Velocity and Acceleration

Frame of Reference

- **Frame of Reference** – how you determine the position. We
- Our Reference:
  - Positive, (+) Moving
  - Negative, (-) Moving
  - If you are not sure of the direction, use
  - Choose your starting position as Zero (0), unless
- **Scalar Quantity** -
  - Magnitude -
  - Direction does
  - Mass, temperature, and
- **Vector Quantity** –
  - Magnitude AND
  - How much and
  - Velocity, force and
  - Use "vector diagrams" to
  - The arrow shows the
  - Length of arrow is proportional to the
  - High velocity to the
  - Low velocity to the
- **Position** – your location using the frame of reference. Ships use
  - Symbol is
  - Vector quantity –
  - I am located
- **Displacement** – change in
  - "How far out of
  - Symbol is
  -
  - Vector Quantity:
  - Units include m
  - You travel 10 km East
  - Displacement = zero (0) when you return to the original
  - You travel 10 km East, stop and then turn around and travel 10 km West.

    10 km East

    10 km West

    Displacement =
  - You travel 10 km East, stop and then turn around and travel 15 km West.

    10 km East

    15 km West

    Displacement =
- **Distance**
  - How far you
  -

- Magnitude
- I drove 20 km today.
- 10 km East
  10 km West
  Distance Traveled =
- 10 km East
  15 km West
  Distance Traveled =

- **<u>Time</u>**
  - Clock
  - Scalar
  - Symbol is
  - Units include
- **<u>Time Interval</u>**
  - Elapsed time,
  - Symbol
  - Scalar
  -
  - Units include

Velocity

- Motion –
- ***<u>Average Velocity</u>***
  - Rate of
  -
  -
  -
  - *<u>Vector Quantity</u>* –
    - We will use positive
  -
  -
  -
  -
  - Average velocity does *not indicate* what happens during the *time interval*. You could have
- Instantaneous velocity – the velocity at any given
  - ***<u>Average velocity IS NOT the average of all the instantaneous velocities. Time</u>***
- Constant velocity - all the instantaneous

- Only true judgment of velocity is a
- Overall Velocity
  - Moving Sidewalk +3m/s
    You walk on it +1 m/s
    Overall velocity +4m/s
  - Moving sidewalk +3m/s
    You walk backwards -1m/s
    Overall velocity +2m/s
- Speed – scalar quantity, distance traveled over

Acceleration

- ***Average Acceleration***
  - Rate of change
  - You are accelerating when your body
  - Toughest time to walk on the bus?
    When
  - Average acceleration =
  - v_f = final velocity
    v_i = initial velocity
  - Units :
  - NOT!!
  - Vector Quantity –
  - If you are moving right or
    - Speeding Up :
    - Slowing Down :
    - This is
  - If you are moving left
    - Speeding Up :
    - Slowing Down :
  - If you do not know direction
    - Speeding Up :
    - Slowing Down :
- Just remember :
  - The direction of the acceleration vector depends on :
    - Whether the object is
    - Whether the object is moving in the
  - Rule of Thumb –
    - *If an object is slowing down, then its acceleration is in the*

- If you are moving from rest
  -
- If you are coming to a stop
  -
- If you are moving at constant velocity
  -
- If you are not moving :
  - *Acceleration is not*

1. 0.30 s after seeing a puff of smoke rise from the starter's pistol, the sound of the firing pistol is heard by the track timer 100.0 m away. What is the velocity of sound?

2. The tire radius on a particular vehicle is 0.62 m. If the tires are rotating 5 times per second, what is the velocity of the vehicle?

3. A bullet is fired with a speed of 720.0 m/s. What time is required for the bullet to strike a target 324 m away? What is the velocity in km/hr?

4. Light travels at 3.0×10^8 m/s. How many seconds go by from the moment the starter's pistol is shot until the smoke is seen by the track timer 100.0 m away?

5. You drive your car from home at an average velocity of 82 km/hr for 3.0 hours. Halfway to your destination, you develop some engine problems and for 5.0 hours you nurse the car the rest of the way. What is your average velocity for the entire trip?

6. From the moment a 40.0 m/s fast ball touches the catcher's mitt until it is completely stopped takes 0.012 seconds. Calculate the average acceleration of the ball as it is being caught.

7. Top-fuel drag racers are able to uniformly accelerate at 12.50 m/s^2 from rest to 100.0 m/s before crossing the finish line. How much time elapses during the run?

8. A race car accelerates from rest at 7.5 m/s^2 for 4.5 seconds. How fast will it be going at the end of that time?

9. You head downstream on a river in an outboard. The current if flowing at a rate of 1.50 m/s. After 30.0 min, you find that you have traveled 24.3 km. How long will it take you to travel back up stream to your original point of departure?

Position and Velocity Graphs

Position-Time Graphs

(you will be drawing 2 graphs)

- Position Time Graphs –
  - Slope =
  - Instantaneous Velocity = Slope of the
  - If there is ***no velocity***, all the instantaneous velocities are zero, the line is
  - If there is ***constant velocity***, all the instantaneous velocities are equal, and the line is
  - If there is ***constant acceleration***, the instantaneous velocities are increasing
  - To determine the ***instantaneous velocity***, take the slope
  - +Slope =
  - -Slope =
- Do not take the position and divide it by the time to determine the
- You must use the slope of the line or the

Velocity-Time Graphs

(draw 2 graphs)

- Constant Positive Velocity (moving right at a
- Constant Negative Velocity (moving left at a
- Positive Velocity (+v) and speeding up (+a) :
- Positive velocity (+v) and slowing down (-a)

- Negative velocity (-v) and speeding up (-a) :
- Negative velocity (-v) and slowing down (+a)

- Velocity-Time Graphs
  - Slope =

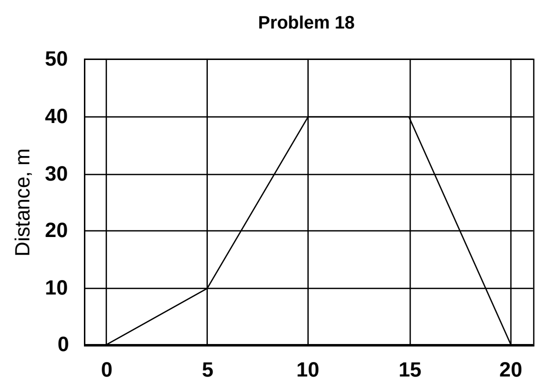
- Slope =

- If there is no acceleration, there is constant velocity, the line is

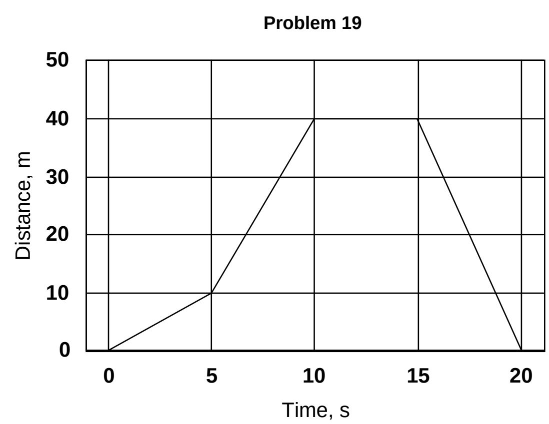
- If there is uniform acceleration (accelerating at a constant rate), the line is an
- Positive acceleration (+a) means :
  - Speeding up if going
  - Slowing down if
- Negative acceleration (-a) means :
  - Slowing down if going
  - Speeding up if going

- Area under the "curve" is the
  - ½ base•height for
  - base•height for

18. Use the following position-time graph to find how far the object travels between:
    a. 0 s to 5 s
    b. 5 s to 10 s
    c. 10 s to 15 s
    d. 15 s to 20 s
    e. 0 s to 20 s



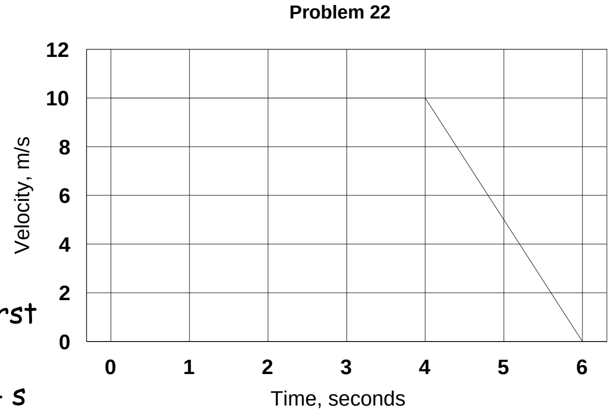
19. Use the following position time graph to find the object's velocity between
    a. 0 s to 5 s
    b. 5 s to 10 s
    c. 10 s to 15 s
    d. 15 s to 20 s



20. Two cars are headed in the same direction, the one traveling 60 km/hr is 20 km ahead of the other traveling 80 km/hr.
    a. Draw a position-time graph showing the motion of the cars.
    b. Use your graph to find the time when the faster car overtakes the slower one.

21. Sarah jogs for 15 min at 240 m/min, walks the next 10 min at 90 m/min, rests for 5 min, and jogs back to where she started at -180 m/min.
    a. Plot a velocity-time graph for Sarah's exercise run.
    b. Find the area under the curve for the first 15 min. What does this represent?
    c. What is the total distance traveled by Sarah?
    d. What is Sarah's displacement from start to finish?

22. The following velocity-time graph describes a familiar motion of a car traveling during rush-hour traffic.
   a. Describe the car's motion from t = 0 s to t = 4 s.
   b. Describe the car's motion from t = 4 s to t = 6 s.
   c. What is the average acceleration for the first 4 s?
   d. What is the average acceleration from t = 4 s to t = 6 s?



Uniform Acceleration

- ***Uniform Acceleration*** – constant acceleration, the velocity changes at uniform or constant rate. All the
  - You are speeding up or
  - Position Time and Velocity Time Graphs:

- If you are moving at constant velocity, you are not accelerating and the following
- Constant velocity means
- If you are going at constant velocity, just use the
- If you are accelerating : use the following formulas!
- So for uniform acceleration (not constant velocity):
-
-
-
-
-
-

- Galileo (1564 – 1642) was the first to really understand acceleration!

Freefall

Acceleration Due to Gravity

- Galileo did many experiments and proved that if you
  - All objects fall to the earth with
  - Mass of the object
  - Distance above the ground
  - Objects accelerate at
  - This varies slightly because of the distance
- Objects dropped will
- Objects thrown up will
- Gravity causes objects to
- Gravity is the attractive force
- When objects are falling, the only force on them is gravity,
- Objects in freefall feel "weightless" because the

Frame of Reference

- Ground level is the reference.

- Acceleration due to gravity :
- Use $a = g = 9.81 \text{ m/s}^2$ any time an object is
- Assume NO air

- Use the same formulas except use

23. A camera is accidentally dropped from the edge of a cliff and 6.0 s later hits the bottom.
    a. How fast was it going just before it hit?
    b. How high is the cliff?

24. A parachutist descending at a speed of 10.0 m/s loses his cell phone at an altitude of 50.0 m.
    a. What is the velocity of the phone just before it hits the ground?
    b. When does the phone reach the ground?

25. A rock is thrown vertically with a velocity of 21 m/s from the edge of a bridge 42 m above the river. How long does the rock stay in the air?

26. A platform diver jumps vertically with a velocity of 4.2 m/s. The diver enters the water 2.5 s later. How high is the platform above the water?

27. A model rocket is launched straight upward with an initial velocity of 50.0 m/s. It accelerates with a constant upward acceleration of 2.0 m/s^2 until its engines stop at an altitude of 150 m.
   a. What is the maximum height reached by the rocket?
   b. When does the rocket reach maximum height?
   c. How long is the rocket in the air?