Welcome to Physics First I Cycle 2 Lesson 2

OBJECTIVE: Define and calculate acceleration, and relate acceleration to force and mass using Newton's Second Law.

VOCAB: *acceleration, deceleration, Newton's Second Law*

CLASSWORK:

Section 2.2 "Understanding Vocabulary" (p. 54 #6-7)

Section 2.2 "Reviewing Concepts" (p. 54 #6,8,9,10)

Section 2.2 "Solving Problems" (p. 55 #4, #5, #7 (a,b,c))

Acceleration

- **Acceleration is the rate at which speed increases**

Time	Speed
0 (start)	0 (start)
1 second	1 km/h
2 seconds	2 km/h
3 seconds	3 km/h
4 seconds	4 km/h
5 seconds	5 km/h

Time	Speed
0 (start)	0 (start)
1 second	2 km/h
2 seconds	4 km/h
3 seconds	6 km/h
4 seconds	8 km/h
5 seconds	10 km/h

- This cyclist is coasting his bike down 2 hills. His speed increases as he goes down each. Which hill gives him a higher **acceleration**?

Calculating Acceleration

- The cyclist starts with a speed of 0 km/hr
- 5 seconds later, the cyclist has a speed of 10 km/hr
- Acceleration is the **change in speed** divided by the **time interval**

Time	Speed
0 (start)	0 (start)
1 second	2 km/h
2 seconds	4 km/h
3 seconds	6 km/h
4 seconds	8 km/h
5 seconds	10 km/h

- The change in speed is (10 km/hr – 0 km/hr) = 10 km/hr
- The time interval is 5 seconds.
- We can express the cyclist's acceleration as

$$\frac{2\ \text{km}}{\text{hr*sec}}$$

Units of Acceleration

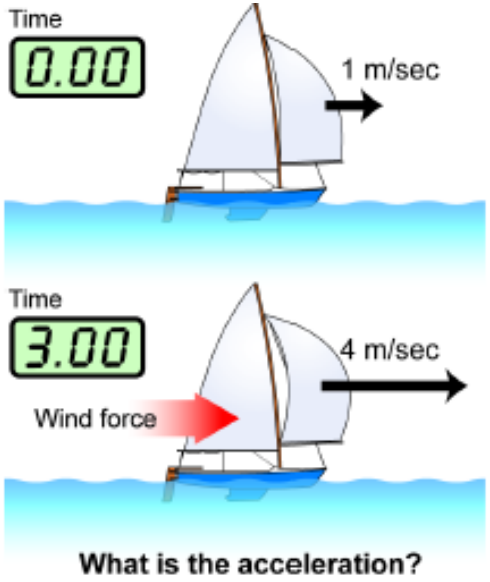
- Acceleration is in units of distance per time, per time!
- Do you see why? Because it's how speed changes with time, and speed is distance per time.
- The usual metric unit of acceleration is (m/sec)/sec, usually written as (m/sec^2). You should think of it mostly as 'meters per second per second' but people often say 'meters per second squared'.
- The cyclist acceleration was = $\frac{2\ km}{hr*sec}$ (these units are ugly!)
- Convert 2 km/(hr*sec) to m/sec^2. Hint: multiply by $\frac{1000\ m}{1\ km}$ and then by $\frac{1\ hr}{3600\ sec}$
- I get about 0.56 m/sec^2.

Formula for Acceleration

ACCELERATION

$$\text{Acceleration } (\text{m/sec}^2) \rightarrow a = \frac{v_2 - v_1}{t} \leftarrow \text{Time (sec)}$$

Change in speed (m/sec)



A sailboat catches a gust of wind. It was moving at 1 m/sec. After 3 seconds, it is now moving at 4 m/sec. What is the acceleration of the sailboat in m/sec^2?

$a = 1\ m/sec^2$

Calculating Acceleration: Your Turn

Calculate the acceleration of an airplane that starts at rest and reaches a speed of 45 m/sec in 9 seconds.

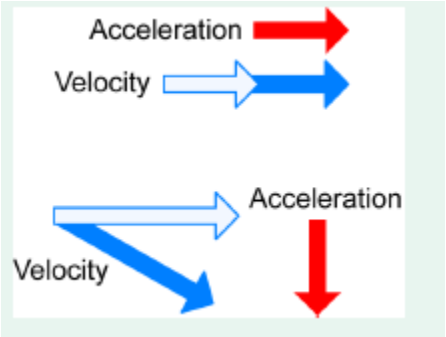
Answer: 5 m/sec^2

Calculate the acceleration of a car that slows from 50 m/sec to 30 m/sec in 10 seconds.

Answer: -2 m/sec^2

Weird, the acceleration is negative. Is that allowed? Sure! How does it feel to hit the gas in a car? To hit the brake? People sometimes use the word **deceleration** to describe a negative acceleration: an objects motion slowing down.

Does Acceleration always involve Changes in Speed?



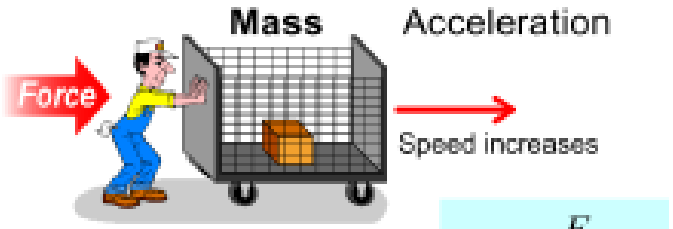
Imagine you are swinging an object tied to a string, in a circle. The direction of the object's motion is constantly changing, even if the speed is not.

Does this also involve **acceleration**? If so, must there also be a **force**?

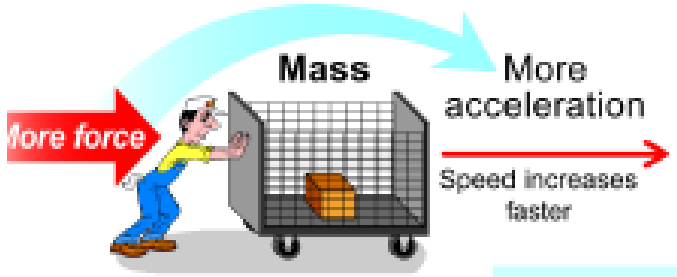
The answer is yes. We will learn more about this later in the course.

Newton's Second Law

•**Newton's Second Law** is "The stronger the net force on an object, the greater the acceleration. The larger the mass of the object, the smaller the acceleration"



$$a = \frac{F}{m}$$



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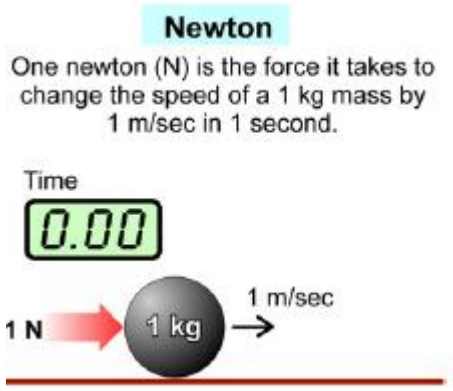
NEWTON'S SECOND LAW

$$\text{Acceleration } (\text{m/sec}^2) \rightarrow a = \frac{F}{m} \leftarrow \text{Force (N)} \quad \leftarrow \text{Mass (kg)}$$



•To use this formula, F should be in Newtons and mass should be in kilograms (not grams). Acceleration will be in m/sec^2.

•The units work out because a Newton is an abbreviation for a $kg*m/sec^2$. Use these units when you work examples.

Applying Newton's Second Law

- We always need to use **net force** when we use Newton's Second Law.
  - You are playing tug of war with a friend. You are pulling on your end of the rope with a force of 500 Newtons. Your friend is pulling with a force of 400 Newtons towards himself. The **net force** is 100 Newtons.
- If an object is accelerating, there must be a net force.
- If an object is not changing its speed or direction of motion, there must be zero net force.
- Remember that a newton is a shortcut to $\frac{\text{kilogram*meter}}{\text{sec}^2}$

What units do we usually use?

Use . . .	. . . if you want to find . . .	. . . and you know . . .
$a=F/m$	acceleration (a)	force (F) and mass (m)
$F=ma$	force (F)	acceleration (a) and mass (m)
$m=F/a$	mass (m)	acceleration (a) and force (F)

- Mass in
- Distance or position in
- Time in
- Speed in
- Acceleration in
- Force in

Let's Work some Problems

Use . . .	. . . if you want to find . . .	. . . and you know . . .
$a=F/m$	acceleration (a)	force (F) and mass (m)
$F=ma$	force (F)	acceleration (a) and mass (m)
$m=F/a$	mass (m)	acceleration (a) and force (F)

- What is the acceleration of a 1,500-kilogram car if a net force of 1,000 N is exerted on it? Answer:

- As you coast down the hill on your bicycle, you accelerate at 0.5 m/sec^2. If the total mass of your body and the bicycle is 80 kg, with what force is gravity pulling you down the hill? Answer:

- You push a grocery car with a force of 30 N and it accelerates at 2 m/sec^2. What is its mass? Answer: