# UNIT 3

# Mechanisms



## WORK ON YOUR KEY COMPETENCES

LS

**Tune up your bike**

Mechanisms are all around us. Our bikes contain most types of simple mechanisms. *Do you know which mechanisms your bike has and what they do?*

*What would you add to your bike to make it safer and more comfortable?*

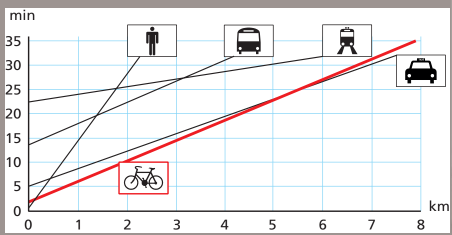
## OXFORD PROJECTS

*Go to your GENiOX Desktop.*

## Think and discuss

1. According to the text, what are the personal and social benefits of cycling as a mode of transport? Discuss the impact of cycling on the economy, the environment and on health.

2. Look at this graph which shows the relationship between distance and time and answer the questions.




a. How long does it take to travel the first kilometre using each mode of transport? Why?

Clue: The starting position of each line on the y-axis shows the time it takes to start moving using each mode of transport.

b. At what point does cycling begin to have an advantage over walking?

c. Until what distance is it faster to cycle than to drive?

# UN promotes cycling in Europe

Cycling as a mode of transport has many social benefits such as boosting the local economy with more green jobs, improving people's health and actively protecting our climate and moving us closer to our sustainable obectives. Cycling also helps to reduce traffic congestion in cities and because bikes need less space than cars, both when they are moving and when they are parked, cycling increases the available public space.

The first ever Pan-European Master Plan for Cycling Promotion aims to extend and improve cycling infrastructure, develop and implement national plans to promote cycling and increase cyclists' safety, and integrate cycling into health policies and the planning of transport infrastructure.

The measures hope to double the use of cycling as a mode of transport.

Source: *Diario Ágora* (translated and adapted)


In addition to the economic, environmental and health benefits of cycling, in urban areas it's often faster to cycle. This is because it's easier to park a bike closer to your final destination and you don't need to travel to a public transport stop or station at the beginning of your journey.

One of the simplest ways to help achieve the Sustainable Development Goals is to start cycling. You can find more information in *The Lazy Person's Guide to Saving the World*.

https://www.un.org/sustainabledevelopment/takeaction

# 1 What's a mechanism?

*What element transmits motion from the pedals of a bicycle to the wheels?*

*What do you call the mechanism that we use to take water from a well by pulling on a rope?*

*What differences are there between a machine and a mechanism?*

The moving parts of a bicycle, a seesaw and a clock are examples of everyday mechanisms. Their parts are different, but they all **make work easier because they transmit and transform force, motion and energy**.

**Mechanisms** are the elements that transmit and transform force and motion from an **input source** (motor) to an **output receptor**, modifying its characteristics.

**Machines** and **mechanical systems** are different mechanisms that we combine to produce a certain effect.

## 1.1. What are the components of machines and mechanisms?

- **Input sources** that create force and motion. Examples include our muscles, the weight of a pendulum in a clock, the energy stored in a spring, the force of flowing water in a river and the force of an electric motor.
- **Transformation and transmission systems** of energy, force or motion. Examples include gears, pulleys and springs.
- **Output receptors** that do the work these objects were made for. Examples include wheels, clock hands and weights.

Input system → Transformation and transmission systems → Output receptor system

When we ride a bike, our legs are the input source because they provide force and motion. The pedal and chain mechanisms transmit this force and motion to the wheels, which are the output receptors. The wheels do the work when they move the bicycle forward. They transform the circular motion of the legs into the forward linear movement of the cyclist's body.

## CLiL activities

1 LS The bike, the seesaw, the clock and the water well are made up of mechanisms. Work with a partner. Look at the photos on the left and discuss which types of mechanisms they use.

## 1.2. Classification of mechanisms

We classify mechanisms by the work they do and how they function.

| Transmission of motion | |
|---|---|
| **Linear transmission** | **Rotary transmission** |
| • lever<br>• pulley<br>• compound pulley system | • friction wheels<br>• pulleys with belts<br>• interlocking gears<br>• sprockets with chains |
| **Transformation of motion** | |
| **Rotary-linear** | **Reciprocating rotary-linear** |
| • wheel • nut and bolt<br>• rack and pinion • crank | • crank and rod • cam<br>• crankshaft • eccentric cam |
| **Motion control** | |
| **Direction control** | **Speed** |
| • ratchet<br>• free wheel | • brakes |
| **Energy accumulation** | |
| **Absorption/Dissipation** | |
| • springs | |
| **Connection** | |
| **Linkage** | **Support** |
| • clutch | • bearing |

No mechanism can produce energy on its own. Mechanisms (simple or complex) can only produce as much energy as they receive, although some of this energy is lost to **friction**[1] and heat.

Mechanisms allow or facilitate the performance of many tasks that couldn't be done without their existence.

[1]**friction:** the force of an object moving past and against another object.

### Another way to classify mechanisms

Mechanisms can also be classified by the number of elements they're made of.

- **Simple mechanisms** perform their function in a single step. Examples are levers, wheels and pulleys.
- **Complex mechanisms** complete the function in several stages. Examples are bicycles, printers and internal combustion engines.

## CLiL activities

**2** **Listen to the four conversations. Who's right? Who's wrong? Correct the wrong sentences in your notebook.**

**3** **In your notebook, describe the usefulness of these mechanisms and identify their driving force, the mechanisms involved and the receptor elements.**

A hypothetical perpetual motion machine

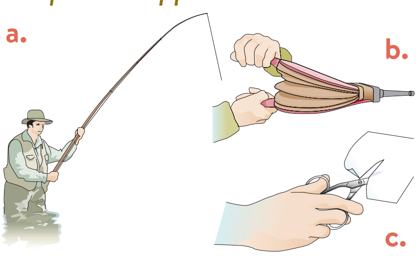
## CLIL activities

**4** With a classmate, study the pictures below. What classes of lever can you see? Where's the fulcrum in each case? Where are the force and the resistance?

*I think this is a (class 3 lever).*

*The fulcrum is (at the end / in the middle...)*

*The force is applied on...*



a. b. c.

**5** **Discuss the following questions with a classmate. Then, listen and check your answers.**

a. What class of lever is a stapler? Why?

b. How many levels do tweezers have?

c. Where's the fulcrum of a class 2 lever?

d. When is a seesaw in a state of equilibrium?

# 2 Linear transmission of motion

**Linear transmission mechanisms** have linear entry and exit movement (as in pulleys) or form an arc of a circle so small that it looks like a linear movement (as in levers).

**Uses:** we use these mechanisms to transmit force.

## 2.1. Levers

*Where can you find levers on a bicycle?* Discuss with your classmates.

A lever is a straight, rigid bar that pivots on a **turning point** called a **fulcrum**. Various forces may act on the lever at once. Each force produces a **torque**.

**Torque** is the product of the force multiplied by the distance from the fulcrum.

Torque = Force x Distance

### The Law of the Lever

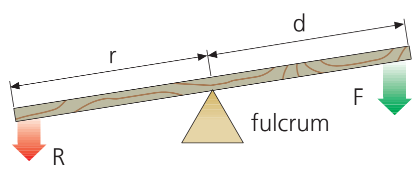
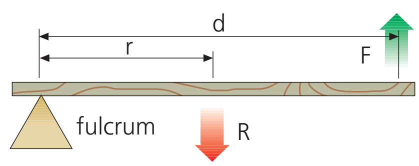
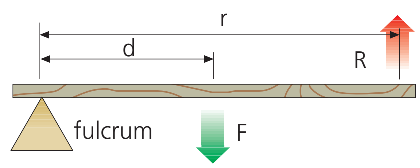
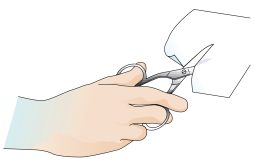
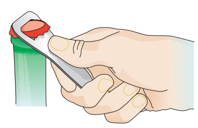
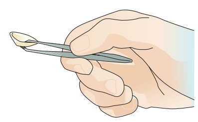
When the forces acting on opposite ends of a lever are equal, we say the lever is in equilibrium. This is the **Law of the Lever**, which we express mathematically as:

$$F \cdot d = R \cdot r$$

*F* is the force applied and *d* is its distance from the fulcrum. *R* is the resistance (or load that we want to move), and *r* is its distance from the fulcrum. In the International System of Units, force is measured in newtons (N), and distance is measured in metres (m).

### Classes of levers

There are three classes of lever. The class of a lever depends on the relative position of the **fulcrum, force applied and resistance.**

<table>
<tr><th>Class 1</th><th>Class 2</th><th>Class 3</th></tr>
<tr>
<td>The fulcrum is between the force and the resistance.<br></td>
<td>The resistance is between the fulcrum and the force.<br></td>
<td>The force is between the fulcrum and the resistance.<br></td>
</tr>
<tr>
<td>The effect of the force applied is increased or decreased.<br></td>
<td>The effect of the force applied is always increased ($d > r$).<br></td>
<td>The effect of the force applied is always decreased ($d < r$).<br></td>
</tr>
</table>

## 2.2. Brakes

Brakes are mechanisms that enable us to slow down or stop a wheel from moving. On a bicycle, brakes are activated by levers (handles) located on the handlebar. When we apply pressure to the levers, they pull a cable that activates the brake system.

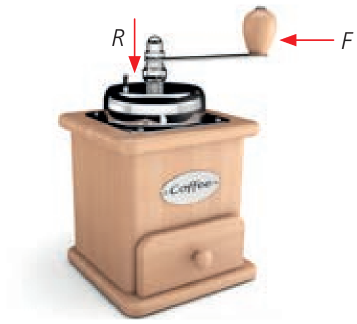
## 2.3. Cranks

A crank has two parts: one is attached to the shaft and the other forms the handle. We use it to reduce the force of the axis of rotation and to move it by applying less force in a more comfortable way.

The crank is a class 2 lever, so it's in equilibrium when:

$$F \cdot d = R \cdot r$$

In this case, $F$ is the applied force; $d$ is the radius of the crank; $R$ is the resistance in the shaft, and $r$ is the radius of the axle.

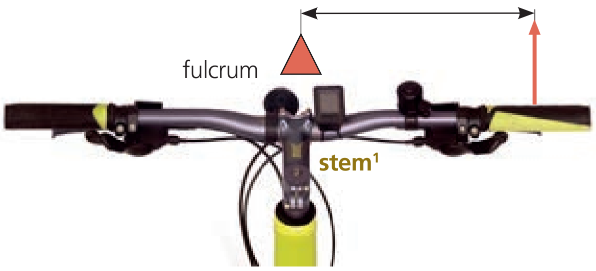



**Uses:** door handles, mechanical pencil sharpeners and tools that require squeezing.

## 2.4. Handlebars

*In your opinion, how do you prefer to ride a bicycle: with your hands on the grips at the end of the handlebar or with your hands on the bar closer to the axle? Which position makes it harder to steer?* Compare your answers with your classmates.

Handlebars work like a crank: the farther away the handles are from the rotation axis, the less force we need to move it. This allows for more precision when turning. The image below shows the equilibrium of forces in the handlebars.




The steering wheel of a car works exactly like handlebars and cranks on a bicycle: it moves the point at which the force is applied away from the axis of rotation to make it easier to move. A steering wheel is shaped like a complete circle, which makes it easier to hold.

[1]**stem:** part of the bicycle that joins the handlebar to the frame.

## CLIL activities

**6** What's a balance beam? How does it work? What class of lever is it? Find information and share it with your classmates.

*A balance beam is a ... that's used to...*

**7** LS Measure the handlebars of your bicycle. What's the distance from the axis to each end? If the handlebars were three times longer, would they be easier to turn? Write your answer in your notebook.

## CLIL activities

**8** In your notebook, order these images from highest to lowest effort and explain why.

## 2.5. Pulleys and compound pulley systems

Discuss in groups. *What kind of mechanism is shown in this image? How does it work? What happens when you pull the end of the rope?*

*Which would be the easiest way to lift the bicycle: using this system or lifting it only with your arms?* Explain your answer.

The image shows how pulleys work. When we pull the rope, the bicycle rises. The rope passes up and down through different pulleys. This means that the bicycle will rise a distance four times less than the amount of rope we pull. For example, if we pull one metre of rope, the bicycle will rise 25 cm.

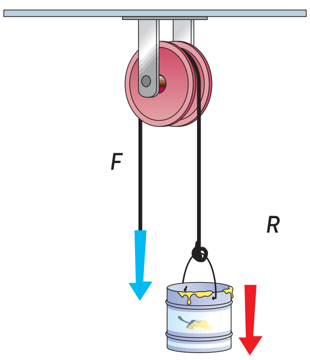
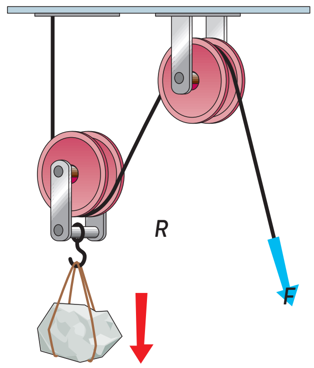
The advantage of this mechanism is that the force necessary to lift the bicycle will be four times less than its weight.

The equilibrium of forces in a pulley depends on the path the rope follows in the system.

### Pulleys

A **pulley** is a wheel that has a groove on the outside. It rotates around a fixed axis. If we attach ropes, belts or chains to a pulley, we can lift objects (resistance: *R*) by applying force (*F*).

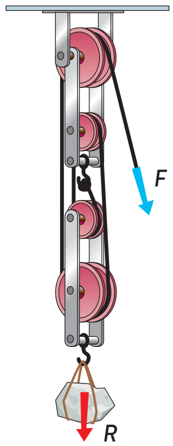
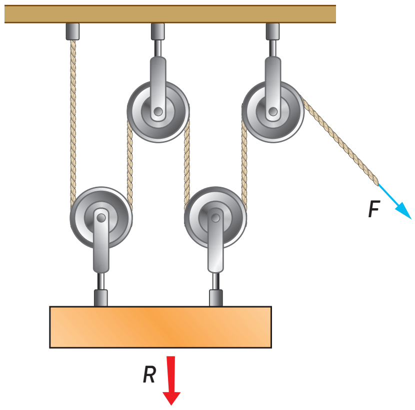
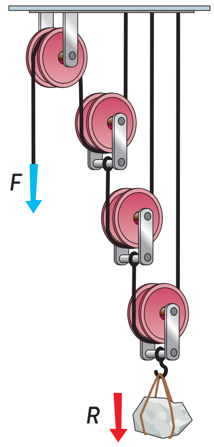
There are different types of pulleys:

| Fixed pulley | Moveable pulley |
|---|---|
| In this type of pulley, the forces are equal because the rope moves the same distance on both sides.<br>The advantage is that we use gravity and our weight to help us. It's easier to lift a weight by pulling down than by pulling up.<br>$F = R$<br>Force = Resistance<br><br> | In this system, the rope follows a double path around the moveable pulleys.<br>We only need half the force to lift the same weight as with a fixed pulley. However, we have to pull the rope twice the distance<br>$F = \frac{R}{2}$<br>$\text{Force} = \frac{\text{Resistance}}{2}$<br><br> |

## Compound pulley systems

**Compound pulley systems** combine fixed and moveable pulleys. They force a rope to make a complex journey between the different pulleys. They're also called block and tackle systems. The more pulleys a compound pulley system has, the less force we need to use.

Here are some of these systems:

| Vertical system | Horizontal system | Exponential system |
|---|---|---|
|  |  |  |
| $F = R / (2 \cdot n)$ ($n$ = the number of moveable pulleys) | | $F = R / 2^n$ |

## CLiL activities

**9** Work with a classmate. How much force do you need to lift a resistance of 600 N with the following?

- **a.** a fixed pulley
- **b.** one fixed pulley and one moveable pulley
- **c.** a fixed pulley and three moveable pulleys

**10** Listen and take notes about pulleys in ancient times. Compare your notes with a classmate and write a summary in your notebook.

**11** Find more information about block and tackle systems. How are they used? Where can we see examples of them around us?

**12** Look at the compound pulley system on a sailing boat on the right. How much force do you need to lift a sail with a resistance of 400 N?

**13** Do you think this person prefers the pulley system she's using in this image, or would she prefer one of the pulley systems shown on the last page? Discuss with a classmate and explain your answer.

[1]**inversely:** in the opposite way.

## The Penny Farthing

To make the Penny Farthing move, the rider turned the pedals on the front wheel. The front wheel was larger than the back wheel to make the bicycle move faster, but this also made it uncomfortable and dangerous to ride.

# 3 Rotary transmission

*What are the differences between the Penny Farthing shown on the left and a modern bicycle? Where's the applied force?* Compare the size of the two wheels. *What new part allowed the Penny Farthing to evolve into the modern-day bicycle?* Discuss with your classmates.

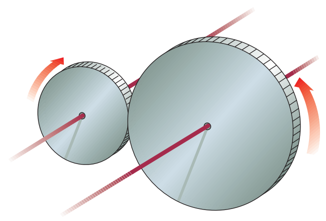
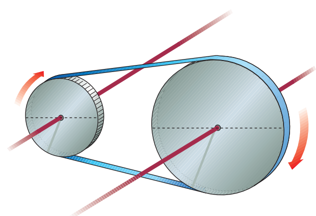
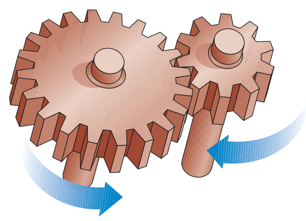
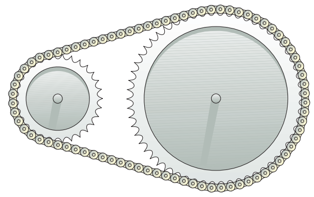
The transmission system on modern bicycles allows us to transmit rotary motion from the pedals to the back wheel. This increases the speed of rotation more easily.

**Rotary transmission mechanisms** connect two rotating elements.

These mechanisms have two purposes:

1. To transfer the rotary force from an input location to another location.
2. To change the rotary speed. To do this, the elements must be different sizes.

To perform these functions we can use:

| Friction wheels | Pulleys with belts | Interlocking gears | Sprockets with chains |
|---|---|---|---|
|  |  |  |  |

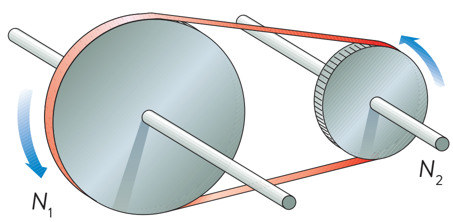
**Uses:** friction wheels and pulleys with belts are often used in toys and other devices with moving parts, such as conveyor belts. Gears and sprockets are used in clocks, cars, bicycles and home appliances.

The relationship between the speeds of the two wheels is **inversely**[1] proportional to their sizes. This is called the **ratio of transmission**:

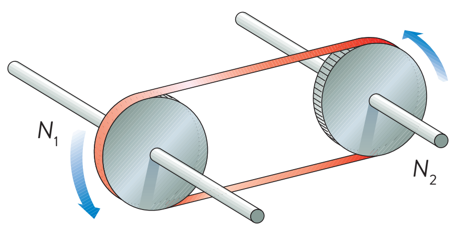
$$\frac{N_2}{N_1} = \frac{D_1}{D_2}$$

where $N$ is the speed of rotation, and $D$ is the diameter of the wheel.

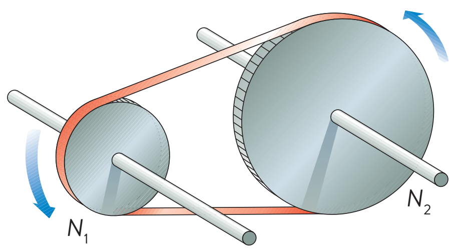
To increase the speed of a rotary system, we transmit motion from a larger (input) element to a smaller (output) element. However, this decreases the rotary force, or torque. To increase the torque of the system, we transmit motion from a smaller (input) element to a larger (output) element:




**Increasing speed system.** Speed increases. The input speed, $N_1$, is less than the output speed, $N_2$.




**Constant speed system.** Speed is constant. The input speed, $N_1$, and the output speed, $N_2$, are equal.

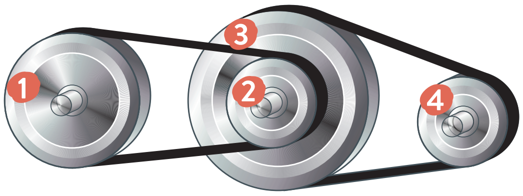



**Decreasing speed system.** Speed is reduced. The input speed, $N_1$, is greater than the output speed, $N_2$.

## 3.1. Belt drives and gear trains

Look at this image and describe how the mechanism works. *Will wheel 2 turn faster or slower than wheel 1? Will wheel 3 turn faster or slower than wheel 2? Will wheel 4 turn faster or slower than wheel 3? Is this an increasing speed system or a decreasing speed system?* Discuss your ideas with your classmates.

pulley 1: $D_1$ = 24 mm
pulley 2: $D_2$ = 24 mm
pulley 3: $D_3$ = 24 mm
pulley 4: $D_4$ = 24 mm




A belt drive is a system of pulleys connected by belts. Each belt connects two pulleys that turn **simultaneously**[1].

Belt drives allow us to reduce or increase the rotary speed without using elements with larger diameters.

To understand how they function, we're going to look at how the wheels interact, step by step:

- Wheel 1 turns Wheel 2, which is smaller and therefore faster. The size ratio is $D_1/D_2$.
- Wheel 2 is directly connected to Wheel 3. They turn together and make the same number of rotations.
- Wheel 3 turns Wheel 4, which is half the size and therefore makes double the rotations.

For one rotation of the driving wheel, wheel 2 will rotate one and a half times, as will wheel 3, which is connected to the same axis. However, wheel 4 will rotate twice as much as wheel 3: 1.5 x 2 = 3 rotations.

To calculate the **ratio of transmission** between the first and the last wheels, we multiply the ratios of the first pair and the second pair of wheels.

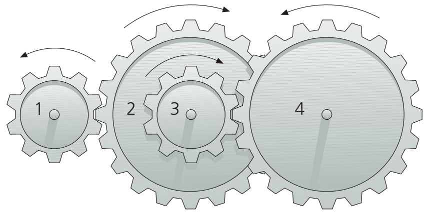
$$\frac{N_4}{N_1} = \frac{D_1 \cdot D_3}{D_2 \cdot D_4}$$

In this expression, *N* = speed and *D* = the diameter of the wheel. The same ratio applies by using the radius (*r*) or the number of teeth (*Z*) on the gear.

If we add more pairs of wheels to this system, we would have to continue multiplying the ratio of each pair by the next pair.

[1]**simultaneously:** at exactly the same time.

### Gear train




In this gear train, there are two pairs of wheels that provide a transmission of rotation from one gear to the next: 1-2, 3-4. Wheels 2-3 are connected to the same axis and turn together.

Interlocking gears are more reliable than friction wheels because they prevent slipping and can increase torque. In contrast, they're noisy, need lubrication and are more expensive.

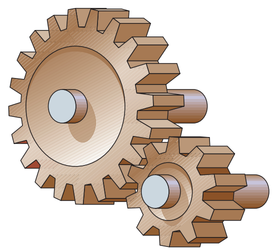
**Uses:** in machine tools, robotics, gear boxes in vehicles and in various kitchen appliances, such as mixers and juicers.

## CLIL activities

**14** Work with a classmate. Study the belt drive diagram on this page. If we double the size of all the pulleys, will the size ratios change? Will the ratio of transmission between the first and last wheels change? Write your answers in your notebook.

**15** Listen and take notes about the issus insect. What makes it unusual? How does it jump straight? What happens when the issus becomes an adult?

**16** Look at the image. Count the cogs. Work out:



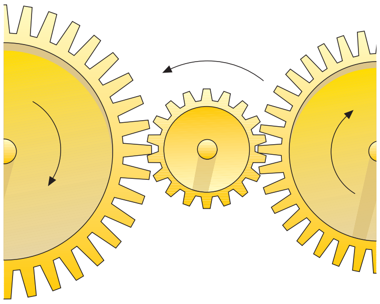
a. How fast will the small wheel turn if the large wheel turns at a speed of 15 rpm?

b. How fast will the large wheel turn if the small wheel turns at 50 rpm?

[1]**axis of rotation:** straight line that an object rotates around.

### Idler gear

In a simple two-gear system, the gears turn in opposite directions. To get the gears to turn in the same direction, we put an extra gear with teeth between them. This is called an idler gear. This gear changes the direction of rotation without changing the ratio of transmission.

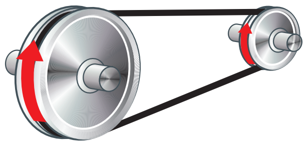


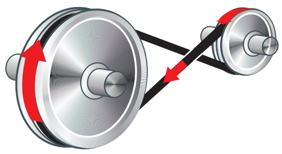
## 3.2. Changes in direction and rotation

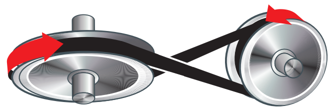
Look at the gear trains on the previous page and discuss in groups: *Do all the pulleys and gears turn in the same direction? Which direction do they turn in?*

We can use various systems to change the direction or **axis of rotation**[1] in a belt drive. We can also vary the distance between the wheels.

### In pulleys





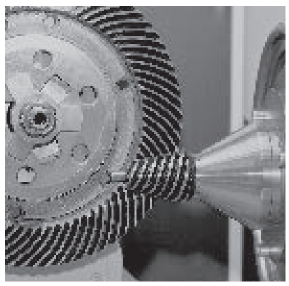


As you can see, belts make it easy to change the direction and the axis of rotation.

### In gears

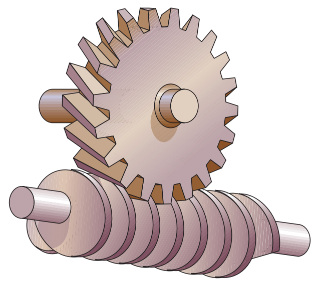
Gear drives require special designs in the cogs in order to change the direction of rotation and the axis of rotation.

We use different types of gears when two axes are parallel, perpendicular or crossed:

| Parallel axes | Perpendicular axes | Crossed axes |
|---|---|---|
|  |  |  |

### Worm drive screw

A worm drive, also called an endless screw, is a special mechanism that's used to reduce rotational speed. It consists of a fixed drive screw and a cogwheel. Each groove of the drive screw interlocks with the teeth of the cogwheel at one, two or three points.



When the screw rotates, the worm gear moves forward one tooth for every groove on the screw. This mechanism isn't reversible.

The screw can move the gear, but the gear cannot move the screw. In this way, the screw acts as a brake.

**Uses:** tuning pegs on guitars, mechanisms in lifts and speed reduction systems.

### CLIL activities

**17** Look at the gear trains. In your notebook, describe the direction and speed of each gear.

*As the fixed drive screw rotates ... the cogwheel...*

**18** Look at the endless screw. The screw has two grooves and the gear has 20 teeth. What's the ratio of transmission?

# 4 Transformation of motion

Some mechanisms transform linear motion into rotary motion. Most of these mechanisms are reversible, which means they can also transform rotary motion into linear motion. The linear motion can be unidirectional or **reciprocating**[1].

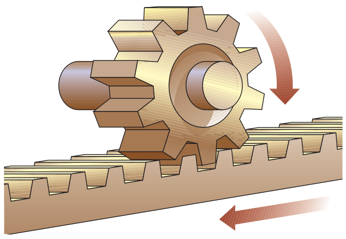
## 4.1. Rotary-linear transformation

### Wheel

The **wheel** is a circular object that rotates around an axis.

With each rotation, the wheel moves a distance that's equal to its circumference, $2\pi r$. As a result, it takes less force to move vehicles with larger wheels and they move more quickly.

### Rack and pinion mechanism



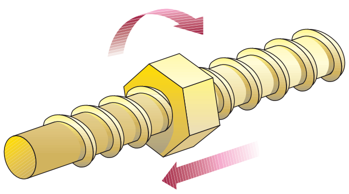
This mechanism has two parts. The **rack** is a straight bar and the **pinion** is a gear. Both have teeth that interlock.

When the pinion rotates, the rack moves. If the mechanism is reversible, the pinion also rotates when the rack moves.

**Uses:** in bottle openers, sliding doors, conveyor belts and any device that requires precise movement

### Nut and bolt mechanism

This mechanism has two parts: a bolt with a spiral groove and a nut that turns around it. When the bolt is **stationary**[2], the nut rotates and moves along the bolt. This is used to fasten different parts together. When the bolt is mobile, it moves through the nut. We use this to lift loads.



**Uses:** to hold things together such as bench vices, taps and scissor jacks for lifting cars.

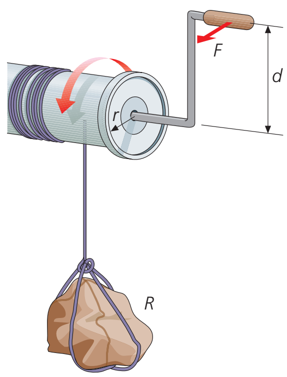
### Winch and crank mechanism

A winch is a cylinder that rotates around a horizontal axis. We attach a rope to a winch and to a load. Then, we turn the crank to rotate the winch. This crank increases the force, and the rope rolls up around the winch, lifting the load.

The increase in force is proportional to the ratio between the radius of the crank and the radius of the winch. These ratios obey the Law of the Lever:

$$F \cdot d = R \cdot r$$

**Uses:** in mechanisms to open and close awnings, in machines used for lifting heavy loads, cranes, and moveable bridges.




[1]**reciprocating:** moving forwards and backwards in a straight line.

[2]**stationary:** not moving.

## CLIL activities

19 Calculate the circumferences of wheels with the following diameters. What distance will each wheel travel in one rotation?

a. 30 centimetres

b. 55 centimetres

c. 70 centimetres

20 Work with a classmate. In your notebook, make a list of objects that contain nuts and bolts or use a nut and bolt mechanism. When's the bolt stationary? When's it mobile?

*...uses nuts and bolts.*

*...uses a nut and bolt mechanism.*

*The bolt is stationary / mobile when...*

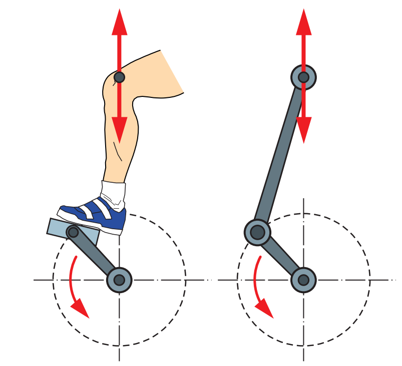
21 Listen to the four descriptions. What object is each one?

22 STEAM Design a device that can move a two-kilogram weight to a new location that's at least one metre away (vertically or horizontally). Use one or more of the mechanisms on this page. Draw the device and build a working model. Present your design to the class.

## 4.2. Reciprocating rotary-linear transformation

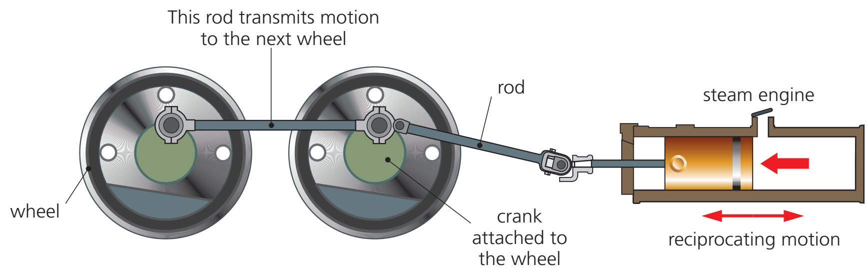
These mechanisms are used when motor movement is restricted, such as the pedal mechanism of a bike, the piston of a steam engine and the cylinders in a car engine. Some mechanisms work in the opposite way, transforming rotary motion into reciprocating linear motion.

### Crank and rod mechanism



> Look at the images on the left. *What similarities can you see between the movement of legs pedalling a bicycle and the rods that turn the wheels on a train?* Discuss with your classmates.

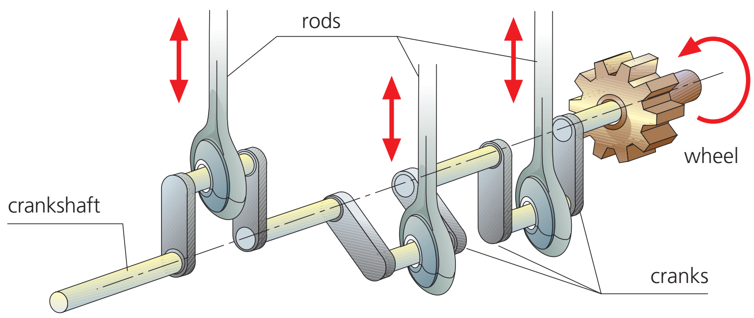
The mechanisms that produce movement in the bicycle and train are the same. The pedal mechanism of a bicycle transforms the reciprocating up and down movements of our legs into continuous rotary motion. In the train wheels, the pistons of the steam engine move the rods forward and backward.




Rods move back and forth (alternating linear movement), while cranks move round and round.

**Uses:** the first steam engines had crank and rod mechanisms. Today we find them in car engines, windscreen wipers and machine tools.

### Crankshift mechanism




A crankshaft is composed of **multiple rods** that are connected to one rotational axis. The rods are connected to cranks, which are connected to the crankshaft. A crankshaft mechanism can synchronise the movements of various parts, such as the multiple pistons of a car engine.

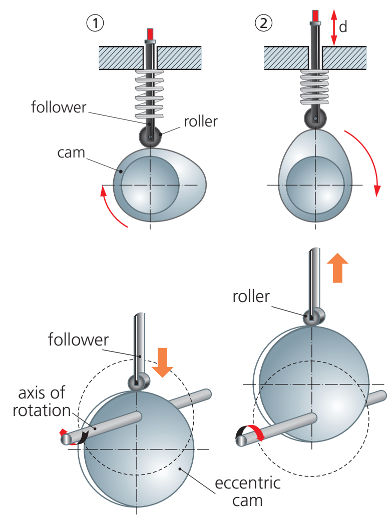
**Uses:** combustion motors, where the combined action of cylinders connected to the cranks transmits a rotational motion in the axis; they're also traditionally used in sewing machines.

### Cam mechanisms

A **cam** rotates on a shaft and pushes a special bar called a **follower.**

An **eccentric cam** is a disc with its axis of rotation positioned off-centre. This means the cam has two radiuses of different lengths. As the cam rotates, it makes the follower rise and fall.

**Uses:** in toys, automatic tools, combustion motors and sewing machines.




## CLiL activities

**23 Listen and answer the questions in your notebook.**

a. Where were the first steam-powered trains used?

b. What fuel was used to power early-steam engines?

c. When did the first steam railway open to the public?

d. Which country in Europe was the next to have trains?

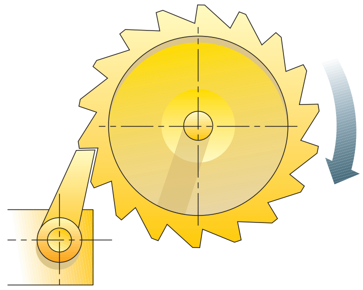
e. Where did early railway lines expand quickly?

# 5 Mechanisms that control motion

## 5.1. Direction control ratchets

A **ratchet** is a mechanism that controls the direction of motion. It allows motion in one direction but not in the other. Some ratchets are reversible, so they can tighten or loosen things in two directions.

**Uses:** in watches, cable-tensors and elevator brake systems.



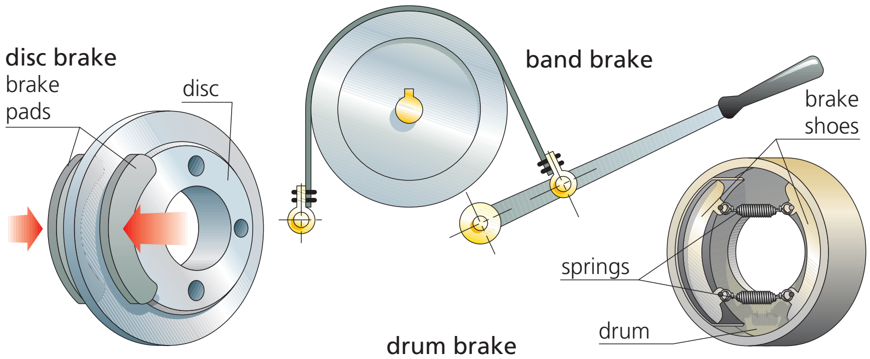
### A ratchet wrench

This consists of a reversible ratchet that allows movement in both directions.

## 5.2. Speed reduction: brakes

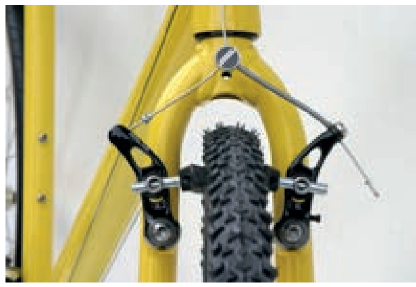
Look at the images on the right and discuss these questions with your classmates: *What kind of brakes does your bicycle have? What kind of brakes is the most common? Which are the oldest? What brakes are the easiest to take apart?*

**Brakes** are mechanisms designed to reduce speed. They use a device that presses against the moving wheel to create friction. There are various types of brake systems according to where the friction is produced. All brakes are activated by some type of lever. The lever transmits force to an output receptor, which puts pressure on the wheel. This produces friction, which slows down the wheel.




- **Disc brakes.** A disc is connected to an axle. Brake pads apply pressure to the disc via friction.
- **Band brakes.** A drum is connected to an axle. A flexible band applies pressure to the outside of the drum. These brakes were used in carriages and they depended on the strength of the driver.
- **Drum brakes.** A drum is connected to the axle. A pair of brake shoes apply pressure to the inside of the drum via friction.

Caliper brake



V-brake

Cantilever brake

### CLIL activities

**24** LS Study the bicycle brake systems on this page. Where are the output receptors? What provides the input force to operate them? What transmits the force?

**25** Listen to an explanation of brake safety for people who drive scooters. Take notes, compare them with a classmate's and write a summary in your notebook.

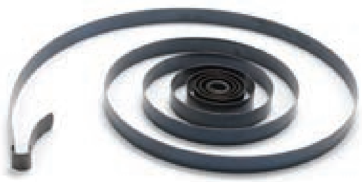
[1]**absorb:** take in or reduce the effect of something.

[2]**accumulate:** collect and store.

[3]**dissipate:** disperse or let go.

## Mechanisms of accumulation

In winding mechanisms, the energy stored in the spring is dissipated slowly.



This is how traditional mechanical watches work, which is why we need to wind them every day so that they don't stop.

Nowadays, there are mechanisms capable of storing energy from our movements, which means we don't have to wind them or use batteries to power them.

# 6 Energy absorption and dissipation

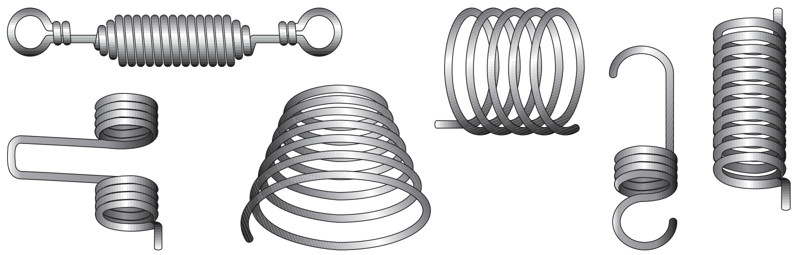
*Do you know what a bicycle suspension system is? Why do bicycles need a suspension system? What's the main part? How does it work? What are some of the problems of rear suspension? How can this be solved?*

We sometimes need mechanisms that can **absorb**[1], **accumulate**[2] and **dissipate**[3] energy. For example, shock absorbers in cars absorb motion to make driving easier on irregular surfaces. Other mechanisms, such as watch springs, accumulate energy that can be used later.

## 6.1. Accumulation: springs

**Springs** are devices that, thanks to the elasticity of the materials which they are made of and their shape, are capable of absorbing energy when we apply force to them. Then, we can dissipate the energy in a controlled way. Depending on the type of external force applied to them, springs work in different ways:

- **Compression.** We push on the spring to make it shorter, as in a sofa.
- **Traction.** We pull on the spring to make it longer, for example, in a metal frame.
- **Torsion.** We bend the spring to make it curve, like a clothes peg.



## 6.2. Dissipation: suspension systems

**Shock absorbers** are usually made with spiral steel springs. **Leaf springs** are made with high-elasticity pieces of steel of different lengths placed on top of each other and joined in the middle. Both systems are useful because they absorb and dissipate motion when the road surface is uneven. This makes driving more comfortable.

**Uses:** both shock absorbers and leaf springs form part of the suspension systems in motor vehicles.

### CLIL activities

**26** Make a list of objects that have springs. What types are they? Do we push, pull or bend them?

**27** Find a picture of a binder clip and then draw one in your notebook. How does a binder clip work? How's it similar to a spring?

### CLIL activities

**28** **Listen to the talk about watch springs. Then, answer the questions.**

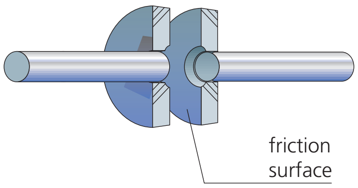
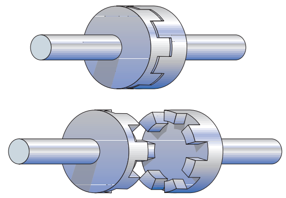
a. When did the first spring-powered clocks appear?
b. What powered most clocks before that time?
c. What portable invention did springs make possible?
d. How often did the first spring watches need to be wound?
e. Why did early watches only have one hand?

## 7 Couplings and clutches

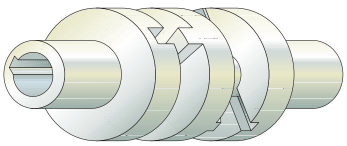
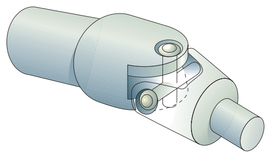
**Coupling mechanisms** transmit rotation from one axis to another. There are different types, depending on the position of the axes. There may be a distance or an angle between the two axes or they may not be perfectly **aligned**[1].

- **Rigid couplings** are used to engage axes permanently.
- **Clutches.** Engaging the clutch allows power to transfer from the engine to the transmission. Disengaging the clutch stops the power transfer.

[1]**aligned:** together in a perfectly straight line.

| Friction clutch | Jaw clutch |
|---|---|
| The ends of two shafts come into contact. When one shaft turns, there's friction. This turns the second shaft.   | Two shafts are connected by interlocking teeth. A jaw clutch is very reliable. It doesn't slip easily.  |

- We use **flexible couplings** when the axes aren't aligned.

| Oldham coupling | Cardan joint (Universal joint) |
|---|---|
| This coupling connects parallel shafts that aren't continuously aligned.  | This joint connects two shafts that are at an angle to each other.  |

## 8 Bearings

**Bearings** support the rotating shaft and keep it in place. They help to reduce friction and allow smoother rotation.

**Plain bearings** allow the shaft to slide through them. **Antifriction bearings** have rolling parts, such as metal balls or rollers, that reduce surface contact.

## 9 Free wheel

On the first bicycles, the axis was attached directly to the cogset. So, when you pedalled backwards, the bicycle would go backwards. Also, the pedals turned in time with the wheel. This meant that if a cyclist was riding fast down a hill, they had to lift their legs high or pedal at the same speed of the turning wheels.

To solve this problem, we have the free wheel. It consists of two saw-toothed, spring-loaded discs that press against each other. When we pedal forwards, motion is transmitted by the chain to the back wheel, but when we pedal backwards, the wheel turns freely.

**Uses**: rear bike wheels and starter engines on cars.

### CLIL activities

**29** **Work with a classmate. Take turns explaining how the four clutches and couplings on this page work. Cover the text and use your own words.**

**30** **Listen and answer the questions below about oil and grease lubricants.**

a. Why do we need to lubricate some engines?

b. What physical difference is there between oil and grease?

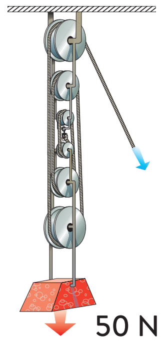
c. Why does a car need to have an oil tank?

d. Why's grease a useful lubricant for gears?

# Revision activities

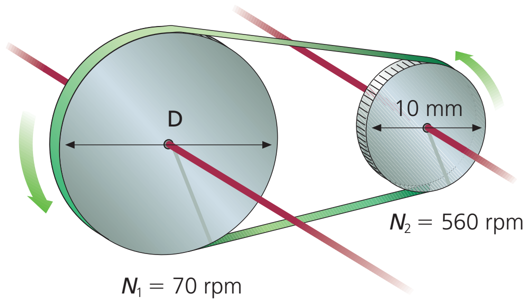
**31** A boy weighing 30 kilograms is sitting at one end of a seesaw. A girl weighing 20 kilograms is sitting at the other end. The girl is 1.5 metres from the fulcrum. How far from the fulcrum must the boy sit to balance the seesaw? How far from the fulcrum must the boy sit if the girl is 3 metres from the fulcrum?

**32** How much force do we need to lift the load in this image? If we apply a force of 30 N, how much weight could we lift?




**33** In your notebook, draw diagrams of the three types of levers.

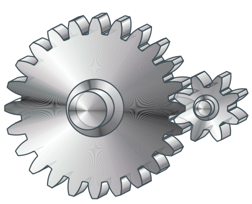
**34** Study the diagram. What's the diameter of the larger wheel? What's the ratio of transmission?



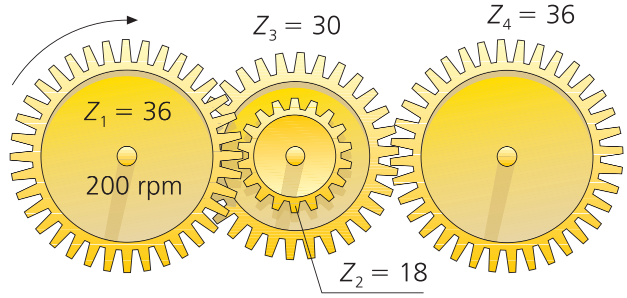

**35** **Study the gear train. Calculate the ratio of transmission.**

a. How fast does the larger gear turn if the smaller gear turns at 60 rpm? Show the direction of rotation.

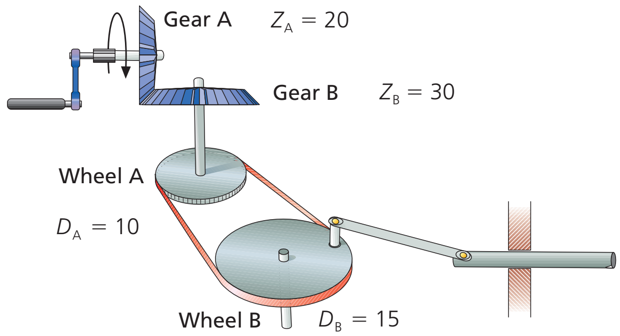
b. If we add another gear between these two gears, will it change the ratio of transmission? Explain.



**36** Calculate the output speed of the gear train. In which direction do the gears in the middle and on the right rotate? If the output speed of the wheel on the right is 60 rpm, what is the input speed of the wheel on the left?




**37** Look at this mechanism:



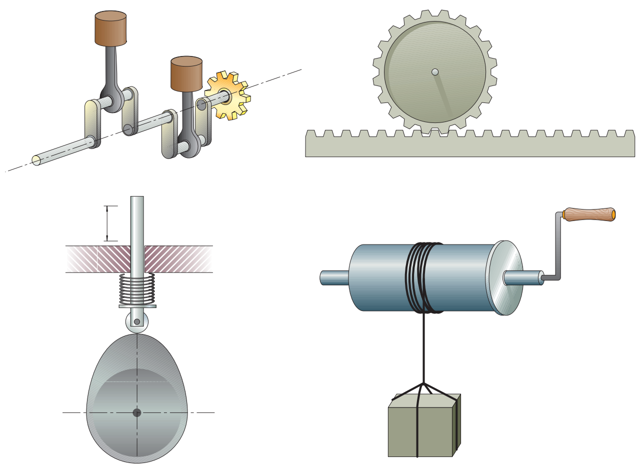

a. Label each part of the diagram. How does each part transmit and transform motion? What is the input? What's the output?

b. If gear A turns at 90 rpm, how many times will the output crank move in one hour?

c. In which direction does gear A turn? In which direction will gear B turn?

d. Is this mechanism reversible? Why or why not?

**38** **Look at the four mechanisms. Read the questions and match each description to a mechanism. Then, answer the questions.**



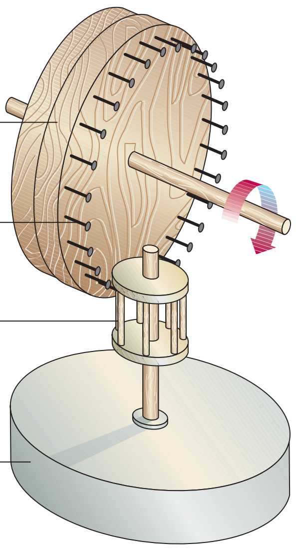
**a.** Which part provides the force that makes the cranks move? Is this a reversible mechanism?

**b.** It turns 2 mm and the rack is moving at 60 cm per minute. If it's turning at a speed of 10 rpm, how many cogs does the gear have?

**c.** What kind of movement describes the follower? What element makes it stick to the side of the cam?

**d.** If the crank is 40 cm long, and the radius of the cylinder is one third that length, how many kilograms will the winch lift if we apply a force of 240 N?

**42** **Traditional windmills used this mechanism to grind grain to make flour. What type of transmission of motion does the mechanism perform? If the gear turns clockwise at 60 rpm, what speed will the wheel turn at and in which direction?**




**43** **In your notebook, draw a diagram of an eccentric cam and label its parts. Explain how it works and give some examples.**

**44** **Are these statements true or false? Correct the false sentences.**

**a.** The cam and the eccentric cam are reversible mechanisms of transformation.

**b.** All ratchets allow motion in one direction but not in the other.

**c.** A band brake consists of a band that applies pressure to a drum connected to an axle.

**d.** Cardan joints transmit motion between two axes that are perpendicular.

**e.** Shock absorbers and leaf springs are mechanisms that reduce speed.

**45** **Analyse these devices: a music box and the mechanism that raises an awning. Describe how they work. Think about how they might transmit motion between their different parts. In each one, identify at least three of the simple mechanisms we have studied in this unit and explain their function in the device.**

## Study skills

**I** **Write a summary of the unit answering these questions.**

- *What's the difference between a machine and a mechanism?*
- *What are the simple mechanisms that transmit and transform motion?*
- *How do we calculate the ratio of transmission in levers, pulleys and gears?*
- *What are gear trains and belt drives? What are they used for?*
- *How can we change the direction of rotation and the axis of rotation in pulleys and gears?*
- *What are the most common types of brake systems?*
- *What are couplings? How do they work?*
- *What's a crank? How does it work? What are its uses?*
- *What types of mechanisms absorb energy?*

**II** **Create a concept map. Include these concepts:** *mechanisms, linear transmission, rotary transmission, transformation of motion, motion control, energy accumulation.*

**III** **Create your own technical dictionary. Write definitions for the following terms. You can include more words of your own:** *lever, pulley, compound pulley system, crank, shock absorber, cam, ratchet, wheel, interlocking gears.*

Passnotes Revision activities Concept map

# Technology workshop

## Building simple mechanisms

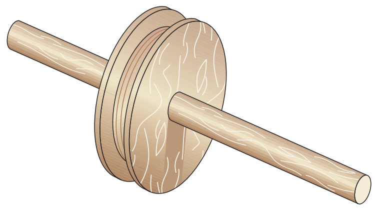
Mechanical engineering that we've studied in this unit is extremely important and is constantly evolving. Current production techniques are characterised by their extreme precision and the finish of the different parts that make up these mechanisms.

In the technology workshop, we can make simple mechanisms using materials such as cardboard, paper, wood and nails.


### Making pulleys

An easy way to make a pulley is to use three discs made of plywood for the wheel. The two outer discs will be the same diameter. The inner disc should be thicker and about 2 mm to 4 mm smaller in diameter. (If it's too small, the belt can get caught.) For our calculations we need to use the diameter of the inner disc.

Glue the three discs together so that they're perfectly centred. Once the glue has dried, cut a hole in the middle to insert the axis.



There are two options:

a. **The pulley turns freely on a fixed axis.** We make the diameter of the hole a little wider than the axis. Be careful not to make the hole too wide, or the pulley will vibrate.

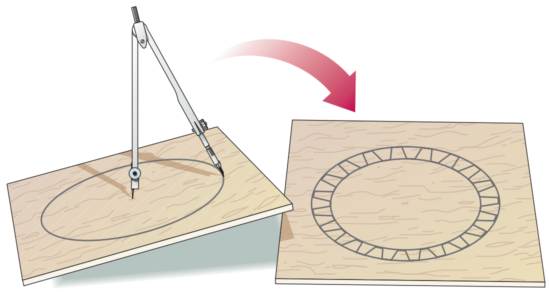
   We put stoppers on each end of the axis to prevent the wheel from falling off. We can use a metal axis to avoid too much friction.

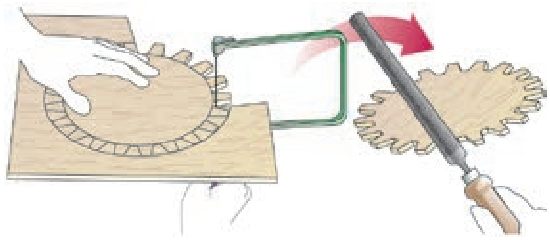
b. **The pulley and the axis turn at the same time.** The diameter of the hole and the axis should be the same. We need to force the axis into the hole and then glue it in place.

   In this case, we use a wood axis.

### Making gears

We can make gears using two simple procedures:





a. **Using plywood.**
   1. We draw the gear using a compass and protractor.
   2. We cut out the gear using a hacksaw. We follow the lines.
   3. We sand the teeth so they are even.

b. **Using chipboard and nails.**
   1. We draw the circle.
   2. We use a protractor to mark the exact place where we will put the nails.
   3. We cut out the circle. We sand it. We put the nails in place.

### Practice

1 Think of other ways to make gears with materials available in the workshop. Try them out.

## Changing the direction of motion (pulleys and gears)

There are different ways to change the axis of rotation. Here are two of them:

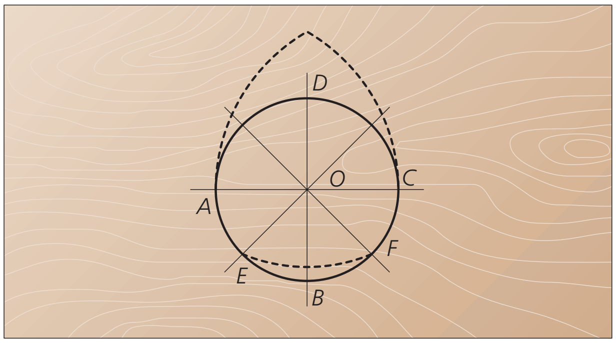
a. We can use pulleys that are connected by a belt at an angle to each other. We can also cross the belt.

b. We can put two gears at a 90° angle. To do this, we make the wheels out of chipboard with nails that function as the gear teeth.

## Making a cam

Making a cam is easy:

1. On a piece of plywood, we draw two perpendicular lines. Then we use a compass to draw a circle. We use the intersection of the two lines as the centre.
2. We draw two more lines to divide the circle into eight equal parts. To do this, we place the compass needle on vertex A and draw an arc starting at vertex C. Then we place the compass needle on vertex C and draw an arc starting at vertex A.
3. We place the needle at vertex D. Then we draw an arc between vertices E and F.
4. Finally, we cut out the cam and sand the edges.

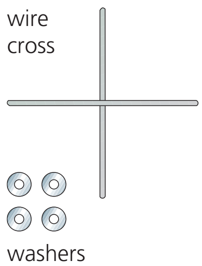


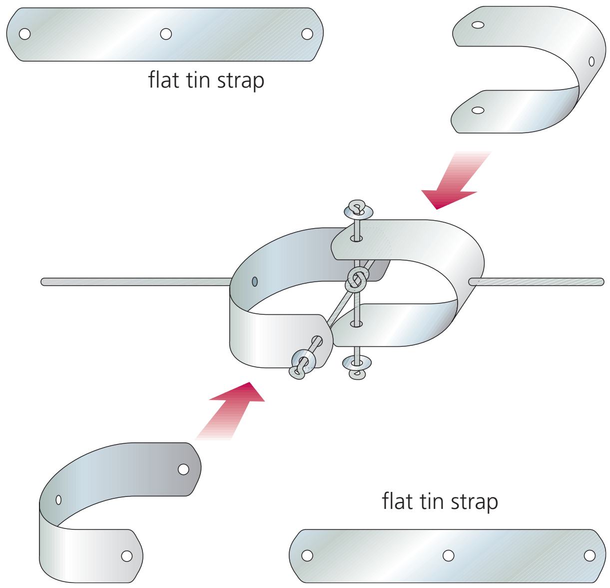

## Making a Cardan joint

As we have seen, Cardan joints transmit rotation between two axes that are at an angle.

Look at the illustration. Prepare the wire cross, washers and flat tin straps.

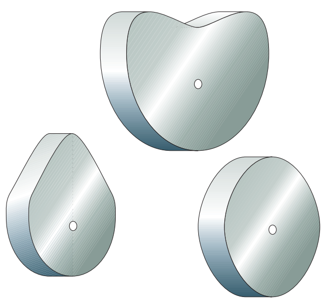
Then assemble the Cardan joint.




## Practice

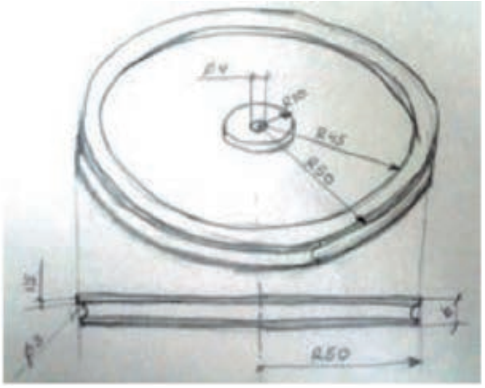
2. Look at the cam you made. As the cam rotates, describe the motion its follower makes.
3. Think of a more complex motion. Then, design a cam that will produce it.
4. Look at the cams on the right. What type of motion will each cam produce in its follower?



## Making a pulley with a 3D printer

We can use 3D modelling programs like **FreeCAD** to design mechanisms. Then we can use a 3D printer to reproduce them.

To start the design, make a sketch of a pulley and all its parts.



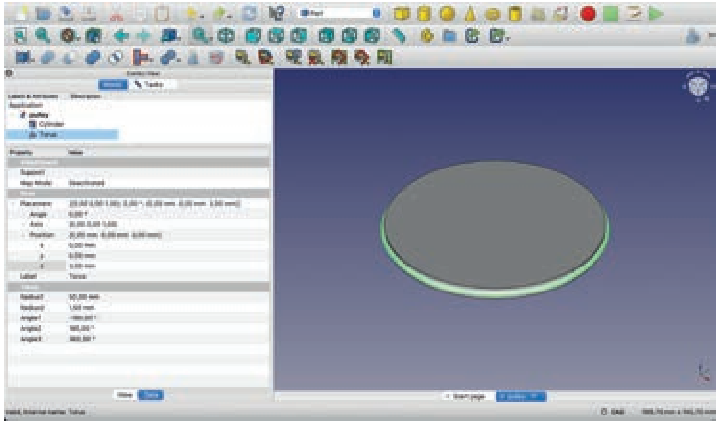
### Designing the pulley

We can design the pulley using a combination of simple shapes, such as several **cylinders** and a **torus**. We're going to combine them using two Boolean operations: **Union** and **Difference**.

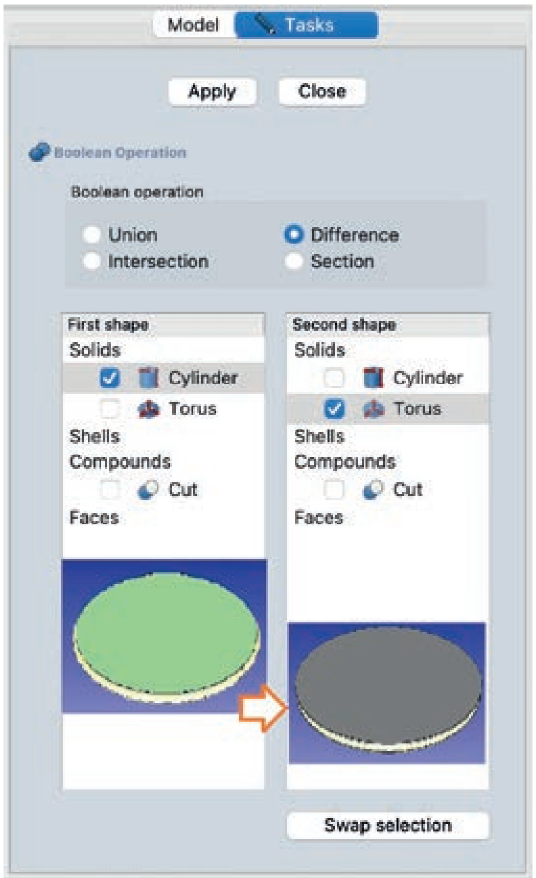
Open the program and select the **Part workbench**. Here we can create various simple shapes, selecting their parameters in the area on the left of the screen. By default, the parts are centred along the z-axis on the XY plane, but we can move them in any direction if we need to. We've marked the fields you need in this picture:


### Centre and groove

1. Create a cylinder with a radius of 50 mm and a height of 6 mm. By default, the name of this part will be **Cylinder**.
2. Create a torus with a **Radius1** of 50 mm and a **Radius2** of 1.5 mm. Under Position, type 3 mm in the z-axis box so that the torus is centred on the cylinder. We will use this torus to make the groove.



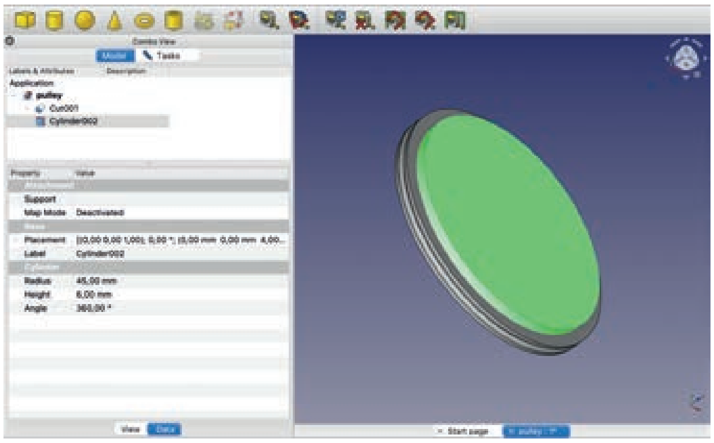
3. Select **Boolean operations** from the toolbar and create a **Difference** between Cylinder and Torus. This creates a new part called **Cut**. This is the part with the groove.



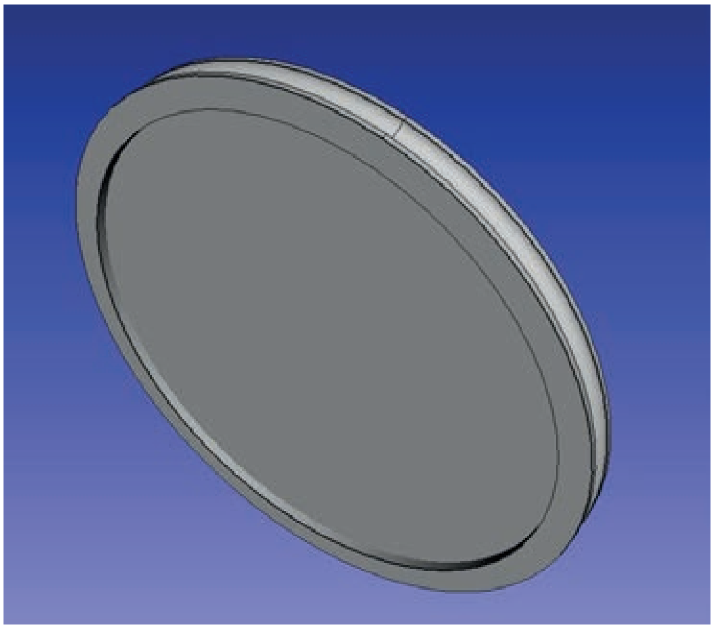
## Reducing the weight of the pulley

To save material, we're going to remove cylinders from the two faces of the pulley.

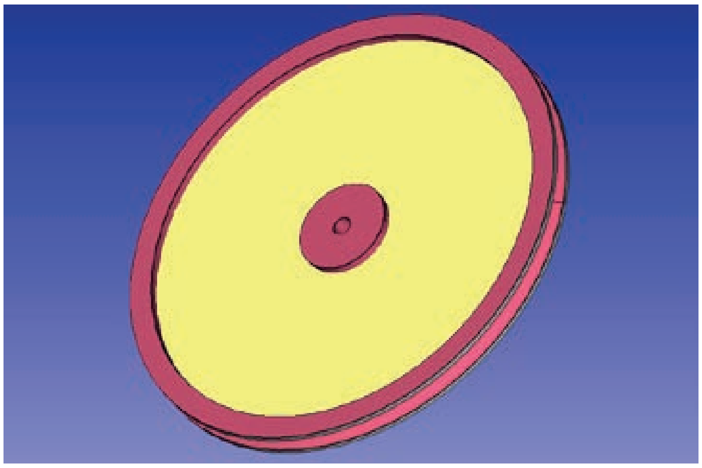
4. Draw a new cylinder called **Cylinder001** with a radius of 45 mm and a height of 2 mm.
5. Select **Boolean operations** and create a **Difference** between Cut and Cylinder001 to make **Cut001**.
6. Create **Cylinder002** with a radius of 45 mm and a height greater than 2 mm. Under **Position**, type 4 mm in the z-axis box.



7. Create a Difference between Cut001 and Cylinder002 to make **Cut002**. This is the lighter part, with material removed from both faces.



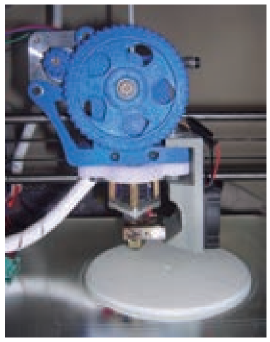
We can rename the parts if we like or use the names that the program provides, so long as we know which part is which.



## Central reinforcement and a hole for the axle

8. Create **Cylinder003** with a radius of 10 mm and a height of 6 mm.
9. Join it to **Cut002** using Boolean operation **Union** to make a part called **Fusion**.
10. Create a new cylinder, **Cylinder004**, with a radius of 2 mm and a height of 10 mm to make the hole for the axle.
11. Create a Difference between **Fusion** and **Cylinder004** to make **Cut003**. Rename this part **Final pulley**.

Printed pulley



3D printer

Save the file with the extension .fcstd. Then, select **Final pulley** to export it as an .stl mesh file. 3D printers use this file type.

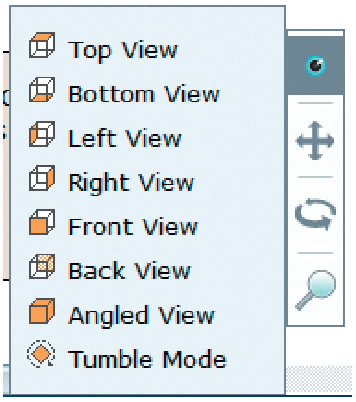
## Practice

**1** **Use this design to make a double pulley. The radius of the second pulley should be 20 mm.**

**2** **How would you make an eccentric pulley? What are some of the uses of this type of pulley?**

# Working with a computer

We use this menu to choose the view we want to work with. The menu also allows us to rotate this perspective to get the most appropriate angle. Try the top view first, then the front, and finally the profile, in order to position the parts well. After this, activate the animation perspective.




## Simulating mechanisms

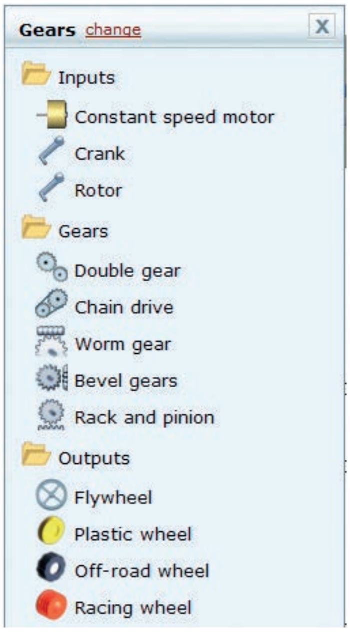
There are computer programs that allow us to experiment with mechanisms. One of these is the simulator **Yenka**, that manipulates mechanical and electrical components. It allows us to visualise in 3D the movement of these mechanisms and to get to know their properties.

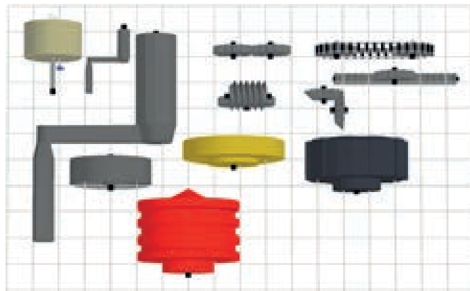
Yenka has a library, which we can access from the main menu. In the library we can select input, transformation and output components, as well as project presentation details.

We can add and modify components:

a. **Design a mechanism**

1. We select the top view (plan) and drag the components of the mechanism from the library to the workspace.



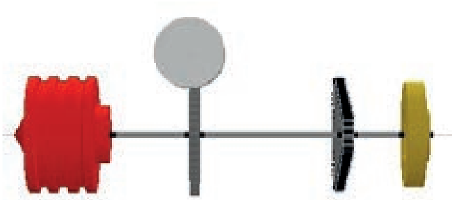



2. To move items horizontally, we use the cursor to drag them to the correct position. To move them vertically, we change the view to either a side or front one.

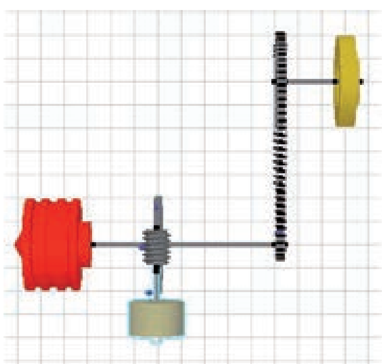
3. We double-click on each component, to modify their key features such as the number of teeth for gears or the rotational speed of a motor, or to rotate them on different planes so that they fit with the rest of the mechanisms.

4. Once the mechanisms are in their final places and the pivot points of their parts are set, we create axes to join them. To do this, we click on the end that has a small black box on it and drag this to the corresponding square in the other mechanism. Once they're correctly joined, the movement will be relayed in the animation.

The simplest way to place the parts and check that they're properly attached is by starting with the motor and then adding in the other parts one by one, with their respective changes in size and position.



Side view to raise the height of the motor with a wormscrew



Plan view of the axes

**b. Presentation**

Once we've designed the mechanism, we can add different elements (numbers and graphics) to provide information on the components (rotation speed, acceleration, number of gear teeth) and their properties.

1. We select an element, such as a number.
2. We drag the target icon on this element to the one we want to manipulate.
3. Finally, we select the property that we want to see reflected.

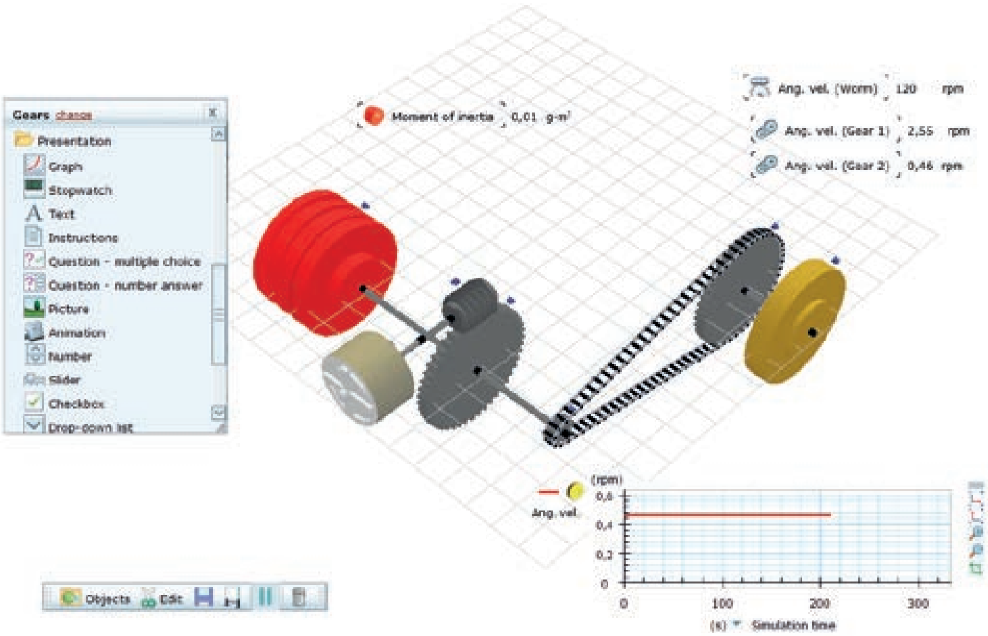
This image shows information about the angular speeds in revolutions per minute of the following elements:

- The motor and the shaft connected to it.
- The small gear in the chain wheel system
- The large wheel in the transmission chain wheel system.

The worm screw transmits motion to the small gear, so they have the same speed. *How fast do they rotate?*

This graphic shows how this property changes over time. It's interesting to note how the properties change when you change the sizes of different parts.

In the image, we can see how the speed of the yellow wheel changes over time. As we can see, it's constant because none of the variables in the system have been changed during the period of study.




We can also add activation buttons, sliding controls, text notes, images and animations, as well as questions and answers. So we can create exercises, tests and explanatory diagrams.

## Practice

1. Study the mechanism on this page. How does it work? How does it transmit motion? Which elements are connected? Which elements rotate at the same speed? Is the speed increasing or decreasing?

2. Use the information about the speed of the various parts. If gear 1 has twelve teeth, how many teeth does the worm drive have? How many teeth does gear 2 have?

3. LS Use the simulator to reproduce the three gear combinations that you use most often on your bicycle. You can do this with a motor and a chain drive, and experiment with the characteristics of different gears.

4. LS Add numbers, explanatory texts and images to your diagram to make it the explanation of this type of transmission in the guided project.

# Technology workshop

## Basic bicycle maintenance

**a. Choosing the right-sized bicycle.**

It's important to choose the right-sized bicycle for high performance and to avoid any problems or injuries. Stand next to the bike holding the handlebars. With your left foot on the ground, lift your right knee forward. The space between your knee and the handlebars should be the width of your hand.

| Height (cm) | Size |
|---|---|
| 71-72 | 15 |
| 73-74 | 15.5 |
| 75-78 | 16 |
| 79-82 | 17 |
| 83-84 | 17.5 |
| 85-88 | 18 |
| 89-90 | 19 |
| 91-92 | 19.5 |
| 93-94 | 20 |

**b. Adjusting the seat.**

As you pedal, your legs should be almost fully stretched when each pedal is at the closest point to the ground. This will help to avoid knee injury.

1. Ask someone to help you get on your bicycle and to hold it steady.
2. Place the heel of your foot on the pedal and stretch your leg fully.
3. Adjust the seat to that height. When you pedal with your toes, your leg will not be completely straight.
4. Notice your position on the seat. If you're sitting too far back, the seat's too low. If you're sitting to far forward, the seat's too high.

**c. Removing the front wheel.**

If your front wheel has a flat tyre, you'll need to remove the wheel.

1. Disconnect the brake system. If your bike has a disc system, don't use the handle when you remove the front wheel.
2. Loosen the nuts on the front axle. Hold the nut on one side in place while you turn the nut on the other side. With a quick release system, just turn the lever.
3. Lift the front of the bicycle so the front wheel comes off.
4. To remove the back wheel, select the highest gear so the chain is on the smallest sprocket. Remove the chain and then remove the back wheel.

**d. Changing the inner tube.**

1. Completely deflate the inner tube.
2. Using tyre levers, slowly lift the edge of the tyre up and over the outside of the rim. Start with the edge next to the valve.
3. Leave the tyre on the rim and remove the inner tube.
4. Check for and remove any sharp objects.
5. Partially inflate the new inner tube and put it inside the tyre. Start with the valve.
6. Very carefully put the tyre back on the rim.
7. Make sure the valve's in the correct position and inflate the inner tube. Put the wheel back on the bicycle.

**e. Re-threading the chain.**

1. Push the arm of the rear derailleur forward, then place the chain on the lower part of the smallest sprocket.
2. Lift the wheel off the ground and turn the pedal backwards. Slowly thread the chain onto the sprocket.
3. Turn the pedal forwards until the chain is completely connected to the gear wheel.

# Which parts of my bicycle should I check?

a. **Before you use your bicycle, always:**

1. Check your **tyres** and their **air pressure** in case you have a flat tyre or slow puncture.
2. Check your **brakes** are working correctly. This is necessary for your own safety and the safety of others.
3. Check that your **chains** and **gears** are properly lubricated. If these parts are rusty or are scraping against each other, they may break.

b. **If you use your bike often, every month you should:**

1. **Check the cables.** Make sure they're not twisted or broken. Check the tension.
2. **Inspect the chain, wheels and sprockets.** Are the teeth in good condition? Does the chain move correctly? Does it slip or jump? Is it scraping against other parts? Replace any damaged parts.
3. **Check the air pressure in the tyres.** You can find the correct tyre pressure on the side of the tyres. Always carry an air pump and repair kit.
4. **Check the chain, sprocket mechanisms and all other moving parts are lubricated.** Occasionally, you will also need to lubricate the seat tube, suspension, cables and any place where there's friction.
5. **Check the suspension pressure.** This is important if your bike has an air or hydraulic suspension system. This needs to be properly adjusted for your weight.
6. **Check the tyres.** Look for cracks, damage and excessive wear.
7. **Inspect all the nuts and bolts.** Make sure they are not too loose or too tight.
8. **Check the frame.** Examine the frame carefully. If you find any cracks or stress marks, don't ride the bike.

c. **Clean your bicycle!**

Dirt and dust can be a mechanism's worst enemy because it causes friction and wear. Clean your bicycle once every three months. Once it's dry, lubricate the moving parts. This will keep your bicycle in good condition and make it last longer.

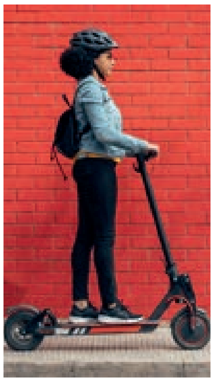
## Practice

**1** LS What mechanisms on your bicycle need lubrication? Why's this necessary? Find information about what type of lubricant you should use on each mechanism on your bicycle, such as the brakes, gear wheels, sprockets, axles and levers.

# Emerging technologies and sustainability

## Personal transporters

Bikes are the most sustainable vehicles because of how much energy and resources they use. In addition, companies are now developing many different types of electric vehicles that can compete with cars on journey time, but are also less expensive and use less energy.

| Electric bike | Electric scooter | Electric motorbike |
|---|---|---|
| A motor helps the rider pedal and accelerate, and stops working when the bike reaches a speed of 25 km/h. The bike can travel at higher speeds if the rider uses their own pedalling strength.<br><br>Speed: 25 km/hour or more with pedalling<br>Range: 150 km | Electric scooters are light, have a good range for short journeys and are cheaper than other electric vehicles.<br><br>Speed: 25 km/hour<br>Range: 20-80 km | Electric motorbikes have a similar power to mopeds. They need a licence plate and riders must follow the same rules as car drivers. Electric motorbikes cannot use bike lanes.<br><br>Speed: 100 km/hour<br>Range: 50-150 km |
| **Electric unicycle** | **Hoverboard** | **Segway** |
| These are the lightest personal transporters. Riders steer them by leaning their body in the direction of travel. Unicycles aren't easy to ride because the wheel moves to help the rider keep their balance. They're the least popular option because they're very expensive.<br><br>Speed: 40 km/hour<br>Range: 20 km | A hoverboard consists of a platform with sensors. Like the electric unicycle, the rider steers by leaning their body. They're difficult to ride, and are more for fun than a serious mode of transport.<br><br>Speed: 12-18 km/hour<br>Range: 15-45 km | Segways are slow and easy to ride. Many people ride them in pedestrian zones, such as tourists and security guards. They're more expensive than scooters.<br><br>Speed: 9-12 km/hour<br>Range: 25 km |

The most popular personal transporters are electric bikes and scooters. Electric bikes are faster, have a longer range and are more comfortable, but they're more expensive, heavier and bulkier.

### Activities

**1** **Read these descriptions of vehicle purchase and maintenance costs. What's the annual cost of each vehicle type?**

- The average annual spend on a car includes: payment instalments €2 370; tax €200; parking and road tolls €103; maintenance €208; insurance €532.
- An average scooter costs €400; it lasts for 5 years; there's no insurance, tax or parking; maintenance €35.

Find the same data for an electric bike.

**2** **Read these comparative descriptions of fuel costs of an electric vehicle and a petrol vehicle and answer the questions.**

**a)** It costs €0.046 to fully charge an electric scooter with a range of 20 km. How much will it cost to travel 100 km?

**b)** If a car uses €9 of petrol per 100 km, how much will we save annually with an electric scooter if we travel 10 km per day?

# Work on your key competences

## Tune up your bike

A bicycle is a compound machine with multiple mechanisms.

The **aim** of this project is to recognise and identify the components of a bike, learn how to tune up your bike and add extra parts to make it safer and more comfortable to ride.


### Analysis

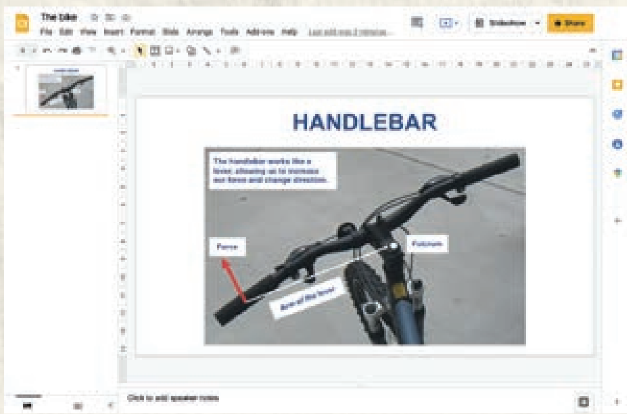
1. What are the parts of a bike? What are their functions?
2. Look at your bike and identify the different mechanisms.
3. Classify the mechanisms by type, function and purpose.
4. Look at the picture and match each number to the name of the part.

| Frame | Front | Wheel | Transmission | Other parts |
|---|---|---|---|---|
| crossbar | handlebars | spokes | front gear | seat |
| down tube | steering tube | hub | cogset | seat post |
| seat tube | suspension | rim | chain | pedal |
| seat stay | front brakes | tyre | back gear | crank |
| chain stay | fork | valve | sprocket | back brakes |

5. Which parts in activity 4 do you think are mechanisms? Which aren't?
6. Which parts do you think form a mechanism in conjunction with other parts?

### Development

7. Write a list of all the moving parts of a bike and classify them according to their motion type: linear, rotary or both. For example a sprocket has rotary motion and the suspension has linear motion.
8. Make a slide presentation showing the mechanisms that make up a bicycle. Follow these steps:
   a) Find images of the parts that a bike has, such as wheels, handlebars, pedals, transmission, front gears, levers, brakes, shock absorbers, front and back gears and bearings. Use images from the Internet or take your own photos.
   b) Insert your images into a presentation program. Use PowerPoint, Libre Office Impress or any other presentation software.
   c) Include images and animations from the mechanism simulator you used in this unit.
   d) Include a section about basic bicycle maintenance.




9. Find information about the evolution of the bicycle throughout history and include it in your presentation.
10. Based on your analysis, add another part to your bike to improve it.

Task guide