Physics 218 — Fall 2007 — Exam 1 Solution **George R. Welch**

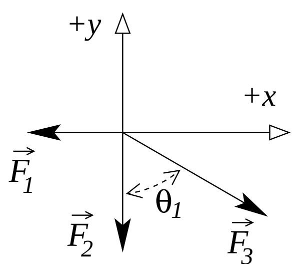
Problem 1. (See for example chapter 2 problems 1, 4, and 5, and exercises 1 and 7.)

(a) $a = \dfrac{dv}{dt} = \underline{\underline{\alpha + 2\beta t}}$

(b) $\Delta x = \displaystyle\int_1^2 v(t)dt = \alpha\frac{t^2}{2} + \beta\frac{t^3}{3}\Big|_1^2 = 2\alpha + \frac{8}{3}\beta - \frac{1}{2}\alpha - \frac{1}{3}\beta = \underline{\underline{\frac{3}{2}\alpha + \frac{7}{3}\beta}}$

Problem 2. (See for example chapter 3 problem 3 and exercises 1 and 2. Also, refer to the force-table experiment from your lab.)

(a) We are told to draw a coordinate system. Your answers will depend on the one you choose. I will choose this:



$$
\begin{aligned}
\vec{F}_1 &= \underline{\underline{-m_1 g\,\hat{\imath} + 0\,\hat{\jmath}}} \\
\vec{F}_2 &= \underline{\underline{0\,\hat{\imath} - m_2 g\,\hat{\jmath}}} \\
\vec{F}_3 &= \underline{\underline{m_3 g \sin\theta_1\,\hat{\imath} - m_3 g \cos\theta_1\,\hat{\jmath}}}
\end{aligned}
$$

(b) The condition for static equilibrium is $\Sigma\vec{F} = 0$ so we have

$$
\begin{aligned}
F_{4x} = -F_{1x} - F_{2x} - F_{3x} &= \underline{\underline{m_1 g - m_3 g \sin\theta}} \\
F_{4y} = -F_{1y} - F_{2y} - F_{3y} &= \underline{\underline{m_2 g + m_3 g \cos\theta}}
\end{aligned}
$$

Problem 3. (See for example chapter 4 problems 5 and 7 and exercises 3 and 6. Also, the missile problem we worked in class.)

(a) He is moving *up* the wall (at constant x) so $\underline{\underline{x(t) = L}}$. He starts from rest at the ground, so $v_{y0} = 0$ and $y_0 = 0$. Thus:

$$
\begin{aligned}
v_y(t) &= v_{y0} + \int_0^t a_y(t)dt = 0 + a_c t \\
y(t) &= y_0 + \int_0^t a_c t dt = \underline{\underline{\frac{1}{2}a_c t^2}}
\end{aligned}
$$

(b) For the grenade the initial conditions are $x_0 = 0$, $y_0 = H$ and $v_{x0} = v_1 \cos\theta$, $v_{y0} = -v_1 \sin\theta$. Thus:

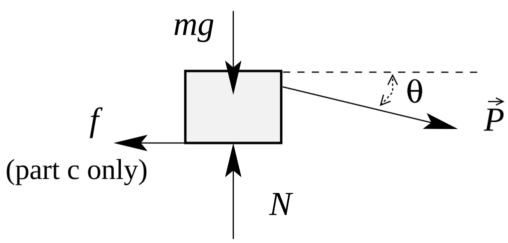
$$\begin{aligned} v_x(t) &= v_{x0} + \int_0^t a_x(t)dt \\ &= v_1 \cos\theta + \alpha t \\ x(t) &= x_0 + \int_0^t v_x(t)dt \\ &= \underline{\underline{v_1 \cos\theta\, t + \frac{1}{2}\alpha t^2}} \end{aligned}$$

$$\begin{aligned} v_y(t) &= v_{y0} + \int_0^t a_y(t)dt \\ &= -v_1 \sin\theta + \frac{1}{2}\beta t^2 \\ y(t) &= y_0 + \int_0^t v_y(t)dt \\ &= \underline{\underline{H - v_1 \sin\theta\, t + \frac{1}{6}\beta t^3}} \end{aligned}$$

(c) For the grenade to hit the prisoner, there must be some time t so that $x_{\text{grenade}}(t) = L$ while $y_{\text{grenade}}(t) = y_{\text{prisoner}}(t)$.

Problem 4. (See for example: chapter 6, problems 1 and 2 and exercise 6.)

The free-body diagram is shown on the left. (Friction f is only for part c only.)



(a) $\Sigma F_x = P\cos\theta = ma \quad \Rightarrow \quad \underline{\underline{a = \frac{P}{m}\cos\theta}}$

(b)

$$\Sigma F_y = N - mg - P\sin\theta = 0 \quad \Rightarrow \quad N = mg + P\sin\theta$$

but

$$N \le F_c \quad \Rightarrow \quad \underline{\underline{P \le (F_c - mg)/\sin\theta}}$$

(c)

$$\begin{aligned} \Sigma F_x = P\cos\theta - f &= ma \\ P\cos\theta - \mu N &= ma \\ P\cos\theta - \mu(mg + P\sin\theta) &= ma \end{aligned}$$

$$\underline{\underline{a = \frac{P}{m}(\cos\theta - \mu\sin\theta) - \mu g}}$$