

## IX. Gravity

$$(A) \quad F_g = \frac{G M_1 M_2}{r^2}$$

$$(B) \quad F_g = m a_g \Rightarrow \frac{G M_1 M_2}{r^2} = M_1 a_g$$

$$a_g = \frac{G M_2}{r^2}$$



### (C) Orbits

1.  $E_1 = E_2$  ( $U = -\frac{G M_1 M_2}{r}$ )

2.  $L_1 = L_2 = r \times p$  b/c  $\sum \tau = 0$

3. Circular orbits

(a)  $F_g = F_c \Rightarrow \frac{G M_1 M_2}{r^2} = \frac{M_1 v^2}{r}$

(b)  $2\pi r = vT$

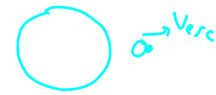
### (D) Bound Systems & Escape Velocity

1. Bound  $\Rightarrow K + U < 0$

2.  $V_{esc} \Rightarrow K + U > 0$

$$\frac{1}{2} m v_{esc}^2 - \frac{G M_1 M_2}{r} > 0$$

$$v_{esc} = \sqrt{\frac{2 G M_2}{r}}$$



3. Sphere with  $\rho(r) = 6r$

(a) find mass:  $m' = \int \rho dV = \int_0^R \rho(r) \underbrace{4\pi r^2 dr}_{dV}$

(b)  $F_g = \frac{GMm'}{r^2}$

(F) Kepler's Laws

1. elliptical orbits with sun at a focal pt.
2. sweeps out equal areas in equal time.
3.  $T^2 \propto R^3$