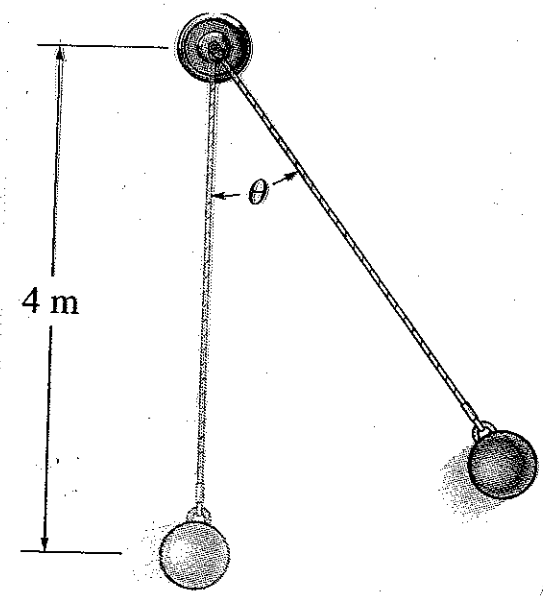
Problem 13.69 (Page 131)

The ball of the figure shown has a mass of 30 kg and a speed $v = 4$ m/s at the instant it is at its lowest point, $\theta = 0°$. Determine the tension in the cord and the rate at which the ball's speed is decreasing when $\theta = 20°$. Neglect the size of the ball.



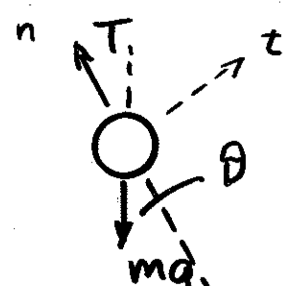
$$+\nwarrow \sum F_n = T - 30(9.81)\cos\theta = 30\frac{v^2}{4}$$

$$+\nearrow \sum F_t = -30(9.81)\sin\theta = 30a_t$$

$$a_t = -9.81\sin\theta = v\frac{dv}{ds}$$

$$ds = 4\,d\theta$$

$$\int_0^\theta -9.81\sin\theta\,(4\,d\theta) = \int_4^v v\,dv$$



$$39.24(\cos\theta - 1) + 8 = \frac{v^2}{2}$$

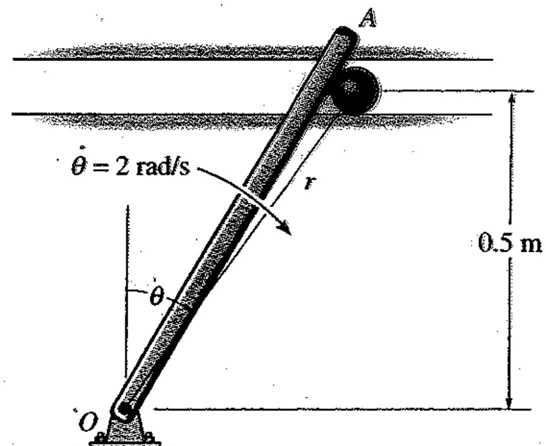
For $\theta = 20°$ $\quad v = 3.357$ m/s

$T = 361$ N

$a_t = 3.36$ m/s²

Problem 13.92 (Page 141)

A particle has a mass of 0.5 kg and is confined to move along the smooth horizontal slot as shown due to the rotation of arm OA. Determine the force of the rod on the particle and the normal force of the slot on the particle when $\theta = 30°$. The rod rotates with an angular velocity of $\dot{\theta} = 2$ rad/sec and an angular acceleration of $\ddot{\theta} = 3$ rad/sec^2. Assume that the particle contacts only one side of the slot.



$r = \dfrac{0.5}{\cos\theta}$ or $r\cos\theta = .5$

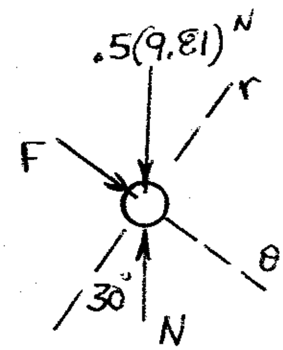
$\dfrac{dr}{dt}\cos\theta - r\sin\theta\,\dot{\theta} = 0$

$\dot{r} = r\tan\theta\,\dot{\theta}$

$\ddot{r} = r\tan\theta\,\ddot{\theta} + \dot{r}\tan\theta\,\dot{\theta}$

$\quad + r\dot{\theta}^2\sec^2\theta$

$= 0.5\left[\tan\theta\,\ddot{\theta} + \dfrac{\sin^2\theta}{\cos^3\theta}\dot{\theta}^2 + \dfrac{\dot{\theta}^2}{\cos^3\theta}\right]$



For $\theta = 30°$, $\dot{\theta} = 2\ r/s$ $\ddot{\theta} = 3\ r/s^2$

$r = 0.577$ m $\dot{r} = .667$ m/s $\ddot{r} = 4.85$ m/s^2

$a_r = \ddot{r} - r\dot{\theta}^2 = 2.54$ m/s^2

$a_\theta = r\ddot{\theta} + 2\dot{r}\dot{\theta} = 4.40$ m/s^2

$\Sigma F_r = N\cos30° - mg\cos30°$
$= .5\,(2.54)$

$\Sigma F_\theta = F + mg\sin30°$
$- 6.37\sin30° = .5(4.4$

$N = 6.37^N \uparrow$ $F = 2.93^N \searrow$

Problem 13.112 (Page 154)

A rocket is in a circular orbit about the earth at an altitude of h = 4 Mm. Determine the minimum increment in speed it must have in order to escape the earth's gravitational field.

For a circular orbit:

$$V_c = \sqrt{\frac{GM_e}{r}} = \sqrt{\frac{66.73(10^{-12})\ 5.976(10^{24})}{4000(10^3) + 6378(10^3)}}$$

$$= 6198.8 \text{ m/s}$$

For a parabolic orbit:

$$V_e = \sqrt{\frac{2GM_e}{r}} = 8766.4 \text{ m/s}$$

$$\Delta V = V_e - V_c = 8766.4 - 6198.8$$

$$= 2567.6 \text{ m/s}$$

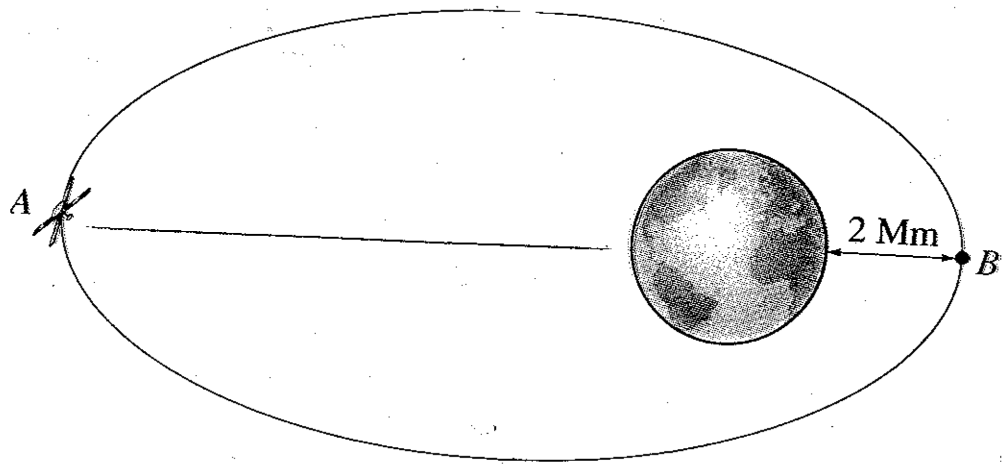
Problem 13.114 (Page 154)

The satellite shown below is moving in an ellitical orbit about the earth with an eccentricity e = 0.25. Determine its speed when it is at its maximum distance A and at its minimum distance B from the earth.

$h = r_o V_o$

$C = \frac{1}{r_o}\left(1 - \frac{GM_e}{r_o V_o^2}\right)$

$e = \frac{C h^2}{GM_e}$



$\frac{r_o V_o^2}{GM_e} = e + 1$

$V_o^2 = \frac{GM_e(1+e)}{r_o}$

$r_o = r_p = 2(10^6) + 6378(10^3)$

$= 8.378 \times 10^6 \text{ m}$

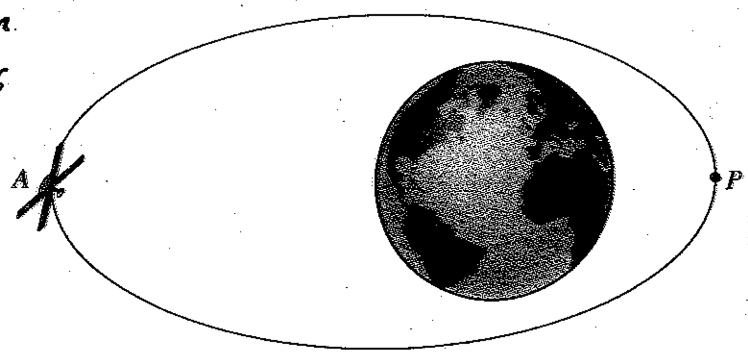
$V_B = V_o = \sqrt{\frac{66.73\times 10^{-12}(5.976)10^{24}(1+.25)}{8.378\times 10^6}} = 7713 \text{ m/s} = 7.71 \text{ Km/s}$

$r_a = \frac{r_o}{\frac{2GM_e}{r_o V_o^2} - 1} = 13.96 \times 10^6 \text{ m} = \left(\frac{1+e}{1-e}\right) r_p$

$V_A = \frac{r_p}{r_a} V_B = 4.63 \text{ Km/sec}$

Problem 13.116 (Page 154)

An ellitical path of a satellite orbiting the earth has an eccentricity e = 0.13. If it has a speed of 15 Mm/hr when it is at perigee P, determine a) its speed when it arrives at apogee A, and b) the distance from the earth's surface (altitude) when it is at A.



$$V_p = V_0 = 15 \frac{Mm}{hr} = 4.167 \frac{Km}{sec}$$

$$e = 0.13 = \frac{Ch^2}{GM_e}$$

$$= \frac{rV_p^2}{GM_e} - 1$$

$$r_p = \frac{(1+e)GM_e}{V_0^2} = 23.96\ Mm$$

$$r_a = \left(\frac{e+1}{1-e}\right) r_p = 33.7\ Mm$$

$$V_A = V_p \left(\frac{r_0}{r_A}\right) = 11.6\ Mm/hr$$

$$d = 33.7(10^6) - 6.378(10^6)$$

$$= 27.3\ Mm$$

Note:

$r_e = 6378\ Km$

$M_e = 5.976(10^{24})\ Kg$

$G = 66.73(10^{-12}) \frac{m^3}{Kg\, s^2}$