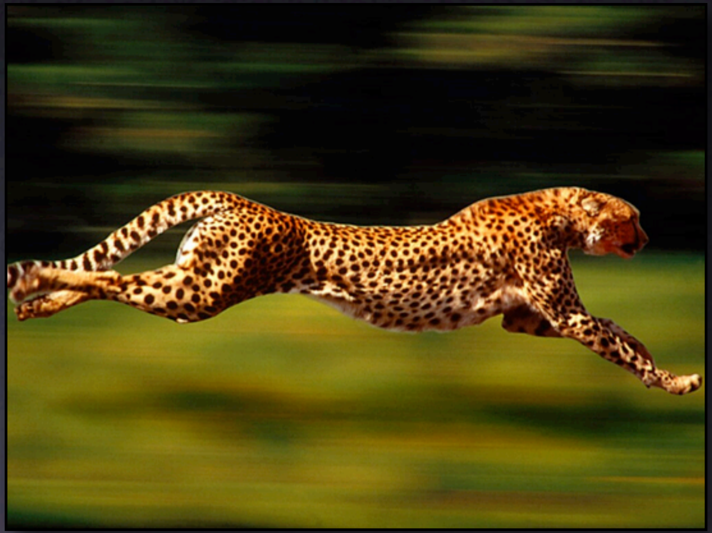
Motion



Physical Science
Sarasota High School

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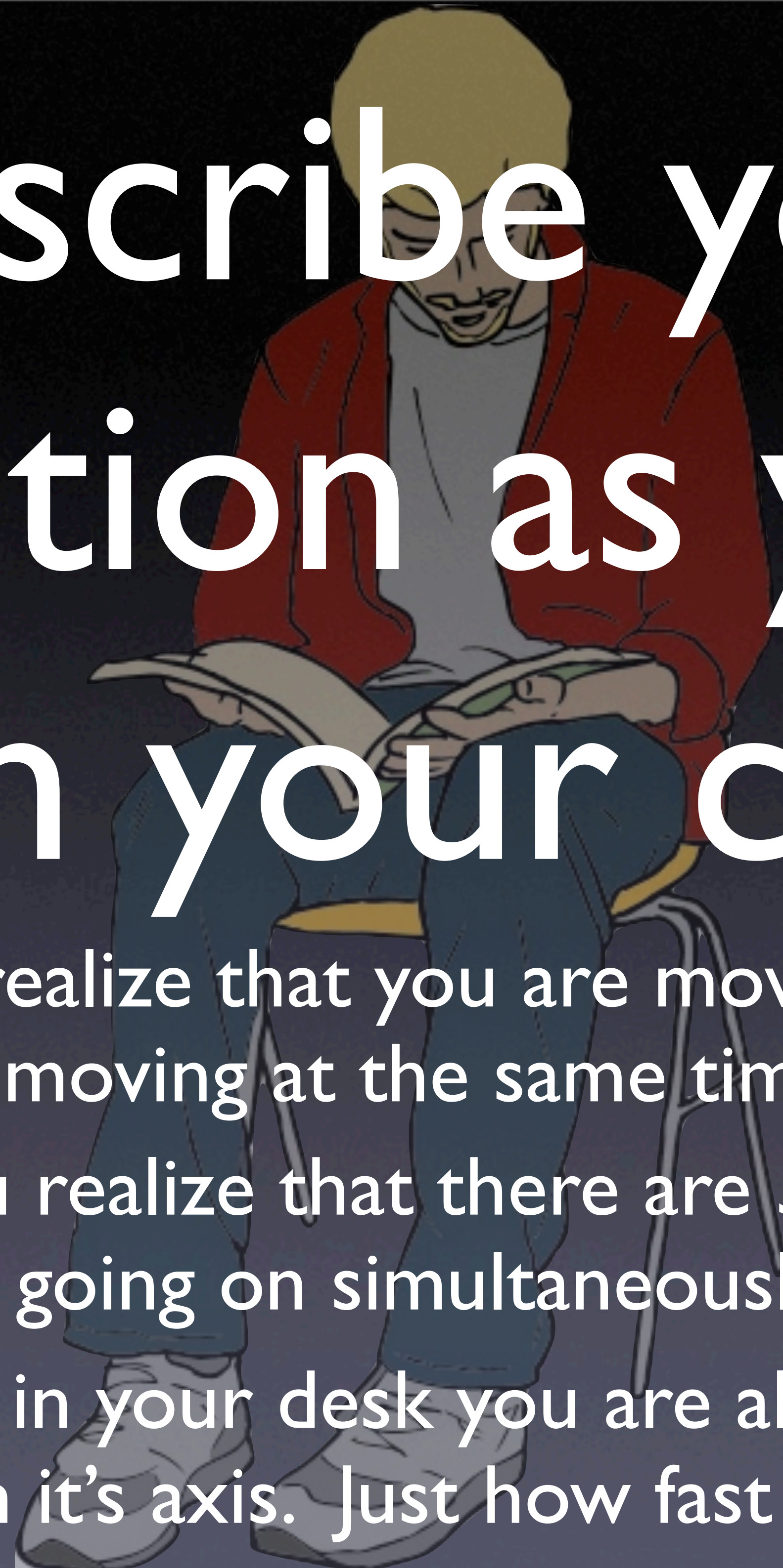
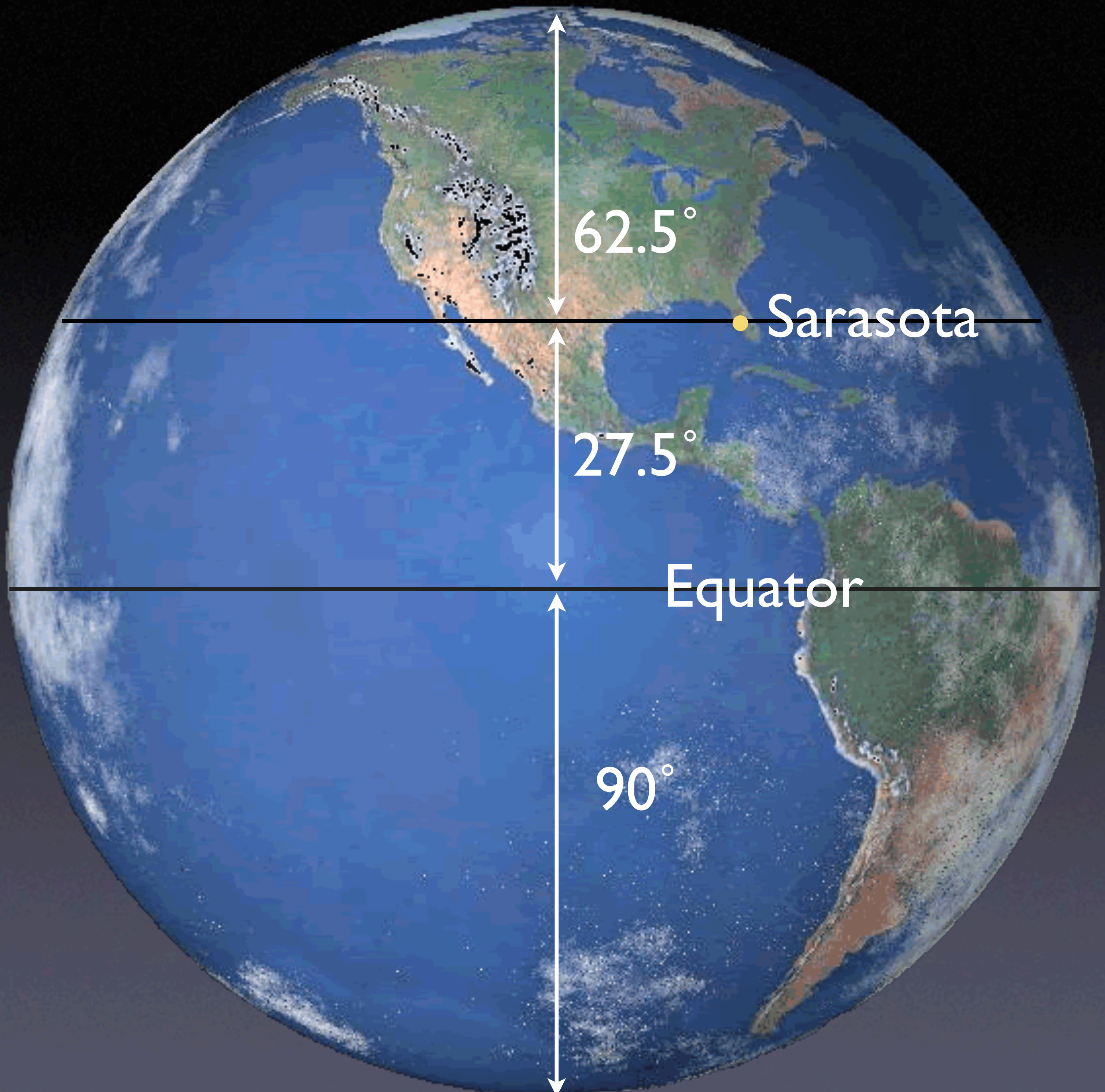


Describe your motion as you sit in your chair.

Do you realize that you are moving and not moving at the same time?

Do you realize that there are 5 motions going on simultaneously?

As you sit still in your desk you are also moving as the Earth spins on it’s axis. Just how fast are you moving?



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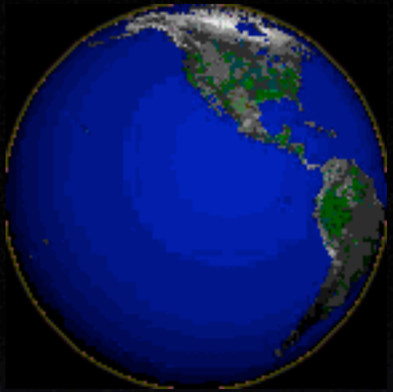
Speed at Sarasota as the Earth rotates on it's axis.



Speed at the Poles $= \frac{0 \text{ miles}}{24 \text{ hours}} = \frac{0 \text{ miles}}{\text{hour}}$

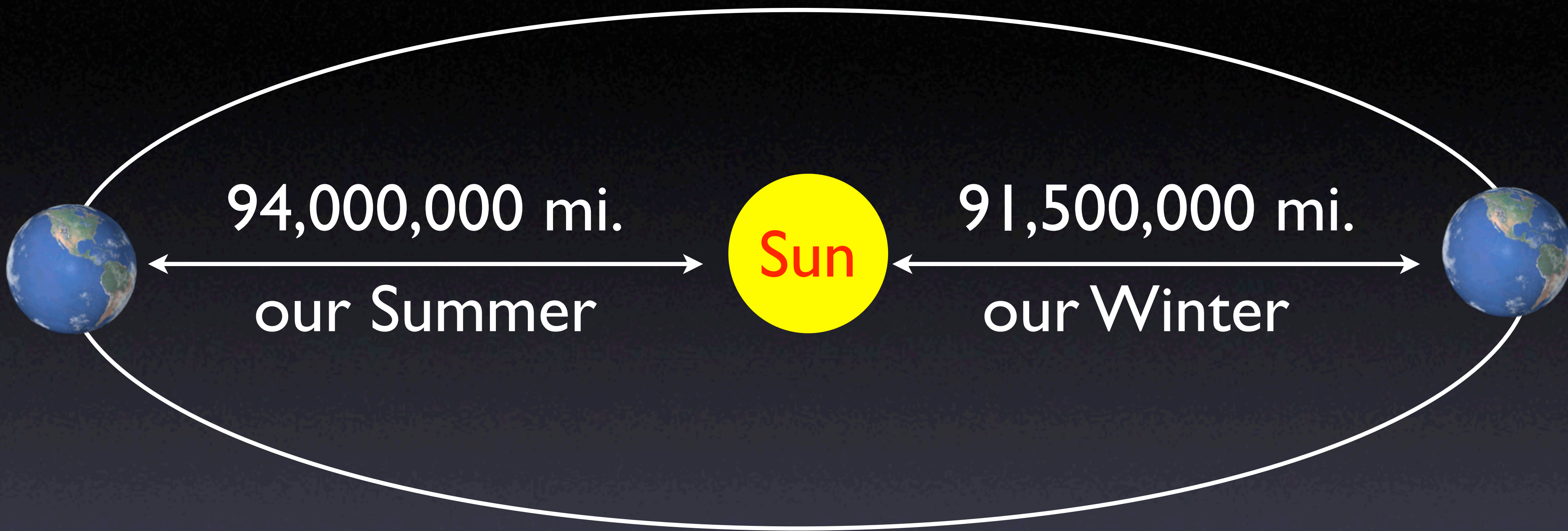
Speed at the Equator $= \frac{25{,}000 \text{ miles}}{24 \text{ hours}} = \frac{1042 \text{ miles}}{\text{hour}}$

Speed at Sarasota = cosine of latitude x speed at equator

cosine of 27.5 ° = 0.887

0.887 x 1042 mi/hr = 924 mi/hr

Speed of Earth's Revolution



Average Distance from Sun = 93,000,000 miles = Radius

Circumference of circle = $2\pi r$ = 2 x 3.14 x 93,000,000 mi.

Distance Earth travels in a year = 584,000,000 miles

$$\frac{584{,}000{,}000 \text{ miles}}{1 \text{ year}} \times \frac{1 \text{ year}}{365.25 \text{ days}} \times \frac{1 \text{ day}}{24 \text{ hrs.}} = 66{,}600 \text{ mi/hr}$$

- Earth Rotating around Sun

Motion is Relative

- To measure motion you must have a reference point that is not moving* to compare motion with.
- Motion can change if you change the reference point.
- If you are driving in a car, the road is moving.
  If you are standing on the road, the car is moving.
  Motion is relative!

What is your speed as you sit still in your chair?

Reference Point	Speed
The ground	0 mi./hr
In space above the Earth	920 mi/hr
Above our solar system	66,600 mi./hr
Above the Milky Way	558,000 mi/hr
Traveling thru space	660,000 mi/hr

Motion is relative!

Speed

- Speed is the amount of distance covered per unit of time.
- The formula for speed is: $\text{Speed} = \frac{\text{Distance}}{\text{Time}}$
- By rearranging the formula you can solve for time or distance.

  $\text{Time} = \frac{\text{Distance}}{\text{Speed}}$ $\text{Distance} = \text{Speed} \times \text{Time}$
- Speeds can be in mi/hr, km/hr, ft/s, m/s, cm/s... any unit of *distance* per unit of *time*.

The North American Eagle (39,000 HP) set the land speed record in 2002 by going 763 mi/hr. At this speed you travel 1 mile in 5 seconds.

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Converting units with DA

The speed of sound is 760 miles per hour.
Convert this speed to feet per second.

Step 1: Write the speed as a fraction.

Step 2: Use a conversion factor to convert miles to feet.

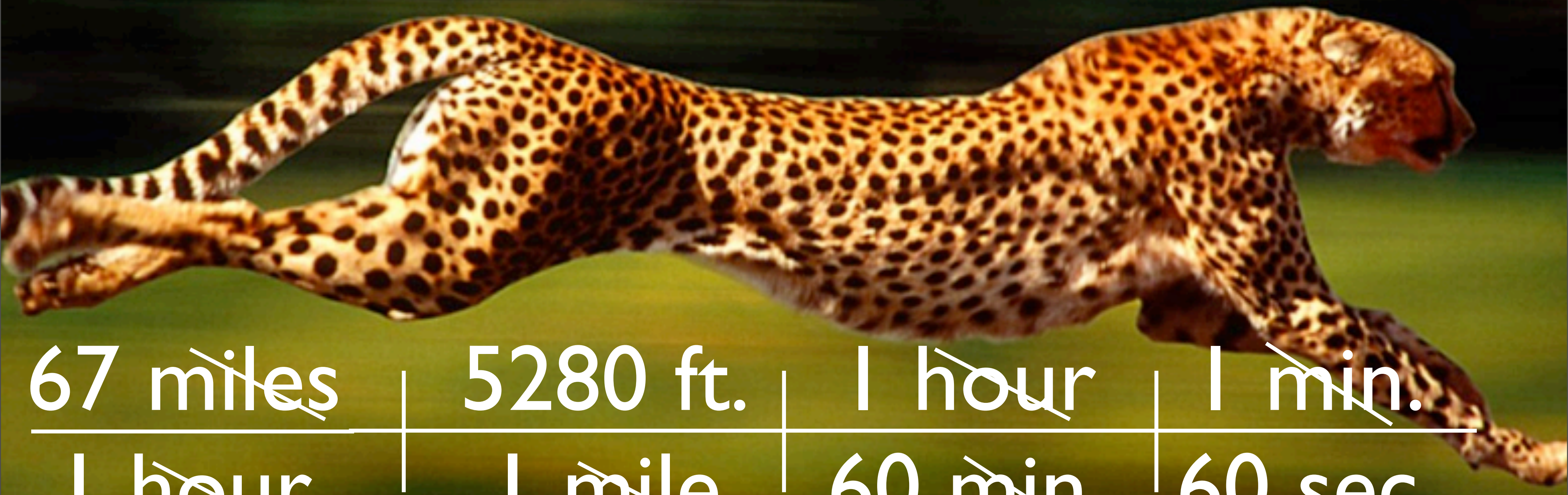
Step 3: Use a conversion factor to convert hrs to minutes.

Step 4: Use a conversion factor to convert min. to sec.

Step 5: Cancel units and multiply through.

$$\frac{760\ \cancel{\text{mi.}}}{1\ \cancel{\text{hr.}}} \cdot \frac{5280\ \text{ft.}}{1\ \cancel{\text{mile}}} \cdot \frac{1\ \cancel{\text{hr.}}}{60\ \cancel{\text{min.}}} \cdot \frac{1\ \cancel{\text{min}}}{60\ \text{sec.}} = 1{,}110\ \text{ft/sec.}$$

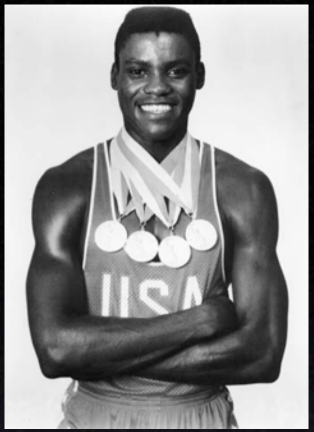
A cheetah, the fastest land animal, is capable of running 67 miles per hour. How many feet per second is this?



$$\frac{67\ \cancel{\text{miles}}}{1\ \cancel{\text{hour}}} \times \frac{5280\ \text{ft.}}{1\ \cancel{\text{mile}}} \times \frac{1\ \cancel{\text{hour}}}{60\ \cancel{\text{min.}}} \times \frac{1\ \cancel{\text{min.}}}{60\ \text{sec.}}$$

67 mi/hr = 98 ft/sec.

In 1988, Carl Lewis set an Olympic record by running **100.00 meters in 9.92 seconds.** Using 1.00 kilometer = 0.621 mile, calculate Carl Lewis' speed in mi/hr.



1. Write the given as a fraction.
2. Convert 100.00 m to km, then km to mi.
3. Convert 9.92 seconds to minutes, then minutes to hours.
4. Multiply through. Use sig figs in your answer.

$$\frac{100.00\ \cancel{m}}{9.92\ \cancel{s.}} \left| \frac{1\ \cancel{km}}{1{,}000\ \cancel{m}} \right| \frac{0.621\ mi}{1.00\ \cancel{km}} \left| \frac{60\ \cancel{s}}{1\ \cancel{min.}} \right| \frac{60\ \cancel{min}}{1\ hr} = \frac{22.3\ mi.}{hr}$$

A car drive 178 mi in 2 hours and 17 minutes? What was its speed?

17 ~~minutes~~	1 hour
1	60 ~~minutes~~

0.28 hr.

178 mi / 2.28 hours =
78.1 mi/hr

Velocity

- Velocity is speed in a certain direction.
- The formula is:

$$V = \frac{\text{distance}}{\text{time}} + \text{Direction}$$

- Velocity is important to ships, planes, rockets... where the direction you are traveling is just as important as speed you are going.
- Examples of velocity are:
  m/s East
  km/hr NorthEast
  mi/hr West

Acceleration

- Acceleration is a change (increase or decrease) in velocity over a period of time.
- To calculate acceleration you subtract the *initial* velocity from the *final* velocity and divide the difference by the time it took the change to occur.
- The formula is written as:

$$\frac{\text{Final Velocity - Original Velocity}}{\text{Time for change to occur}} \quad \text{or} \quad \frac{\Delta V}{t}$$

- A delta sign, Δ, means “a change in”.
- Examples of acceleration: m/s/s, km/hr/s, mi/hr/s...

Acceleration Problem

What is the acceleration of a car that accelerates from 40 mph to 70 mph in 3.6 seconds?

Step 1: Determine what formula you will use.

$$a = \frac{Vf - Vi}{t}$$

Step 2: Isolate your variables.

Vf = 70 mi./hr   Vi = 40 mi./hr   t = 3.6 sec.

Step 3: Plug in the values and solve.

70 mi./hr - 40 mi./hr = 30 mi./hr

30 mph / 3.6 sec = 8.3 miles/hr./sec.

Acceleration

A brainless skateboarder rolls down a ramp in 3.8 s.
then across a 33 meter road in 2.4 s.
At what rate did he accelerate down the ramp?

1. Draw a diagram to help you better understand the problem.

2. Write the formula for acceleration.

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

3. Solve for Vf. 33 m / 2.4 s = 14 m/s

4. Identify your variables: Vf = 14 m/s , Vi = O m/s, t = 3.8 s

5. Solve for acceleration: $\frac{14 \text{ m/s} - 0 \text{ m/s}}{3.8 \text{ s}}$ = 3.7 m/s/s

Vectors

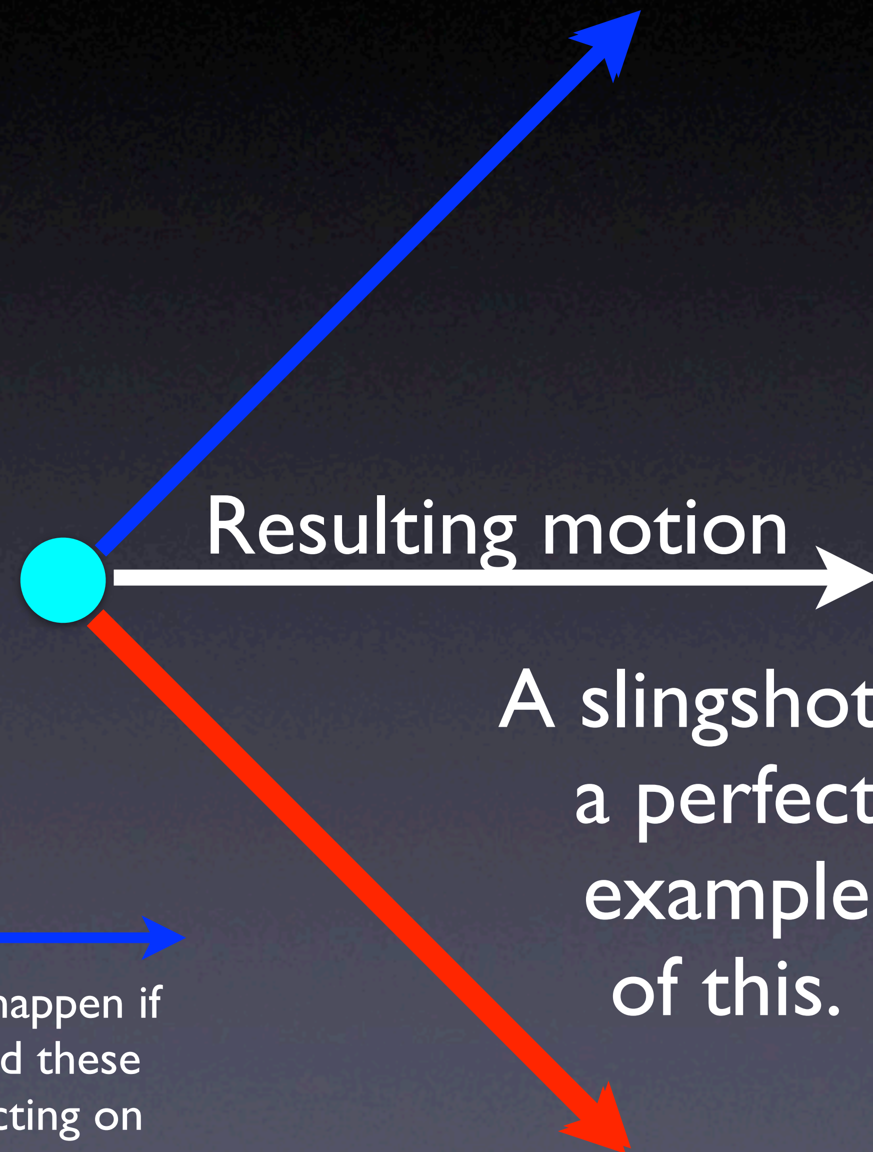
In Physics, vectors (arrows) are used to show the size and direction of a force acting on an object.

small force pulling to the right

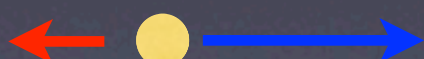
large force pulling to the left

large force pushing up

small force pulling down

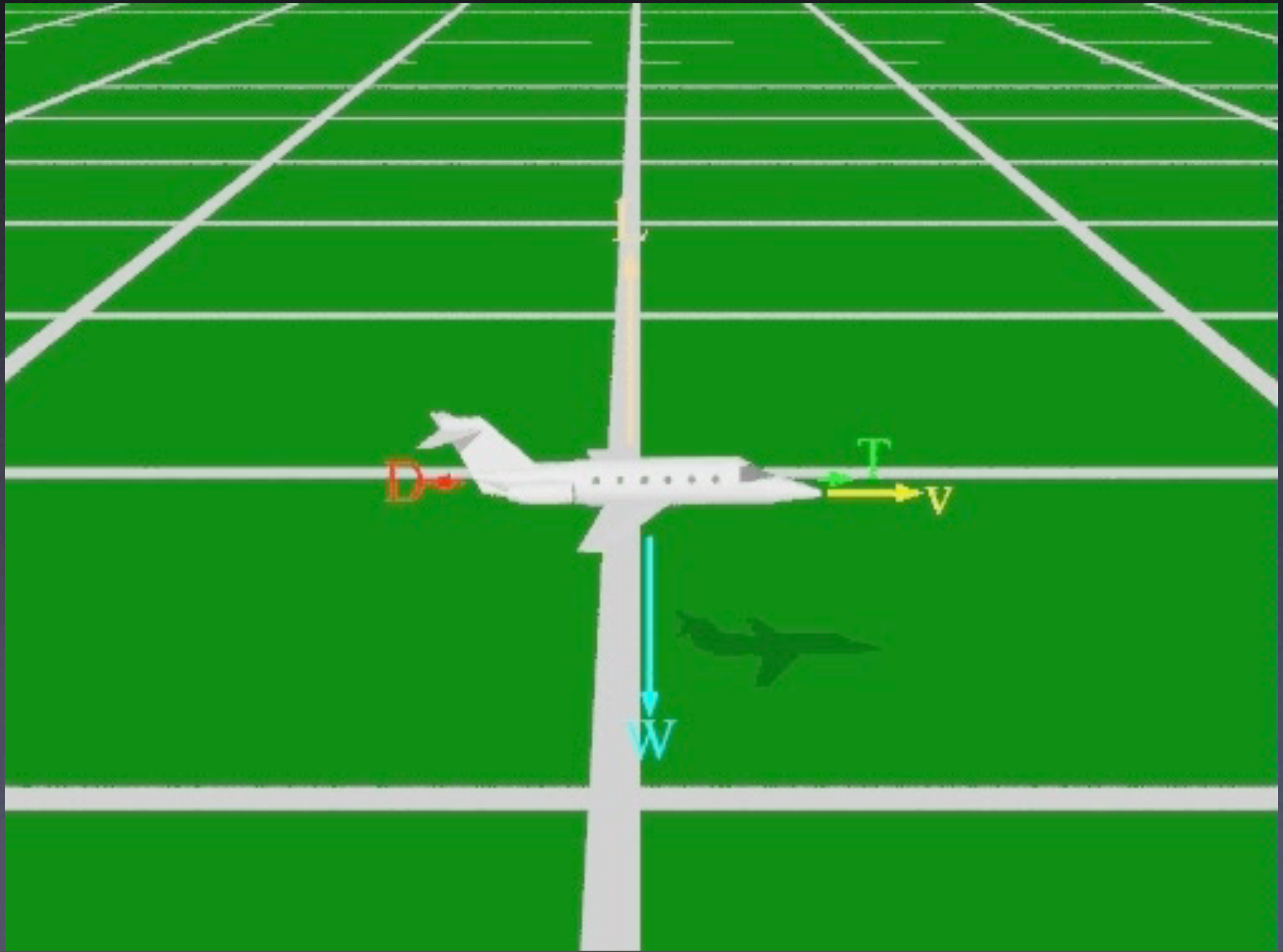


A slingshot is a perfect example of this.



What would happen if you combined these two forces acting on an object?

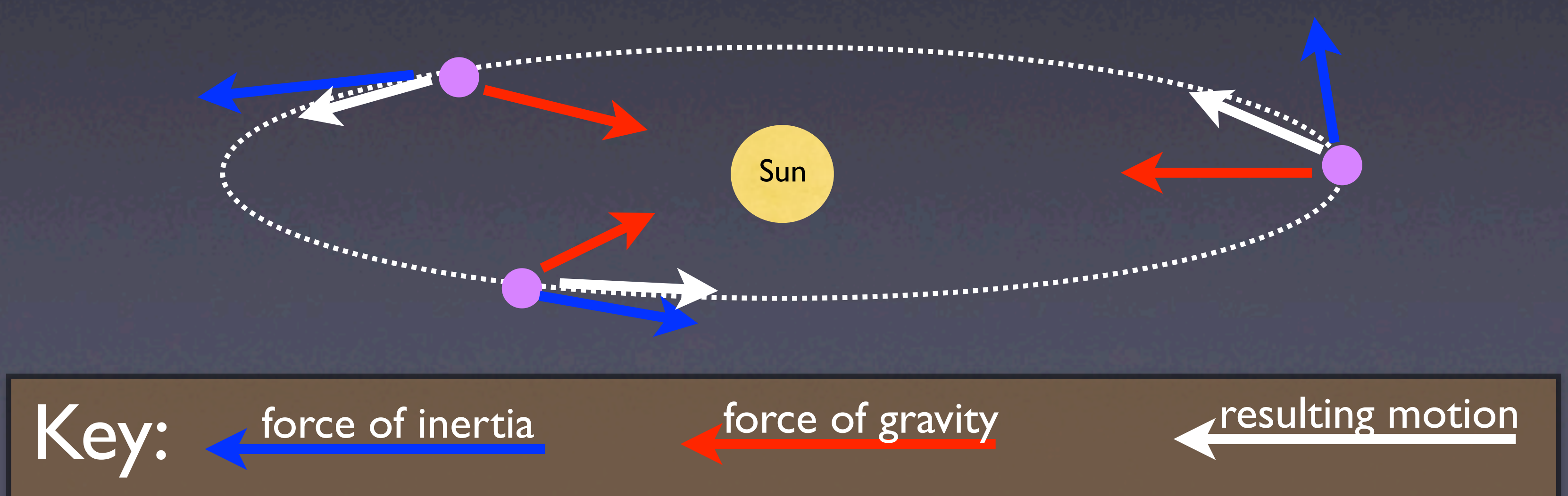
Vectors are arrows that show size and directions of forces.



Centripetal Force

Centripetal force is any force that causes an object to move in a circle. A centripetal force is the force that is pulling on the object from the center of the circle - causing the object not to move, as inertia would cause, in a straight line.

The centripetal force that keeps the Earth and other planets in orbit around the sun is the gravitational attraction of the sun.



Momentum

$M_{om} = m \times v$

- Momentum is the energy of a moving object.
- The formula for momentum is mass x velocity. Mass must be in kilograms while velocity must be in m/s + direction.
- When two object collide, momentum is conserved. The total amount of momentum remains the same.
- The formula can be rearranged to solve for mass (M_{om}/v) or velocity (M_{om}/m)

Momentum

What motion will occur when these two football players collide?

Mass = 150 kg
velocity = 10 m/s N
M_{om} = 1500 kg x m/s N

Total Momentum
1500 kg x m/s N
- 1300 kg x m/s S
200 kg x m/s N

Mass = 100 kg
velocity = 13 m/s S
M_{om} = 1300 kg x m/s S

Velocity = Momentum / Mass

Velocity = 200 ~~kg~~ x m/s N / 250 ~~kg~~

Velocity of the combined masses = 0.80 m/s N

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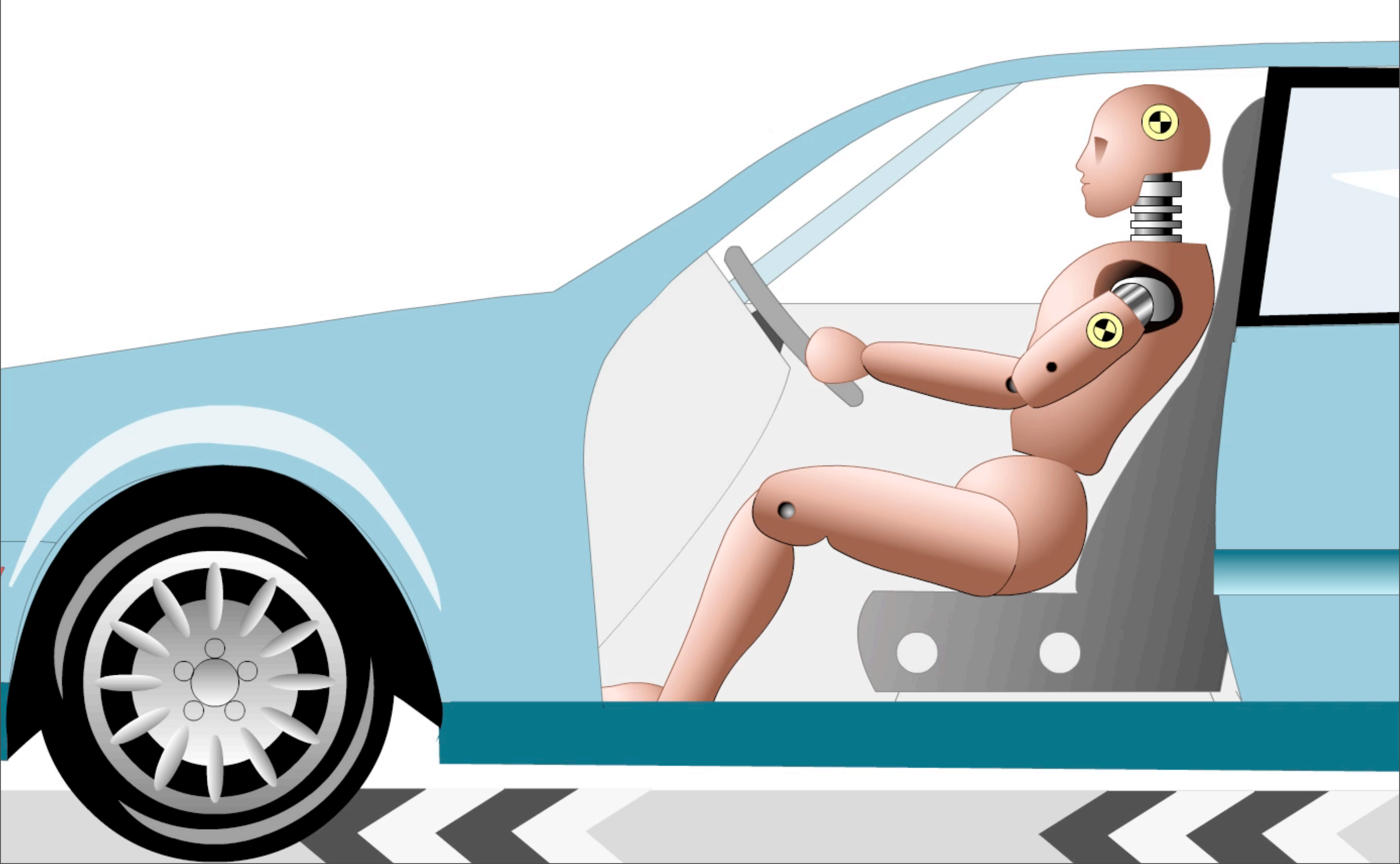
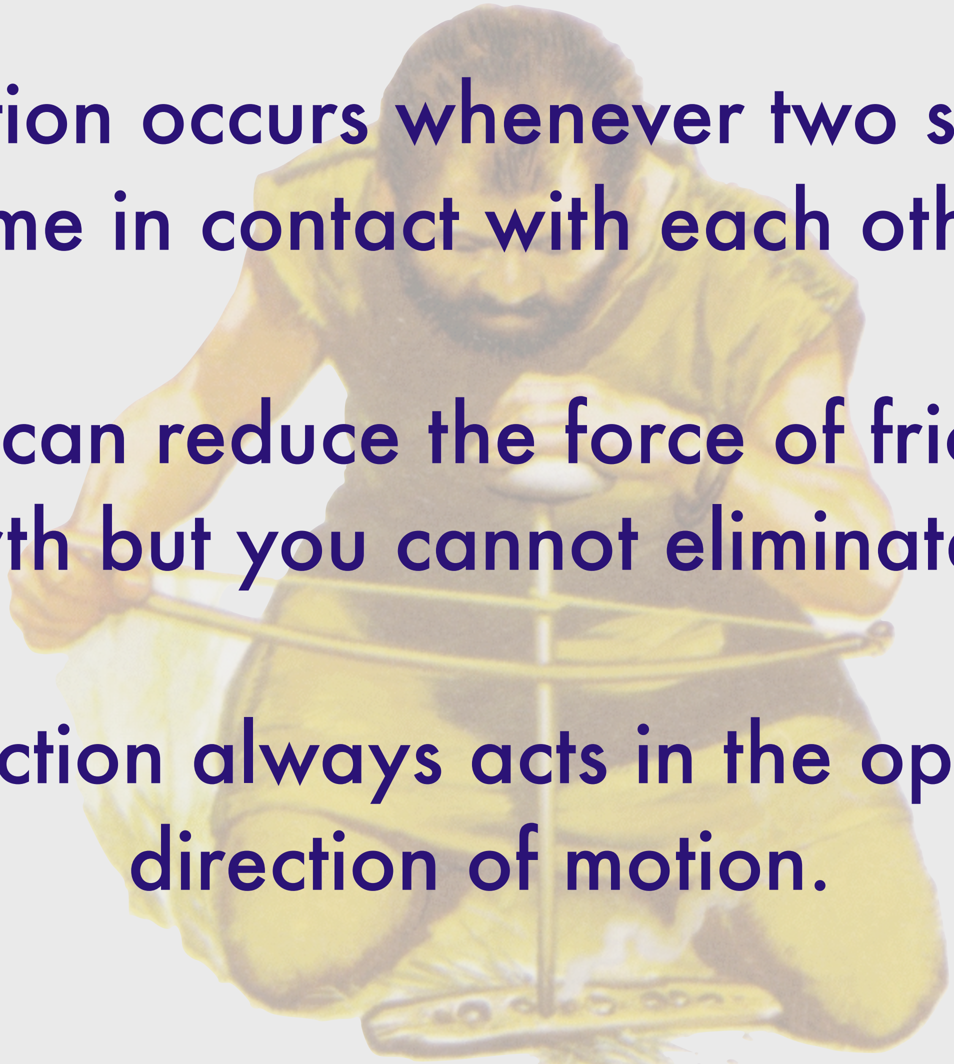
Inertia



Examples of Inertia:

The resistance of an object to change its motion.

Friction



- Friction occurs whenever two surfaces come in contact with each other.
- You can reduce the force of friction on Earth but you cannot eliminate it.
- Friction always acts in the opposite direction of motion.

4 Types of Friction

1

Friction caused when an object slides or rubs against another surface.

4 Types of Friction

2

Friction between a rolling object and the surface it rolls on.

4 Types of Friction

3

The friction of something going through a liquid or gas.

4 Types of Friction

4

The friction between two solid objects that are not moving relative to each other.

Friction can be Helpful

Auto brakes

Lighting a match.

Walking

Flying

Without friction you would not be able to turn a door knob, food wouldn't stay on your fork... friction can be good.

Friction can be Harmful

Rug Burn

Air resistance

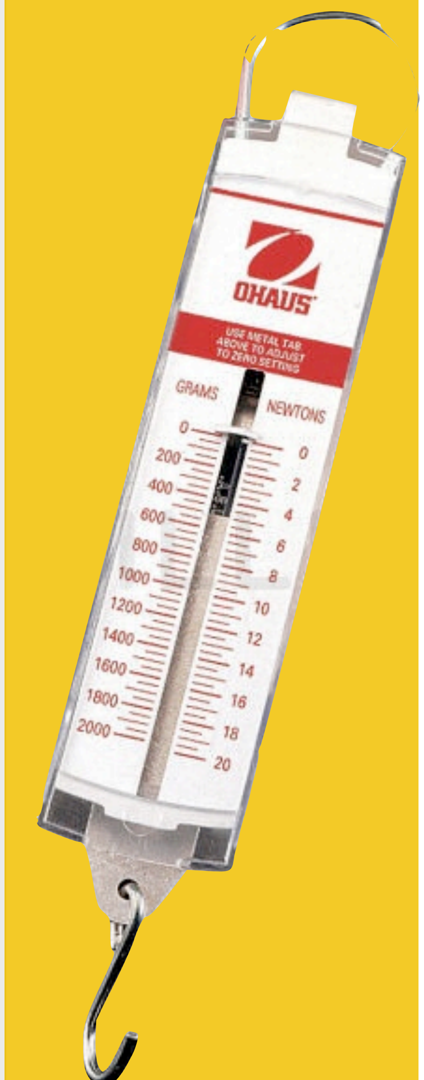
Worn Shoes

Engine Wear

Friction always converts moving energy to heat & wears down surfaces. Lubricants are used to reduce friction.

Surface Friction Lab

In this lab you will rate several surfaces by the amount of friction they produce when you drag a 0.5 kg. mass across them.

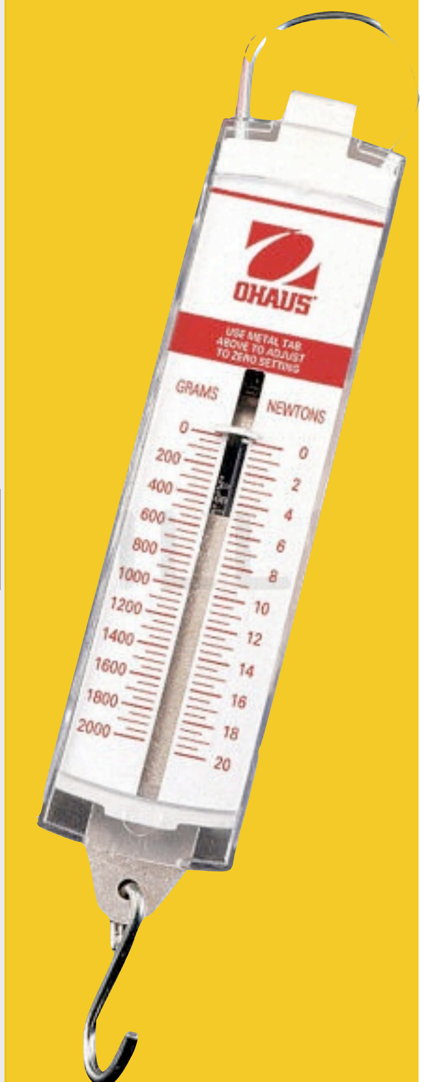


Surface Friction Lab

You will measure force in Newtons.

(Force = mass x acceleration)

1 Newton of force is required to cause a 1.0 kg mass to accelerate at a rate of 1.0 m/s/s.



Friction Data Table

Surface	Force Trial 1	Force Trial 2	Force Trial 3	Force Trial 4	Average force of Friction
carpet					
bare floor					
wood					
lab table					
copper					
rubber					

Friction Ranking

Ranking	Surface
1 highest friction (most newtons)	
2	
3	
4	
5	
6 lowest friction (least newtons)	

Surface Friction Lab

Title: Surface Friction

Purpose: To measure the amount of sliding friction on six surfaces and then rate the surfaces from highest to lowest friction.

Materials: Newton scale, 0.5 kg. mass, six surfaces.

Surface Friction Lab

Procedure:

1. Place the 0.5 kg. mass on a surface.

2) Attach the Newton scale to the mass.
3) Slowly pull on the scale until the mass moves.
4) Record the force required to move the mass.
5) Repeat 4 times and average (recording each).
6) Repeat Steps 1-5 with all 6 surfaces.
7) Rank your surfaces from: 1 (highest sliding friction) to 5 (lowest sliding friction).

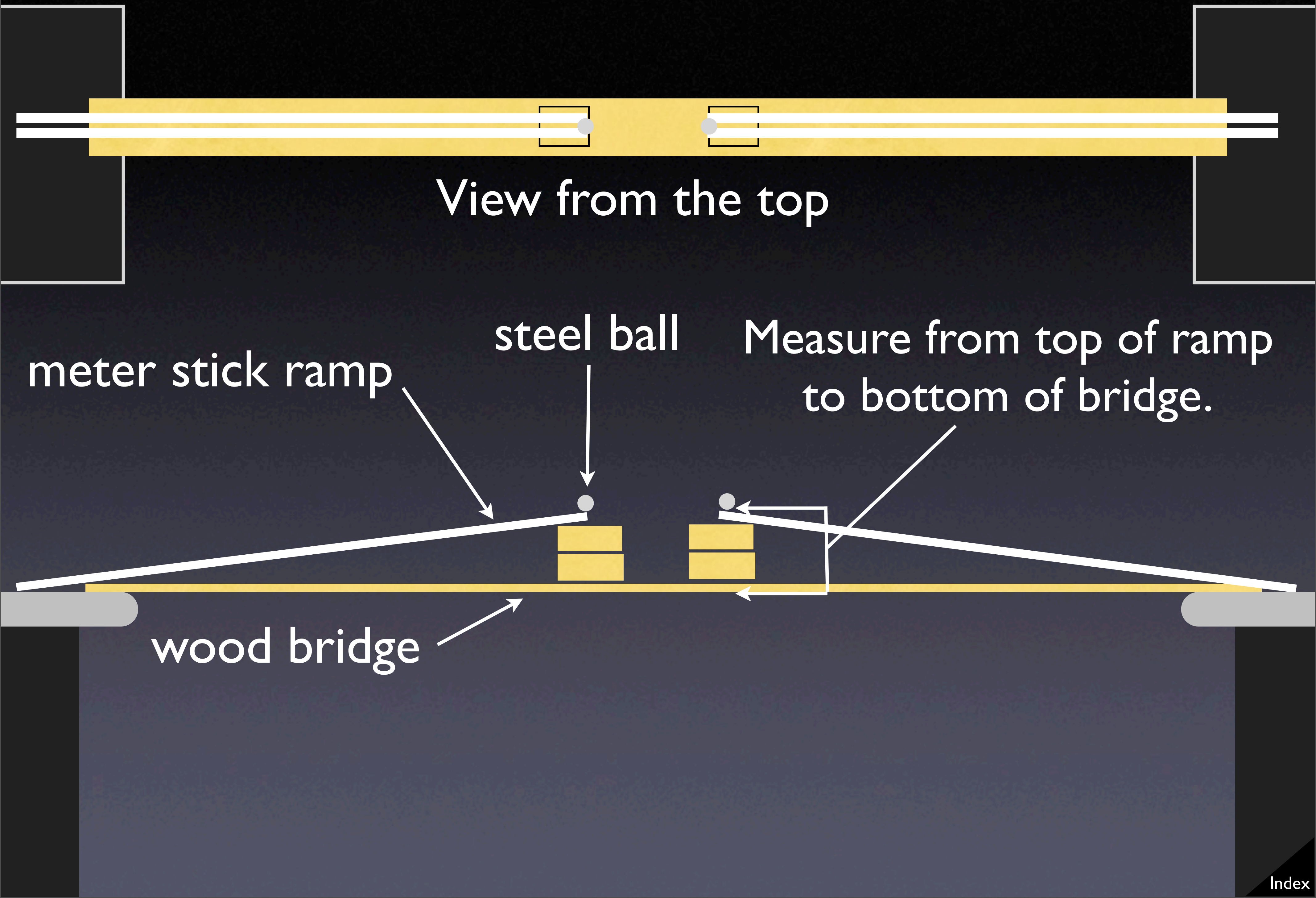
Surface Friction Lab

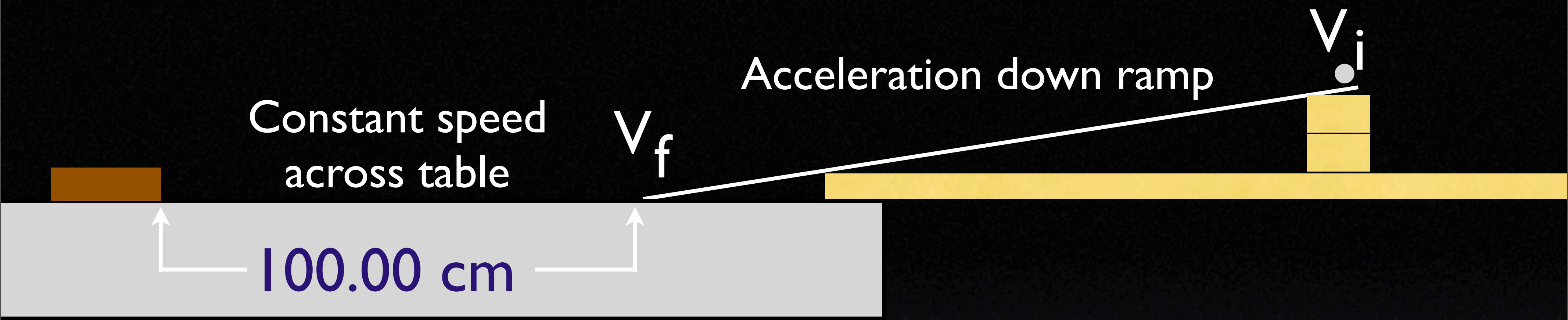
Writeup you lab neatly in ink or typed. Staple your rough draft to the back of your final draft. Lab due Monday.

Speed, Velocity & Acceleration Lab

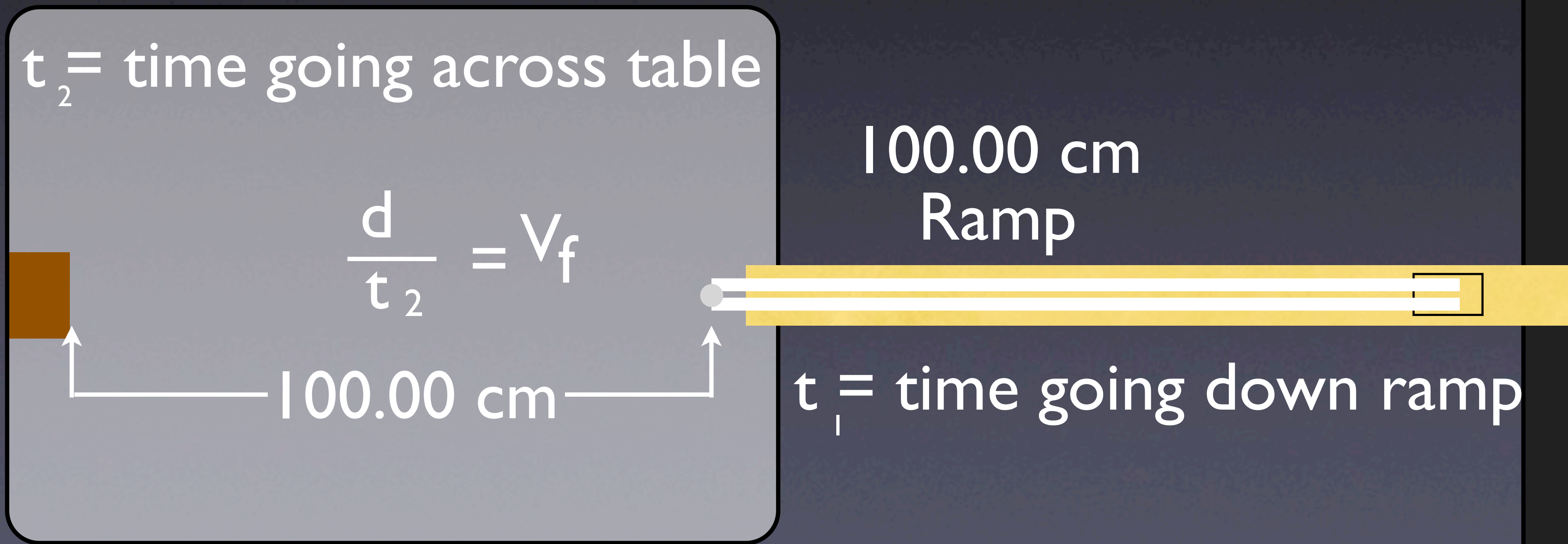
PreLab Discussion

Speed, Velocity & Acceleration Lab





The ball going down ramp is accelerating while the ball going across table is moving at a constant velocity. The speed the ball goes across the table is the final velocity off the ramp.

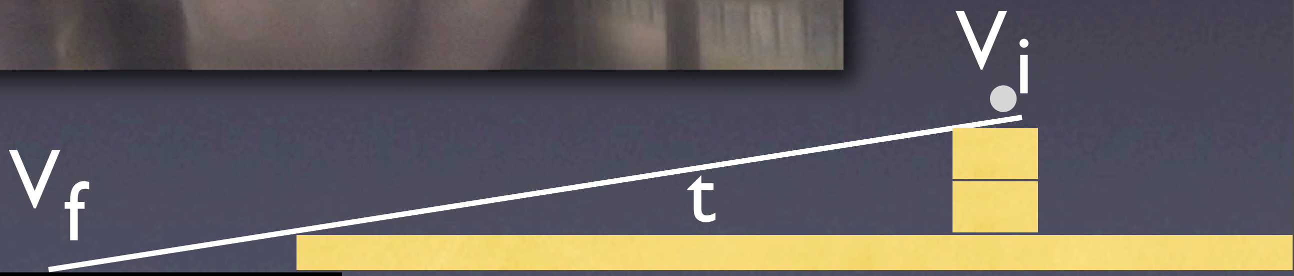


Directions

- Get a stamp once your group is done collecting the data.
- Measure all distances in cm.
- Wear your stopwatch around your neck to prevent from breaking it. Do not play with it - use it only to take lab times.
- The small numbers on the stopwatch are in hundredths of a second. 00123 is 1.23 sec.
- When finish begin working on calculating final velocity and acceleration (show work).

Acceleration

Post Lab Discussion

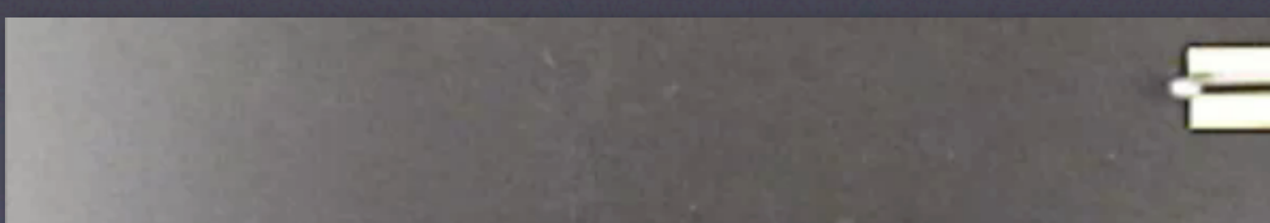


If you could stop the ball going down the ramp every 1/3 second, what it would the distance the ball traveled look like?

Acceleration down ramp

Constant speed across table

If you could stop the ball going across the table every 1/3 second, what it would the distance the ball traveled look like?



Can you explain the difference?

Show your work including units for:

- Final velocity
- Acceleration
- Draw lines on your graph to validate your answers to questions 1, 2 and 3

Graphing your Lab data

Graph 1: Final Velocity (y) vs. Ramp Height (x)
Graph 2: Acceleration(y) vs. Ramp Height (x)

1. Graphs smaller than 2/3 size of graph paper will not be accepted.

2. Use good scales (0.1, 0.2, 0.25, .5, 1...)

3. Draw a linear curve of best fit for both graphs.

4. Draw a line to show how you interpolated or extrapolated answers to Q. 1 & 2. No lines - no credit!

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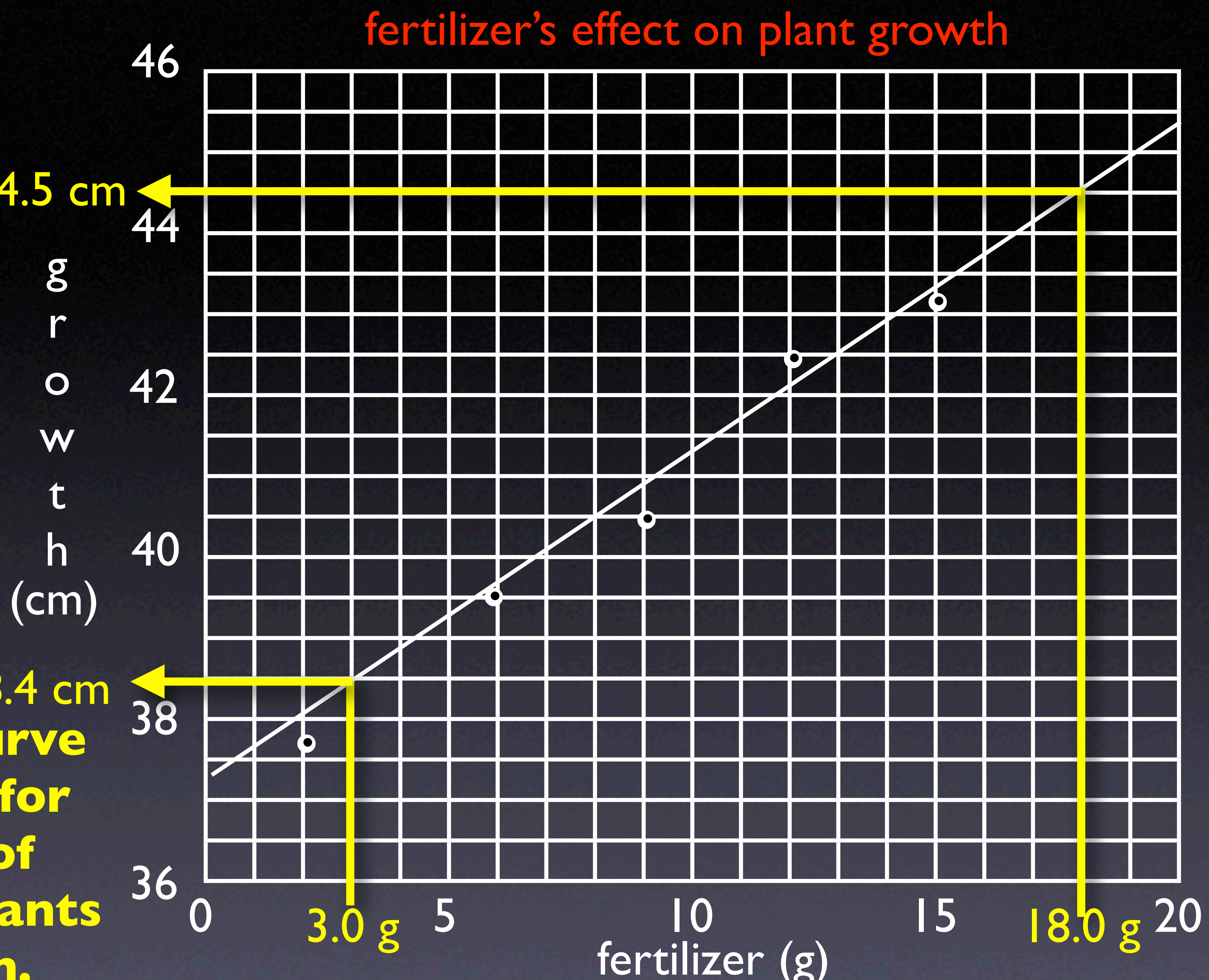
Slope of a curve:

To determine how much the y-axis changed per one change in your x-axis.

In this instance, how many cm of plant growth will one gram of fertilizer produce?



Slope of the curve tells you that for every gram of fertilizer the plants grew 0.41 cm.

1. Select two points on your x-axis. Subtract them. Include units. (Δx) 15.0 g
2. Find the two corresponding values on the y-axis. Subtract them. (Δy) 6.1 cm
3. Divide Δy/Δx. Be sure to include units! 6.1 cm/15.0 g = 0.41cm/g

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Breaking the speed of sound

The speed of sound in air is 740 mi/hr. When a jet goes faster than this it creates a sonic boom.