PHYS 107 - Week 2 - Wednesday

Reminder : $\vec{v} = \dfrac{\Delta \vec{x}}{\Delta t}$ = slope of position vs. time

$\vec{a} = \dfrac{\Delta \vec{v}}{\Delta t}$ = slope of velocity vs. time

We only consider problems with constant acceleration $\vec{a}$

Then :

$$\left.\begin{aligned} x &= x_0 + v_0 t + \tfrac{1}{2} a t^2 \\ v &= v_0 + a t \end{aligned}\right\} \text{determine } x, v \text{ at time } t$$

$$v^2 = v_0^2 + 2a(x - x_0) \;\} \text{ determine } v \text{ after distance } x - x_0$$

* Gravity and free fall

Empirical observations:

- near the Earth's surface all objects released above the ground experience <u>them same</u> acceleration

$$\vec{a} = \underset{\substack{\uparrow \\ \text{downward} \\ \text{direction}}}{-g} = -\underbrace{9.80}_{\text{magnitude}} \, \mathrm{m/s^2}$$

$$|g| = |\vec{g}| = 9.80 \, \mathrm{m/s^2}$$

- this is independent of the material, mass, density, etc ('as found by Galileo')

- this is true as long as air resistance and other frictional forces can be neglected

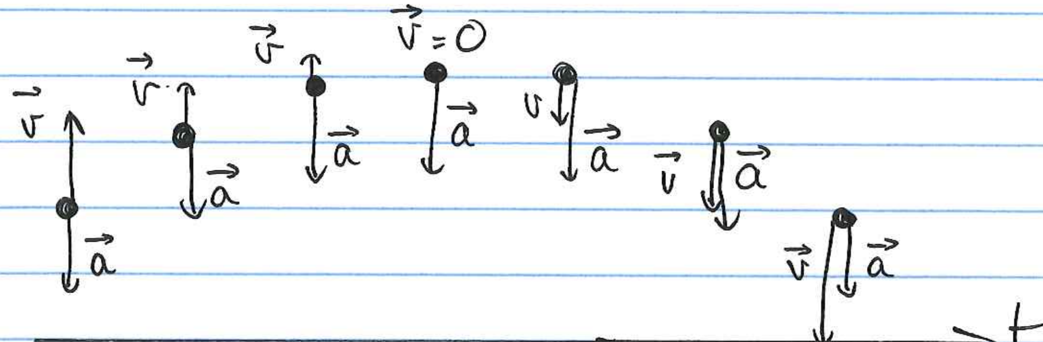
Demo of penny & feather in vacuum

Video of feather and hammer drop on the moon

Video of feather and bowling ball in NASA facility

Q 1D-kin 8c, 9d

* Vertical motion (kinematics) of a ball thrown up:



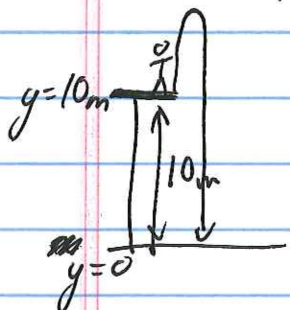
$\vec{a} = -9.80\ m/s^2$ all the time

but $\vec{v}$ changes from + to −

With vertical position y:

$$y = y_0 + v_0 t + \frac{1}{2} a t^2 = y_0 + v_0 t - \frac{1}{2} g t^2$$

Example : ~~off~~ olympic diver jumps up with an initial velocity $v_0 = +2\,m/s$



a) when does the diver return to the height of the board ?

b) how long is she in the air ?

a) $\underset{\overset{\parallel}{y_0}}{y} = y_0 + v_0 t + \frac{1}{2} a t^2$

$\rightarrow 0 = v_0 t - \frac{1}{2} g t^2 \qquad g \simeq 10\,m/s^2$

$\rightarrow t\left(v_0 - \frac{g}{2} t\right) = 0$

$\rightarrow$ either $t = 0$ or $t = \frac{2 v_0}{g} = 0.4\,s$

b) $y = 0$ when $0 = y_0 + v_0 t - \frac{1}{2} g t^2$

$\rightarrow t = \frac{-v_0 \pm \sqrt{v_0^2 - 4 y_0 \left(-\frac{1}{2} g\right)}}{2\left(-\frac{1}{2} g\right)}$

$\rightarrow t = +1.63\,s \ (\underbrace{\text{or} \ -1.23\,s}_{\text{not a valid solution for this problem}})$

Additional questions :

c) what was her maximum height ?

d) with what velocity did she enter the water ?

c) <u>when</u> did she reach maximum height?
back at board height after 0.4 s
$\rightarrow$ maximum height after 0.2 s

or: maximum height when $v = 0$

$$0 = v = v_0 - gt \rightarrow t = \frac{v_0}{g} = 0.2\,s$$

$$\rightarrow y = y_0 + v_0 t - \frac{1}{2} g t^2 \quad \text{with } t = 0.2\,s$$

$$= 10\,m + (0.2\,s)(2\,m/s) - \frac{1}{2}(10\,m/s^2)(0.2\,s)^2$$

$$= 10.2\,m$$

d) $v = v_0 + at = v_0 - gt$ with $t = 1.63\,s$

$$\rightarrow v = 2\,m/s - (10\,m/s^2)(1.63\,s)$$

$$= -14.3\,m/s \quad \text{(downward)}$$

Q 1D-kin 9-b-c
Q 1D-kin 9 d

* Graphical analysis :