# How Trains Turn?

Trains routinely navigate large turns.

Have you ever taken a good look at a fast moving train and wondered how it turns? I bet you think it's all about the tracks; as the tracks gradually curve, they take the train along with them. Well, that's true, but it's really only part of the story. The other part is all about the train's strange wheels.

The Wheel and Axle

The **wheel and axle** is one of the six simple machines. Trains and cars have them, but the design and function for both are quite different.
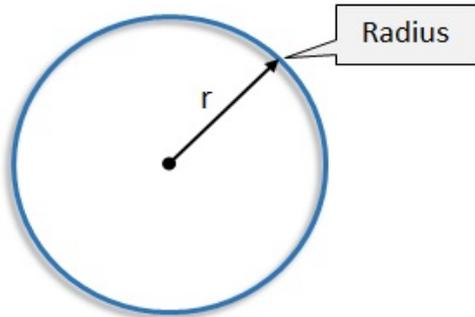
Unlike trains, cars are not confined to tracks. A car can turn wherever it is safe and legal to do so. But a train is stuck on its tracks, and that's a good thing. A train off its tracks is usually called an accident!
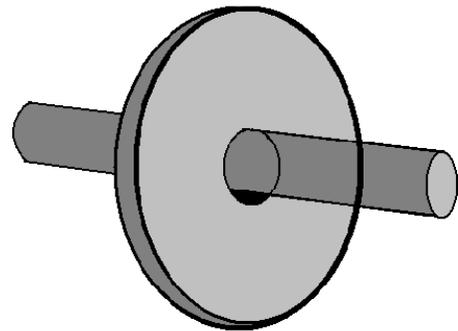

Wheel and Axle

Tricky Turns

Radius

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Turning a car or a train is not as simple as it seems. This has something to do with radius. The radius of a circle is the distance from the center of the circle to its perimeter.

Look at the image below. Now, imagine there is a one person walking clockwise around the blue circle, and another doing the same around the green circle. Which do you think would have to walk farther to arrive back where they started?

If you guessed the person walking along the blue circle, you would be correct. That's because the farther you are from the center of the circle, the greater the distance you have to cover to travel all the way around it.
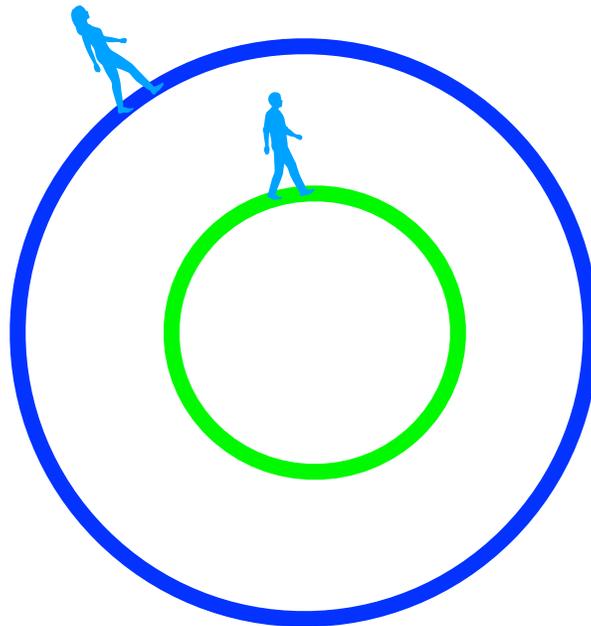
Runners begin in staggered positions.

You can see how radius affects a track race. In the photo to the left, there are eight runners preparing to run a 400-meter race, or one lap around the track. If you didn't know anything about radii, it might seem as if the race is not fair. Some of the runners are starting way ahead of others!

But wait! This race is fair. Lane 1, or the innermost lane, is exactly 400 meters in length. But lane 2 is 6.4 meters longer than lane 1, and lane 3 is 6.4 meters longer than lane 2. Remember, the farther you are from the center of a circle, the greater the distance you have to travel to complete one circuit.

Do the Math!

There are eight lanes on a track. In a 400-meter race, if each runner starts 6.4 meters ahead of the runner to the left, how many meters ahead does the runner in lane 8 start from the runner in lane 1?

In order to make sure that everyone is running exactly 400 meters, each runner begins in a staggered position to make up for the increased length of each lane. The runners in lanes 2 through 8 each start about 6.4 meters ahead of the runner in the lane to their left.
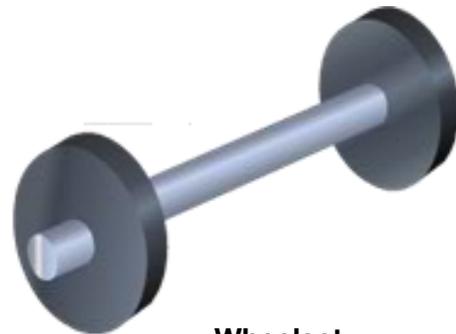
The Differential

When a driver turns an automobile, the wheels closest to the center of the circle, cover a shorter distance than the wheels furthest away. In order to make the turn without skidding and slipping, the outside wheels have to turn faster than the inside wheels.

To accomplish this, cars use a specialized wheel and axle called a differential. A differential allows each of the front tires to turn at different speeds. Let's take a closer look to see how a differential is engineered.

Inside wheels cover shortest distance.

Some wheels and axles have a fixed axle or shaft. In other words, one axle joins two wheels together. This is called a wheelset. The wheels move as a single unit.

Wheelset

A differential has two wheels and also two axles. Each axle is connected to series of gears in the center of a drive shaft, but they are not connected to each other. This allows each wheel to turn independently and at different speeds, enabling cars to make smooth, effortless turns.
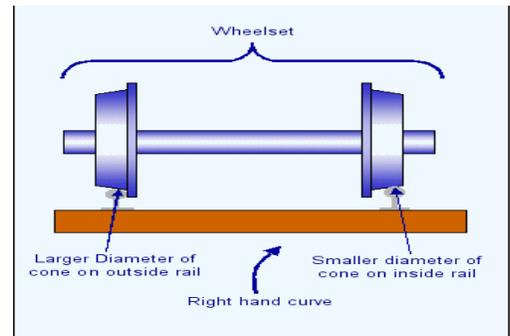

Car Differential

Conical Wheels

Trains however do not have differentials. If they did, there would be a risk of them falling off their tracks! Trains have fixed wheelsets, but still must navigate turns. So, how then do they do it? The secret is in how the wheels of a train are engineered.

Diameter of wheels is uniform.

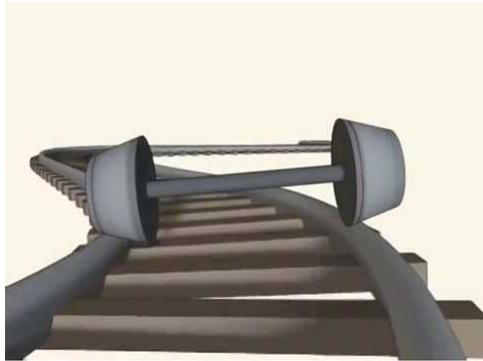**Diameter** of wheels varies.

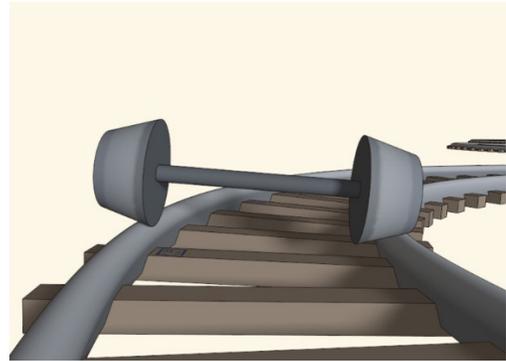| Car Wheels	Train Wheels
The wheels of a car are cylindrical. They are also the same size from one side to the other.	The wheels of a train are conical. They are not the same size from one side to the other.

The conical wheels of a train shift and slide every so slightly across the track enabling it to turn smoothly.

The train is turning left.

The train is turning right.

Vocabulary

1. **circuit**: move all the way around something to end where you began

2. **conical**: cone-shaped

3. **cylindrical**: cylinder-shaped

4. **diameter**: the distance from one side of an object to the other

5. **differential**: a specialized wheel and axle where each wheel moves independently from the others

6. **radius**: the distance from the center of a circle to its perimeter

7. **wheelset:** two wheels on a fixed axle