Chapter **8** (Benson)

**E06** $L_1 = 1.6$m, $L_2 = 0.6$m & $\theta_1 = 30^0$: $mgL_1(1-\cos\theta_1) = mgL_2(1-\cos\theta_2)$, $\theta_2 = 50^0$ .

**E09** $m = 500$ g & $k = 120$ N/m: $mg(y+0.6) = ky^2/2$, $60y^2 - 4.9y - 2.94 = 0$, so $y = 26.6$ cm .

**E11** $m_1 = 2$ kg, $m_2 = 4$ kg & $k = 40$ N/m: (a) $-m_2gd + kd^2/2 = 0$, $d = 2m_2g/k$, $d = 1.96$ m; (b) $-m_2gs + (m_1+m_2)v^2/2 + ks^2/2 = 0$ & $s = 0.50$ m, $v = 2.21$ m/s .

**E14** $m = 100$g, $\theta = 30^0$, $k = 5$N/m & $s_1 = 4$ m: (a) $mv_1^2/2 = mgs_1\sin\theta$, $v_1 = 6.26$ m/s; (b) $E_i = mv_1^2/2$, $E_f = kA^2/2 - mgA\sin\theta$, $E_i = E_f$, $A = 0.99$ m .

**E17** $E = mgH = 3U/4 + U = 7mgy/4$; thus $y = 4H/7$ .

**E21** $v_i = 25$ m/s & $y_i = 40$ m: (a) $E_i = mv_i^2/2 + mgy_i = mv_1^2/2$, $v_1 = 37.5$ (m/s); (b) $E_i = mv_2^2/2 + mgy_2$ & $v_2 = 15$ m/s, $y_2 = 60.4$ m .

**E29** $K_i = (83)(38.9^2)/2 = 6.28\times10^4$ (J) & $U_i = (83)(9.80)(10^3) = 81.4\times10^4$ (J), so $E_i = 876$ kJ. $E_f = (1/2)(83)(7^2) = 2$ (kJ), so $W = 874$ kJ .

**E48** $v_{esc} = \sqrt{2GM/R}$: (a) 2.38 km/s; (b) 5.04 km/s; (c) 60.4 km/s .

**E52** To escape need $E = mv^2/2 - GmM/r = 0$, thus $v_{esc} = \sqrt{2GM/r}$. Since $v_{orb} = \sqrt{GM/r}$, we see that $v_{esc} = \sqrt{2}\, v_{orb}$ .

**E57** $m = 0.3$ kg, $k = 8$ N/m, $d = 52$ cm & $A = 24$ cm: $kA^2/2 = \mu_k mgd$, $\mu_k = 0.15$ .

**E62** $-mgh = -\mu_k mgd$, $\mu_k = h/d = 40/83 = 0.482$ .

**P05** Top: $T_1 + mg = mv_1^2/r$; Bottom: $T_2 - mg = mv_2^2/r$. By $E_1 = E_2$, we find $v_2^2 = v_1^2 + 4gr$, thus $T_2 - T_1 = 6mg$ .

**P06** (a) $E_i = mgL$, $E_f = mv^2/2 + mgL/2$, $v^2 = gL$, $T = mv^2/(L/4) - mg = 3mg$; (b) If $T = 0$, then $v^2 = gL/4$ at the top of the circle. $E_i = mgL(1-\cos\theta)$; $E_f = mv^2/2 + mgL/2 = (5/8)\,mgL$. Set $E_i = E_f$ to find $\cos\theta = 3/8$ .

**P07** $E_i = mgL$; $E_f = mv^2/2 + 2mg(L-y)$, At highest point: $mg \le mv^2/(L-y)$, thus $v^2 \ge g(l-y)$. Set $E_i = E_f$ to find $y \ge 3L/5$ .

**P08** $E_i = mgH$ & $E_f = mv^2/2 + 2mgr$. At highest point: $mg \ge mv^2/r$, so $v^2 \le gr$. Set $E_i = E_f$ to find $H \le 3r/2$. (Teacher: Jyh-Shinn Yang, 89.11.22)

**P10** (a) $E_i = mgh$, $E_f = mv^2/2 + mg(2R)$. At the highest point $\sum F_y = N + mg = mv^2/R$, so $v^2 \ge gR$. Set $E_i = E_f$ to find $H \ge 5R/2$; (b) $E_i = mg(5R)$, $E_f = mv^2/2 + mg(2R)$, thus $v^2 = 6gR$. $\sum F_y = N + mg = mv^2/R$, thus $N = 5mg$ .

**P11** (a) $N > 0$ & $F_c = mg\cos\theta - N = mv^2/R$, so $v^2 \le gR\cos\theta$. $E = mgR = mv^2/2 + mgR\cos\theta_1$, leads to $\cos\theta_1 \ge 2/3$, $\theta_c = \cos^{-1}(2/3)$; (b) Lower point or greater angle w.r.t. the vertical: $mv^2/2 + W_f = mgR(1-\cos\theta_2)$, $v^2 = 2gR(1-\cos\theta_2) - A_f \le gR\cos\theta_2$, $\cos\theta_2 \ge 2(1-B_f)/3$, $\cos\theta_c = 2(1-B_f)/3$, $\cos\theta_c < 2/3$ or $\theta_c > \cos^{-1}(2/3)$ .

**P16** (a) $v=\sqrt{GM/r}=7.8\,\mathrm{km/s}$; (b) $E=-GmM/2r = -2.31\times10^9$ J; (c) $\Delta E/\Delta t = (1.73\times10^7)/(3.156\times10^7) = 0.55\,(\mathrm{W})$; (d) $f=P/v=0.55/(7.8\times10^3)=71\,(\mu\mathrm{N})$ .

**Chapter 13**

**E08** (a) $\sum F_x$: $-(6+7.5)GM^2/L^2 = -13.5GM^2/L^2$;

$\sum F_y$: $15\sin 60^0 GM^2/L^2 = 13.0GM^2/L^2$;

(b) $\sum F_x$: $(15-10)\cos 60^0 GM^2/L^2 = 2.5GM^2/L^2$;

$\sum F_y$: $-25\sin 60^0 GM^2/L^2 = -21.7GM^2/L^2$ .

**P03** (a) $U(x) = -2GmM/(a^2+x^2)^{1/2}$; (b) $F_x = -dU/dx = -2gmMx/(a^2+x^2)^{3/2}$; (c) $dF_x/dx = 0$ leads to $x=\pm a/\sqrt{2}$. (Teacher: Jyh-Shinn Yang, 89.11.22)