Physics 211 Lecture 39

- Record
- HW
- Lab - do & turn in
- project
- Final → 12/11 From 8-11 AM
  ⇒ extra asycronous "classes"

Today: Newtons Law of gravity, principle of equiv., weight, g, gravitational potential energy done right, escape speed, satellites, Intro. to Fluids, pressure, buoyancy ...

Newtons Law of gravity

$a_r = \frac{v^2}{r}$ and at the moon $a_r = g_{@moon}$

$$v_{moon} = \frac{2\pi r_{moon}}{T_{moon}}$$

$$g_{moon} = 0.00272\ m/s^2$$

$$\frac{g_{@moon}}{g_{earth}} \sim \frac{1}{3600}$$

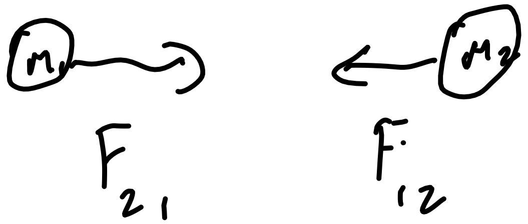
& $\frac{r_{moon\ orbit}}{r_{earth}} \sim 60$

$r_{earth} \rightarrow R_e$

$3600 = 60^2$

Newton found $g \propto \frac{1}{r^2}$

⇒



$$\vec{F}_G = \vec{F}_{12} = \vec{F}_{21} = \frac{G m_1 m_2}{r_{12}^2}\hat{r}$$

attractive

r is center to center distance

$$G = 6.67 \times 10^{-11} \frac{N m^2}{kg^2}$$

⇑ universal constant

⇑ small number ⇒ weak force

weight ⇒ Force of gravity on an object

$F_G = mg$ on earth $g = 9.8\ \frac{m}{s^2}$

$\Rightarrow mg = \frac{G M_e m}{R_e^2}$ ⇒ $F_G = 9.8\,N$ on a 1 kg mass

can cancel m from both sides

$\Rightarrow g = \frac{G M_e}{R_e^2}$ or $g = \frac{GM}{r^2}$

note for mars $g_{mars} = \frac{G M_{mars}}{R_{mars}} \simeq 3.8\ m/s^2$

Gravitational potential energy

$$\Delta U = U_f - U_i = -W(i \to f)$$

$$W = \int_{x_i}^{x_f} F_x \, dx \Rightarrow \Delta U = U_\infty - U_r = -\int_{x_i}^{x_f} F_G \, dx$$

$x_f \to \infty$, $x_i \to r$

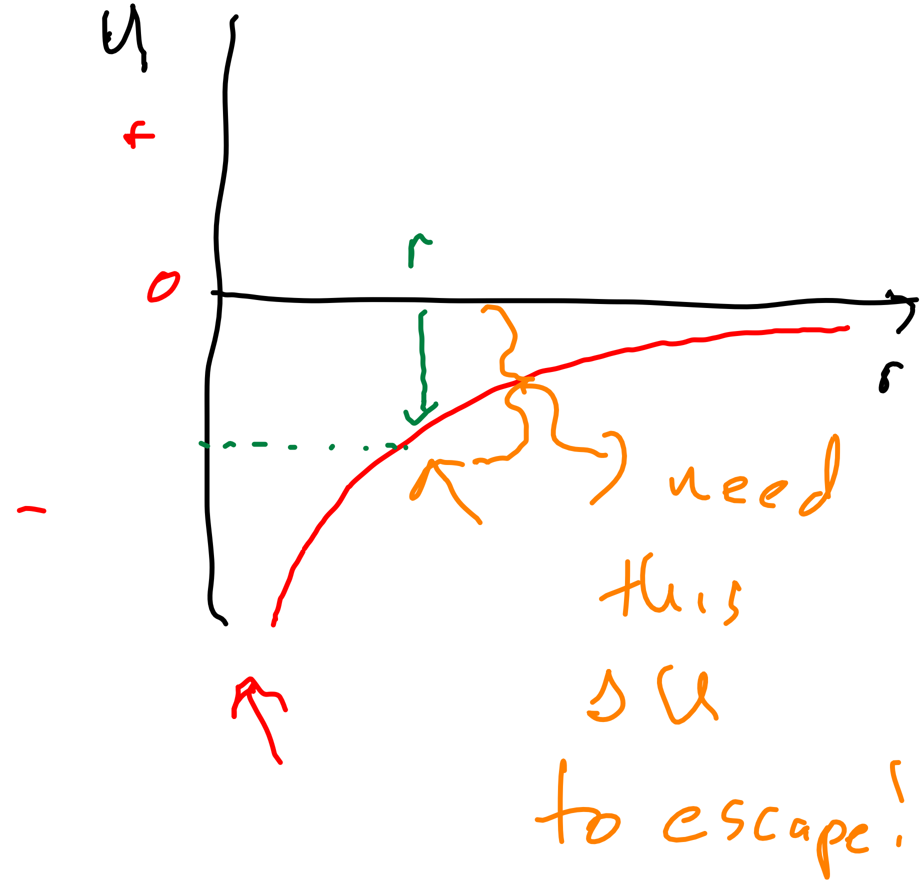
$$F_G = -\frac{G m_1 m_2}{x^2}$$

$$\Delta U = G m_1 m_2 \int_r^\infty \frac{dx}{x^2} = -\frac{G m_1 m_2}{x} \Big|_r^\infty$$

$$= \frac{G m_1 m_2}{r}$$

choose $U_\infty = 0$

$$\Rightarrow \quad U_G = \frac{-G m_1 m_2}{r}$$



Escape speed

$$E_{mech} = K + U = \text{const.}$$

$$K_i + U_i = K_f + U_f$$

$K_f \to 0$, $U_f \to 0$ → For escape

$$K_i + U_i = 0$$

$$\frac{1}{2} m v_{escape}^2 - \frac{GMm}{r_i} = 0$$

$$\Rightarrow v_{escape} = \sqrt{\frac{2GM}{r_i}}$$

$M \to M_e$, $r_i \to R_e$

For earth

$\cong 11200 \frac{m}{s}$

$\approx 25000 \frac{miles}{hr}$

Satellites orbit (circular)

$a_r = \frac{v^2}{r}$ & $F = \frac{GMm}{r^2}$

$F = m a_r \Rightarrow \frac{G M_e m}{r^2} = m \frac{v^2}{r} \Rightarrow v = \sqrt{\frac{G M_e}{r}}$

orbital energy (mech)

$$K + U \Rightarrow \frac{1}{2} m v^2 - \frac{GMm}{r}$$

$$E_{orbital} = \frac{1}{2} U_G = -\frac{GMm}{2r}$$