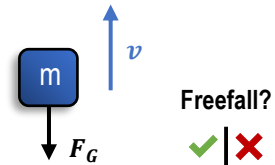
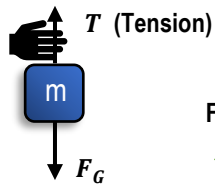
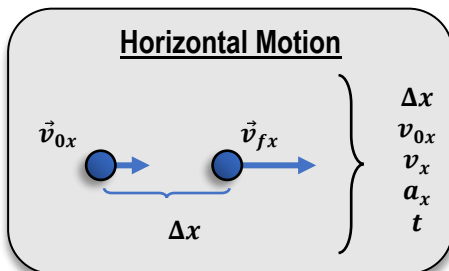


## CONCEPT: INTRO TO VERTICAL MOTION & FREE FALL

- Objects are in **free fall** if the only force acting on them is \_\_\_\_\_ ( $F_G$ ), even if they're moving *upwards*.

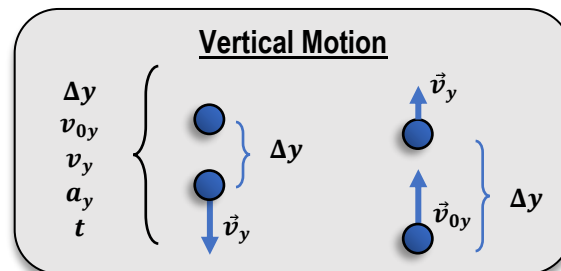


- Objects in **free fall** experience \_\_\_\_\_, so we use **UAM Equations** to solve problems.



### Horizontal UAM Equations

- |                                                          |
|----------------------------------------------------------|
| (1) $v_x = v_{0x} + a_x t$                               |
| (2) $v_x^2 = v_{0x}^2 + 2a_x \Delta x$                   |
| (3) $\Delta x = v_{0x} t + \frac{1}{2} a_x t^2$          |
| (4) $\Delta x = \left( \frac{v_{0x} + v_x}{2} \right) t$ |



### Vertical UAM Equations

- |                                                          |
|----------------------------------------------------------|
| (1) $v_y = v_{0y} + a_y t$                               |
| (2) $v_y^2 = v_{0y}^2 + 2a_y \Delta y$                   |
| (3) $\Delta y = v_{0y} t + \frac{1}{2} a_y t^2$          |
| (4) $\Delta y = \left( \frac{v_{0y} + v_y}{2} \right) t$ |

- Objects in free fall always **accelerate** down with free fall acceleration ( $g$ )

**$g$  (on Earth) always =  $9.8 \text{ m/s}^2$**  → (Regardless of weight!)

**$a_y = \pm g = \underline{\quad} 9.8 \text{ m/s}^2$**

**EXAMPLE:** You drop a ball from rest from a 100 m-tall building. Calculate the ball's velocity right before hitting the ground.

### MOTION w/ ACCELERATION

- 1) Draw Diagram & list 5 variables
- 2) Identify known & target variables
- 3) Pick UAM Eq. **without** "Ignored" Variable
- 4) Solve

- PRO-TIP:** If you always take the UP direction as **positive**, then  $a_y = -g = -9.8 \frac{\text{m}}{\text{s}^2}$

PRACTICE: A rock is thrown upward with a speed of 27.0 m/s from the roof of a 31.0-m-tall building. The rock doesn't hit the building on its way back down and lands in the street below. **(a)** What is the speed of the rock just before it hits the street? **(b)** How much time elapses from when the rock is thrown until it hits the street?

#### MOTION w/ ACCELERATION

- 1) Draw Diagram & list 5 variables
- 2) Identify known & target variables
- 3) Pick UAM Eq. *without* "Ignored" Variable
- 4) Solve

#### Vertical UAM Equations

$$(1) v_y = v_{0y} + a_y t$$

$$(2) v_y^2 = v_{0y}^2 + 2a_y \Delta y$$

$$(3) \Delta y = v_{0y} t + \frac{1}{2} a_y t^2$$

$$(4) \Delta y = \left( \frac{v_{0y} + v_y}{2} \right) t$$

PRACTICE: A student throws a set of keys vertically upward to her sorority sister who is in a window 14.00 m above. The second student catches the keys 1.50 s later. **(a)** With what initial velocity were the keys thrown? **(b)** What was the velocity of the keys just before they were caught?

#### MOTION w/ ACCELERATION

- 1) Draw Diagram & list 5 variables
- 2) Identify known & target variables
- 3) Pick UAM Eq. *without* "Ignored" Variable
- 4) Solve

#### Vertical UAM Equations

$$(1) v_y = v_{0y} + a_y t$$

$$(2) v_y^2 = v_{0y}^2 + 2a_y \Delta y$$

$$(3) \Delta y = v_{0y} t + \frac{1}{2} a_y t^2$$

$$(4) \Delta y = \left( \frac{v_{0y} + v_y}{2} \right) t$$