

2010 Physics Trial Exam 1 Solutions

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Area of study 1 – Motion in one and two dimensions

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

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

Q3 Centripetal force, W .

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

Q5 Gravitational potential energy changes to elastic potential energy: $mgh = \frac{1}{2}kx^2$, $40 \times 10 \times (2 + x) = \frac{1}{2} \times 4.0 \times 10^4 \times x^2$,
 $50x^2 - x - 2 = 0$, $x = 0.21 \text{ m} = 21 \text{ cm}$.

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: $\frac{1}{2}mv^2 - \frac{1}{2}mV^2 = mgh$, $v^2 - V^2 = 2gh$,
 $v = \sqrt{V^2 + 40}$.

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

Q8 Vertical component: $v_y^2 = u_y^2 + 2as_y$,
 $v_y = \sqrt{u_y^2 + 2as_y} = \sqrt{0 + 2 \times 10 \times 2} = \sqrt{40}$, $\therefore \sqrt{\frac{V^2 + 40}{2}} = \sqrt{40}$,
 $V = \sqrt{40} = 6.3 \text{ ms}^{-1}$.

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

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

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

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:

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

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 $\propto \frac{1}{r^2}$.

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

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

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

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

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

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

Area of study 2 – Electronics and photonics

Q1 $V_2 = \frac{R_2}{R_1 + R_2} \times 9.0 = 6.0 \text{ V}$; $V_4 = \frac{R_4}{R_3 + R_4} \times 9.0 = 3.6 \text{ V}$.
 $V_{PQ} = 6.0 - 3.6 = 2.4 \text{ V}$.

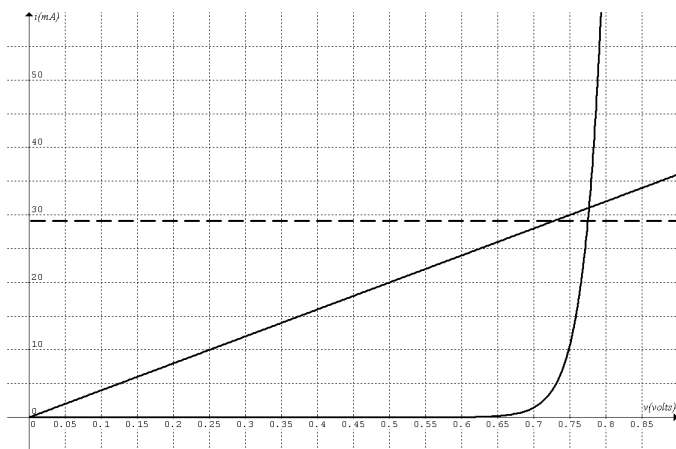
Q2 $R_{\text{total}} = \frac{1}{\frac{1}{0.5+1} + \frac{1}{3+2}} = \frac{15}{13} \text{ k}\Omega$.

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

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

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

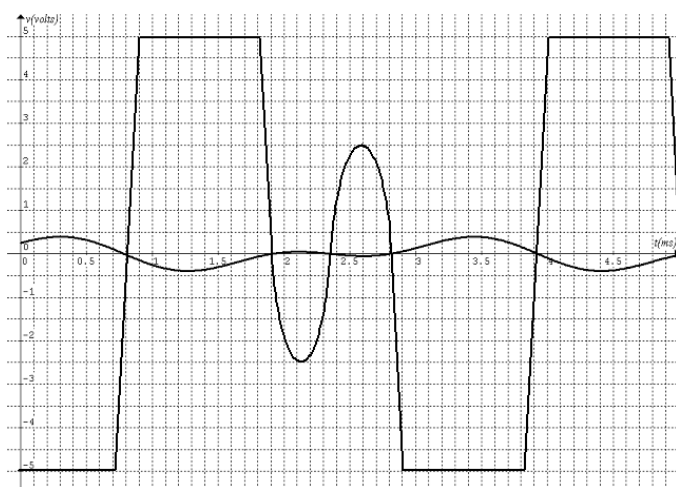
Q5



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

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

Q7

Q8 25°C .

Q9 $\frac{R}{15 \times 10^3} = \frac{8.0}{4.0}$, $R = 30 \times 10^3 \Omega = 30 \text{ k}\Omega$.

Q10 The resistance of the thermistor will be higher than $15 \text{ k}\Omega$ when the temperature is below 15°C , the voltage across it (output voltage) will then be above 4.0 V 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, $\therefore$ the stress is greatest at point P. A

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

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

Q5 C

Q6 A

Q7 C

Q8 D

Q9 B

Q10 $\sigma = \frac{8900}{\pi \times 0.40^2} \approx 18 \text{ kPa}$. D

Q11 The door is kept in equilibrium, $\therefore$ net torque is zero. C

Q12 $\tau = r_{\perp} F = 0.75 \sin 60^\circ \times 3 = 1.95 \text{ Nm}$ clockwise. A

Q13 Net torque is zero.
 $\therefore$ the torque of the spring-closer is 1.95 Nm anticlockwise. A

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