Velocity with Average Acceleration

- If an object's **average acceleration** during a time interval is known, the **change in velocity** during that time can be found.
  - The definition of **average acceleration**:

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{\Delta t}$$

  - Solving for final velocity v_f:

$$v_f = v_i + \bar{a}\Delta t$$

Velocity with Average Acceleration

- In cases in which the **acceleration** is constant, the **average acceleration, ā**, is the same as the **instantaneous acceleration, a**. The equation for final velocity can be rearranged to find the time at which an object with **constant acceleration** has a given velocity.

$$v_f = v_i + at$$

Displacement with Constant Acceleration

- Recall that for an object moving at a constant velocity, displacement is equal to average velocity times the time interval.

$$d = \bar{v}t$$

- For an object that is changing velocity and uniformly accelerating, the average velocity can be written

$$\bar{v} = \frac{v_f + v_i}{2}$$

- Combining the two:

$$d = \frac{v_f + v_i}{2} t$$

Displacement with Constant Acceleration

- If the v_i, a and Δt are known, the displacement can be found by combining….

$$v_f = v_i + at \qquad d = \frac{v_f + v_i}{2} t$$

- Substituting the equation for v_f into the the 2nd equation results in

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

Displacement with Constant Acceleration

- Solve this equation ($v_f = v_i + at$) for time….

$$t = \frac{v_f - v_i}{a}$$

- Substituting the equation for "*t*" into $d = \frac{v_f + v_i}{2} t$ results in

$$v_f^2 = v_i^2 + 2ad$$

- This is known as the "*timeless equation*"

The Fab Four

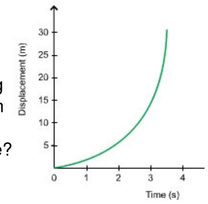
$$d = \frac{v_f + v_i}{2} t$$

$$v_f = v_i + at$$

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

$$v_f^2 = v_i^2 + 2ad$$

Section Check



- A position-time graph of a bike moving with constant acceleration is shown on the right. Which statement is correct regarding the displacement of the bike?

A. The displacement in equal time interval is constant.

B. The displacement in equal time interval progressively increases.

C. The displacement in equal time interval progressively decreases.

D. The displacement in equal time interval first increases, then after reaching a particular point it decreases.

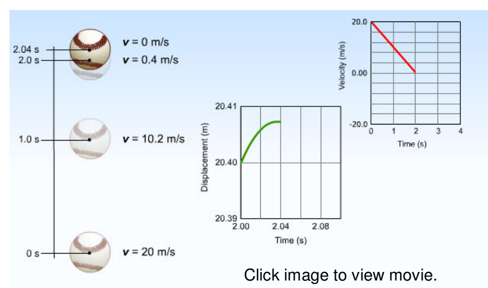
Acceleration Due to Gravity

- Galileo concluded:
  - neglecting the effect of the air, all objects in **free fall** had the same acceleration.
  - It didn't matter what they were made of, how much they weighed, what height they were dropped from, or whether they were dropped or thrown.
- The acceleration of falling objects, given a special symbol, ***g***, is equal to ***9.80 m/s²***.
- The acceleration due to gravity is the acceleration of an object in **free fall** that results from the influence of Earth's gravity.

What is ***free fall***?

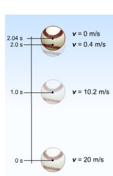
- Free Fall is the motion of the body when **<u>air resistance is negligible</u>** and the action can be considered **<u>due to gravity alone</u>**.

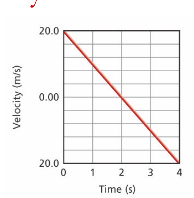
Acceleration Due to Gravity

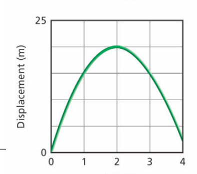


Acceleration Due to Gravity

- At the top of the flight, the ball's velocity is 0 m/s.
- What would happen if its acceleration were also zero?







Acceleration Due to Gravity

- At the top of the flight, the ball's velocity is 0 m/s.
- What would happen if its acceleration were also zero?
  - Then, the ball's velocity would <u>not be changing</u> and would remain at 0 m/s.
  - If this were the case, the ball would not gain any downward velocity and would simply hover in the air at the top of its flight.