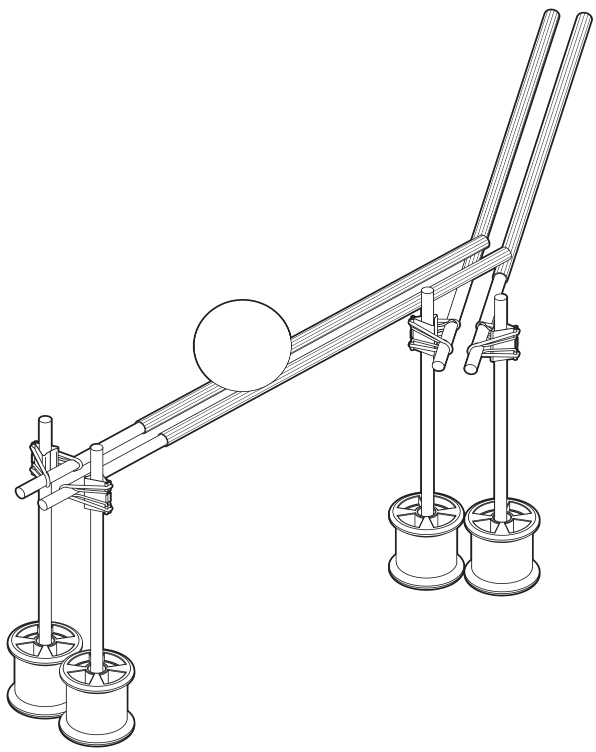


BALL RUN WORKSHEET

GETTING STARTED

5-10m

The ball run is an intricate STEM build that teaches you planning, construction, teamwork and most importantly how to persevere when faced with not succeeding during your first attempt.

Perseverance and planning are key when completing this activity. Don't forget to test your materials before you start your design phase.

Be sure to share your ideas with your team members, as collaboration is an important part of being an engineer.

VOCABULARY

Acceleration - The rate of increase in speed or velocity.

Prediction - Declaration of what will happen based on reason and knowledge.

Impediment - A hindrance or obstruction. Something that makes things more difficult.

Slope - An incline or slant, such as a hill or ramp

Force - A push or pull that acts on an object.

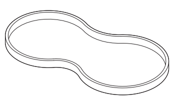
Gravitational Potential Energy - The energy stored in an object when it is elevated. This energy is converted to kinetic energy when the object falls back down.

Kinetic Energy - The energy of motion.

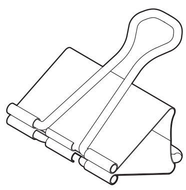
Momentum - The tendency of a moving object to keep moving. This is calculated by mass x velocity.

Friction - The resistance that one surface or object encounters when moving over another.

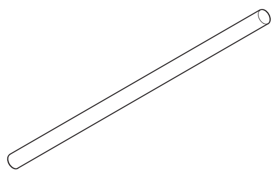
EACH TEAM WILL NEED



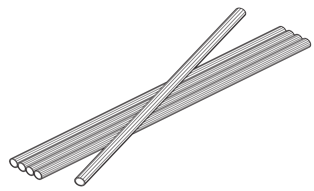
Elastic Band
20



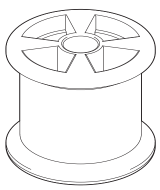
Bulldog Clip
16



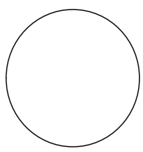
Wooden Dowel
14



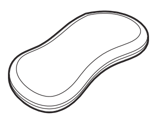
Paper Straw
10



Cotton Reels
6



Ping-Pong Ball
1



White Tac

WARM-UP ACTIVITY

A

10-15m

Everybody is in a rush to get from A to B. Moving things as efficiently as possible has been a challenge that engineers have been trying to solve for thousands of years. Their creativity and perseverance has allowed cities to thrive and has even put humans on the moon!

Consider and discuss the following:

- What systems have been created throughout history to help move things along a specific course? (Aqueduct, power lines, underground etc.).
- Where does the water in your home come from?
- Where does the water in your home go?
- What problems could arise with this system?

Thinking about the mechanisms that allow water to run through pipes will help you design and prototype your ball run.

Experiment with the different materials provided; think about how different shapes and structures will have an impact on the forces applied to the ball and how this will affect your final result.

MAIN CHALLENGE

30-40m

As a group, you're going to design and build your very own ball run.

Firstly, you'll need to discuss and design your ball run before you start your construction. Don't be surprised if you have to redesign sections of your build part way through, this is all part of the engineer's design process, to test prototypes and find the best design.

Using the materials provided, your design must ensure that the ball remains on the run for as long as possible without the ball stopping.

Once completed and tested, there will be a class discussion about your findings.

DID YOU KNOW?

The oldest roller coasters are thought to have originated from Russia in the 17th Century and were built of ice!

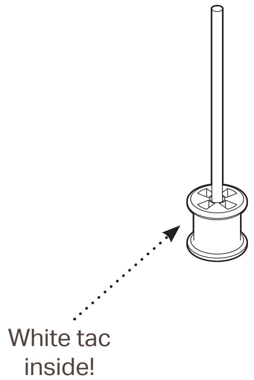
Wood was used up until the 1950's to create these adrenaline rides and it wasn't until 1959 that Disneyland introduced the first steel roller coaster.

BUILDING THE BALL RUN

The ball run itself will be designed by you to meet the criteria of the task. Here are a few tips and tricks that can help get you started with your design!

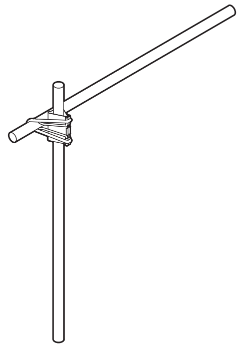
A

Form a stand by sticking a wooden dowel to a cotton real. It may be necessary to pad the cotton reel with a small piece of white tac to gain a good grip. Think carefully about the height that you want the dowel to be!



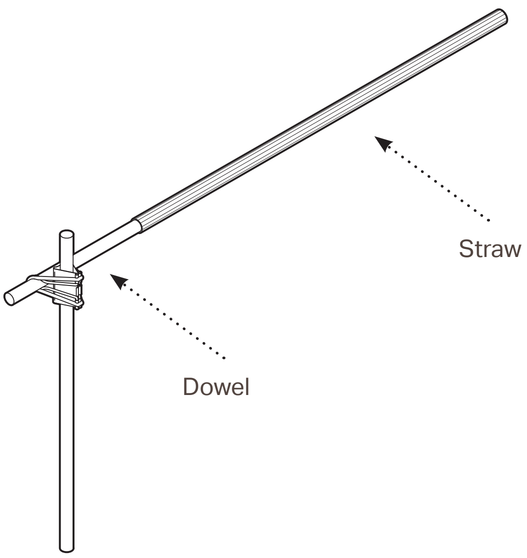
B

Create a right angle with a second dowel, using a bulldog clip to hold it in place. Again, a piece of white tac or rubber band will be helpful to hold in place. Wrap the band around the joint several times to ensure that it is secure.



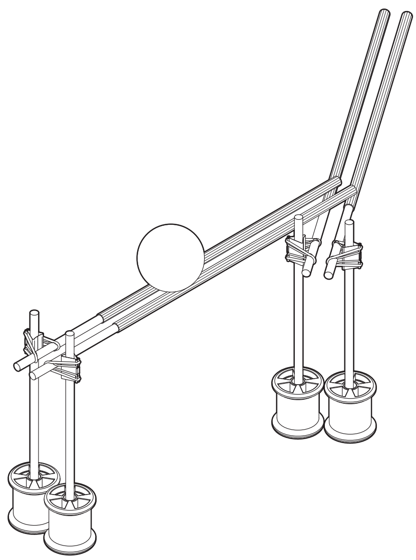
C

Add length to your run by attaching a straw to the end of the dowel.



D

Create several stands with rails and once you have as many as you want, secure the stands vertically to a flat surface using white tac. An example ball run is shown below. Perhaps you could use cotton reels to add stability to the base of your run. Get ready to roll!



BALL RUN

10-15m

NEWTON'S LAWS

KS1/2 PROOF OF CONCEPT

Think back to when you have ridden a bike. What happens when you ride your bike down a hill compared to when you are riding along flat land? You go faster!

That is because gravity is pulling you down the hill. If you are on a flat surface, there is nowhere for gravity to pull you, so you stay still (unless you are pedalling - but that's a different kind of force!).

Think about your ball run, what changes could you make to make certain parts of your ball run more effective?

KS3/4 DEEPER LEARNING

NEWTON'S FIRST LAW

An object will remain at rest (or in a state of constant motion) unless acted upon by an external force. What would the external force be for a ball on a slope that results in the ball rolling downhill? Gravity! Gravity is pulling the ball downwards.

NEWTON'S SECOND LAW

This describes the relationship between force, mass and acceleration as $F = ma$. The mass of an object is constant wherever it is in the universe, whereas weight is the force acting on that mass due to gravity.

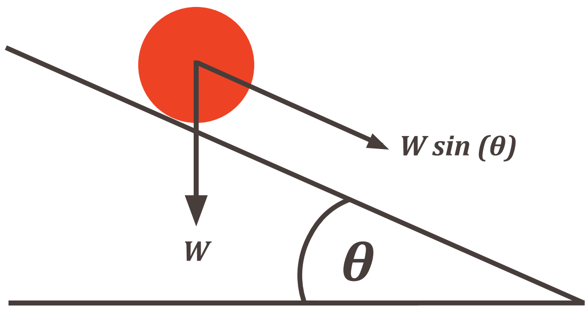
The rate of acceleration due to earth's gravity can be taken as a constant $g = 9.8\ m/s^2$.
So if we apply the $F = ma$ to look at the force on the ball due to gravity, we have:

$W = mg$ Weight W = mass m x acceleration due to gravity g

NEWTON'S THIRD LAW

Whenever two objects interact, they exert equal and opposite forces on each other.
When a ball is at rest on a table the force of gravity is being cancelled out by an equal and opposite force from the table. However, on a **slope** the force from the surface is acting on the ball at an angle.

We know that the force directly downwards due to gravity is weight, and if we know the angle of the slope we can use trigonometry to calculate what the resultant force in the direction of the slope will be.



Downhill force = sine of 'angle of the slope' (or $W \sin \theta$)

So while the force of gravity on the ball is constant, the maths shows us that the steeper the hill, the greater the force acting in the direction of the slope. This means, as you might expect, the steeper the slope the greater the acceleration.

What does this mean for the design of your marble run?

QUIZ

10-15m

What do you call energy stored in an elevated object?

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....

What does every engineer do before starting construction?

....

....

What is friction?

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....

Why is friction important to consider when designing your ball run?

....

....

Name the force acting on the ball.

....

....

QUIZ

What is an impediment?

....

....

What were the world's oldest roller coasters made out of?

....

....

What happens if you increase the slope angle?

....

....

Where was the first steel roller coaster introduced?

....

....