Physics 201 - Lecture 5

Review - Motion of a Single Object

position → $\vec{x}(t)$

velocity → $\vec{v}(t) = \frac{d\vec{x}}{dt}$

acceleration → $\vec{a}(t) = \frac{d\vec{v}}{dt}$

speed → $|\vec{v}|$

distance → $|\vec{x}|$

} Instantaneous

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displacement → $\Delta\vec{x} = \vec{x}_f - \vec{x}_i$

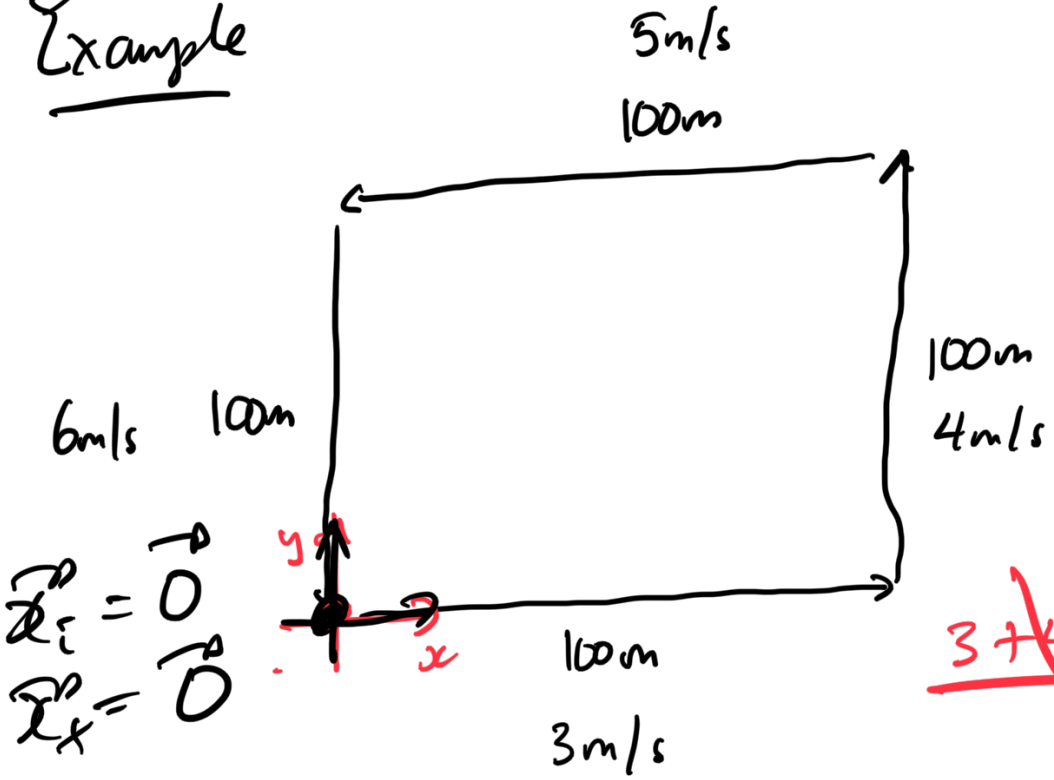
average velocity → $\vec{v}_{avg} = \frac{\Delta\vec{x}}{\Delta t} = \frac{\vec{x}_f - \vec{x}}{t_f - t}$

average speed → $S_{avg} = \frac{\text{total distance}}{\text{total time}}$

} Average quantities

time-averaged [illegible]
(over some interval, Δt)

Example



$\vec{x}_i = \vec{0}$

$\vec{x}_f = \vec{0}$

$3 + 4 + 5 + 6$

$= 4.5$ m/

① What is the total time?

$$T = t_1 + t_2 + t_3 + t_4$$

$$= \frac{100\text{m}}{3\text{m/s}} + \frac{100\text{m}}{4\text{m/s}} + \frac{100\text{m}}{5\text{m/s}} + \frac{100\text{m}}{6\text{m/s}}$$

$= 33.3\,s + 25\,s + 20\,s + 16.7\,s$

$= 95.0\,s$

② What is the average speed?

$$S_{avg} = \frac{\text{total distance}}{\text{total time}} = \frac{400\,m}{95\,s}$$

$$= 4.21\ m/s$$

③ What is the displacement?

$$\Delta\vec{x} = \vec{x}_f - \vec{x}_i$$

$$= \vec{0} - \vec{0}$$

$$= \vec{0}$$

④ What is the average velocity?

$$\Delta\vec{v} = \frac{\Delta\vec{x}}{\Delta t} = \vec{0}$$

Special Case.

Motion in 1D with constant acceleration

only along x-axis.

→ examples →

- car starting from rest at a stop light and speeding up.
- → track slowing down at a stop light.
- → object falling straight down or going straight up through the air.

$$\vec{a}(t) = a$$

$$\cancel{\vec{a}(t)} = \frac{d\cancel{\vec{v}}}{dt} = \frac{dv}{dt}$$

a

$$\frac{dv}{dt} = a$$

$$\boxed{v_f = at + v_i}$$

$$\boxed{v_f = v_i + at} \quad (1)$$

v_i: starting speed

$a > 0$: speeding up

$a < 0$: slowing down.

$$\vec{v} = \frac{d\vec{x}}{dt}$$

$$v = \frac{dx}{dt} \quad (1D)$$

$$x_f = x_i + v_i t + \frac{1}{2} a t^2$$

$$\underbrace{x_f - x_i}_{\Delta x} = v_i t + \frac{1}{2} a t^2$$

$$\Delta x = v_i t + \frac{1}{2} a t^2 \quad (2)$$

v_f ✗ Δx ✓

$$v_f = v_i + a t \quad (1)$$

Δx ✗ v_f ✓

Unknowns :

- ✓ a
- ✓ $t \leftarrow \Delta t$
- ✓ v_i
- ✓ v_f
- ✓ Δx

2 equations

5 unknowns

→ You have to tell me 3 of the unknowns!

→ I'll solve for the other two!

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v_i
x

$$\Delta x = v_f t - \frac{1}{2} a t^2 \quad (3)$$

a
x

$$\Delta x = \left(\frac{v_f + v_i}{2} \right) t \quad (4)$$

t
x

$$v_f^2 = v_i^2 + 2a\Delta x \quad (5)$$

$$\Delta t = t_f - \cancel{t_i}^{\,0}$$

$\Delta t = t_f = t$

① identify the 3 things that you are given.

② Find an equation that has those three things, plus one other. Solve for it.

③ Solve for the ~~fifth~~ thing

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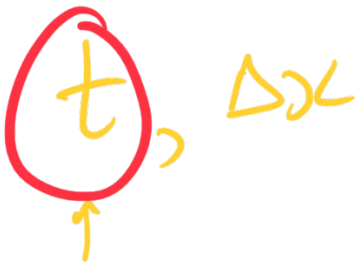
8 a) 1st sentence ✓ $a = 1.55$ m/s

2nd sentence ✓ $v_f = 80$ km/hr

$= 22.2$ m/s

Clause "rest" ✓ $v_i = 0$ m/s



$$V_f = V_i + at$$

$$t = \frac{V_f - V_i}{a}$$

$$= \frac{22.2\ m/s - 0\ m/s}{1.55\ m/s^2}$$

$$\boxed{t = 14.3\ s}$$

(b) $a = -1.55\ m/s^2$

$V_i = 22.2\ m/s$

$V_f = 0$

$t = ?$

$$t = \frac{v_f - v_i}{a} = \frac{0 - 22.2}{-1.55}$$

$$= 14.3 \text{ s}$$

c)

v_i	$= 22.2$ m/s
v_f	$= 0$ m/s
t	$= 8.3$ s
a	$= ?$

$$a = \frac{v_f - v_i}{t} = \frac{0 - 22.}{8.3}$$

10/10 :) ✓

$a = -2.67\ m/s^2$ ↑

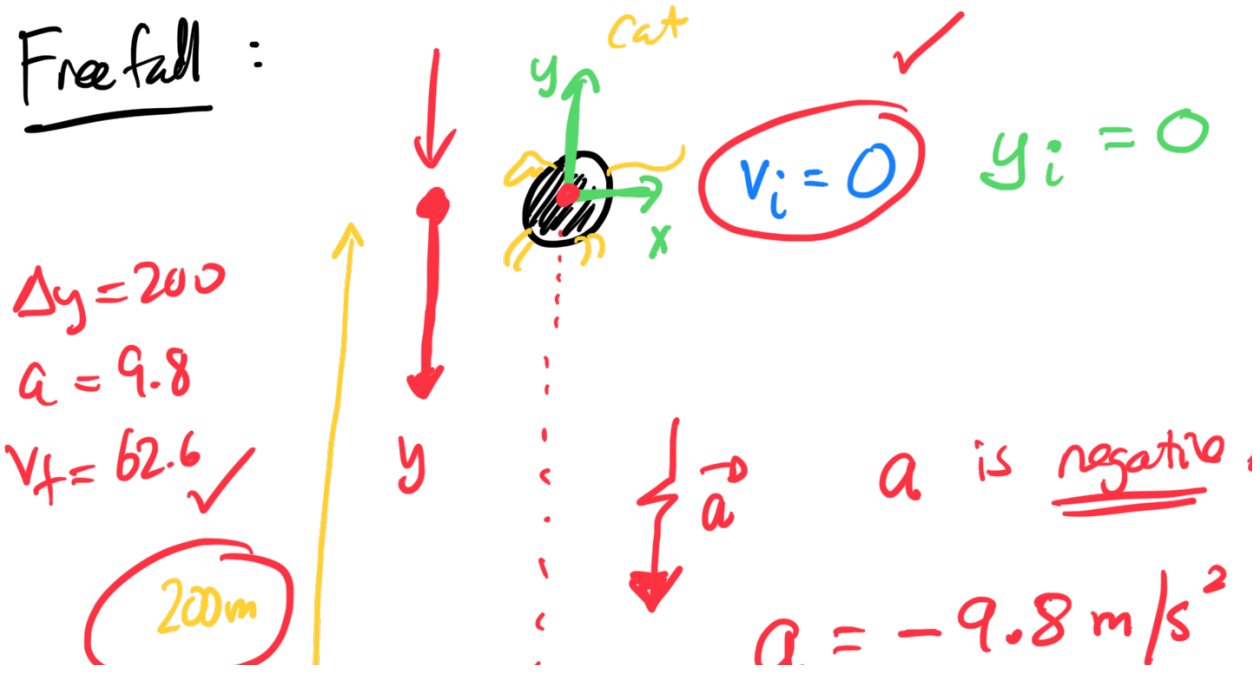
Slowing down.

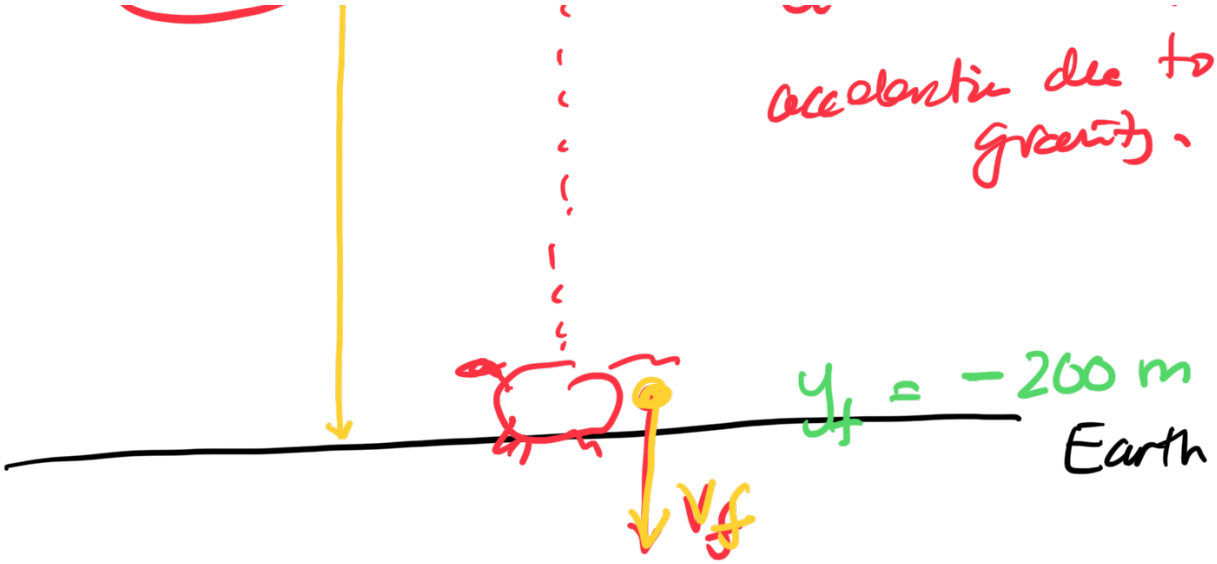
if @ $= -2.68\ m/s^2$

then rate of deceleration is 2.68

difference → 1%

Freefall :





Coordinate Systems

→ Make a choice, and then follow it.

$$\Delta y = y_f - y_i = -200 - 0$$

1. $\Delta y = -200$ m
2. $a = -9.8\ m/s^2$
3. $v_i = 0$
4. ?

v_f =

J

$$v_f^2 = \cancel{v_i^2}^{0} + 2a\Delta y$$

$$v_f^2 = 2(-9.8)(-200)$$

$$v_f^2 = 3920 \qquad v_f = \pm\sqrt{3920}$$

$$\boxed{v_f = -62.6 \text{ m/s}}$$

(~ 130 mph