Problem 1:
(B) Kepler's third law: $(T_1/T_2)^2 = (R_1/R_2)^3$. $(1440/80)^2 = (aR_E/R_E)^3$. a = 6.87.

Problem 2:
(A) Rolling $\omega = v/R$. Energy conservation: $\frac{1}{2} mv^2 + \frac{1}{2} I\omega^2 = mgh$. $\omega^2 = gh/R^2$.
$L = mR^2\omega = mR(gh)^{1/2}$.

Problem 3:
(B) Harmonic oscillator T + U = constant, $\omega^2 = k/m$.
$\frac{1}{2} kA^2 = \frac{1}{2} mv^2 + (1/8)kA^2$. $v = (3k/(4m))^{1/2} A = (3^{1/2}/2)\omega A = 3^{1/2}\pi fA$

Problem 4:
(A) Total angular momentum about the point P before the collision:
$L = I\omega - MvR = \frac{1}{2} MR^2*2v/R - MvR = 0$. The total angular momentum is conserved in a collision between two interacting objects.

Problem 5:
(C) Harmonic oscillator potential: $U(x) = \frac{1}{2}kx^2$ + constant, $\omega^2 = k/m$.

Problem 6:
(E) $F = dp/dt$, $dp = p(t+dt) - p(t) = (m-|dm|)(v+dv) + |dm|(v-u) - mv = mdv - |dm|u$.

Problem 7:
(E) Answers A - D are wrong. $(1/u)dv = -dm/m$.
Integrate: $v/u = -\ln(m/m_0)$ until the fuel is used up.

Problem 8:
(D) $T = 2\pi(L/g)^{1/2}$

Problem 9:
(C) What do you know about motion in any central potential without looking at a formula sheet?

Problem 10:
(A) $E = \frac{1}{2}m\dot{r}^2 + \frac{L^2}{2mr^2} + U(r), \quad E_{\min} \to \dot{r} = 0.$

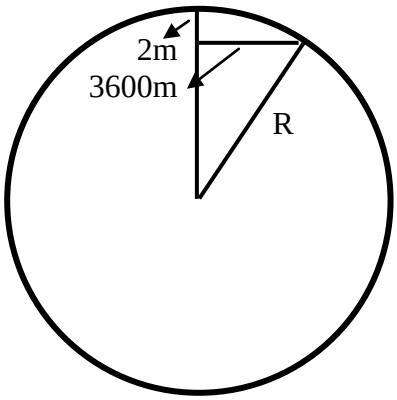
Problem 11:
(D) The system is in equilibrium. Each spring is stretched by the same force.
$F = k_1x_1 = k_2x_2$. $x_2 = k_1x_1/k_2. = x_1/3$.
$W_1/W_2 = (\frac{1}{2}k_1x_1^2)/(\frac{1}{2}k_2x_2^2) = 9/3 = 3$.

Problem 12:
(E) Use the parallel axis theorem.

Problem 13:
(A) Let T = the tension in the string. $T\cos\theta = mg = 20N$, $T\sin\theta = 10$ N, $\tan\theta = 0.5$.

Problem 14:
(D) $F_{avg} = \Delta E/\Delta x = ½mv^2/0.025m = 250/0.025$ N = 10000.

Problem 15:
(C) For a satellite orbiting near the surface of a planet of radius R we have
$mv^2/R = mg'$, where g' is the gravitational acceleration near the surface.
$v^2 = Rg' = 0.4*9.8*R$.



$R^2 = (3600\ m)^2 + (R - 2m)^2 \sim (3600\ m)^2 + R^2 – 4\ m*R$
$R = (3600\ m)^2/(4\ m)$
$v^2 = 3600^2 10*0.4/4\ (m/s)^2$, v = 3.6 km/s.