Fast, Faster, Fastest! (Level 3)

Description	Learners will understand the concepts of speed, how to calculate speed, distance covered and time taken, and plot motion-time graphs. They will use these concepts to design a game.
Leading question	What does it take to set a speed record?
Subjects covered	Science, Math, Physical Education
Total time required	40-60 min a day for 5 days
Resources required	Disposable plastic bottles, popsicle sticks, toothpicks, glue, tape, a clock or a watch, sand, string, beads, a skipping rope, a ruler, a clock or a watch, paper, and pencils *Optional*: Graph paper
Learning outcomes:	By the end of this project, learners will be able to: Knowledge-Based Outcomes: 1. Identify and differentiate between different types of motion. 2. Measure time and express it in different units. 3. Explain that speed is expressed as the distance travelled in unit time. 4. Create and analyse distance and time graphs. 21st Century Skill Outcomes: 1. Show creativity in designing games the results of which they will plot on graphs. 2. Think critically to generate hypotheses and test them. 3. Collaborate effectively while receiving, clarifying and implementing feedback.
Previous Learning	Effects of force on an object, meaning and causes of motion
Supervision required	Medium

Day 1 -

Today, you will find out what speed is and how time is used to measure it.

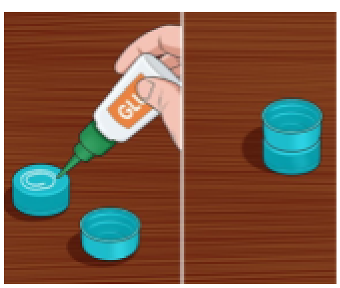
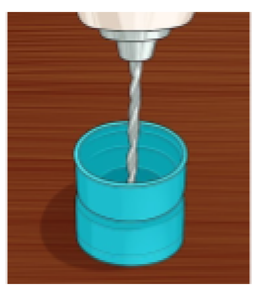
Time	Activity and Description
5 minutes	**Speed and Time** What do you think of when you hear the word speed? - Who are the fastest athletes or people you know? - What are the fastest animals you know? - What are the fastest vehicles you know? Speed is the rate of change of motion per unit of time.

<table>
<tr><td></td><td>- The more an object moves per unit of time, such as a minute or second, the faster it is said to be, and the more its speed.
- The less an object moves per unit of time, the slower it is said to be, the less its speed.
Because speed is measured as motion per unit of time, time is essential to understand speed.

Note: Show learners a clock or a watch and ask them to identify the slowest, slower and fastest hands.

Why is the second hand the fastest? (The second hand is the fastest because it moves the most out of the three hands in one minute).</td></tr>
<tr><td>10 minutes</td><td>Making an Hourglass
Let us make our own watch-like device that measures time! This device is known as an hourglass. Unlike a watch or a clock, it does not use any electricity and works on the force exerted by the earth on objects or gravity!

Let us make an hourglass! To do this:
1. Glue and stick together two plastic bottle caps such that the closed ends of the caps are on top of each other
2. Create a small hole that penetrates both bottle caps using a sharp object like a nail or drill (help learners out with this for safety reasons).
3. Add some sand to one of the bottles.
4. Secure the caps onto the bottles and flip the bottle with the sand to see the sand pass through to the second bottle.
5. If needed, tape the bottle caps from the outside to make sure the sand doesn't leak out.

  
We will use the hourglass in an experiment later today!</td></tr>
<tr><td>10 minutes</td><td>Making a Simple Pendulum
How is the motion shown by the hand of a clock and a car on the road different?

The hands of a clock repeat the same motion in fixed intervals or periods of time. Such motion is called periodic motion. The motion of a car or a bird may not repeat itself in regular intervals of time. Such motion is called non-periodic motion.</td></tr>
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<tr>
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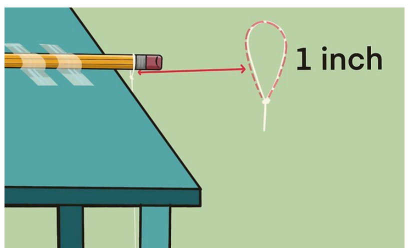
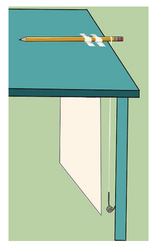
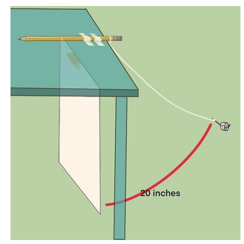
Let us now make a device that shows periodic motion. This device is called a simple pendulum.
To make a simple pendulum:

Use a nail on the wall, hook on the ceiling, or tape a small pencil/ stick to the table making sure that it juts out 2 inches or so.
Take a 20 cm long string and tie a loop in it to hang it on the nail/ hook/ pencil/ stick.
On the other end of the string, tie a small weight such as an eraser, sharpener or a rock. You have made your pendulum!
Move the pendulum and notice how the weight shows periodic motion.



</td>
</tr>
<tr>
<td>15 minutes</td>
<td>
Time Period of a Simple Pendulum
Let us perform an experiment to measure how fast or slow the simple pendulum that we just designed moves! To measure the time, we will first fix or calibrate our hourglass using the watch, and then use it to measure time.

<u>Calibrating the Hourglass</u>

How will you calculate how much time it takes for sand to completely pass from one bottle to another? (use a watch/ clock to measure the time).
Measure the time taken by the sand in the hourglass to move completely into the other bottle.
How much time did the sand take? What can you do to increase/ decrease this time to one minute? (add/ remove sand in the hourglass).
Make necessary changes to your hourglass and make sure the sand empties in exactly 1 minute!

<u>Calculating the Time Period of a Simple Pendulum Using an Hourglass</u>

How will you use the hourglass to calculate how many to-and-fro movements or oscillations the simple pendulum would complete in 30 seconds? (count the number of oscillations it completed in 1 minute, and divide the number by 2).
How will you find out how much time it takes to complete one oscillation? (Divide 30 seconds by the total no. of oscillations in 30 seconds).

Note: Ask learners to draw the table below, fill in the materials required and the method, conduct the experiment based on the method, and write their observations. Once done, ask them to find out the time taken for one oscillation and write it as an inference.
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</table>

<table>
<tr><td></td><td>
<table>
<tr><td>Materials required</td><td>A calibrated hourglass and a simple pendulum</td></tr>
<tr><td>Method</td><td>
1. Take the weight of the pendulum to one extreme and let the pendulum start oscillating.
2. At the same time, turn the hourglass over.
3. Count the number of oscillations as the sand in the hourglass flows into the other bottle and fill in the observation table.
4. Repeat Steps 1, 2 and 3 thrice and populate your observations.
5. Take an overage of the observations and calculate the mean no. of oscillations in 30 seconds.
</td></tr>
<tr><td>Observations:</td><td>
Sample observation:
<table>
<tr><td>Trial</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td>No. of oscillations in 1 min</td><td>12</td><td>14</td><td>10</td></tr>
<tr><td>No. of oscillations in 30 s</td><td>6</td><td>7</td><td>5</td></tr>
</table>
No. of oscillations in 30 seconds = (6 + 7 + 5)/3 = 6
</td></tr>
<tr><td>Inferences</td><td>Time taken for one oscillation = 30/6 = 5 seconds</td></tr>
</table>
- How many oscillations did your pendulum make in 30 seconds?
- How much time did one oscillation take?

The time taken to complete one oscillation is known as the time period of a simple pendulum.
</td></tr>
<tr><td>At-home activities</td><td>Ask learners to use an hourglass and a simple pendulum and find out ways to increase and decrease the time period of the pendulum.</td></tr>
</table>

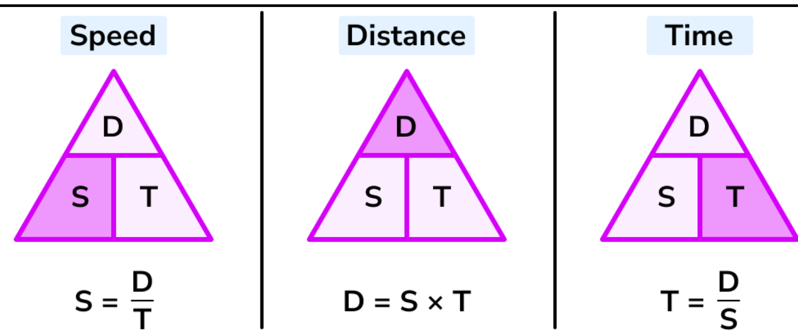
Day 2

Today, you will find out about different types of motion, the relationship between motion and time, and start working on your sports event!

Time	Activity and Description
5 minutes	**Introduction** What did you do to increase and decrease the time period of the simple pendulum? *(Increasing the length of the string increases the time period of the simple pendulum, and decreasing the length decreases the time period.)*

	So far we have learned about what speed is, how speed and time are related to each other, and how to measure the time period of a periodic motion. Today, let us start with learning about two more types of motion!
10 minutes	**Rectilinear and Circular Motions** ***Note:*** *For this activity, use objects - such as a chair or a box - to mark two spots: Middle Point (in the middle of the room) and Far Point (along the edge of the room).* I will give you some instructions. As you follow those instructions, observe the kind of motion you show: - Move from the Middle Point to the Far Point. - Move around the Middle Point, making sure that you don't get any nearer or farther than the middle point, but keep moving! *(instruct the learners to stop once they complete two or three circles around the Middle Point).* What did you notice about your motion when you followed each instruction? - How did you move when you travelled from the Middle Point to the Far Point? *(moved from one spot to the other in a straight line)* - How did you move when you travelled at the same distance from the Middle Point? *(moved around one spot along a circle)* Let us find out what the kinds of motion we showed while following each instruction is called! - When you moved from Middle Point to Far Point, you travelled along a straight line. Such motion that takes place along a straight line is called **rectilinear motion**. - When you moved around the Middle Point, staying at the same distance from the middle point, you basically moved along the boundary or the circumference of a circle with the Middle Point being its centre. Such motion that takes place around a fixed centre, along a circular path, is called **circular motion**. Can you think of some more examples of rectilinear motion? Circular motion? *(Rectilinear motion - such as a car moving along a straight road, a train moving along a straight track, and a bicycle moving along a straight path* *Circular motion - such as spinning a rock tied to a string, the Earth moving around the Sun, and a car moving along a circular road)*
10 minutes	**Relationship Between Speed and Time** You know that speed is the distance covered per unit of time. Let us play with rectilinear motion and find out how speed varies if we vary distance and time! I will give you some instructions. As you follow the instructions, you must show rectilinear motion only! I will record the amount of time you take to follow the instructions using a watch/ clock:

	1. Move from Middle Point to Far Point as slowly as you can, but you cannot stay in one place! *(record the time in seconds that the learners take to cover the distance and make a note of it)* 2. Move from Middle Point to Far Point as fast as you can! *(record the time in seconds that the learners take to cover the distance and make a note of it)* ***Tip:*** *If more than one learner is participating in the project, divide into teams or pairs to take turns performing the activity and recording time.* Let us think about the motion we showed. - While following which of the two instructions was your speed greater? Lesser? *(greater - Instruction 2, lesser - Instruction 1)* - While following which instruction do you think you took more time to cover the distance between Middle Point and Far Point? *(Instruction 2)* - Based on this, how do you think speed and time are related? If the distance is constant, speed is greater if the time taken to cover the distance is less. Similarly, it is less if the time taken to cover the distance is more. Speed = $\frac{Distance\ Covered}{Time\ Taken}$
10 minutes	**Calculating Speed** Have you ever heard of terms such as 20 km per hour or 30 miles per hour? What do they mean? *(measures of speed)* Just like time, speed can be measured using the formula we studied just now. Let us calculate our speeds during the motion we showed just now! Based on the formula, what information do you need to know to measure your speed? *(the distance travelled and time taken to travel the distance)* ***Note:*** - *Get learners to measure the distance between Middle Point and Far Point using a ruler or a measuring tape (in inches or centimeters).* - *Provide them with the time taken to follow instructions 1 and 2 that were noted earlier.* - *Ask them to calculate the speed and guess its unit.* The unit of Speed is the unit of distance per unit of time. For example, metres per second (m/s) or kilometres per hour (km/ h). In your case, the unit should be centimetres or inches per second (cm/s or inch/ s),
5 minutes	**Game Evening** Think of an activity that involves rectilinear motion that you would like to play with your friends in the sports evening! It’s OK if the activity involves more than one type of motion, but one of them must be rectilinear!

	Tip: *If needed suggest activities such as kangaroo hops, one-legged hops, walking backwards or jumping a rope along a line.* On further days, we will plan how to turn this activity into an exciting game using motion, speed and time!
At-home activities	Inform a family member or a friend of what rectilinear motion means and share your activity idea with them. Ask them if they can think of something more exciting!
Optional Literacy/ Numeracy Activity	 Learners can use the equation speed = distance/time (and its derivations as shown above) to solve work problems: ● If you walk at a speed of 5 km/h every day to from home to school covering a distance of 1.5 kilometres, in how much time do you complete this journey? Convert your answer into minutes. ● If one day you wake up late for school and you start running from your home at a speed of 15 kilometres per hour to get to the school. How much time would that journey take you? ● If your friend who goes to a different school walks at a speed of 4 kilometres per hour and gets to school in 40 minutes, how far is his home from school?

Day 3 –

Today, you will express different types of motions in graphical forms and think about the rules for your game!

Time	Activity and Description
5 minutes	**Introduction** What are the different types of motion that we learned about in the previous classes? *(periodic, non-periodic, rectilinear, circular)* What activity involving rectilinear motion, among other types of motion if any, did you choose? Today, we will use this activity, and some activities, to understand how to plot distance-time graphs!

20 minutes

Distance-Time Graphs

We need to collect distance-related data to be able to draw distance-time graphs! Let us do some preparation for this.

Note: *Ask learners to draw a line between Mid Point and Far Point (marked on the previous day), and measure and mark these points on the line:*

- *¼ of the distance between Mid Point and Far Point*
- *½ of the distance between Mid Point and Far Point*
- *¾ of the distance between Midpoint and Far Point*

Once done, ask learners to copy the table shown below and add the activity they had chosen on the previous day to the table.

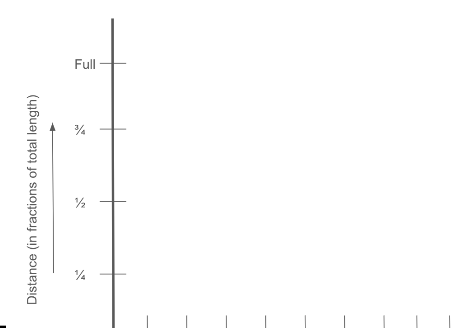
Activity	**Time Taken to Cover…**			
	¼ Distance	**½ Distance**	**¾ Distance**	**Full Distance**
<Learner to fill>				
Skipping a rope				
Hopping				
One-legged hop				
Activity - 4				
Activity - 5				

Now, you will perform each activity to move from Middle Point to Far Point, and I will record the time you take to cover the different distances.

Note: *If more than one learner participates in the project, divide learners into teams or pairs to take turns performing the activity and recording time.*

Now, let us use this data to make a distance-time graph! Let us understand how:

- On a sheet of paper, mark a point in the centre. This is the **origin** of the graph.
- Draw an **X-axis** as a horizontal ray starting at the origin.
- Divide the X-axis into equal parts and label it “time.” Now, mark the seconds on it in intervals of 5.
- Draw a **Y-axis** as a vertical ray starting at the origin.



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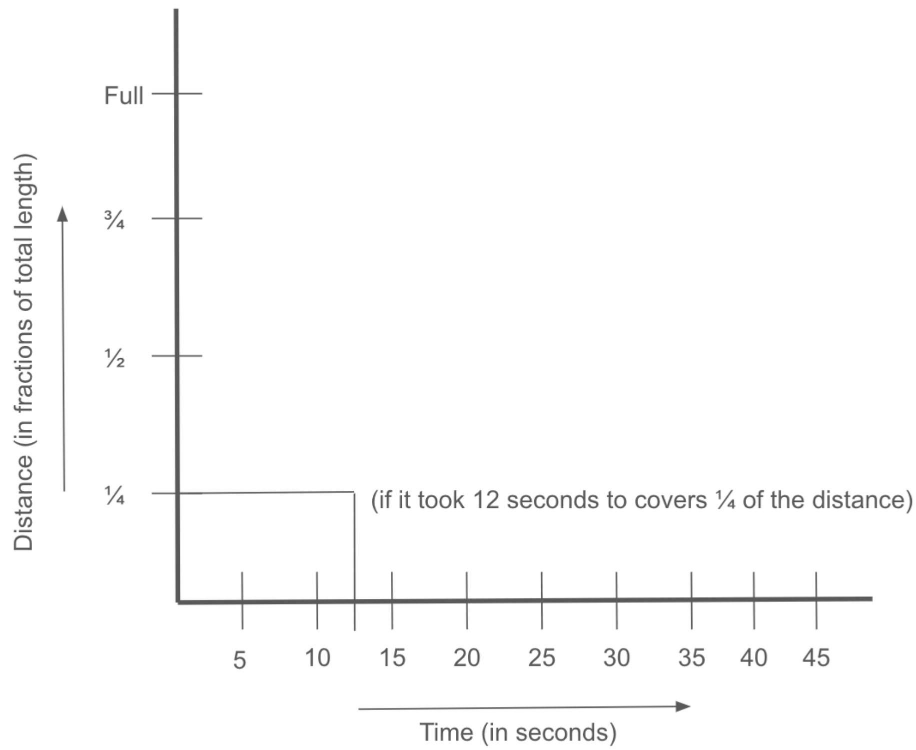
- Divide the Y-axis into 4 equal parts and label it “Length” or “Distance.” Now, mark the distance as ¼, ½, ¾, and full.

Now let us learn how to plot the data we recorded in the table earlier!

Note*:*

- *Use an example of a data point to explain to the learners how to mark time taken to cover a fraction of the total distance (as shown below).*
- *Once done, ask them to join all the marked points.*
- *After completing the graph for one activity, they can draw copies of the graph and do the same for the rest.*



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</tr>
<tr>
<td>5 minutes</td>
<td>

Reading Distance-Time Graphs
Let us now try to relate our motion with the graphs we just plotted.

- During which activities did you cover distance faster?
    - Was your speed during these activities fast or slow?
    - What does the distance-time graph for those activities look like?
- During which activities did it take you longer to cover the distance?
    - Was your speed during these activities fast or slow?
    - What does the distance-time graph for those activities look like?

When we move faster, we move at a greater speed and cover more distance per unit of time. For such **fast motion, the distance-time graph is steeper** and closer to the Y-axis. When we

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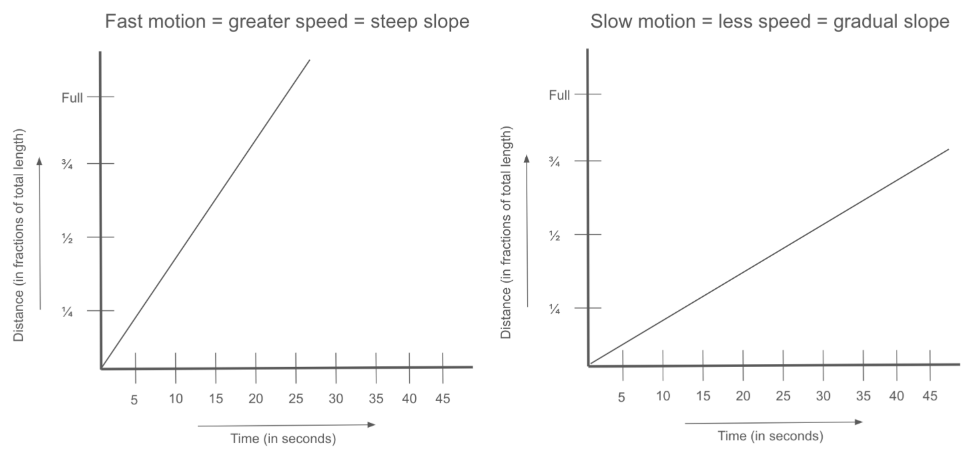
</table>

	move slower, we move at a lesser speed and cover less distance per unit of time. For such **slow motion, the distance-time graph is less steep** and closer to the X-axis. ***Note:*** *Use the images shown below to explain how the gradient of the graph varies with speed in uniform rectilinear motion.* 
10 minutes	**Uniform and Non-Uniform Motion** Let us look at the graphs a little more closely. - In which cases did you get a straight line when you joined the points you had marked? - In which cases did you get a set of individual line segments? When we move at the same speed throughout the motion, the distance-time graph is a line segment because we cover equal distances in equal intervals of time. Such motion is called **uniform motion**. When we move at different speeds during different parts of the motion, the distance-time graph looks irregular. Such motion is called **non-uniform motion**. Can you think of some examples of uniform and non-uniform motion? Uniform motion: A car moving at a constant speed along a straight road, a train moving at a constant speed along a straight track. Non-uniform motion: A bird moving at a random speed, a paper aeroplane flying in random directions at random speeds.
At-home activities	Think of ways in which you can represent the activity you chose for your game evening on a graph.
Optional Literacy/ Numeracy Activity	Numeracy Extension: Convert the speeds calculated in the activities from centimetres per second to meters per minute Literacy Extension: do you sometimes wish you could change the speed of certain events in your life? Do you wish time would go by slowly when you're having fun with your friends? Do you wish it goes by faster when you're studying for exams? Write a short essay on how you

	would change the speed of certain events if you could. Make sure to use the correct punctuation.

Day 4 –

Today, you will explore how speed can be increased or decreased by making a model skateboard!

Time	Activity and Description
5 minutes	**Introduction** What do you think is the fastest a toy car can go? Can we increase this speed? How? We learned about speed, uniform motion and non-uniform motion. Today, we will explore different scientific concepts to learn how to increase speed in different model vehicles that we will make!
15 minutes	**Making a Skateboard** ***Note***: *Learners will create a model skateboard using the steps below:* - *Cut a popsicle stick or any stick in half and glue the two pieces side by side. This is your skateboard* - *Turn the skateboard upside down and add glue where you want to place the axles (toothpicks). Press the toothpicks into the glue crosswise* - *Thread the beads onto the ends of the axles (toothpicks) for wheels.*  Let us start our series of experiments!
10 minutes	**Friction - Experiment 1** Why do you think wheels were invented? - Let us experiment with pushing a small object like an eraser or sharpener with your index finger on a smooth surface like a table. - Using the same force, let's now try pushing the object while it is placed on our mini skateboard. In which case does it move faster and more easily? Please record your observations in the table below **Experiment** | **Hypothesis and Evidence** | **Conclusion** | **Suggested Explanation**

<table>
<tr>
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<table>
<tr><td>On the skateboard
Speed = Distance / Time (X=Y/Z)</td><td>H: Easier to move and faster
E:</td><td>It is easier and faster to move the object</td><td>It was easier to move it because…</td></tr>
<tr><td>Not on the skateboard</td><td></td><td></td><td></td></tr>
</table>

A wheel reduces friction by allowing the contacting surfaces to roll rather than to drag or slide over each other. By reducing friction, a wheel can enable you to use less force to move an object.
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<tr>
<td>10 minutes</td>
<td>
Experiment - 2
We will pick a few different surfaces to understand how friction can be further reduced by the surface we use.

Note: Ask learners to move the skateboard on different surfaces.

<table>
<tr><th>Surface</th><th>Hypothesis</th><th>Evidence</th><th>Conclusion</th></tr>
<tr><td>Smooth wooden or tile floor
Speed = Distance / Time (X=Y/Z)</td><td>Fast – Low Friction</td><td>Fast – Low Friction</td><td>The vehicle moves faster since there is less friction or resistance</td></tr>
<tr><td>Sweater on a surface (bumpy or uneven surface)</td><td></td><td></td><td></td></tr>
<tr><td>Grass</td><td></td><td></td><td></td></tr>
<tr><td>Dirt or Rubble</td><td></td><td></td><td></td></tr>
</table>

So the smoother and less resistant a surface is, the less friction there is and the faster the object moves with less force.
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<tr>
<td>At-home activities</td>
<td>
Make a game out of the activity you chose:
- What are some rules?
- How do you decide if someone has won?
- How can you include distance-time graphs in the game?
- How can you include calculating speed in the game?
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</tr>
</table>

Day 5 -

Today, you will play the game you designed with your friends!

<table>
<tr><th>Time</th><th>Activity and Description</th></tr>
<tr><td>10 minutes</td><td>Preparation
Note: Ask learners to gather 6-8 friends/family beforehand for the game evening. They will take the first 10 minutes to brief them on the rules of the games and what will be done with the data (calculate speed/ plot graphs etc)</td></tr>
<tr><td>20 minutes</td><td>Game Evening
Note: Learners will play games with their friends, capture data in observation tables (show them the sample below, if needed) and plot graphs. If there aren’t enough players, learners can populate the table below for ‘players’ instead of ‘teams.’
<table>
<tr><th></th><th>Team A</th><th>Team B</th><th>Team C</th><th>Team D</th></tr>
<tr><td>Hopping</td><td>Participant: X

Distance: x in cm / m

Time taken: x in mins / seconds

Speed: Distance / Time (x mtrs or cms / x seconds)

Participant: Y

D:
T:
S:</td><td></td><td></td><td></td></tr>
<tr><td>Rolling a Pencil</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Flying a Paper Plane</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Etc.</td><td></td><td></td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td>10 minutes</td><td>Reflection
- What did you enjoy during this project?
- What did you not enjoy?
- What did you learn about speed, distance and time that you did not know before?</td></tr>
</table>

Additional enrichment activities:	Learners can further explore concepts of thrust, lift and drag using the project: Need for Speed (https://resources.educationaboveall.org/resources/ages-11-14/managing-our-need-speed-level-3)

Modifications for simplification	Learners can choose to just calculate distance, speed and time during the game, and not plot graphs for the motion.

ASSESSMENT CRITERIA

A majority of my students were able to:

☐ Complete equations to calculate speed, distance and time.
☐ Identify different types of motion.
☐ Understand the different units of time.
☐ Graphically represent speed.
☐ Identify factors affecting speed.

~~APPENDIX~~