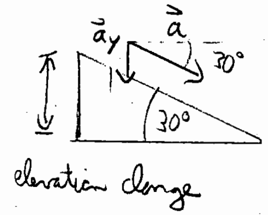
PHYS 171 — Homework #3 — AQ 2005

1) Skier accelerating at $-30.°0$ at $2.00\ \frac{m}{s^2}$



a) $a_y = |\vec{a}| \cdot \sin 30° = \underline{\underline{1\ \frac{m}{s^2}}}$

b) $a = \text{const} = 2.00\ \frac{m}{s^2}$

Elevation change: $\Delta y = 325\,m \Rightarrow$ distance on snow:

$\Delta y = r \cdot \sin 30°$

$\Rightarrow r = \frac{\Delta y}{\sin 30°} = 650\,m$

$r(t) = x_0 + v_0 t + \frac{1}{2} a_r t^2$ ← acceleration in direction of skier's path

$\Rightarrow r_{final} = \frac{1}{2} a_r t_{final}^2$

$\Rightarrow t_{final} = \sqrt{\frac{2 r_{final}}{a_r}} = \sqrt{\frac{\cancel{2} \cdot 650\,m}{\cancel{2}\ m/s^2}} = \underline{\underline{25.5\ s}}$

2) Fire hose: $V_{water} = 5.5\ \frac{m}{s}$; $V_{0x} = V_{water} \cdot \cos\theta_0$, $V_{0y} = V_{water} \cdot \sin\theta_0$

Path of water: horizontally: $x(t) = V_{0x} \cdot t = R$ ← range

vertically: $y(t) = V_{0y} \cdot t - \frac{1}{2} g t^2 = 0$ ← end position on ground

$\Rightarrow t = 0$ and $t = \frac{2 V_{y0}}{g}$

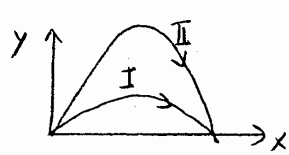
$\Rightarrow R = V_{0x} t = V_{0x} \frac{2 V_{y0}}{g} = \frac{2 V_{water}^2 \sin\theta_0 \cos\theta_0}{g} = \frac{V_{water}^2 \sin 2\theta_0}{g}$

Trig.: $2 \sin\alpha \cos\alpha = \sin 2\alpha$

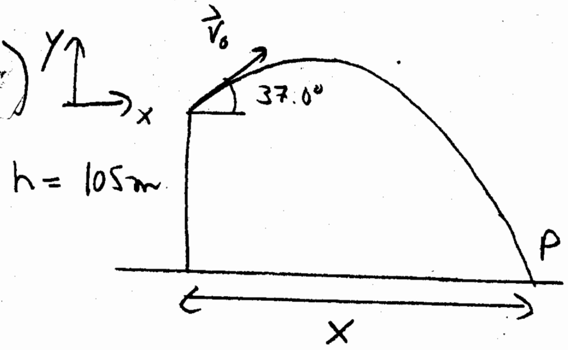
$\Rightarrow \sin 2\theta_0 = \frac{R g}{V_{water}^2} = \frac{(3.0\,m)(9.80\ m/s^2)}{(5.5\ m/s)^2} = 0.972$

$\Rightarrow \theta_0^{(1)} = \underline{\underline{38.2}}$, $\theta_0^{(2)} = \underline{\underline{51.8^0}}$

Reason for two angles:



Different length of paths I + II, takes water longer to reach ground at II, but also reaches higher altitude.

3) 

$|\vec{v}_0| = 125\,\frac{m}{s}$, $\varphi_{v_0} = 37°$

a) Need only analyse vertical components.

$V_{y_0} = |\vec{V}_0| \sin 37° = 75.23\,\frac{m}{s}$

$y(t) = y_0 + V_{0y}t + \frac{1}{2}a_y t^2$; $y_0 = h = 125\,m$

$= V_{0y}t - \frac{1}{2}gt^2 + 125\,m$; $a_y = -g$.

$\Rightarrow t^2 - \frac{2V_{0y}}{g}t - \frac{2y_0}{g} = 0 \Rightarrow t_{1,2} = \frac{V_{0y}}{g} \pm \sqrt{\left(\frac{V_{0y}}{g}\right)^2 + \frac{2y_0}{g}}$

$\underline{\underline{t_1 = 16.6\,s}}$

b) Projectile flies with const. velocity in x-direction.
Need only analyze horizontal movement.

$V_{x_0} = |\vec{V}_0| \cos 37° = 99.8\,\frac{m}{s}$

$\Rightarrow x(t_2) = V_{x0}\,t_2 = \underline{\underline{1660\,m}}$

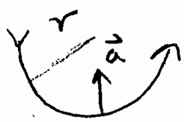
c) Horizontal velocity doesn't change: $V_x(t_2) = V_x(t=0) = V_{x0}$

$V_y(t_2) = V_{0y} - g\,t_2 = \underline{\underline{-87.8\,\frac{m}{s}}}$

d) $|\vec{V}(t_2)| = \sqrt{V_x^2(t_2) + V_y^2(t_2)} = 133\,\frac{m}{s}$

e) $\tan\varphi_{v(t_2)} = \frac{V_y(t_2)}{V_x(t_2)} \Rightarrow \varphi_{v(t_2)} = \underline{\underline{-41.3°}}$ (= 41.3° below horizontal)

4) <u>Jet plane:</u> $v = 1800 \frac{km}{h} = 500 \frac{m}{s}$



$r = 3.98\,km = 3980\,m$

Uniform circular motion: $a = \frac{v^2}{r} = 62.8 \frac{m}{s^2} = \underline{\underline{6.4 g}}$

Direction: $\underline{\underline{up}}$

5) <u>Vectors:</u>

$\vec{A}: \ |\vec{A}| = 60.0, \ \varphi_A = 28.0^\circ \Rightarrow A_x = 53.0, \ A_y = 28.2$

$\vec{B}: \ |\vec{B}| = 40.0, \ \varphi_B = 54.0^\circ \Rightarrow B_x = -23.5, \ B_y = 32.4$

$\vec{C}: \ |\vec{C}| = 46.8, \ \varphi_C = 270^\circ \Rightarrow C_x = 0, \ C_y = 46.8$

$\vec{R} = \vec{A} + \vec{B} + \vec{C} \Rightarrow \left.\begin{array}{l} R_x = 29.5 \\ R_y = 13.7 \end{array}\right\} \begin{array}{l} |\vec{R}| = \sqrt{R_x^2 + R_y^2} = 32.5 \\ \tan\varphi_R = \frac{R_y}{R_x} \Rightarrow \varphi_R = 25^\circ \end{array}$

6) <u>Force:</u> $F = 250\,N$, $a = 2.20 \frac{m}{s^2}$

$F = ma \Rightarrow m = \frac{F}{a} = \frac{250\,kg \frac{m}{s^2}}{2.20\,m/s^2} = \underline{\underline{114\,kg}}$

7) Car: $m = 1045\,kg$, $a = 1.20 \frac{m}{s^2}$

$\Rightarrow F = ma = (1045\,kg)(1.20 \frac{m}{s^2}) = \underline{\underline{1250\,N}}$

8) Weight of $m = 60\,kg$:

Earth: $F = mg = (60\,kg)(9.8 \frac{m}{s^2}) = \underline{\underline{588\,N}}$

Moon: $F = \underline{\underline{102\,N}}$

Mars: $F = \underline{\underline{222\,N}}$

Outer space: No acceleration $\Rightarrow \underline{\underline{F \equiv 0}}$

9) Position of pellet: $x(t) = x_0 + v_0 t + \frac{1}{2} a t^2$; $V_0 = 0$, $x_0 = 0$

$$= \frac{1}{2} a t^2$$

$$\Rightarrow t = \sqrt{\frac{2x}{a}} \quad ; \; x = 0.700\,m$$

Velocity: $v(t) = V_0 + at$

$$\Rightarrow a = \frac{V}{t} = \frac{V}{\sqrt{2x}} \sqrt{a} \Rightarrow \sqrt{a} = \frac{V}{\sqrt{2x}}$$

$$a = \frac{V^2}{2x} = \frac{\left(160 \frac{m}{s}\right)^2}{2x}$$

$$= \underline{\underline{1.83 \cdot 10^4 \frac{m}{s^2}}}$$

$$\Rightarrow F = ma = \underline{\underline{96\,N}}$$

10) Car $m = 1050\,kg$ stopped in $t = 6.9\,s$, $V_0 = 90 \frac{km}{h}$

$$= 25\, m/s$$

$$a = \frac{\Delta V}{\Delta t} = \frac{0 \frac{m}{s} - 25\, m/s}{6.9\,s} = -3.6 \frac{m}{s^2}$$

$$\Rightarrow F = m \cdot a = \underline{\underline{-3800\,N}}$$