# P2010 LECTURE 4

- CAPA due Friday!
- Written HW due Thursday! Need to know your TA's name.
- Textbook: on its way to store.

Recall from Monday: constant acceleration equations:

1) $v = v_0 + at$
2) $x = x_0 + v_0 t + \frac{1}{2} a t^2$
3) $v^2 = v_0^2 + 2a(x - x_0)$

$x_0, v_0$ are $x, v$ at $t = 0$

$x, v$ are at time $t$

$a$ is constant

An example: car is moving to right at $v_0 = +21 \frac{m}{s}$ (about 40 mph)

Brakes applied, car stops in 3 seconds. What is $a$?

At $t = 0$, $v = v_0$

At $t = 3s$, $v = 0$ : use eq. 1 : $0 = v_0 + at_1$

(↑ call it $t_1$)

$-v_0 = a t_1$

$\frac{-v_0}{t_1} = a$

(plug in numbers as late as possible!) so $a = \frac{-21 m/s}{3s} = -7 \frac{m}{s^2}$

Note here that $a < 0$: $a$ is to the left eventhough $v$ to right.

In general: $a, v$ have same sign: speed increasing

opposite sign: speed decreasing.

# Acceleration ≠ velocity!

You can feel acceleration but not velocity. You can eat dinner on a plane moving at 600 mph. You don't know your velocity if you don't look out the window. But, if you are accelerating (say, in the takeoff roll) it's obvious: you are pressed into the seat back.

2 ways to accelerate forward:

1) Start at low speed, hit the gas
2) Start off moving backwards, then brake.

In both cases, you feel pressed backward: $a$ is forward.

$a$ is rate of change of $v$, not $v$:

Rate of change of something ≠ the something!

Example: "How warm is it?" "Temp is falling by 1 deg./hour"

Answer is irrelevant to question! Knowing $\frac{\Delta T}{\Delta t}$ tells you nothing about $T$ itself.

Now, back to gravity.

Remember, acceleration in freefall is always $-g$, defining up as $+x$ direction.

Example: drop an object from rest. $x_0 = 0$, $v_0 = 0$.

$$\Rightarrow x = -\frac{1}{2}gt^2, \quad v = -gt. \qquad \text{Approximate } g \approx 10\ \mathrm{m/s^2}$$

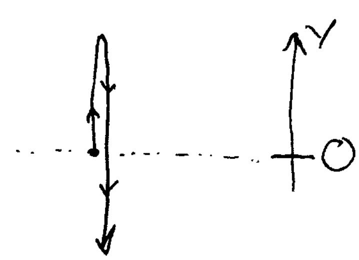
so $x = \left(-5\,\frac{m}{s^2}\right)(t^2)$ , $v = \left(-10\,\frac{m}{s^2}\right)t$ (Note dimensions)

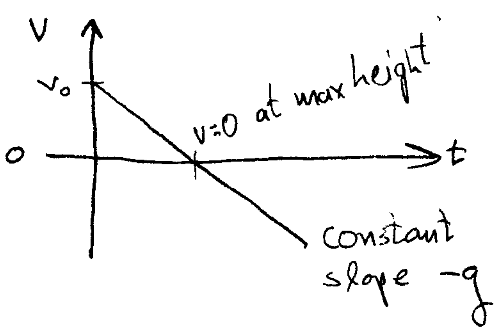
| t | x | v | a |
|---|---|---|---|
| 0 | 0 | 0 | ← $-10\,\frac{m}{s^2}$ |
| 1 s | -5 m | $-10\,\frac{m}{s}$ | ← -10 |
| 2 s | -20 m | $-20\,\frac{m}{s}$ | ← -10 |
| 3 s | -45 m | $-30\,\frac{m}{s}$ | ← -10 |
| 4 s | -80 m | $-40\,\frac{m}{s}$ | ← -10 |

Now, take projectile fired upward at $V_0 = +10\,\frac{m}{s}$.
Call the vertical direction $+y$.

$y_0 = 0$ ; $V_0 = +10\,\frac{m}{s}$ ; $a = -g = -10\,\frac{m}{s^2}$

$$V = V_0 - gt$$
$$y = \cancel{y_0}^{\,0} + V_0 t - \frac{1}{2} g t^2$$




Time to reach $y_{max}$? At $y_{max}$, $V = 0$ : use $V = V_0 + at$

$$0 = V_0 - gt \implies -V_0 = -gt$$
$$10\,\frac{m}{s} = 10\,\frac{m}{s^2}\,t$$
$$1\,s = t$$