

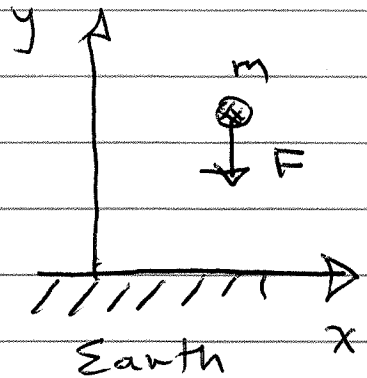
# Kepler Redux

Near earth's surface:

$$F_x = 0$$

$$F_y = -mg$$

$$g = 9.8 \text{ m/s}^2$$



General Rule:

$$F = \frac{GM_1 M_2}{r^2}$$

attractive and  
along line connecting  $M_1$  to  $M_2$

if  $M_1$  and  $M_2$  are spherical  
use centers as their  
locations



$\otimes$   
 $M_1$

$$G = 6.67 \cdot 10^{-11}$$

Universal = Amazing

Earth on you

Earth on Moon

Sun on Jupiter

Black hole on Sun

Andromeda galaxy on Milky  
way galaxy !!

k2

If  $GM_1M_2/r^2$  is general, should be able to derive earth surface rule from it

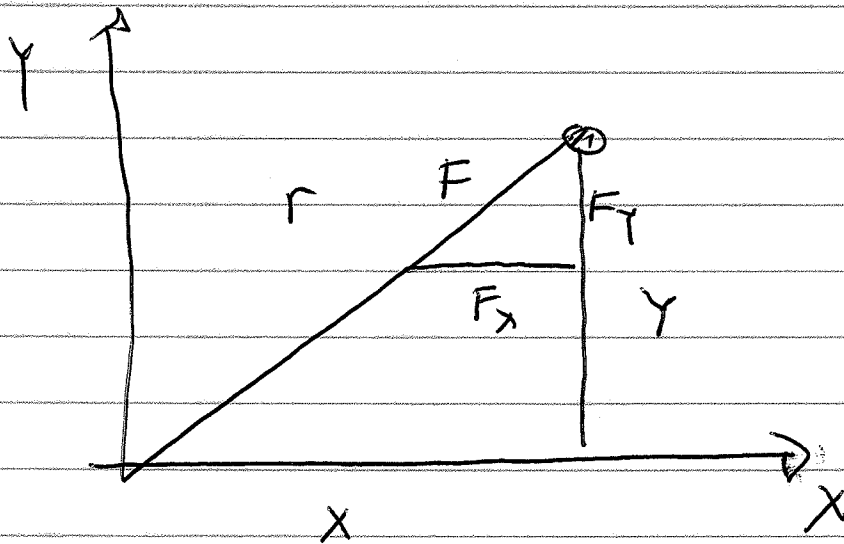
$$M_{\text{earth}} = 6 \cdot 10^{24}$$

$$R_{\text{earth}} = 6.4 \cdot 10^6 \text{ m}$$

$$F = \frac{GM_{\text{earth}}m}{R^2} = \frac{6.67 \cdot 10^{-11} \cdot 6 \cdot 10^{24}}{(6.4 \cdot 10^6)^2} \text{ m}$$

9.8 !!

Components (for your code)



$$F = \frac{GM_1M_2}{r^2}$$

$$r = \sqrt{x^2 + y^2}$$

$$F_x/F = x/r \quad F_x = F \frac{x}{r} = \frac{GM_1M_2 x}{r^3}$$

K3

Potential  
Energy

$$U = mgy$$

} near Earth's  
surface

general

$$U = -\frac{GM_1M_2}{r}$$

$$U + \frac{1}{2}m(v_x^2 + v_y^2) = E = \text{constant}$$

↑  
KE

Thursday: often conserved quantities!