frac{400\times10^{6}}{2.0\times10^{-3}} = 2.0\times10^{11}\,\text{Nm}^{-2}$ C

Q4 $\sigma = \frac{F}{A}$, $A = \frac{F}{\sigma} = \frac{1.8\times10^{5}}{450\times10^{6}} \approx 4.0\times10^{-4}\,\text{m}^{2}$ C

Q5 $\varepsilon = \frac{\Delta L}{L}$, $\Delta L = \varepsilon L = \left(4.0\times10^{-3}\right)\times10.00 = 0.04$

Length at breaking point $= 10.00 + 0.04 = 10.04$ m C

(*Note: Problems with significant figures and decimal places*)

Q6 Only point S is in the plastic region. B

Q7 Y has a greater gradient and X has a greater area under. D

Q8 300MPa stress is in the elastic region.

Energy per cubic metre $= \frac{1}{2}\sigma\varepsilon = \frac{1}{2}\times\left(300\times10^{6}\right)\left(1.5\times10^{-3}\right)$

$= 2.25\times10^{5}$ J

Total energy $= \left(2.25\times10^{5}\right)\times\left(10\times10^{-4}\right) = 225$ J A

Q9 Each support force $= \frac{80\times10+120\times10}{2} = 1000$ N C

Q10 Net torque about support $P = 0$.

$^{-}600\times3.0+^{-}1200\times2.0+^{+}F_Q\times4.0 = 0$, $F_Q = 1050$ N D

Q11 Assuming the footbridge is supported at its two ends, the under of the concrete slab will be in tension. D

Q12 The bridge does not return to its original shape because the material used in the slab has been extended beyond its elastic limit. B

Detailed study 3 – Further electronics

1	2	3	4	5	6	7	8	9	10	11	12
C	B	B	C	A	C	B	C	C	C	C	B

Q1 $\frac{N_s}{N_P} = \frac{V_s}{V_p}$, $\frac{N_s}{3600} = \frac{12}{240}$, $N_s = 180$ C

Q2 B

Q3 $12 - 2\times0.7 = 10.6$ V B

Q4 $V_{pp} = 2\times7 = 14$ V C

Q5 From display, $T = 20\times4 = 80$ ms.

$f = \frac{1}{T} = \frac{1}{80\times10^{-3}} = 12.5$ Hz A

Q6 From graph, the capacitor discharges by 63% in 0.01 s.

$\tau = RC$, $C = \frac{\tau}{R} = \frac{0.01}{100} = 0.0001\,\text{F} = 100\,\mu\text{F}$ C

Q7 From graph, at $t = 0.03$ s, capacitor voltage $= 0.5$ V

Current through the resistor $= \frac{V}{R} = \frac{0.5}{100} = 0.005\,\text{A} = 5\,\text{mA}$ B

Q8 The capacitor discharges by 63% in 0.01 s, the period of the unsmoothed signal is 0.02 s, .: the capacitor will discharge by more than 63%. C

Q9 $\tau = R_{load}\times C$. If R_{load} is reduced, τ is also reduced resulting in a larger fluctuation in the ripple voltage. C

Q10 The 6 V Zener diode keeps the output at 6 V or below. C

Q11 $P_{av} = VI \approx 5\times\left(20\times10^{-3}\right) = 0.1$ W C

Q12 B

Please inform physicsline@itute.com re conceptual, mathematical and/or typing errors