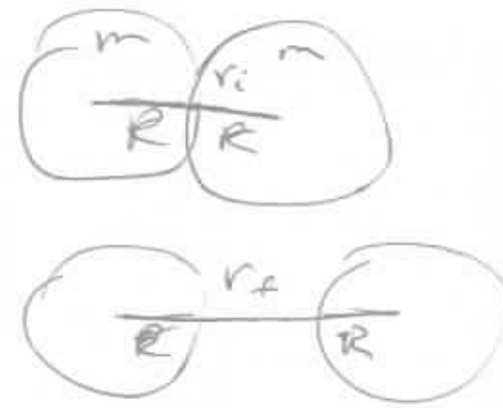
12-38.

i

f



Find: Energy to change separation from r_i to r_f.

$$\Delta U_g = U_{gf} - U_{gi}$$

$$= Gm^2\left(-\frac{1}{R_f} - \left(-\frac{1}{R_i}\right)\right)$$

$$= Gm^2\left(\frac{1}{R_i} - \frac{1}{R_f}\right)$$

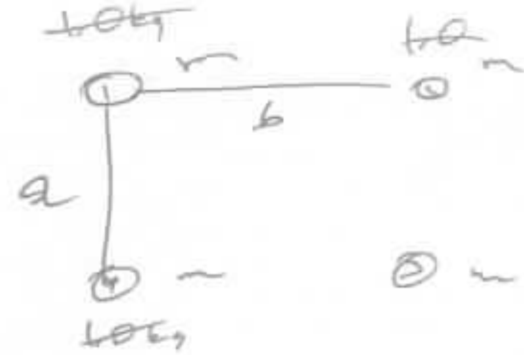
$R_i < R_f$, $\therefore$ ~~energy~~ ΔU_g is +.

This makes sense because one has to force the balls apart against their natural attraction.

$$\Delta U_g = \left(6.67\times10^{-11}\,\frac{N\,m^2}{kg^2}\right)(0.59\,kg)^2\left(\frac{1}{0.24\,m} - \frac{1}{1.0\,m}\right)$$

$$= 7.3\times10^{-11}\,J$$

12-36.



Calculate energy change as arrangement is assembled:

Let ~~Bring~~ ② come in from infinity to b.

$$U_{12} = -\frac{Gm^2}{b} - 0 \quad U_i$$

Let ③ come in:

~~$U_{13} = -Gm^2$~~

$$U_{12} = -\frac{Gm^2}{a} \qquad U_{13} = -\frac{Gm^2}{\sqrt{a^2+b^2}}$$

Now bring in ④

$$U_{14} = -\frac{Gm^2}{a} \qquad U_{34} = -\frac{Gm^2}{b} \qquad U_{24} = -\frac{Gm^2}{\sqrt{a^2+b^2}}$$

Total

$U_{1234} =$

$= -Gm^2\left(\frac{2}{a}+\frac{2}{b}+\frac{2}{\sqrt{a^2+b^2}}\right)$

$\cancel{= 2Gm^2}$

12-39.

Given: M_m, R_m, m_r

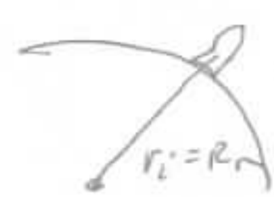
Goal: K_{min} for rocket to escape Moon

System: rocket + moon

ext forces: none

$\Delta K < 0$

$\Delta U_g > 0$



$W_{ext} = \Delta E_{sys}$

$0 = \Delta K + \Delta U_g$

$= (\cancel{K_f}^{\,0} - K_i) + (\cancel{U_{gf}}^{\,0} - U_{gi})$

$= -K_i - U_{gi}$

$K_i = K_{min} = -U_{gi}$

$= +\frac{G M_r m_m}{R_m}$

Check K_i is +

to find v_{esc}, use $K = \frac{1}{2} m v^2$

12-51.

We can use result of last problem:

$$K_{min} = \frac{G m_s m_r}{R_s}$$

$$\frac{1}{2} \cancel{m_r} V^2 = \frac{G m_s \cancel{m_r}}{R_s}$$

$$\cancel{V^2 = \frac{2 G m_s}{R_s}}$$

$$\cancel{V =}$$

$$R_s = \frac{2 G m_s}{V^2}$$

$$= \frac{2\left(6.67 \times 10^{-11} \frac{N m^2}{kg^2}\right)\left(2.0 \times 10^{30} kg\right)}{\left(3.0 \times 10^{8} \frac{m}{s}\right)^2}$$

$$= 2960 m$$

$$\sim 3 km$$