DESCRIBING MOTION

PES 1000 – PHYSICS IN EVERYDAY LIFE

MOTION IN ONE DIRECTION

- If an object can only move along a line, this is called one-dimensional motion (motion in one direction).
- We can use the sign of a numbered value to indicate direction along this line.
  - We choose one direction along the line and call that positive.
  - Negative is in the opposite chosen direction.

DISTANCE & POSITION

- Distance: the length of a straight- or curved- path from one point to another
  - Distance (or distance travelled) is a scalar value
  - Variable used: *d* or *l* or *s* or *x*
  - SI Units: meters (m)
  - US Customary Units: feet (ft)
- Position: the straight-line distance between two points AND the direction from the first to the second
  - Position is the vector version of distance
  - Variable used: $\vec{r}$
  - Units: meters or feet
  - Direction: compass direction (north east), angles (30 degrees to the left) or one of many other ways

SPEED & VELOCITY

- Speed: the rate that distance is changing with time
  - Speed is a scalar value
  - Variable used: v
  - SI Units: meters per second (m/s)
  - US Customary Units: feet per second (ft/s)
- Velocity: the rate that position is changing with time
  - Velocity is the vector version of speed
  - Variable used: $\vec{v}$
  - Units: m/s or ft/s
  - Direction: compass directions, angles, etc.

RELATIONSHIP BETWEEN AVERAGE SPEED AND DISTANCE

- If you're interested in how average speed and distance are related, here are the equations the relate them:
- Speed is defined as (change in distance) / (change in time)
- "Change in …" is found by taking the final value (x or t) and subtracting the original value (x_o or t_o)
  - So speed $v = \frac{x - x_o}{t - 0}$
- Re-arrange this to find out what distance (x) is at any time:
  - $x = x_o + v * t$ or, in words, distance travelled (x) depends on where you start (x_o), how fast you go (v), and how long you travel (t)
- This is the familiar 'travel equation': distance travelled = (average speed) * (travel time)

CAR EXAMPLE

- Say that a car is traveling in a straight line at an average speed of 60 mph for 3 hours.
  - Total distance traveled is (60 mph) * (3 h) = 180 miles
  - Every hour, the car travels the same distance (60 miles)
- If we include direction, then the car's velocity is 60 mph to the right. Its position at the end is 180 miles to the right.

ACCELERATION

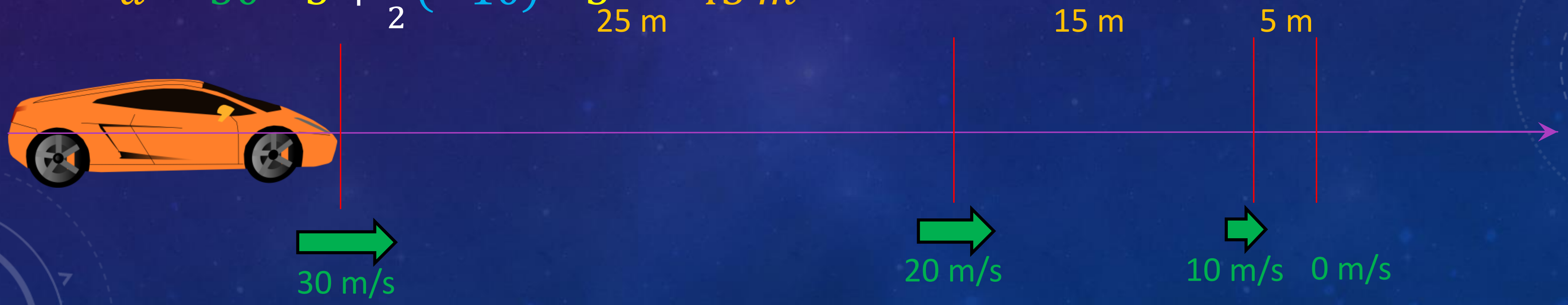
- Acceleration: the rate that speed is changing with time
  - The same word is used for both the scalar and vector versions. Acceleration in this context is a scalar value.
  - Variable used: a
  - SI Units: meters per second per second (m/s/s or m/s^2)
  - US Customary Units: feet per second per second (ft/s/s or ft/s^2)
- Acceleration: the rate that velocity is changing with time
  - Acceleration in this context is a vector value.
  - Variable used: $\vec{a}$
  - Units: m/s^2 or ft/s^2
  - Direction: compass directions, angles, etc.

RELATIONSHIP BETWEEN SPEED, DISTANCE, AND ACCELERATION

- If you're interested in how speed, distance, and constant acceleration are related, here are the equations the relate them:
- Acceleration is defined as (change in speed) / (change in time)
  - So acceleration, $a = \frac{v - v_o}{t - 0}$
- Combine this with the distance and average speed equation to find distance travelled (d) after some time:
  - $d = v_o * t + \frac{1}{2} a * t^2$ or, in words, distance travelled (d) depends on how fast you were going initially (v_o), your acceleration (a), and how long you accelerate (t)
- Don't forget that direction is indicated by sign, so that if you decelerate, a is a negative number

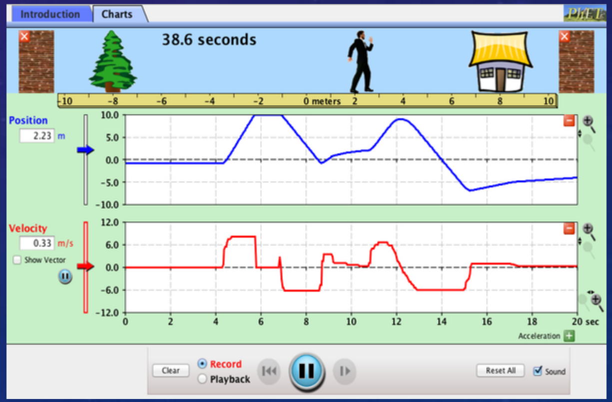
CAR EXAMPLE

- Say that a car is traveling in a straight line at an initial speed of 30 m/s. The driver hits the brakes and decelerates to a stop at 10 m/s^2 for 3 seconds.
  - The speed decreases by 10 m/s each second.
  - The car travels a gradually decreasing distance every second.
  - What total distance did the car travel in those 3 seconds?
  - $d = 30 * 3 + \frac{1}{2}(-10) * 3^2 = 45\ m$



'MOVING MAN' SIMULATION

- The 'Moving Man' simulation lets you experiment with the relationships between the quantities of position, velocity, and acceleration
- It can be found here: https://phet.colorado.edu/en/simulation/legacy/moving-man
- Let's play with the simulation:



- (You may need to install Java script in your browser: https://java.com/en/download/)

CONCLUSION

- Motion in one dimension can be described using these terms:
  - Distance travelled (a scalar value) or position (a vector value)
  - Speed (scalar) or velocity (vector), which measures distance/position changes with time.
  - Acceleration (scalar or vector), which measures speed/velocity changes with time.
- In the special case of constant speed (no acceleration) we can use the travel equation:
  - Distance = speed * time
- In the special case of constant acceleration, we observe the following:
  - Speed changes by the *same amount* every second.
  - Distance travelled changes by a gradually *increasing* (or *decreasing*) amount every second.