General physics (1011), worked-out solutions to all Assignment Question (15%)

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1. $A_x = 44.0\cos 28.0^\circ = 38.85 \quad A_y = 44.0\sin 28.0^\circ = 20.66$

$B_x = -26.5\cos 56.0^\circ = -14.82 \quad B_y = 26.5\sin 56.0^\circ = 21.97$ **1pt**

$C_x = 31.0\cos 270^\circ = 0.0 \quad C_y = 31.0\sin 270^\circ = -31.0$

(a) $(\vec{\mathbf{A}} + \vec{\mathbf{B}} + \vec{\mathbf{C}})_x = 38.85 + (-14.82) + 0.0 = 24.03 = 24.0$ **1pt**

$(\vec{\mathbf{A}} + \overline{\mathbf{B}} + \vec{\mathbf{C}})_y = 20.66 + 21.97 + (-31.0) = 11.63 = 11.6$

(b) $|\vec{\mathbf{A}} + \vec{\mathbf{B}} + \vec{\mathbf{C}}| = \sqrt{(24.03)^2 + (11.63)^2} = 26.7 \quad \theta = \tan^{-1}\frac{11.63}{2403} = 25.8^\circ$ **0.5pt**

(c) $A_x = 44.0\cos 28.0^\circ = 38.85 \quad A_y = 44.0\sin 28.0^\circ = 20.66$

$C_x = 31.0\cos 270^\circ = 0.0 \quad C_y = 31.0\sin 270^\circ = -31.0$

$(\vec{\mathbf{A}} - \vec{\mathbf{C}})_x = 38.85 - 0.0 = 38.85 \quad (\vec{\mathbf{A}} - \vec{\mathbf{C}})_y = 20.66 - (-31.0) = 51.66$ **1pt**

$|\vec{\mathbf{A}} - \vec{\mathbf{C}}| = \sqrt{(38.85)^2 + (51.66)^2} = \underline{64.6} \quad \theta = \tan^{-1}\frac{51.66}{38.85} = 53.1^\circ$

2. (a). The horizontal velocity is determined from the horizontal motion at constant velocity.

$$\Delta x = v_x t \rightarrow v_1 = \frac{\Delta x}{t} = \frac{3.0\text{ m}}{13\text{ s}} = 2.308\text{ m/s}$$

The initial y velocity is found using the equation,

$y = y_0 + v_{y0}t + \frac{1}{2}a_y t^2 \rightarrow 0 = 4.0\text{ m} + v_{y0}(1.3\text{ s}) + \frac{1}{2}\left(-9.80\text{ m/s}^2\right)(1.3\text{ s})^2 \rightarrow$ **1pt**

$v_{y0} = 3.293\text{ m/s}$

The magnitude and direction of the initial velocity are the following

$$v_0 = \sqrt{v_x^2 + v_{y0}^2} = \sqrt{(2.308\text{ m/s})^2 + (3.293\text{ m/s})^2} = 4.0\text{ m/s}$$

$\theta = \tan^{-1}\frac{v_{y0}}{v_x} = \tan^{-1}\frac{3.293\text{ m/s}}{2.308\text{ m/s}} = 55^\circ$ above the horizontal **0.5pt**

(b) The maximum height will be reached when Vy=0. So,

$v_y^2 = v_{y0}^2 + 2a\Delta y \rightarrow 0 = (3.293\text{ m/s})^2 + 2\left(-9.80\text{ m/s}^2\right)\left(y_{\max} - 4.0\text{ m}\right) \rightarrow$ **0.5pt**

ymax= 4.6 m

(c) To find the velocity when he enters the water, the horizontal velocity is the (constant) value of Vx=2.308 m/s. The vertical is found from the equation,

$$v_y = v_{y0} + at = 3.293\ \text{m/s} + \left(-9.80\ \text{m/s}^2\right)(1.3\ \text{s}) = -9.447\ \text{m/s}$$ **0.5pt**

The magnitude and direction of the velocity are found as follows

$$v = \sqrt{v_x^2 + v_y^2} = \sqrt{(2.308\ \text{m/s})^2 + (-9.447\ \text{m/s})^2} = 9.725\ \text{m/s} \approx 9.7\ \text{m/s}$$

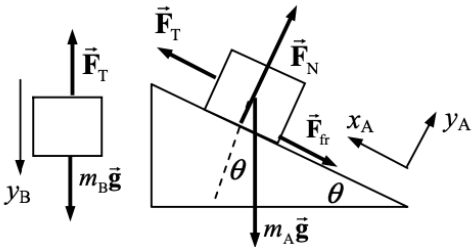
$$\theta = \tan^{-1}\frac{v_y}{v_x} = \tan^{-1}\frac{-9.447\ \text{m/s}}{2.308\ \text{m/s}} = -76^\circ \text{ (below the horizontal)}$$ **1pt**

3. (a) Given that m_B is moving down, m_A must be moving up the incline, so the force of kinetic friction on m_A will be directed down the incline. Since the blocks are tied together, they will both have the same acceleration, so $a_{yB} = a_{xA} = a$. Write Newton's second law for each m a s s.

$$\sum F_{y\,B} = m_B g - F_T = m_B a \rightarrow F_T = m_B g - m_B a$$

$$\sum F_{x\,A} = F_T - m_A g \sin\theta - F_{ff} = m_A a$$

$$\sum F_{y\,A} = F_N - m_A g \cos\theta = 0 \rightarrow F_N = m_A g \cos\theta$$ **1pt**



0.5pt

Take the information from the two y equations and substitute into the x equation to solve for the acceleration.

$$m_B g - m_B a - m_A g \sin\theta - \mu_k m_A g \cos\theta = m_A a \rightarrow$$

$$a = \frac{m_B g - m_A g \sin\theta - m_A g \mu_k \cos\theta}{(m_A + m_B)} = \frac{1}{2} g \left(1 - \sin\theta - \mu_k \cos\theta\right)$$ **1pt**

$$= \frac{1}{2}\left(9.80\ \text{m/s}^2\right)\left(1 - \sin 34^\circ - 0.15\cos 34^\circ\right) = 1.6\ \text{m/s}^2$$

(b) To have an acceleration of zero, the expression for the acceleration must be zero.

$$a = \frac{1}{2} g \left(1 - \sin\theta - \mu_k \cos\theta\right) = 0 \rightarrow 1 - \sin\theta - \mu_k \cos\theta = 0 \rightarrow$$

$$\mu_k = \frac{1 - \sin\theta}{\cos\theta} = \frac{1 - \sin 34^\circ}{\cos 34^\circ} = 0.53$$ **1pt**

4. (a). The pilot's initial speed when he hit the snow was 45 m/s. The work done on him as he fell the 1.1 m into the snow changed his kinetic energy. Both gravity and the snow did work on the pilot during that 1.1-m motion. Gravity did positive work (the force was in the same direction as the displacement), and the snow did negative work (the force was in the opposite direction as the displacement).

$$W_{\text{gravity}} + W_{\text{snow}} = \Delta\text{KE} \rightarrow mgd + W_{\text{snow}} = -\frac{1}{2}mv_0^2 \rightarrow$$

$$W_{\text{snow}} = -\frac{1}{2}mv_0^2 - mgd = -m\left(\frac{1}{2}v_i^2 + gd\right) = -(88\text{ kg})\left[\frac{1}{2}(45\text{ m/s})^2 + \left(9.80\text{ m/s}^2\right)(1.1\text{ m})\right]$$

$$= -9.005 \times 10^4\text{ J} \approx -9.0 \times 10^4\text{ J} \qquad \textbf{1pt}$$

(b) The work done by the snow is done by an upward force, while the pilot moves down.

$$W_{\text{snow}} = F_{\text{snow}}\, d \cos 180^\circ = -F_{\text{snow}}\, d \rightarrow$$

$$F_{\text{snow}} = -\frac{W\text{snow}}{d} = -\frac{-9.005 \times 10^4\text{ J}}{1.1\text{ m}} = 8.186 \times 10^4\text{ N} \approx 8.2 \times 10^4\text{ N} \qquad \textbf{1pt}$$

(c) During the pilot's fall in the air, positive work was done by gravity and negative work by air resistance. The net work was equal to his change in kinetic energy while he fell. We assume he started from rest when he jumped from the aircraft.

$$W_{\text{gravity}} + W_{\text{air}} = \Delta\text{KE} \rightarrow mgh + W_{\text{air}} = \frac{1}{2}mv_{\text{f}}^2 - 0 \rightarrow \qquad \textbf{1pt}$$

$$W_{\text{air}} = \frac{1}{2}mv_{\text{f}}^2 - mgh = m\left(\frac{1}{2}v_{\text{f}}^2 - gh\right) = (88\text{ kg})\left[\frac{1}{2}(45\text{ m/s})^2 - \left(9.80\text{ m/s}^2\right)(370\text{ m})\right]$$

$$= -2.3 \times 10^5\text{ J}$$

5. The flow speed is the speed of the water in the input tube. The entire volume of the water in the tank is to be processed in 4.0 h. The volume of water passing through the input tube per unit time is the volume rate of flow,. So,

$$\frac{V}{\Delta t} = Av \rightarrow v = \frac{V}{A\Delta t} = \frac{\ell wh}{\pi r^2 \Delta t} = \frac{(0.36\text{ m})(1.0\text{ m})(0.60\text{ m})}{\pi(0.015\text{ m})^2(3.0\text{ h})\left(\frac{3600\text{ s}}{1\text{ h}}\right)} = 0.02829\text{ m/s} \approx 2.8\text{ cm/s} \qquad \textbf{1.5pt}$$