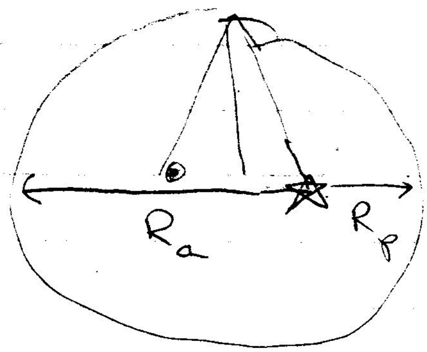
Last Time

- Keper's Laws

(1) Elliptic Orbits



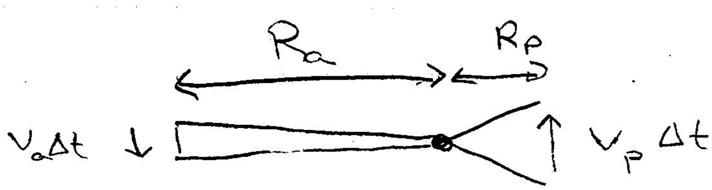
$$R_A = \bar{R}\,(1+e)$$

$$R_p = \bar{R}\,(1-e)$$

$$\bar{R} = \frac{R_p + R_a}{2}$$ = also called a = "semimajor axis"

(2) The area swept out per time is constant.

$$\left.\frac{\Delta A}{\Delta t}\right|_{\text{apheliond}} = \left.\frac{\Delta A}{\Delta t}\right|_{\text{perihelion}}$$



$$\frac{1}{2} V_a \Delta t\, R_a = \frac{1}{2} V_p \Delta t\, R_p$$

(3) Finally

$$T^2 \propto \bar{R}^3$$

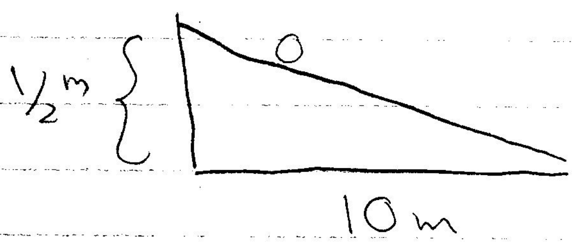
orbital period

1 year for earth

Semi-major axis

$= 1\,AU = 1.5 \times 10^8$ km

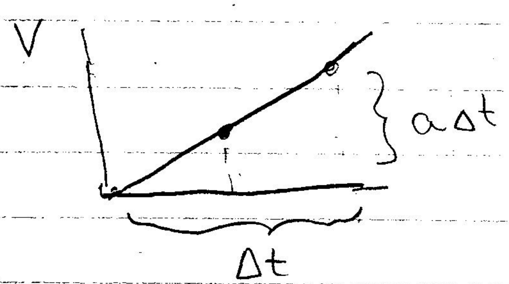
Gallileo - Constant Acceleration in 1D



1. $L \propto \frac{1}{2} t^2$
2. balls of different mass fall at the same rate

} Gallileo's great idea

We explained this with a graph



$$\Delta V = a \, \Delta t$$

$$\bar{V} = \frac{1}{2} a \, \Delta t$$

So the distance, $L = \bar{V} \Delta t = \left(\frac{1}{2} a \Delta t\right) \Delta t$

$$\Delta x = \frac{1}{2} a \, \Delta t^2$$

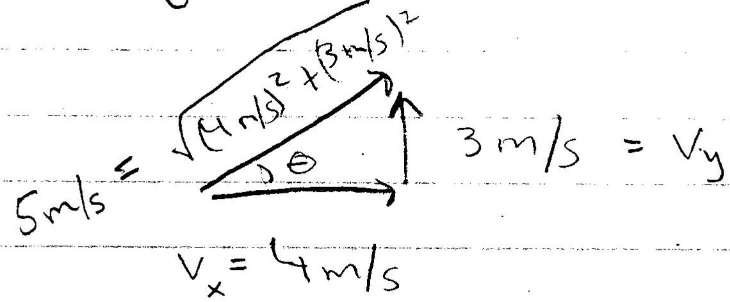
More practice today

$$\Delta x = V_i \, \Delta t + \frac{1}{2} a \, \Delta t^2$$

- Found the free fall acceleration $g = 9.8 m/s^2$

Vectors in 2D (200 years after Newton + Gallilea
Gibb's

- Length and Direction



$$\tan\theta = \frac{3 m/s}{4 m/s} \rightarrow \theta = \tan^{-1}\frac{3}{4} =$$

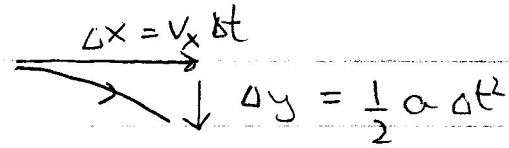
- We add vectors tip to tail

Motion in 2D -

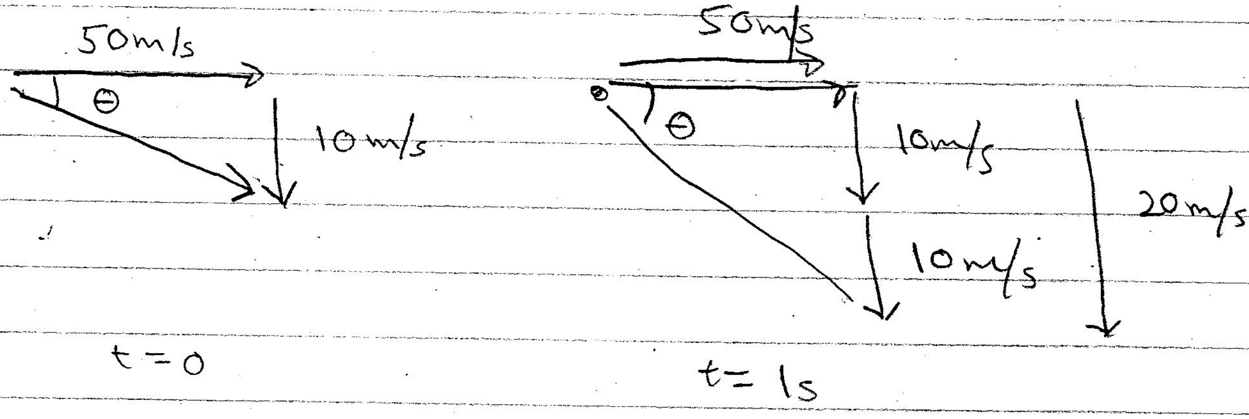
- The horizontal motion continues at constant speed, the vertical motion falls in the normal way

$$\Delta x = V_x \Delta t$$

$$\Delta y = \frac{1}{2} g \Delta t^2$$



- In each time step $\Delta t = 1s$ gravity adds $10 m/s$ of velocity in the downword vertical direction



$$\Delta V_y = a \, \Delta t$$

Question

- Estimate the "exit speed" off the bat of a baseball

- If the angle off the bat is 30° determine how far the baseball went? Here is how to get started:

  1. Determine the initial upward speed in m/s and horizontal speed in m/s. Round to the nearest 5 m/s. Take $g = 10 m/s^2$

  2. Determine the "hang time", i.e. the time in the air
     - make a graph of V_{up} vs. time (velocity in upward direction)

  3. Explain your result <u>without</u> formulas (like gallileo)

Work in Groups / Hand in one neat paper per group