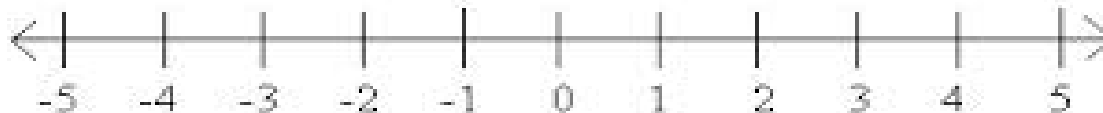


# Momentum

- Momentum,  $p$ , is the product of mass and velocity.
- $p=mv$
- Recall that velocity is a measure of an object's speed, indicating direction
- Often, positive and negative numbers are used to indicate direction:



# Conservation Laws

- Mass cannot be created or destroyed
- Energy can only be transferred from one type to another
- The total charges (positive and negative) within a system must be constant.
- Momentum before and after a collision must be the same

# Calculating momentum

- What is the momentum of a 5 kg cat walking at a speed of 4 m/s to the right?
- Right is usually defined as “positive”
- $p=mv$
- $p=(5 \text{ kg})(+4 \text{ m/s}) = 20 \text{ kg m/s}$

# Calculating momentum

- What is the momentum of a 16 kg dog walking at a speed of 3 m/s to the left?
- Left is usually defined as “negative”
- $p=mv$
- $p=(16 \text{ kg})(-3 \text{ m/s}) = -48 \text{ kg m/s}$

# Calculating momentum

- What is the total momentum of two 400 kg cars that are initially moving at each other at 15.0 m/s? What is it after they come to rest when they collide with each other?
- Before:
  - Car A =  $(400)(15.0) = 60000$  kg m/s
  - Car B =  $(400)(-15.0) = -60000$  kg m/s; total = 0!
- After colliding, since they are both at rest (velocity = 0), their total momentum is again 0!