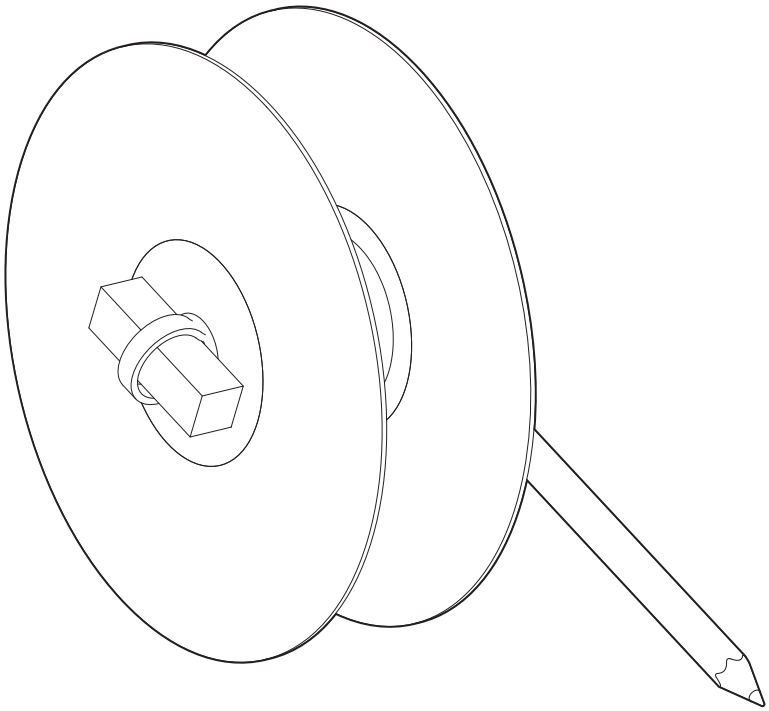


CD RACER WORKSHEET

GETTING STARTED

5-10m

CD Racers are a classic STEM-based build that incorporate the science behind potential and kinetic energy.

This build requires perseverance and determination, as it's surprisingly tricky. If one of the several elements isn't quite right, the project won't work.

It's your job to work out where the problem lies, and how you will go about fixing it. Up for the challenge?

VOCABULARY

Friction - A force between two surfaces that are sliding, or trying to slide across each other.

Potential Energy - Stored energy.

Kinetic Energy - The energy an object possesses due to its motion.

Acceleration - The rate of change of velocity of an object with respect to time.

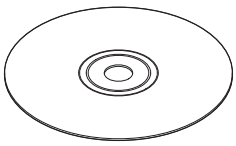
Force - An interaction that, when unopposed, will change the motion of an object.

Mass - The property of a physical body that is a measure of the amount of matter in an object.

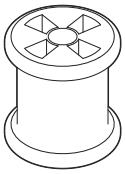
Gravity - A force that tries to pull two objects towards each other.

Velocity - The measure of how fast an object moves in a particular direction.

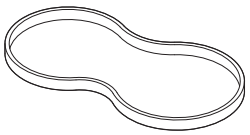
YOU WILL NEED



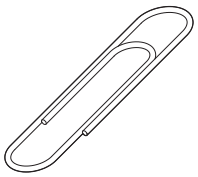
CD
2



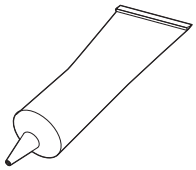
Cotton Reel
1



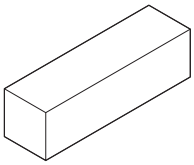
Elastic Band
1



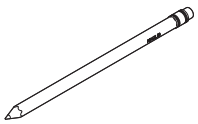
Paper Clip
1



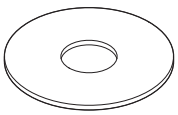
Glue
1



Rubber
1 inch



Pencil
1



M10 Washer
1

WARM-UP ACTIVITIES

A

5-10m

Watch the CD Racer video provided and take a look at one in action.

Now you have 10 minutes to answer the following questions. You also have the option to discuss them as a class.

1. Where is the energy stored?
2. What type of energy is stored?
3. Why do you need high friction and low friction material to make the CD Racer move?

B

10-15m

Using online resources, research the basic principles behind Newton's three Laws of Motion.

You have 15 minutes to complete the following -

1. For each of the three laws write a sentence, in your own words if possible, to summarise what that law tells us.
2. For each of the three laws write a sentence on how this can be observed in the behaviour of your CD racer.

MAIN CHALLENGE

30-40m

On your own or in a team, you are going to build a CD Racer using the materials from the list.

Before starting construction, research and design your CD Racer; don't forget to think about and incorporate the scientific principles covered in the warm-up activity.

The CD Racers must be stable enough to travel 3 metres and complete 3 successful journeys.

The success of this will be measured by how fast your CD Racer reaches the finish line.

Once completed and tested, there will be a quiz at the end to test your knowledge.

DID YOU KNOW?

Sir Isaac Newton was an English mathematician, physicist, astronomer and author, who is widely recognised as one of the most influential scientists of all time. His laws of motion and theory underpin much of modern day physics and engineering.

BUILDING THE CD RACER

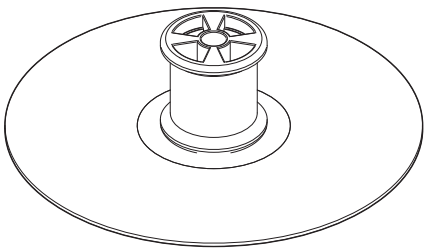
Follow these simple steps to build your CD Racer.

A

Place glue around the centre of the first CD. Press the cotton reel onto the CD.

Ensure you can see straight through the middle of both the CD and the cotton reel.

We used UHU All Purpose Adhesive, but you have the option to use hot glue and even white tac. If you're unsure ask an adult.

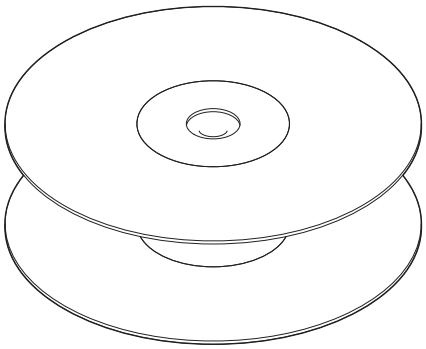


B

Take the second CD and place glue around the centre, then press this onto the other side of your cotton reel.

Again check that you can see through the centre of both holes, and that both CDs line up.

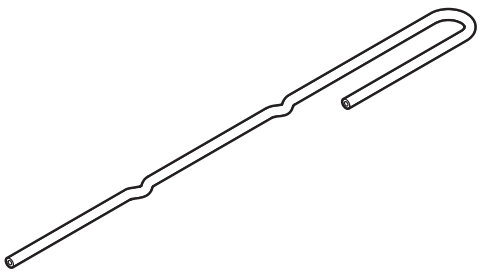
Allow the structure to dry for 5 minutes.



C

Next, take your paperclip and create a hook. It should look like the image below.

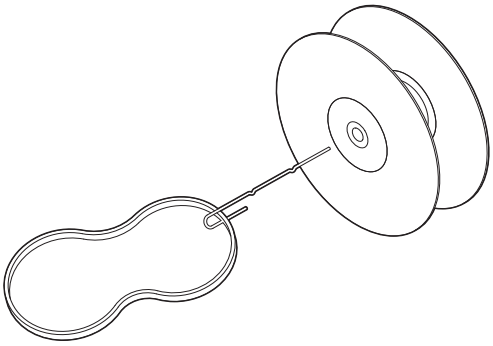
Be careful of any sharp edges on the paperclip.



D

Hook an elastic band onto the paperclip and use this to thread the elastic band through the centre of your CD.

Top Tip - The shorter and thicker your elastic band, the more energy you will be able to produce.

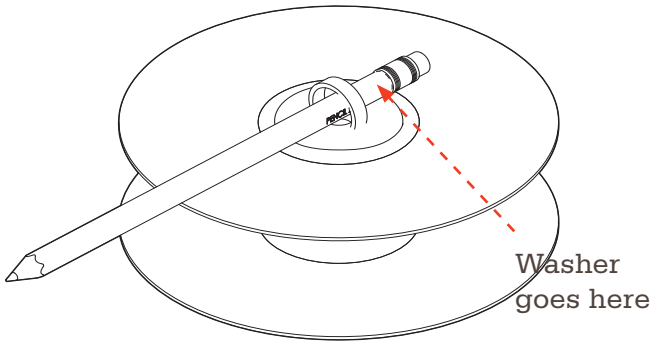


E

Take your washer and place the elastic band through the centre.

Thread the pencil through the remaining elastic band loop, securing the washer in place.

The low friction quality of the washer will ensure that the CD can turn whilst the pencil stays in the same orientation.

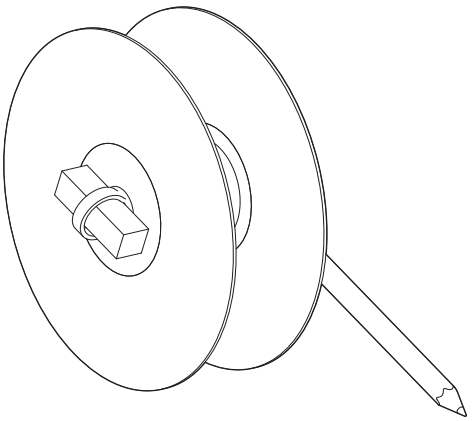


F

Using scissors, cut about an inch section of rubber.

Then place the rubber through the elastic band on the opposite side to the pencil. This rubber increases the friction between the elastic band and the CD to ensure the wheels spin as efficiently as possible.

Now you're ready to race!

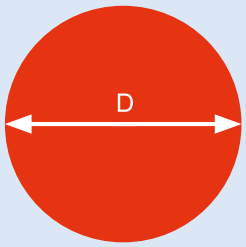


CD RACER WHEELS & AXLES

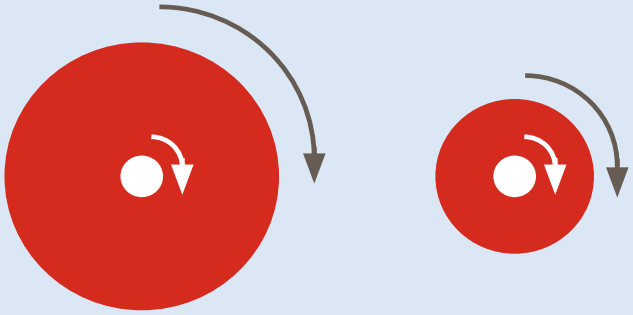
10-15m

KS1/2 PROOF OF CONCEPT

Why do you think we chose to use CDs? We chose them because of their large diameter. The diameter is the distance between two widest points of your CD.



Larger wheels have a larger length around the outside; we call this length the perimeter. This means that for every single turn of the axle, larger wheels should allow your CD Racer to travel further in approximately the same amount of time, resulting in a faster racer.



With this in mind, think about what would happen if you had used smaller wheels?

KS3/4 DEEPER LEARNING

Now we've learnt that larger wheels can result in a faster CD Racer, we're going to take a closer look at what role friction plays and how we might optimise it in order to help our CD Racers travel faster.

Friction is the resistive force to the movement between two surfaces and is what helps wheels move.
Wheels depend on this resistive force in order to allow the wheel to travel forwards on its perimeter. Low friction will result in the wheels slipping and spinning on the spot, resulting in little movement.
Friction can be calculated by using the following equation:

$$Fr = \mu R$$

Where Fr is friction, μ is the coefficient of friction and R is the normal reaction force.

This presents a few things we need to balance. While building a heavier racer will result in a higher friction force, if we consider Newton's Second Law, a heavier racer will require a higher driving force in order to result in the same acceleration.

$$F = ma$$

Where F is the force, m is the mass and a is the acceleration.

Therefore, we should be thinking about how to increase μ, the coefficient of friction, between the wheel and the surface it is rolling over. Generally, the rougher the surface, the higher the coefficient of friction. What sort of things could you add or change about the outside surface of your wheels to make them be able to withstand a higher turning force without slipping?

Top tip - experiment with rubber bands, white tac or hot glue gun dots to help make the outside edges of your CDs rougher.

QUIZ

15-20m

What is the diameter of a circular object?

.....

.....

What is friction?

.....

.....

Who was Sir Isaac Newton?

.....

.....

How can you make your CD Racer go faster?

.....

.....

What two types of energy does the CD Racer build display?

.....

.....

QUIZ

How can you increase the friction between two surfaces?

.....

.....

What is the force acting on the CD Racer when it is stationary?

.....

.....

What impact would smaller wheels on your CD Racer have on your design?

.....

.....

What force do wheels need to roll forwards or backwards?

.....

.....

If the CD Racer was heavier, would the driving force need to be higher or lower to make it move?

.....

.....