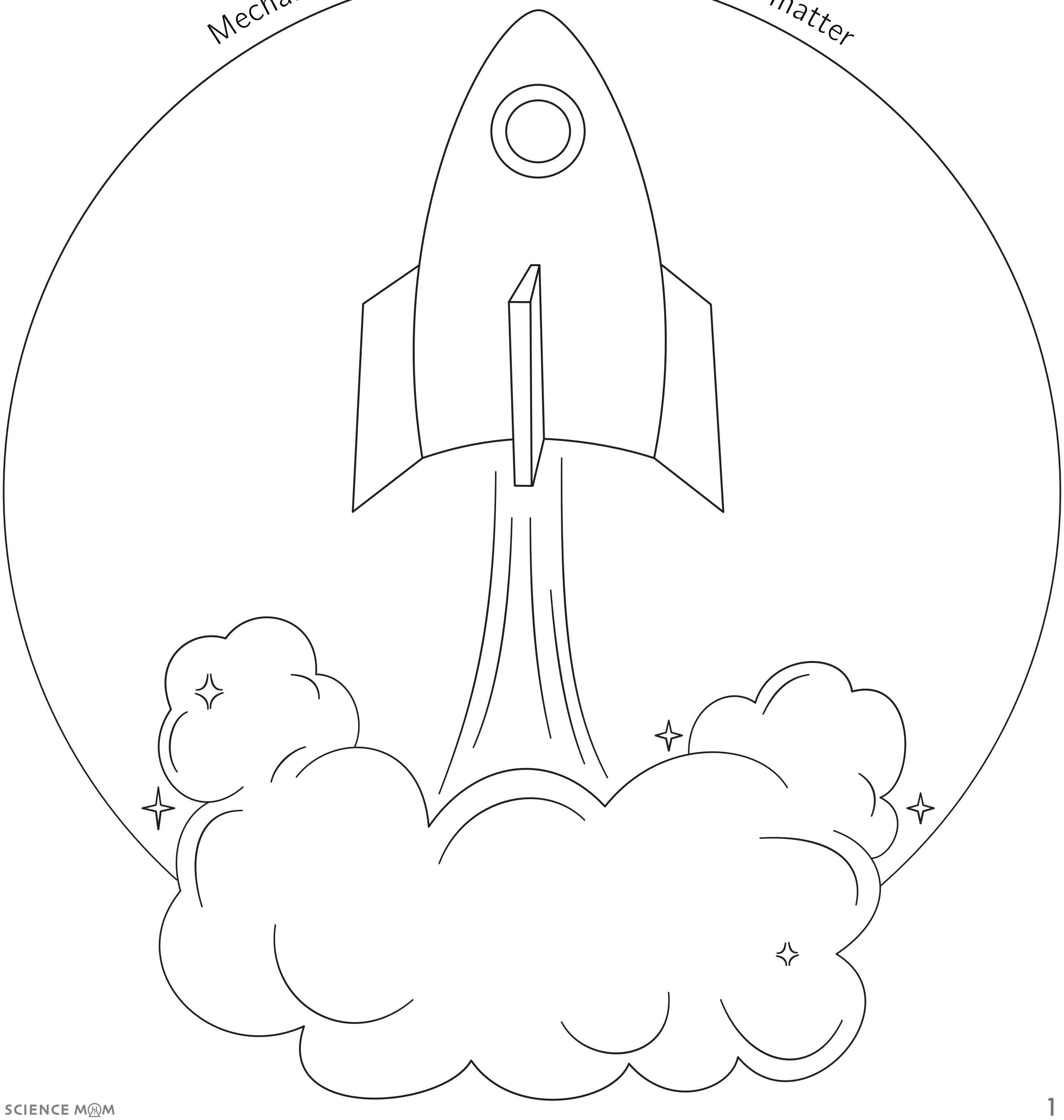
Physics 1

Mechanics: The interactions of forces and matter



Physics One

Kinematics, Newton's Laws, Forces, Machines, and Rotational Motion

Lesson	Date	Topic	Pages
intro	Wednesday Sep 6	Introduction & Quiz Show Practice	-
1	Monday, Sep 11	What is physics?	4-5
2	Wednesday, Sep 13	Mighty Measures	8-13
3	*self-paced*	Fun Physics Tricks	14-15
4	Monday, Sep 18	Tracking Motion	16-21
5	Wednesday, Sep 20	Graphing Motion	22-26
6	*self-paced*	Physics Memory Game & Function Carnival	27-28
7	Monday, Sep 25	Velocity	29-33
8	Wednesday, Sep 27	Acceleration and Forces	34-37
9	*self-paced*	Degree Golf and Cup Stack Challenge	38-39
10	Monday, Oct 2	Relative Motion & Colliding Vectors	40-41
11	Wednesday, Oct 4	LINEAR MOTION QUIZ SHOW	
12	*self-paced*	Assessment	44-45
13	Monday, Oct 9	The law of inertia	46-49
14	Wednesday, Oct 11	Mass vs Weight	50-53
15	*self-paced*	Tablecloth Pull, Egg Drop & Inertia hat	54-56
16	Monday, Oct 16	The law of acceleration	57-61
17	Wednesday, Oct 18	Actions and reactions	62-66
18	*self-paced*	Balloon rockets	67-69
19	Monday, Oct 23	Force Pairs	70-74
20	Wednesday, Oct 25	Gravity & free fall	75-77
21	*self-paced*	Water Rockets	79-81
22	Monday, Oct 30	NEWTON'S LAWS QUIZ SHOW	
23	Wednesday, Nov 1	Forces & Balance	-
24	*self-paced*	Center of Mass & Block Challenge	-
25	Monday, Nov 6	Momentum	-
26	Wednesday, Nov 8	Kinetic vs Potential Energy	-
27	*self-paced*	Double bounce	-
28	Monday, Nov 13	Work & Power	-
29	Wednesday, Nov 15	Simple Machines 1	-
30	*self-paced*	Build it Challenge! *Choose from Mystery Box, Tensegrity Table, or Pulley*	-

Lesson	Date	Topic	Pages
31	Monday,Nov 27	Simple machines 2	-
32	Wednesday,Nov 29	ENERGY & MACHINES QUIZ SHOW	-
33	*self-paced*	Where's the mass?	-
34	Monday, Dec 4	Rotational Motion 1	-
35	Wednesday, Dec 6	Rotational Motion 2	-
36	*self-paced*	Racing wheels	-
37	Monday, Dec 11	Quantum Weirdness	-
38	Wednesday, Dec 13	FINAL QUIZ SHOW	
39	*self-paced*	Assessment	-

Project Supply List:

Lesson 3 - Five Fun Physics Tricks
- 2 bottles with a narrow neck (plastic recommended)
- Piece of paper or a dollar bill
- 3 matches or flat-tipped toothpicks
- 2 feet yarn or string
- 2 books of approximately the same size

Lesson 9 - Cup Stack Challenge
- 15 stackable paper cups
- 4 to 6 index cards or squares of paper
- String or ribbon
- Tape

Lesson 15 - Inertia Activities
- Wire hanger
- 2 tennis balls
- Silk scarf
- Cotton scarf
- 3 water bottles
- Hard boiled eggs
- Toilet paper tube or piece of paper and tape
- Aluminum pie pan or piece of paper
- A large cup

Lesson 18 - Racing Balloons
- 2 Balloons (long balloon-animal types if available)
- 2 straws
- 2 binder clips or clothespins
- 10-20 feet of fishing line
- 10-20 feet of yarn
-

Lesson 21 - Water Rockets
- Empty plastic 2 liter or 1 liter bottles
- A rubber cork and tubing to fit to a bike pump
- Fins to stabilize the bottle
- Bike pump
- Water

**Note: both the cork and tubing and fins for stabilization are available in a water rocket kit.*

Lesson 24
- Popsicle stick
- Pine cleaner
- 4 hex nuts or other weights such as coins
- 2 forks
- match
- Glass cup

Lesson 27 - Double Bounce
- A larger ball that bounces such as a basket ball or soccer ball
- A smaller ball that bounces such as a tennis ball or racquet ball

Lesson 30 - Build it Challenge (choose one)
- MYSTERY BOX
    - Cereal box
    - String
    - Round wooden dowel or a marker
    - Tape
    - Eyelet or pulley wheel (optional)

- TENSEGRITY TABLE
    - 10 wooden popsicle sticks
    - Scissors
    - String
    - Hot glue, super glue, or duct tape

- PULLEY
    - 2 pulley wheels
    - string
    - 4 small and equal-sized weights

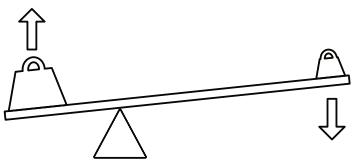
Lesson 36 - Racing Wheels?
- Cardboard
- Scissors
- Pencils
- Pennies
- Tape or glue

PHYSICS – THE FUNDAMENTAL SCIENCE

Physics is a broad field of science dedicated to understanding matter, space, energy, and time. It has dozens of different areas of specialization!

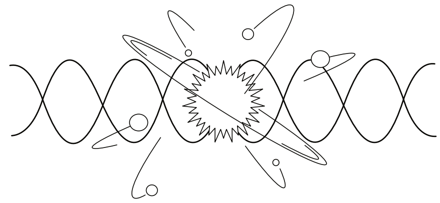
If you could spend a day working with a physicist, which of these areas would you like to explore? Put a star or checkmark by your top three choices.

CLASSICAL MECHANICS



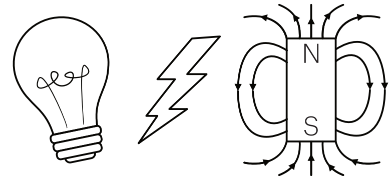
☐ The study of how big-ish things move and behave

QUANTUM MECHANICS



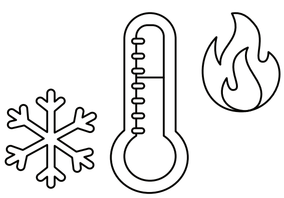
☐ The study of how very small particles behave

ELECTROMAGNETISM



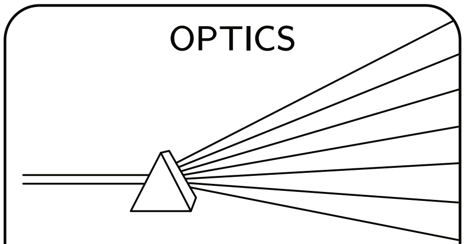
☐ The study of electric and magnetic fields

THERMODYNAMICS



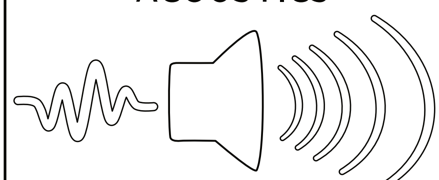
☐ The study of heat, energy, and entropy

OPTICS



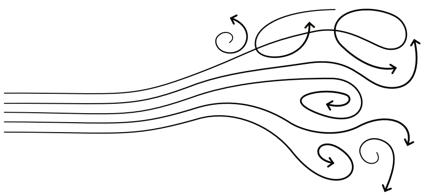
☐ The study of the behavior and properties of light

ACOUSTICS



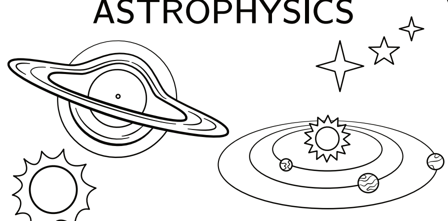
☐ The study of mechanical waves such as sound

FLUID DYNAMICS



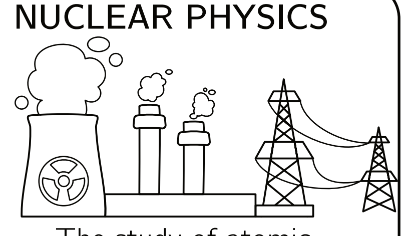
☐ The study of the flow of liquids and gases

ASTROPHYSICS



☐ Physics in outer space! How stars, black holes, and solar systems work

NUCLEAR PHYSICS



☐ The study of atomic nuclei and the generation of nuclear energy.

WHICH AREAS SOUND MOST INTERESTING TO YOU AND WHY?

___

___

___

___

FOR BEST LEARNING

1 DO THE HANDS-ON ACTIVITIES

Gather all of the supplies in advance. Record your results and share them with a friend.

My plan for doing the activities:

____

____

____

2 USE THE NOTES

Fill them out! This can be done in advance, during, or after watching the video lesson.

My plan for using the notes:

____

____

____

3 LEARN THE VOCABULARY

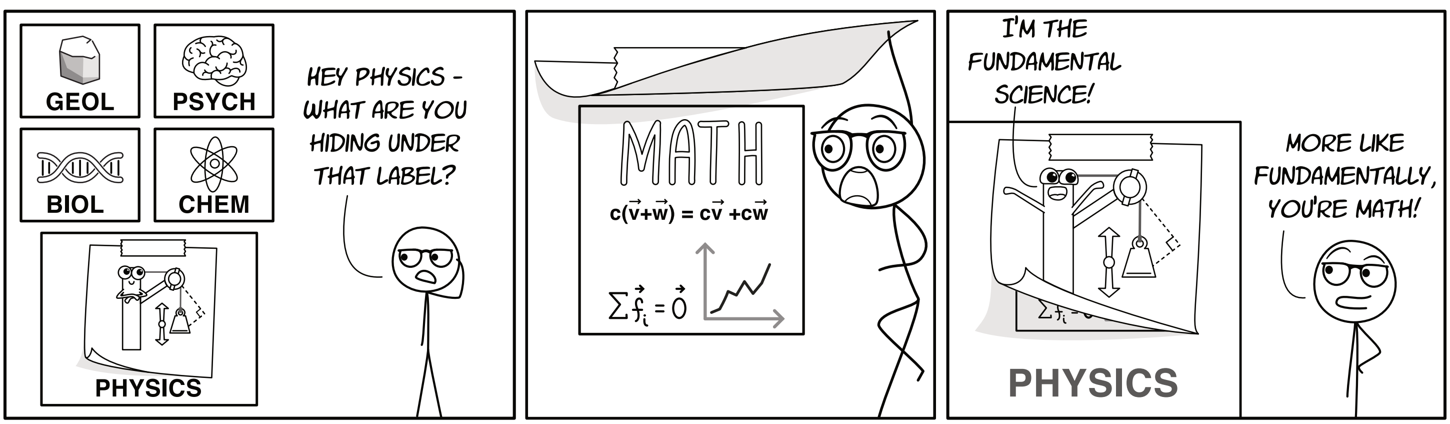
Play the memory game weekly or use the vocabulary list to make flashcards.

My plan for learning the language of physics:

____

____

____



4 DO ALL OF THE PHYSICS PUZZLES

Each lesson has a page of exercises called physics puzzles. For best learning, these should be completed individually after each lesson. Solve them on your own before looking at the answer key!

The physics puzzles will:

- Give you a solid foundation for more advanced science courses
- Strengthen your critical thinking and reasoning skills
- Show you how math can be used to solve real-world problems
- Prepare you to defeat Math Dad in our quiz shows

My plan for conquering the physics puzzles is to:

____

____

____

Are you ready for physics?

To build a strong knowledge base in physics you'll need some math skills! How do you feel about each of these areas? If your knowledge is shaky in one of these topics, you could strengthen it before starting this course.

NUMBERS & ARITHMETIC

Strong arithmetic skills with addition, subtraction, multiplication, division, fractions and decimals.

Can perform calculations using both positive and negative numbers and use a calculator to carry out more complex calculations.

For example: Use a calculator to find the decimal approximation of the number $\sqrt{31}$ accurate to two decimal places.

SLOPE & COORDINATE PLANE

Be able to plot and interpret points in the plane.

Can interpret the meaning of a simple graph.

Know that slope is rise over run.

VARIABLES & EQUATIONS

Know that a variable is a letter or symbol representing an unknown value.

Be able to substitute a value in place of a variable.

Can solve a simple equation involving a variable.

For example: $3 + a = 5$. What is a? $4x = 12$. What is the value of x?

EXPONENTS

Understand and be able to expand exponents.

For example: 10^3 means $10 \cdot 10 \cdot 10$, which equals 1,000.

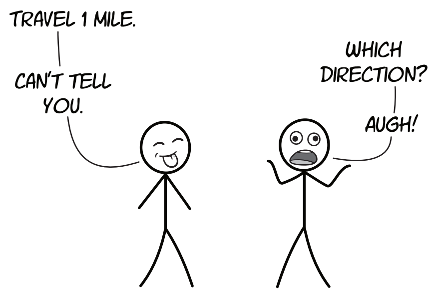
Can recognize and interpret numbers in scientific notation.

For example: $4.5 \times 10^4 = 45{,}000$

Unit 1: Kinematics

In this unit, we'll learn how to describe and explain the motion of objects using graphs, diagrams, numbers, and words. We'll start with looking at how measurements are made.

SCALAR

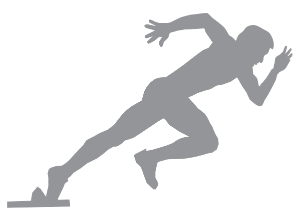


A quantity that has a magnitude (measurement) but no direction

VECTOR

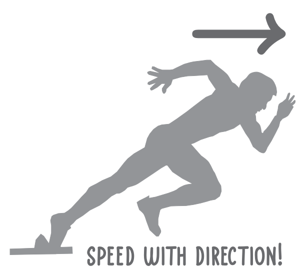
$\vec{v}$ A quantity that has both magnitude and direction

SPEED



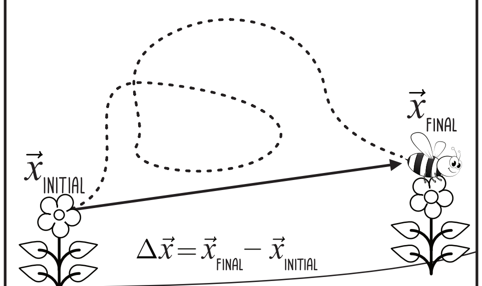
$\frac{d}{t}$ Distance divided by time

VELOCITY



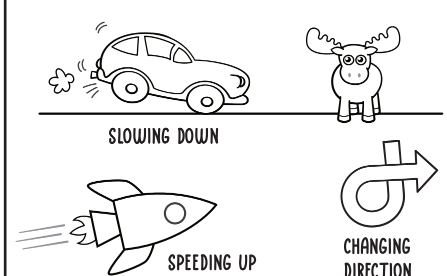
$\frac{\Delta\vec{x}}{\Delta t}$ Change in position over time

DISPLACEMENT



$\Delta\vec{x}$ The straight line distance between initial and final position

ACCELERATION



$\vec{a} = \frac{\Delta\vec{v}}{\Delta t}$ The rate of change of velocity

The science of motion!

FILL IN THE BLANKS:

one	*advantage*	*units*	*standard*	*prefixes*

The metric system or SI (International System of Units) is the international _______________ of measurement. The SI has 7 base _______________ that are defined in relation to universal constants. One _______________ of SI is that it has only ___________ unit for each quantity or type of measurement. Each SI unit uses the same _______________ to represent a multiple of a power of 10. A kilometer will always have 1,000 meters and a kilogram 1,000 grams.

CONVERTING UNITS:

Use the steps shown in the two examples below to complete the next conversions:

1. How many feet long is a marathon?

A marathon is 26.2 miles.
There are 5,280 feet in 1 mile.

$$26.2 \text{ mi} = 26.2 \text{ mi} \cdot 1$$

$$= 26.2 \text{ mi} \cdot \frac{5{,}280 \text{ ft}}{1 \text{ mi}}$$

$$= \frac{26.2 \cancel{\text{mi}} \cdot 5{,}280 \text{ ft}}{1 \cancel{\text{mi}}}$$

$$= 138{,}336 \text{ ft}$$

2. How many meters tall is Math Dad?

There are 3.28 feet in 1 meter.

$$5.5 \text{ feet} = 5.5 \text{ ft} \cdot 1$$

$$= 5.5 \text{ ft} \cdot \frac{1 \text{ m}}{3.28 \text{ ft}}$$

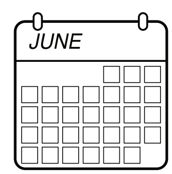
$$= \frac{5.5 \cancel{\text{ft}} \cdot 1 \text{ m}}{3.28 \cancel{\text{ft}}}$$

$$= 1.68 \text{ m}$$

3. How many marathons would it take to equal the circumference of the Earth?

Circumference of the Earth = 24,902 miles.

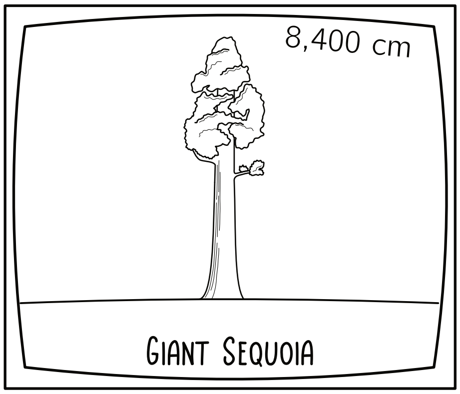
4. How many minutes are there in June?

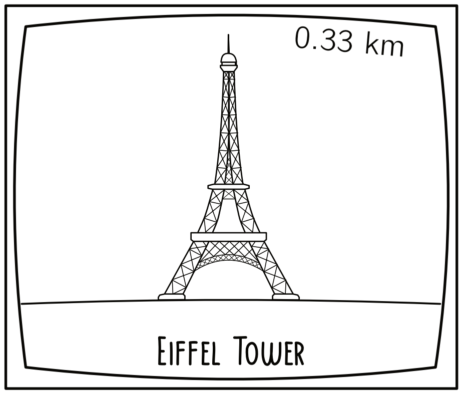


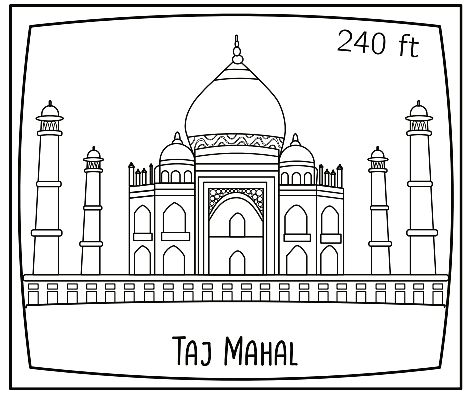
When we multiply a number by a unit conversion fraction, we're really just multiplying by 1!

Mighty Measures

Measuring is an important tool in physics. Can you rank the following from shortest to tallest? Each has been measured accurately, but the measurements are in different units!







Use the table to convert each of the measurements above to meters. Then sketch each object onto the grid below to see how they compare in height to the Great Pyramid of Giza.

Imperial system

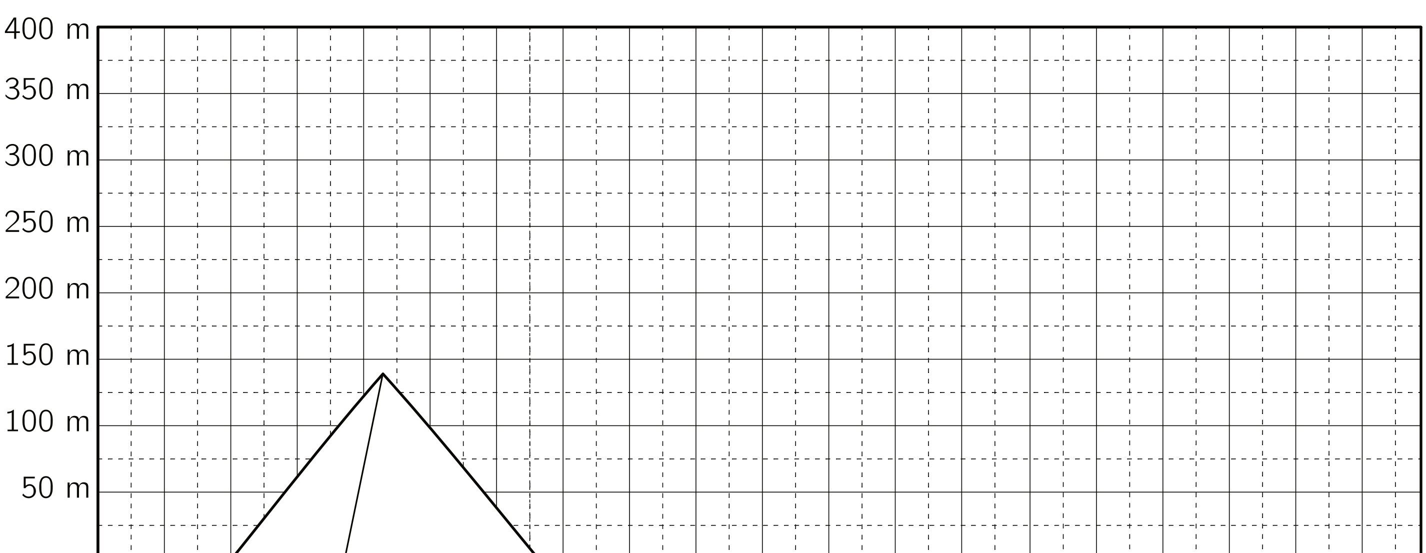
1 foot = 12 inches
1 mile = 5,280 feet

Metric system

1 meter = 1,000 millimeters
1 meter = 100 centimeters
1 kilometer = 1,000 meters

Converting imperial to Metric

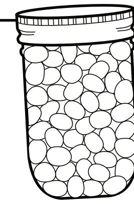
1 inch = 2.54 centimeters
1 mile = 1.609 kilometers
1 foot = 0.3 meters



Direct vs Indirect Measurement

Some things, like the volume of a jar, can be measured directly. When candy is in a sealed jar, the number of candies can't be counted directly, but measurements can be used to give a good *estimation*.

How many candies in the jar?



1 pint jar = 473 cm^3

1 candy = 1.65 cm^3

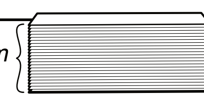
17 candies fit on the bottom row of the jar

The jar is almost 10 candies tall

A single piece of paper is too thin to be measured with a ruler – or is it?
Use the clues below to measure the thickness of a piece of paper *indirectly!*

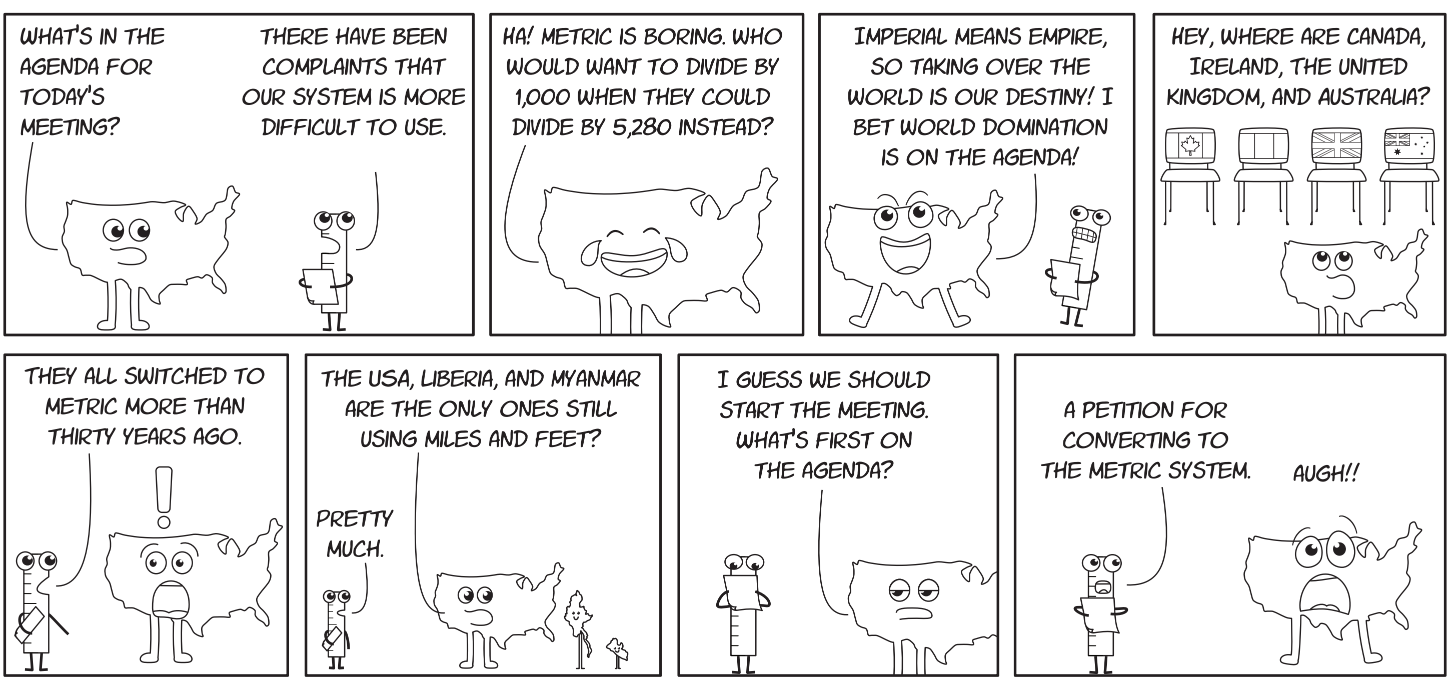
How thick is 1 piece of paper?

2.2 cm



A stack of 100 papers is 2.2 cm tall.

A MEETING OF IMPERIAL MEASURES



THE BASE UNITS	WHERE THEY CAME FROM	HOW THEY ARE DERIVED TODAY
Length meter (**m**)	The distance from North Pole to the equator divided by ten million	How far light travels in a vacuum during 1/299,792,458 of a second
Time Second (**s**)	1/86,400 of a day	Trillions of oscillations of radiation between two levels of cesium-133
Quantity Mole (**mole**)	The number of atoms in 12 grams of carbon	The amount of a substance with $6.02214076 \times 10^{23}$ particles.
Electric current Ampere (**A**)	1/10 the electric current that produces a force of 2 dyn/cm	The flow of $6.2415090744 \times 10^{18}$ elementary charges per second.
Temperature Kelvin (**K**)	Celsius minus 273 degrees	0°K is 1/273.16 the temperature of the triple point of pure water.
Luminous intensity Candela (**cd**)	The brightness of a standard candle flame	The brightness of a green-yellow light at 5.4×10^{14} hertz
Mass Kilogram (**kg**)	The weight of one liter of water	The kg is derived from the speed of light and Planck's constant

SI Prefixes

Fill in the missing prefixes, symbols, and multipliers below:

Symbol

Prefix

SMALLER

BIGGER

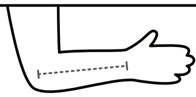
Prefix	pico		micro		centi	**base unit**		mega		tera	
Symbol		*n*		*m*			*k*		*G*		*P*
	1 trillion times smaller	*1 billion times smaller*	*1 million times smaller*	*1,000 times smaller*	*100 times smaller*	1	*1,000 times bigger*	*1 million times bigger*	*1 billion times bigger*	*1 trillion times bigger*	***Quadrillion times bigger!***
Exponential Multiplier	10^{-12}		10^{-6}		10^{-2}		10^{3}		10^{9}	10^{12}	10^{15}

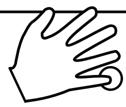
For more about metric prefixes and notation, check out the table in the appendix!

Mighty Measures Physics Puzzles

Matching Lengths:

Draw a line to match each distance with its best measurement.


The average length from elbow to wrist


The average width of a pinky finger


The distance run in 10 minutes


The distance walked in 10 minutes

1 km

1 in

1 mm

1 ft

1 yd

1 mi

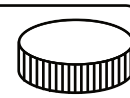
1 cm

1 m

The width of a credit card.


The length of a baseball bat


The length of a baseball bat + a baseball


The height of a hockey puck

A Table on Computer Data:

Use your knowledge of the metric system to complete the table below and fill in the blanks below:

Unit:	***Number of bytes:***
byte	1
Kilobyte (KB)	1,000
Megabyte (MB)	
Gigabyte (GB)	
Terabyte (TB)	
Petabyte (PB)	

_______________ KB = 1 MB.

_______________ megabytes = 1 gigabyte.

1 terabyte = _______________ megabytes.

_______________ GB = 1 PB

How many kilobytes are in a petabyte?

____

Convert units to answer each question. Practice doing neat work!

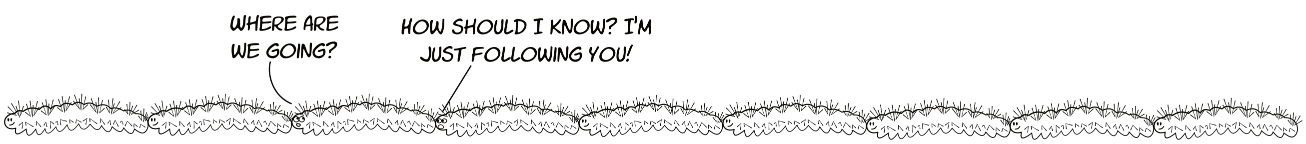
1. Jerry says he'll trade Jill 41 dimes for 16 quarters. Jill agrees. Who has more money after the trade and why?

2. How many dollars are the same value as 61 quarters?

3. How many Abs are in 10 Gabs?

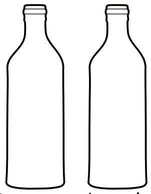
1 Ab = 4 Babs
3 Babs = 7 Cabs
2 Cabs = 3 Dabs
7 Dabs = 1 Fab
6 Fabs = 1 Gab

4. How many Babs are in 3 Fabs?

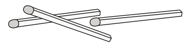


5. The pine processionary caterpillar (*Thaumetopoea pityocampa*) is 4 cm long. When migrating, the caterpillars march in a single-file line. If a line of caterpillars is just under 1 mile long, how many caterpillars are marching in the line?

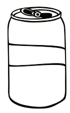
MATERIALS



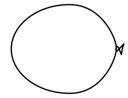
2 water bottles with narrow necks



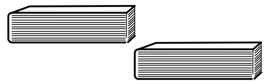
3 matches or flat-tipped toothpicks



An empty aluminum can



A balloon



2 books that are approximately the same size

About 60 cm (2 ft) of yarn or string

A dollar bill or similarly-sized piece of paper

A small piece of paper that can be crumpled into a ball

GOALS

- Experience curiosity and wonder about physics!
- Get hands-on experience with physics principles that we will learn about later in this course.
- Bonus: Learn 5 tricks that can stump your friends and family members!

1 MIGHTY MATCH CHALLENGE

Can you hang a water bottle from the edge of a table using only 3 matches and yarn?

1. Tie the yarn to a water bottle that weighs no more than 0.4 kg (1 pound or 16 ounces). The yarn should extend from the bottle in one long loop. Make sure the yarn is secure and supports the weight of the bottle.

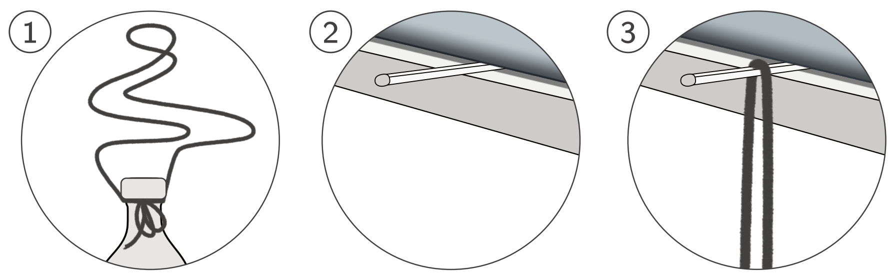
2. Place a match on the edge of a table so that it dangles a bit more than half-way over the edge. Place a counterweight (such as books) on the end of the match to hold it in place.

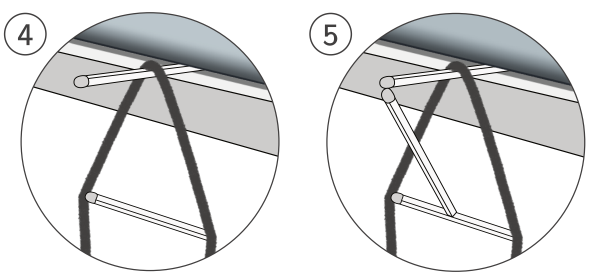
3. Hang the bottle from the match so that the string is up against the side of the table.

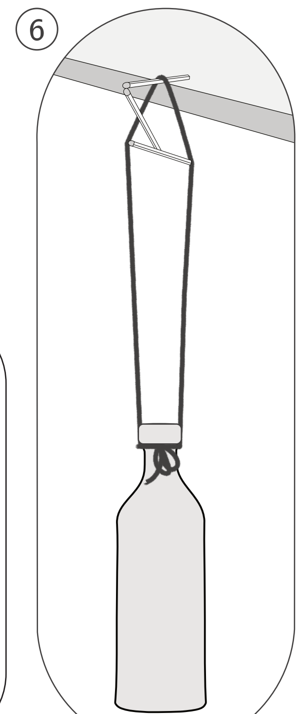
4. Place a second match about one match length below the table match and orient it so that it is wedged between the two strands of string.

5. Wedge a third match between the two matches so that the heads are touching. Adjust as needed.

6. Once the matches are steady, remove the counterweight.







WHAT IS HAPPENING?

Why do you think this trick works? Don't try to look up the answer yet - explore and come up with your own ideas first!

2 DOLLAR BILL CHALLENGE

Can you pull the dollar from between two bottles without tipping them over?

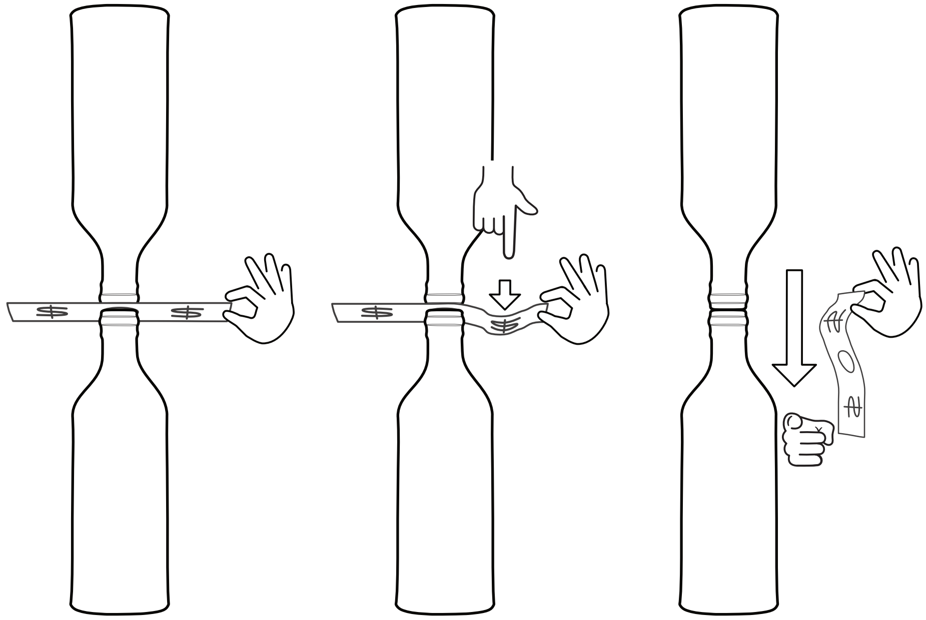
1. Place a dollar bill between two glass bottles. Challenge a friend to remove the bill without touching the bottles.

2. To remove the bill, pinch one end of the bill with one hand. Don't pull. This hand need to remain stationary.

3. Push down with your other index finger to form a bit of a valley.

4. Slap down quickly with the flat index finger, pushing on the area where the dip in the dollar bill was. The other hand that is pinching the dollar bill should remain stationary.

With a bit of practice, you'll be able to push fast enough on the bill that it will slide out but the the water bottles will stay in place!



What is Happening? *Why do you think this trick works? Don't try to look up the answer yet. Explore and come up with your own ideas first!*

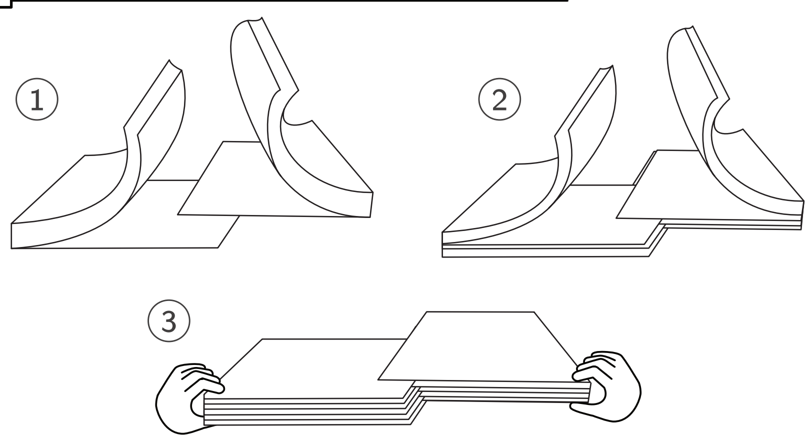
3 BOOK PULL CHALLENGE

Can you pull pull two books (or post-it notes) apart when the pages are overlapped?

1.Take two books or two packs of post-it notes and place them on a table or other flat surface. Hold up all but the back cover and overlap the back covers so that ¼ to ½ of one of the pages is covered by the other book.

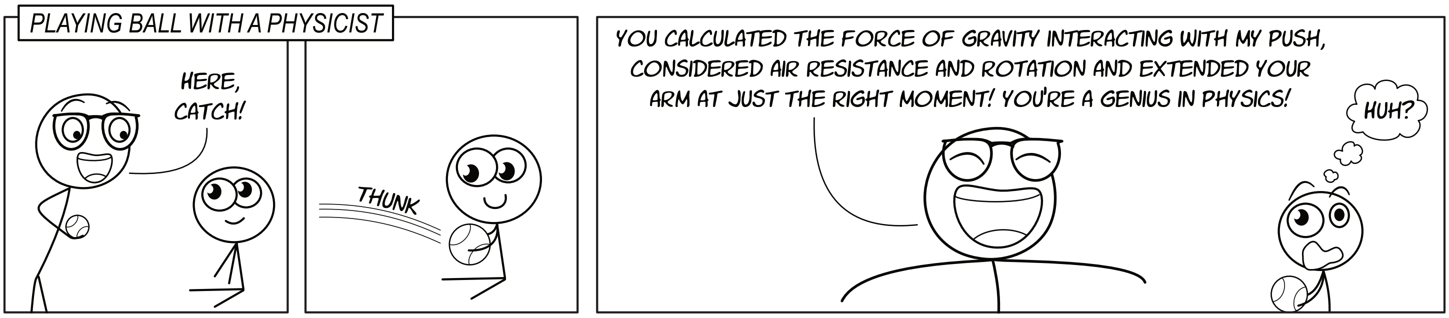
2. Let the pages flip down so that they alternate.

3. Once the pages have been interwoven and the books are closed, challenge someone to hold on the spine of each book and pull them apart.



What is Happening? *Why do you think this trick works? Don't try to look up the answer yet. Explore and come up with your own ideas first!*

Measuring Motion



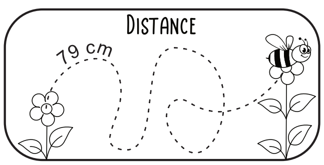
You already have a lot of experience with **mechanics**, the branch of physics that studies the motion of objects. Understanding vectors will help give you tools to make models and speak the language of physics!

Why *study vectors?*
To make models that help us understand and predict the motion of objects!

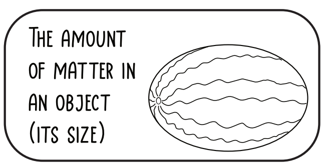
SCALARS vs VECTORS

Scalars

DEFINITION:



→ ______________



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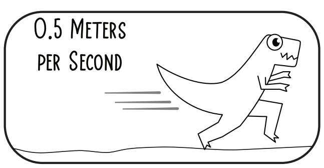

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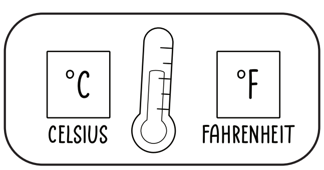

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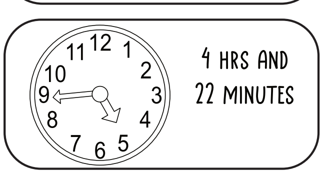
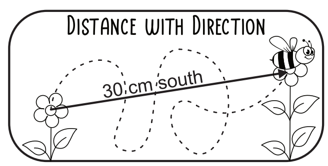


→ ______________

Vectors

DEFINITION:



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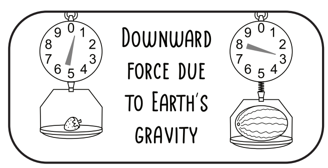

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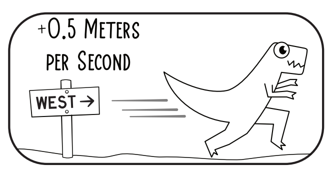

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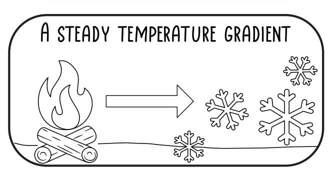

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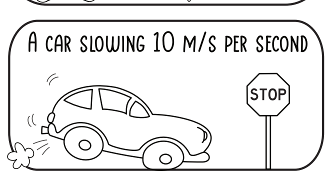


→ ______________

FILL IN THE BLANKS:

vector	*magnitude*	*direction*	*scalar*

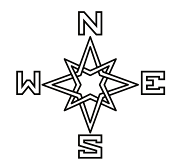
Sometimes, we only care about how big a measurement is. A quantity that tells us the a size or ________________ without telling us a direction is called a ___________ quantity. In other situations, we need to know both measurement AND ______________ . This direction can be described in relation to an object using terms like up, down, north, south, east, west, left, or right. A quantity that has both a magnitude and a direction is called a ___________ quantity.

CIRCLE ALL OF THE VECTORS:

3 liters	5 ft per second east of the yellow car	100 square kilometers	60 kilometers per hour
20 meters higher	24 lbs downward	6 kilometers south	21 degrees
42	80 lbs per square inch	20 degrees Celsius	4 gallons per minute

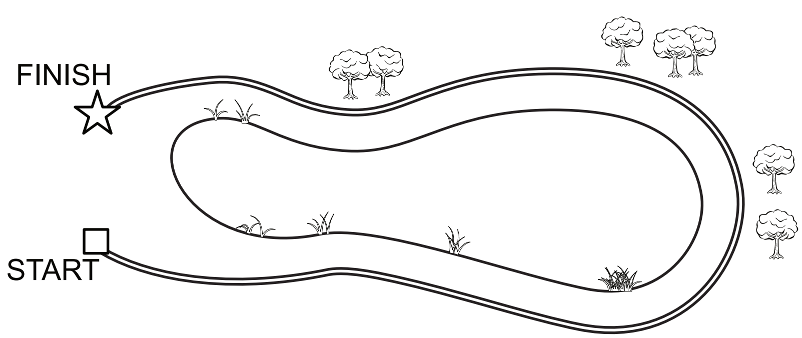
Below are the courses for three different races. Use the scale and compass to estimate both the distance and displacement from start of each race to the finish of each race.

1 km



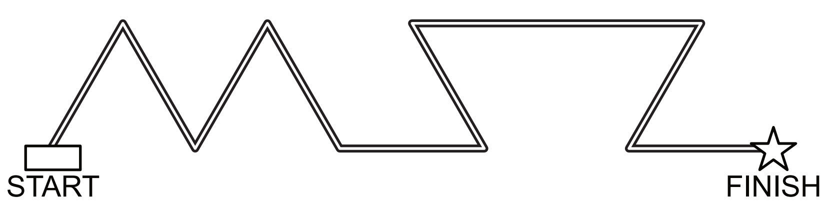
Distance: ________________________

Displacement: ____________________



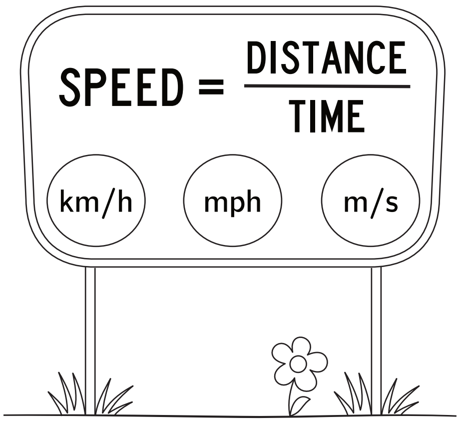
Distance: ________________________

Displacement: ____________________

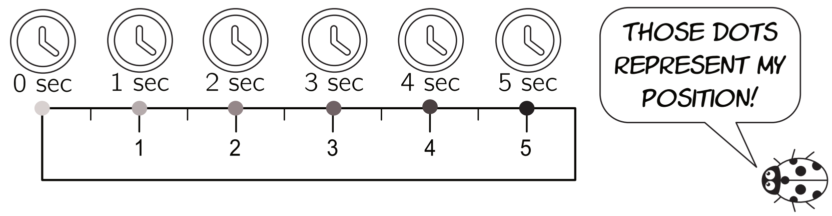


Distance: ________________________

Displacement: ____________________

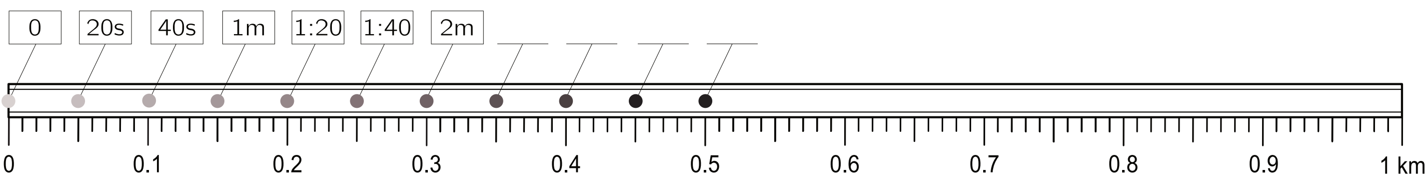


When we know the distance traveled and how much time it took, we can calculate how fast an object was moving, or its **speed**. The ladybug on the ruler moved 5 cm in 5 seconds, so its speed is 5 cm/5 seconds or 1 cm/s.



Calculating Speed

The dots below indicate the position of a runner every 20 seconds as they run along a path.

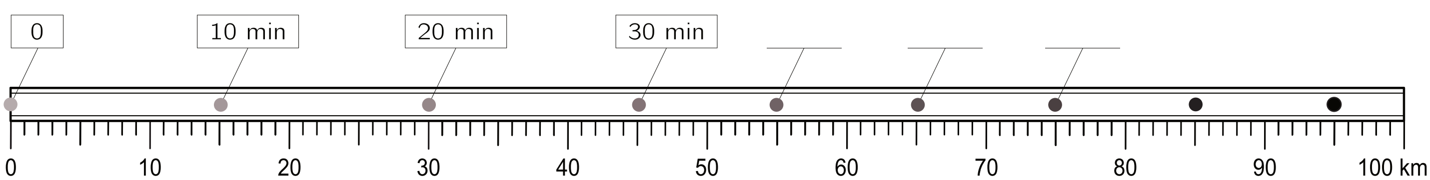


How far did they run?

How fast did they run?

Assuming that it kept the same pace, how long will it take to run 1 kilometer?

The dots below indicate the position of a car every 10 minutes driving South.



How fast did the car travel during the first 45 km?

When did the car slow down?

How long did it take the car to reach the 75 km mark?

Measuring Motion Physics Puzzles

IS IT A VECTOR?

Draw lines to classify each measurement below as either a vector, a scalar, or neither a vector or scalar.

100 kg

-10 °F

8 m/s^2 down

29 cm

30 m south

VECTOR

SCALAR

NEITHER

400 ft^2

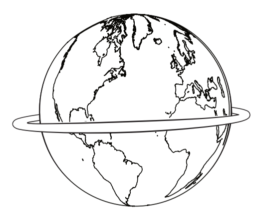
enormous

20 gal/min

32

north

MEASURE THIS MOTION:



1. Eli travels around the equator of the world in 70 days, arriving back in the exact same position from which he started his journey. What is his displacement?

2. Aisha and Arjun are training to run a 5K race. They ran for 24 minutes and want to know if they reached their daily running goal of completing 3 kilometers. Which will be most useful in answering their question: distance or displacement?

3. Kat drove 200 miles in 4 hours. What was her average speed?