2010 Physics Trial Exam 1 Solutions

Area of study 1 – Motion in one and two dimensions

Q1 Speed = circumference / time taken $= \dfrac{\pi \times 120}{60} \approx 6.28 \text{ ms}^{-1}$.

Q2 $F_{net} = ma = m\dfrac{v^2}{r} = 75 \times \dfrac{6.28^2}{60} \approx 49 \text{ N}$

Q3 Centripetal force, W.

Q4 Force constant k = gradient $= \dfrac{20 \times 1000}{0.5} = 4.0 \times 10^4 \text{ Nm}^{-1}$.

Q5 Gravitational potential energy changes to elastic potential energy: $mgh = \dfrac{1}{2}kx^2$, $40 \times 10 \times (2 + x) = \dfrac{1}{2} \times 4.0 \times 10^4 \times x^2$,

$50x^2 - x - 2 = 0$, $x = 0.21 \text{ m} = 21 \text{ cm}$.

Q6 It is possible for the skier to move under gravity only, i.e. zero reaction force from the ski slope along the entire parabolic path *QR*. This occurs when the path of the skier's projectile motion is the same as the parabolic path *QR*. In this situation the skier experiences weightlessness.

Q7 At *R*, increase in kinetic energy = decrease in gravitational potential energy: $\dfrac{1}{2}mv^2 - \dfrac{1}{2}mV^2 = mgh$, $v^2 - V^2 = 2gh$,

$v = \sqrt{V^2 + 40}$.

Vertical component: $v_y = \sqrt{V^2 + 40} \sin 45° = \sqrt{\dfrac{V^2 + 40}{2}} \text{ ms}^{-1}$.

Q8 Vertical component: $v_y{}^2 = u_y{}^2 + 2as_y$,

$v_y = \sqrt{u_y{}^2 + 2as_y} = \sqrt{0 + 2 \times 10 \times 2} = \sqrt{40}$, $\therefore \sqrt{\dfrac{V^2 + 40}{2}} = \sqrt{40}$,

$V = \sqrt{40} = 6.3 \text{ ms}^{-1}$.

Q9 Horizontal component: $Vt = 4$, $t = \dfrac{4}{\sqrt{40}} = 0.63 \text{ s}$.

Alternatively, vertical component: $s_y = u_y + \dfrac{1}{2}at^2$,

$2 = 0 + \dfrac{1}{2} \times 10 \times t^2$, $t = 0.63 \text{ s}$.

Q10 $\Delta\vec{p} = m\Delta\vec{v} = 0.0525(^+280 - 0) = {}^+14.7 \text{ kg ms}^{-1}$.

Q11 $4.20 \times v = 14.7$, $v = 3.5 \text{ ms}^{-1}$.

Q12 Work done by F_{av} = change in kinetic energy of the rifle:

$F_{av} \times 0.025 = \dfrac{1}{2} \times 4.20 \times 3.5^2$, $F_{av} \approx 1.03 \times 10^3 \text{ N}$.

Q13 Action: Rifle on cushion. Reaction: Cushion on rifle.

Q14 The net force on the ball must be zero for it to move in a straight line at constant speed. Corner C provides a reaction force on the ball opposite to the force of gravity.

Q15 Weight W = force of gravity $\propto \dfrac{1}{r^2}$.

At $r = 1R$, $W = 9.6 \text{N}$.

At $r = 2R$, $W = \dfrac{1}{4} \times 9.6 = 2.4 \text{ N}$.

Q16 $\dfrac{a_B}{a_A} = \dfrac{g_Y}{g_X} = \dfrac{M_Y}{M_X} = \dfrac{2M_X}{M_X} = 2$.

Q17 $\dfrac{W_B}{W_A} = \dfrac{m_B g_Y}{m_A g_X} = \dfrac{2m_A \times 2}{m_A} = 4$.

Q18 $a = \dfrac{4\pi^2 r}{T^2}$, $T^2 = \dfrac{4\pi^2 r}{a}$.

$\therefore \dfrac{T_B{}^2}{T_A{}^2} = \dfrac{\frac{1}{g_Y}}{\frac{1}{g_X}} = \dfrac{g_X}{g_Y} = \dfrac{1}{2}$, $\therefore \dfrac{T_B}{T_A} = \dfrac{1}{\sqrt{2}} \approx 0.71$.

Area of study 2 – Electronics and photonics

Q1 $V_2 = \dfrac{R_2}{R_1 + R_2} \times 9.0 = 6.0 \text{ V}$; $V_4 = \dfrac{R_4}{R_3 + R_4} \times 9.0 = 3.6 \text{ V}$.

$V_{PQ} = 6.0 - 3.6 = 2.4 \text{ V}$.

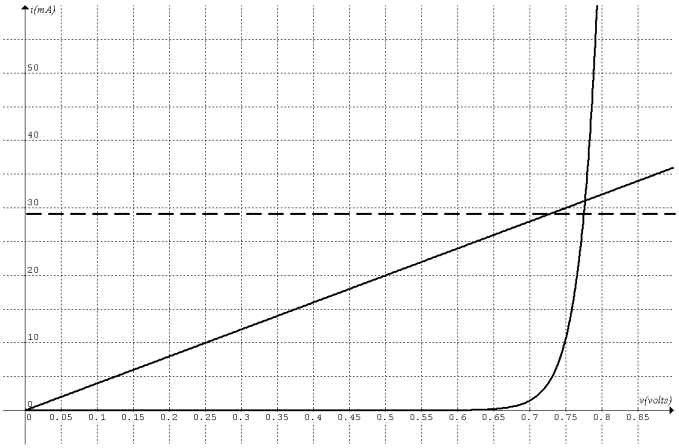
Q2 $R_{total} = \dfrac{1}{\frac{1}{0.5+1} + \frac{1}{3+2}} = \dfrac{15}{13} \text{k}\Omega$.

$I = \dfrac{V}{R_{total}} = \dfrac{9.0}{\frac{15}{13} \times 10^3} = 7.8 \times 10^{-3} \text{ A} = 7.8 \text{ mA}$.

Q3 $P_{total} = VI = 9.0 \times 7.8 \times 10^{-3} \approx 0.070 \text{ W}$.

Q4 When $V = 0.50 \text{ V}$, $I = 20 \text{ mA}$. $R = \dfrac{0.50}{20 \times 10^{-3}} = 25 \ \Omega$

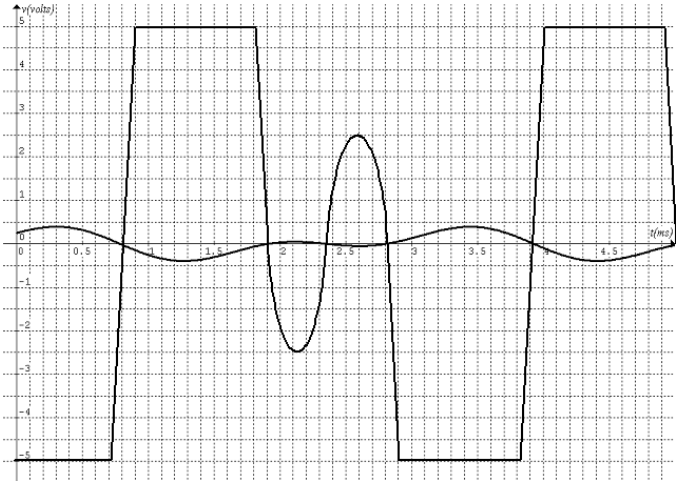
Q5



When $I = 29$ mA, $V_{resistor} + V_{diode} = 0.725 + 0.775 = 1.5$ V.

Q6 Voltage gain $= \dfrac{\Delta v_o}{\Delta v_i} = \dfrac{-5}{+0.1} = -50$.

Q7



Q8 25°C.

Q9 $\dfrac{R}{15\times10^3} = \dfrac{8.0}{4.0}$, $R = 30\times10^3\ \Omega = 30\ \text{k}\Omega$.

Q10 The resistance of the thermistor will be higher than 15kΩ when the temperature is below 15°C, the voltage across it (output voltage) will then be above 4.0V and the alarm will remain on.

Q11 C

Q12 B and D.

Detailed study 2– Investigating materials and their use in structures

1	2	3	4	5	6
A	A	B	D	C	A

7	8	9	10	11	12	13
C	D	B	D	C	A	A

Q1 The combined weight of the cable and the mass is greatest at point P. A

Q2 Since the tension is greatest at point P, .: the stress is greatest at point P. A

Q3 $E = \text{gradient} = \dfrac{0.275}{0.004} \approx 69$ GPa. B

Q4 $\sigma = E\varepsilon$, $\varepsilon = \dfrac{\sigma}{E}$. For constant σ, $\dfrac{\varepsilon_{al}}{\varepsilon_{steel}} = \dfrac{E_{steel}}{E_{al}}$. D

Q5 C

Q6 A

Q7 C

Q8 D

Q9 B

Q10 $\sigma = \dfrac{8900}{\pi\times0.40^2} \approx 18$ kPa. D

Q11 The door is kept in equilibrium, .: net torque is zero. C

Q12 $\tau = r_{\perp}F = 0.75\sin 60°\times3 = 1.95$ Nm clockwise. A

Q13 Net torque is zero.
.: the torque of the spring-closer is 1.95 Nm anticlockwise. A

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