Chapter **6** (Benson)

E04 $\mu_s = 0.8$, $\mu_k = 0.6$, $\theta = 37^0$ & $m = 1\,\text{kg}$: (a) Since $mg\sin\theta < \mu_s(mg\cos\theta)$, block does not start to move; (b) $\sum F_\perp = N - mg\cos\theta - F\sin\theta$, $f_k = \mu_k N$, $\sum F_\parallel = F\cos\theta - mg\sin\theta - f_k = ma$, $a = 6.86\,\text{m/s}^2$.

E17 $\sum F_x = F\cos\theta - \mu\,(mg + F\sin\theta) = F(\cos\theta - \mu\, sin\theta) - \mu\, mg$. (a) $F > \mu_s mg/(\cos\theta - \mu_s\sin\theta)$ for block to move; (b) If $\mu_s = \cot\theta$, $F \to \infty$; (c) $\mu_k = \cot\theta$, $\sum F_x = F\cos\theta - \mu_k(mg + F\sin\theta) = -\mu_k mg = ma$, $a = -\mu_k g$.

E19 m_A (top) $= 2\,\text{kg}$, m_B (bottom)$= 5\,\text{kg}$ & $\mu_s = 0.25$: (a) 0; (b) For m_A: $F_s = \mu_s m_A g = m_A a$, $a = \mu_s g$. For m_B: $F - F_s = m_B a$, $F = \mu_s(m_A + m_B)\,g = (0.25)(2+5)(9.8) = 17.2\,(\text{N})$.

E20 $m_A = 2\,\text{kg}$, $m_B = 3\,\text{kg}$ & $F = 60\,\text{N}$: $F = (m_A + m_B)\,a$, $N = m_A a$, $F_s = m_A g \le \mu_s N \Rightarrow \mu_s \ge g/a = (m_A + m_B)\,g/F = 0.82$.

E32 $v = 400\,\text{km/h} = 111.1\,\text{m/s}$, m (pilot) $= 70\,\text{kg}$ & $r = 2\,\text{km}$: Let P be the lift acting normal to the wing. $\sum F_x = P\sin\theta = Mv^2/r$; $\sum F_y = P\cos\theta - Mg = 0 \Rightarrow \tan\theta = v^2/(rg)$. So $\theta = 32.2^0$; (b) $\sum F_y = N\cos\theta - mg = 0$, $N = mg/\cos\theta = 811\,\text{N}$.

E33 (a) $\sum F_\perp = N - mg\cos\theta = mv^2/R$ & $\sum F_\parallel = 0$ or $mg\sin\theta = F_s \le \mu_s N \Rightarrow g\sin\theta_m = \mu_s\,(g\cos\theta_m + v^2/R)$; (b) $R = 40\,\text{cm}$, $T = 2\,\text{s}$, or $v = 1.257\,\text{m/s}$ & $\mu_s = 0.75$. $(1+\mu_s^2)\cos^2\theta_m + (2\mu_s^2 v^2/gR)\cos\theta_m + \mu_s^2 v^4/(g^2R^2) - 1 = 0$, $\cos\theta_m = 0.631$, $\theta_m = 50.9^0$.

E34 $v = 7\,\text{m/s}$ & $r = 4\,\text{m}$: $\sum F_x = N = mv^2/r$, $\sum F_y = F_s - mg = 0$ & $F_s \le \mu_s N \Rightarrow \mu_s \ge rg/v^2 = 0.8$.

E45 $r = 6.5\,\text{m}$: (a) $\sum F_y = N + mg = mv^2/r$, $v \ge \sqrt{gr} = 7.98\,\text{m/s}$; (b) v=9.5m/s & m=40 kg. $\sum F_y = N + mg = mv^2/R$, $N = m[(v^2/R) - g] = 163\,\text{N}$.

E46 $M = 4\pi^2 r^3/(GT^2)$ & $G = 6.67\times10^{-11}\,\text{N}\cdot\text{m}^2/\text{kg}^2$: (a) $r = 3.84\times10^5\,\text{km}$ & $T = 27.32\,\text{d} \to M_E = 6.02\times10^{24}\,\text{kg}$; (b) $r = 1.49\times10^8\,\text{km}$ & $T = 365.3\,\text{d} \to M_s = 1.97\times10^{30}\,\text{kg}$.

E55 $R_e = 6,370\,\text{km}$, $h_d = 315\,\text{km}$ & $h_w = 360\,\text{km}$: $(T_d/T_w)^2 = (r_d/r_w)^3 = (6685/6730)^3$, $T_d/T_w = 0.99$. $nT_w = (n+0.5)T_d$, $n/(n+0.5) = 0.99$, $n = 49.5$.

E73 $m = 60\,\text{kg}$ & $\mu_s = 0.4$: $F_s = mg \le \mu_s F$, $F \ge mg/\mu_s = 1.47\,\text{N}$.

P01 $F\cos\theta = \mu_s(mg - F\sin\theta)$, $F = \mu_s mg/(\cos\theta + \mu_s\sin\theta)$. $\partial F/\partial\theta = 0 \Rightarrow \tan\theta = \mu_s$. $F_{min} = mg\sin\theta$. (Teacher: Jyh-Shinn Yang, 89.10.28)

P02 $m_t = 2\,\text{kg}$, $m_b = 4\,\text{kg}$ & $\mu_k = 0.2$. $T - m_t g\mu_k = m_t a$ & $F - T - (m_t + m_b)\,g\mu_k - m_t g\mu_k = m_b a \Rightarrow F = (3m_t + m_b)\,g\mu_k + (m_t + m_b)\,a$. (a) $a = 0$, $F = 19.6\,\text{N}$; (b) $a = 2\,\text{m/s}^2$, $F = 31.6\,\text{m/s}^2$.

P05 $T + \mu\, mg = mv^2/R_1$ & $T - \mu\, mg = mv^2/R_2$, where $T = Mg$. Thus $R_2/R_1 = (M + \mu\, m)/(M - \mu\, m)$.

P06 $m=2\,\mathrm{kg}$, $L=4\,\mathrm{m}$, $v=3\,\mathrm{m/s}$ & $\theta=20^0$. (a) $a_r = v^2/L = 2.25\,\mathrm{m/s^2}$, $a_t = g\sin\theta = 3.35\,\mathrm{m/s^2}$; (b) $T = mg\cos\theta + mv^2/L = 18.4 + 4.5 = 22.9\,(\mathrm{N})$.

P10 $T\sin\theta = mv^2/r$ & $T\cos\theta = mg \Rightarrow v^2 = gr\tan\theta$, where $r = L\sin\theta$. $T = 2\pi r/v = 2\pi\sqrt{L\cos\theta/g}$.

P11 (a) $mg\sin\theta - \mu_s N = m(0)$ & $N = mg\cos\theta \Rightarrow \tan\theta_s = \mu_s$; (b) $a = g(\sin\theta_s - \mu_k\cos\theta_s)$, $d = a\,t^2/2 \Rightarrow t^2 = 2d/[g(\sin\theta_s - \mu_k\cos\theta_s)]$, thus $t = \sqrt{2d/[\,g\cos\theta_s(\mu_s - \mu_k)]}$.

P12 $m=0.5\,\mathrm{kg}$, $M=2\,\mathrm{kg}$, $\mu_s=0.6$ & $\theta=40^0$. When F_0 is a maximum, the frictional force is downward. $\sum F_x = N\sin\theta + \mu N\cos\theta = ma$, $a = N(\sin\theta + \mu\cos\theta)/m$; $\sum F_y = N\cos\theta - \mu N\sin\theta - mg = 0$, $N = mg/(\cos\theta - \mu\sin\theta)$. $F_0 = (M+m)a = (M+m)g(\sin\theta + \mu\cos\theta)/(\cos\theta - \mu\sin\theta) = 71\,\mathrm{N}$. When F_0 is a minimum, the frictional force is upward, $F_0 = (M+m)a = (M+m)g(\sin\theta - \mu\cos\theta)/(\cos\theta + \mu\sin\theta) = 3.9\,\mathrm{N}$.

P13 $\sum F_x = N(\sin\theta + \mu\cos\theta) = mv^2/r$ & $\sum F_y = N(\cos\theta - \mu\sin\theta) - mg = 0 \Rightarrow v = \sqrt{gr(\mu + \tan\theta)/(1 - \mu\tan\theta)}$.

(Teacher: Jyh-Shinn Yang, 89.10.28)