LET'S LEARN WITH PAPER ROBOT CARS!

Summary:

The following activities are being used to learn concepts in physics and math using a single robot: the two wheeler paper car.

Students will learn about units and conversions by measuring distances and time.

This information will be used to introduce the concept of speed to students.

Finally, by taking several calculations, students can learn about averages (mean, median, mode).

Subjects Topics Covered:

- Math - Measurements and Conversions
- Physics - Speed
- Math - Statistics

Learning Objectives:

- Take measurements and convert between different units.
- Learn the difference between base units and derived units through calculation of speed.
- Learn and know how to use the formula of speed.
- Know the different ways of calculating average.

Materials needed:

- Printable robot car
- Rulers marked with different units of measurement - https://www.amazon.com/dp/B073GN6XPH/ref=psdc_1069364_t1_B073GM75MG
- Stopwatch/Timer - https://www.amazon.com/dp/B07D15FNPL/ref=sspa_dk_detail_0?pd_rd_i=B07D16MQ4Y&pf_rd_m=ATVPDKIKX0DER&pf_rd_p=a54d13fc-b8a1-4ce8-b285-d77489a09cf6&pf_rd_r=XRZYG62VTPG3PC115Q2N&pd_rd_wg=fb7VD&pf_rd_s=desktop-dp-sims&pf_rd_t=40701&pd_rd_w=c0u1R&pf_rd_i=desktop-dp-sims&pd_rd_r=d0f45425-9685-11e8-b87d-57bbe9c8dcbd&th=1

LET'S LEARN WITH PAPER ROBOT CARS!

Some words to know:
- **Measurement** - The amount or size of something is known as a measurement.
- **Unit** - A unit is just one of something. It is used as a standard for measurement.
- **Conversion** - Changing from one unit to another.

For example, what is your age? If you are 10 years old:

10 is the **measurement** of your age.
Years is the **unit** that is used to count how many years you are.

Let's say you want to know how many months old you are.
On your birthday, you are 120 months old.

120 is the **measurement** of you age.
Months is the **unit** that is used to calculate your age.

How did we get from 10 years to 120 months?

Since 1 year is equal to 12 months:

$$10 \text{ years} \times 12 = 120 \text{ months}$$

To **convert** someone's age from **years** to **months**, we **multiply** by 12.

What if we have someone's age in **months** and want to **convert** to **years**?

$$120 \text{ months} \div 12 = 10 \text{ years}$$

We should **divide** by 12.

Similarly, we can measure other quantities as well. In the following activity, we will be measuring the distance traveled by your paper robot car. Before that, let's see what all you know so far.

Pre-Activity Questionnaire

Choose an answer for the questions below:

1. Which is the biggest length?
   - ☐ 1 centimeter
   - ☐ 1 inch
   - ☐ 1 foot
   - ☐ 1 meter
   - ☐ I don't know

2. How many centimeters is 1 meter?
   - ☐ 3
   - ☐ 10
   - ☐ 100
   - ☐ 1000
   - ☐ I don't know

3. How many inches is 1 foot?
   - ☐ 3
   - ☐ 10
   - ☐ 12
   - ☐ 100
   - ☐ I don't know

4. How many inches is 1 yard?
   - ☐ 3
   - ☐ 12
   - ☐ 36
   - ☐ 100
   - ☐ I don't know

5. How easy do you think conversions are?
   - ☐ Super easy
   - ☐ A little confusing
   - ☐ I hate conversions!

Activity Instructions for the Teacher

<u>Measurement and Units Activity</u>
1. Before the activity starts, create a track using marker or tape on the floor with different measurements in increasing order (given in the worksheet) up till 1 meter.
2. Split the students into groups of three students.
3. Pass out the activity worksheets to all the students.
4. Divide the roles for the activity for each student:
    a. One student will be the driver.
    b. One student will be the timer.
    c. One student will measure the distance.
5. Give them rulers with different measurement units.
6. Give each group a stopwatch.
7. Explain the basic outline of the activity:
    a. Tell the student who is measuring the distances to place the car at the starting position and have the student measuring time ready to start.
    b. Using the controls of the car from an electronic device, make the car travel in a straight line until the first checkpoint. The driver and timer should start the car and stopwatch at the same time. When the driver stops the car, the timer should pause the stopwatch.
    c. The student measuring distances should measure and record the length from the start to this checkpoint using the rulers having different measurements to fill up the worksheet.
    d. After they are done with the activity, explain to the students how to convert from one unit to another (like finding out how many centimeters is 1 inch?) and have them follow the same procedure for several different units (that will be mentioned in the worksheet).
    e. Have them fill out the worksheets and then move onto the next activity.

<u>Speed Activity</u>
1. Explain the concept of speed.
2. Ask them to find the distance of some of the distances (mentioned in the worksheet).
3. Ask them to share some of their answers.

<u>Average Activity</u>
1. Explain what average is and the different ways of finding average (mean, median and mode)
2. Ask them to write down their speed for one of the units calculated (probably m/s as that is a commonly used unit for speed) on the board. If there aren't any repeated values, add one or two repeating values for the sake of calculating the mode.
3. Make them calculate the mean, median and mode for all the speeds written on the board.

MEASUREMENTS AND UNITS WITH PAPER ROBOT CARS

Activity Instructions:
- For this activity, you will need:
  - The paper robot car
  - Rulers with different units of measurement
  - Stopwatch
  - A marker or some tape
- There are three roles for the students:
  - The driver
  - The timer
  - The evaluator
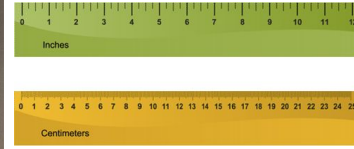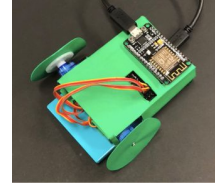
  Divide the roles among yourselves.
- Evaluator: Keep the car's two front wheels at the start position.
- Driver: You need to have an electronic device with WiFi connection. Connect to the car's "ESP_XXXX" wireless network. (XXXX will actually be a number that is the car's ID).
- Driver: Search 192.168.4.1 on the device's internet browser (like Google Chrome or Safari). A web page should appear with four buttons for controlling the car.
- Timer: Set up the stopwatch so that it starts at 0.
- Driver and Timer: Driver should press the forward button and start moving the car in a straight line. Timer should start the stopwatch at the same time that the car starts moving.
- Driver and Timer: Stop the car at the first checkpoint. Timer should pause (do not press stop) the stopwatch at the same time that the car stops moving.
- Evaluator: Using the ruler marked with centimeters (cm), measure the distance from the start position to the first checkpoint. Record the measurement in the given worksheet. If you need help with this task, ask the driver and timer for assistance.
- Evaluator: Measure the same distance, but use the ruler marked with inches instead. Record the measurement in the given worksheet.
- Timer: How much time did the car take to travel from the start to checkpoint? Record it in the worksheet.
- Repeat the same for all checkpoints until you reach the last checkpoint.

WORKSHEET

Some abbreviations:

- Centimeter - cm
- Inch - in
- Feet - ft
- Meter - m
- Seconds - s

Record the values you found in the table given below:

Distance (cm)	Distance (in)	Distance (ft)	Distance (yard)	Distance (m)	Time (s)
1					
2					
	1				
	6				
		1			
		2			
			1		
				1	

How can we use this information to **convert** from one unit to another?

Let's say, we want to find how many centimeters are 3 inches.

- **Step 1:** Identify the bigger unit.
  - Look at the 4th row of the above table. If you compare between the number values for cm and and inches, which number is bigger?_____
  - What is that number's unit? _____
    This is the **smaller** unit.
  - Which is the **bigger** unit then? _____
- **Step 2:** First, we will convert from the bigger unit to the smaller unit.
  - Look at the table again, and find how many centimeters is 1 inch. Write it in the box:

_____

- **Step 3:** Multiply the number in the box with the number of inches you wanted to convert to centimeters. So, in this example, you will multiply that number with 3.

$$\underline{\quad 3 \quad} \textbf{ in } \quad \text{X} \quad \underline{\qquad\qquad} = \underline{\qquad\qquad\qquad} \textbf{ cm}$$

number in box

- **Step 4:** If we want to convert from the smaller unit to the bigger unit. Divide the number you calculated in step 3 by the number in the box from step 2.

$$\underline{\qquad\qquad} \textbf{ cm } \quad \div \quad \underline{\qquad\qquad} = \underline{\qquad\qquad\qquad} \textbf{ in}$$

number in box

HOW FAST CAN YOUR CAR GO?

Remember how you measured the amount of time it took to travel to each checkpoint? Now, we are going to use all that information to learn about **speed**!

The basic definition for speed is how much **time** something takes to move a certain **distance**.

We have already calculated these two values in our previous activity. Now, let's calculate the car's speed!

$$Speed = Distance \div Time$$

So, for each measurement you took, you will divide the distance by time to obtain the speed.
How will you know which measurement to use? Use any!
The **unit** of speed changes based on the unit of distance and time.
So, what is the unit of speed? It is the unit of distance divided by the unit of time.
For example, if the car moved **3 cm** in **3 s**, the speed is **1 cm/s**.

Now, let's use some of the measurements from the table from the previous activity to calculate speed! Fill up the blank cells in the table given below:

Distance	Distance Unit	Time	Time Unit	Speed	Speed Unit
2	cm				
6	in				
2	ft				
1	yard				
1	m				

LET'S AVERAGE IT OUT

Now, let's learn about average!

In Math, **average** means a 'central' number for a set of many numbers that measure the same thing. So, which number best represents the set of numbers?

Let's say you want to calculate the average of ages of 5 people. Their ages are 9, 10, 10, 10 and 11 years. How would you do this?

There are three ways to calculate the average:
- **Mean** - Add up all the values and divide by the number of values.

$$\frac{9 + 10 + 10 + 10 + 11}{5} = \frac{50}{5} = \textbf{10 years}$$

- **Median** - Write all the values in ascending order. Cross out the numbers at the ends and keep going until only one number in the center is not crossed out.
    - Step 1:

        9, 10, 10, 10, 11

    - Step 2:

        9, 10, 10, 10, 11

    - Step 3:

        9, 10, (10), 10, 11

    Therefore, the median is **10 years.**
- **Mode** - The number that is repeated the most in the set.

    9, 10, 10, 10, 11

    9 appears **1** time, 10 appears **3** times, and 11 appears **1** time. Therefore, the mode is **10 years.**

Now, let's do an activity with the entire class.

Write down what value of speed you got for the unit **m/s** on the board.

- First, let's calculate the **mean** of all the speeds in the class.
    - What is the sum of all the speeds?

    _____

    - What is the number of values written on the board?

    _____

    - Calculate the mean:

    _____

- Second, let's calculate the **median** of all the speeds in the class.
    - Write all the speeds in increasing order:

    _____

    - Cut out the values from both ends untils you get one value in the center.
    - What is the median?

    _____

- Finally, let's calculate the **mode** of all the speeds in the class.
    - Write down how many times each speed appears on the board:

    _____
    _____
    _____
    _____
    _____
    _____

    - Which is the number that appears the most, the mode?

    _____

References:

- https://www.ck12.org/measurement/tools-for-measurement-of-customary-and-metric-lengths/lesson/Appropriate-Tools-for-Measurement-of-Squares-and-Rectangles-MSM7/
- NASA calculator controlled robot worksheet
- https://www.teachengineering.org/activities/view/nyu_unitconv_activity1
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