A LEVEL DESIGN ENGINEERING

# 6.4 MECHANISMS PART 3

# Design & Technology – Starter

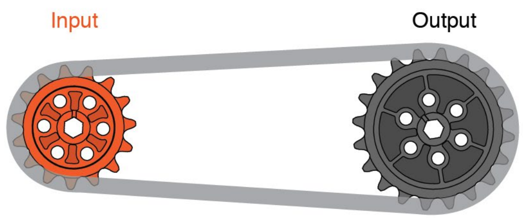
## PLEASE SIT DOWN IMMEDIATELY & WORK IN SILENCE

**The diagrams here show the mechanism from a bike…** What is the mechanism called?

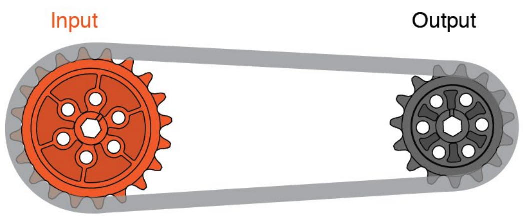
Each diagram shows three different configurations. In each situation the pedals are connected to the orange wheel and the grey to the back wheel of the bike.

What impact would the different configurations have on the riding of the bike? Refer to the speed and torque in your answer.

What different riding situations would you use these configurations in?








# Learning objectives

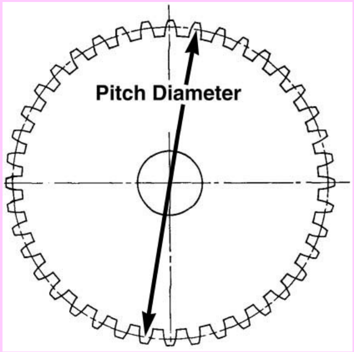
- ❑ What is the pitch circle diameter and module of a gear?
- ❑ How do we work with compound gear trains?
- ❑ How do we calculate the gear ratio of different mechanisms

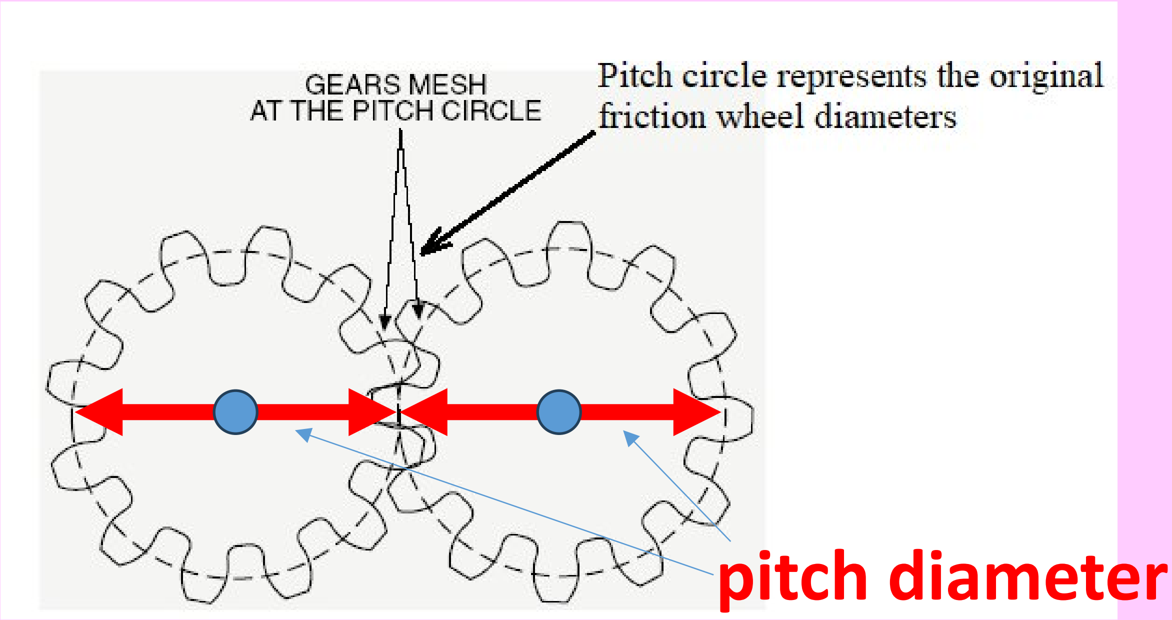
# Key words:

Mechanism, gear, cam, linkage, lever, chain and sprocket, belt and pulley, basic machine principle, mechanical advantage, velocity ratio

# Explanation

# What is the pitch circle diameter?




Visualise the meshed gears as two **friction wheels** without gear teeth.

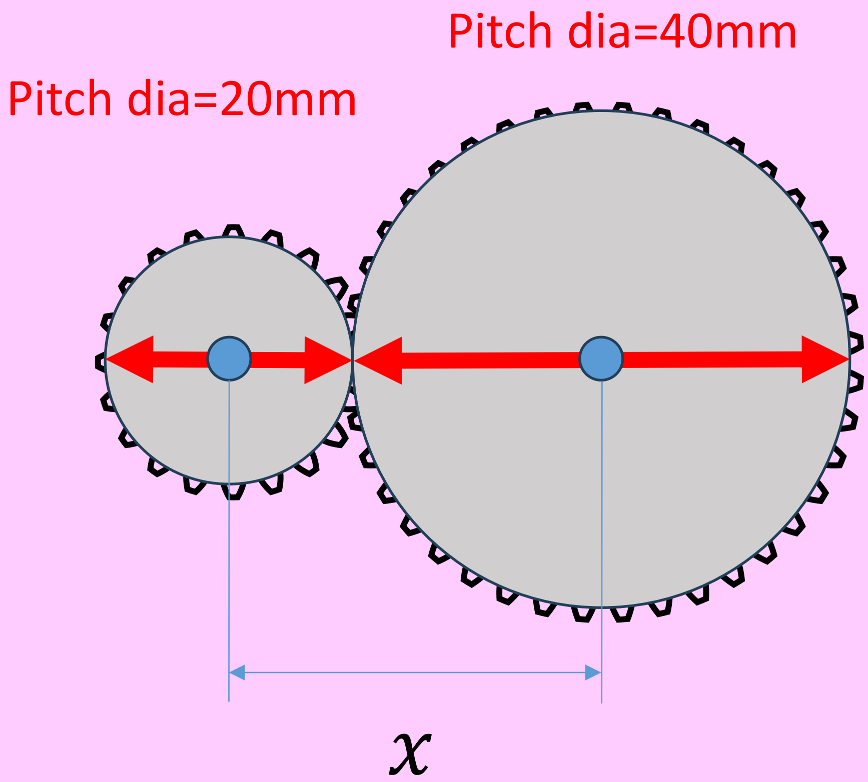
Each wheel has a diameter known as the **pitch diameter**.

Learning objectives:

- What is a mechanism?
- What are the types of mechanism?
- How are mechanisms used in products?

# Explanation

## How can we apply the **pitch circle diameter**?




We can use the pitch circle diameter to work out the **distance between the two axles**.

$$distance\ x = \frac{pitch\ circle\ dia}{2} + \frac{pitch\ circle\ dia}{2}$$

$$distance\ x = \frac{20}{2} + \frac{40}{2}$$

$$distance\ x = 30mm$$

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Explanation

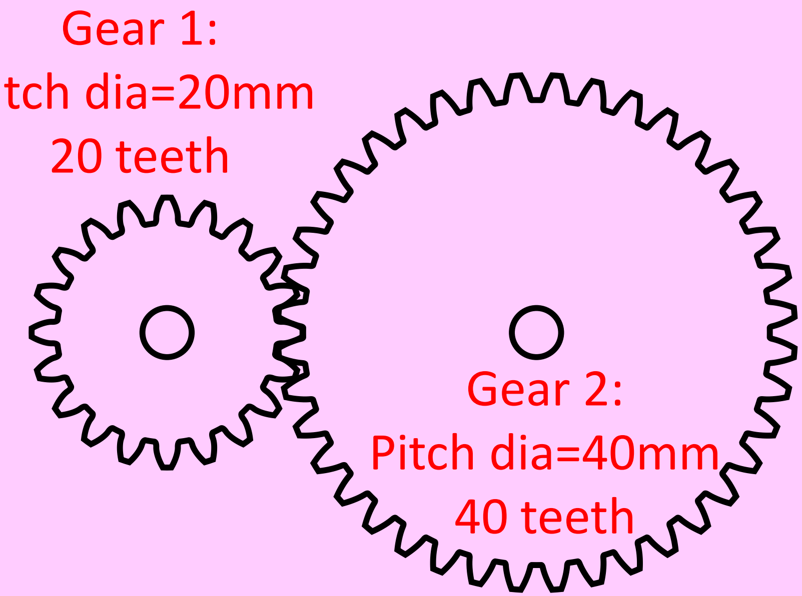
# What is the module of a gear?

Gears must have the same **tooth pitch**

**Tooth pitch** is the **number of teeth per mm** around the circumference

This is called the **module** of the gears

$$\boldsymbol{module} = \frac{pitch\ circle\ diameter(mm)}{number\ of\ teeth}$$




$$gear\ 1\ module = \frac{20}{20} \qquad gear\ 2\ module = \frac{40}{40}$$

$$\boldsymbol{gear\ 1\ module = 1} \qquad \boldsymbol{gear\ 2\ module = 1}$$

Learning objectives:

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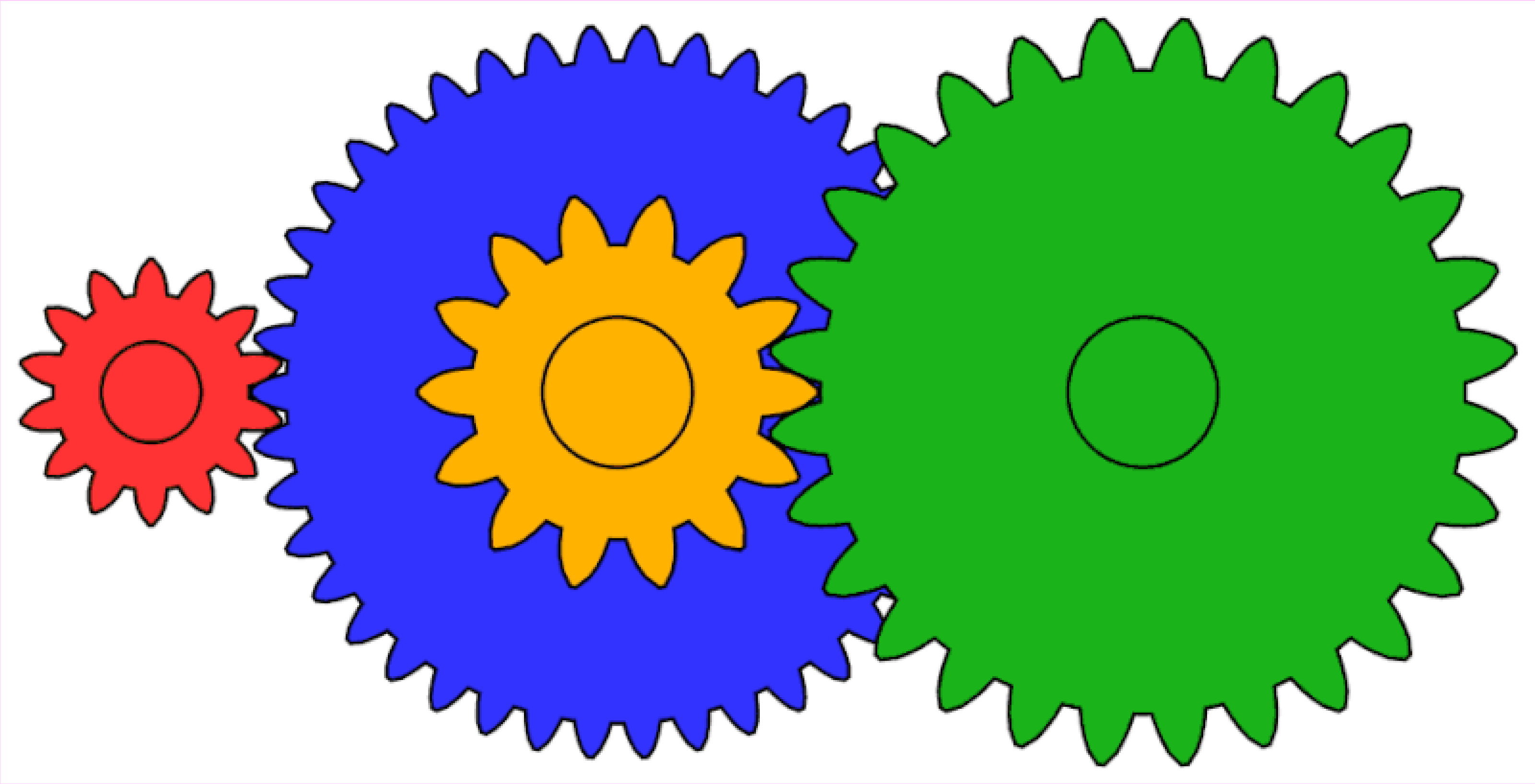
# Explanation

## What is a compound gear train?



Learning objectives:

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# Explanation

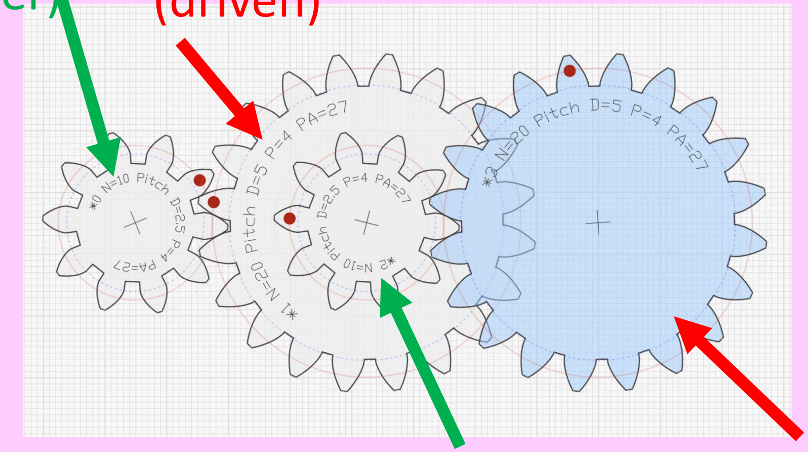
## How do we calculate the gear ratio of compound gear trains?

$$\text{Overall } gear\ ratio = \left(\frac{no\ of\ teeth\ on\ driven}{no\ of\ teeth\ on\ driver}\right) \times \left(\frac{no\ of\ teeth\ on\ driven}{no\ of\ teeth\ on\ driver}\right)$$

$$\text{GR} = \left(\frac{20}{10}\right) \times \left(\frac{20}{10}\right)$$

$$\text{GR} = 2 \times 2$$

$$\text{GR} = 4$$




Learning objectives:

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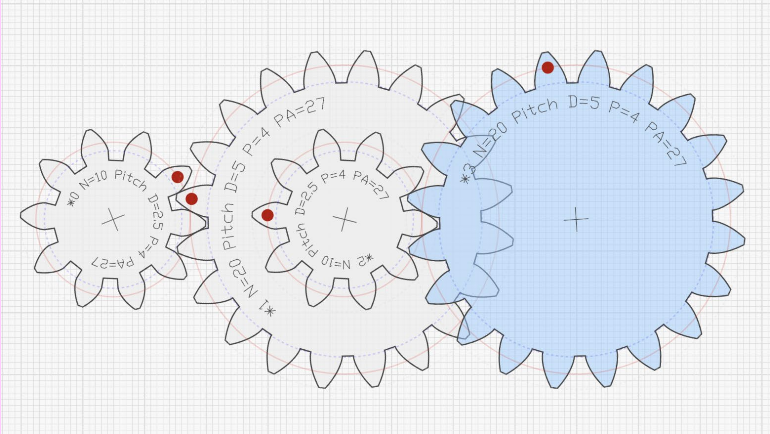
# Explanation

## How do we calculate speeds and torque?

**Input**
Speed 100 rpm
Torque 10 Nm




**Gear Ratio = 4**

**Output**
Speed ? rpm
Torque ? Nm

**The output will rotate slower**

**The output will provide greater torque**

$$speed\ of\ output = \frac{input\ speed}{gear\ ratio}$$

$$speed\ of\ output = \frac{100}{4}$$

$$speed\ of\ output = 50\ rpm$$

$$output\ torque = input\ torque\ \times gear\ ratio$$

$$output\ torque = 10\ \times 4$$

$$output\ torque = 40\ Nm$$

Learning objectives:

- ❑ What is a mechanism?
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Explanation

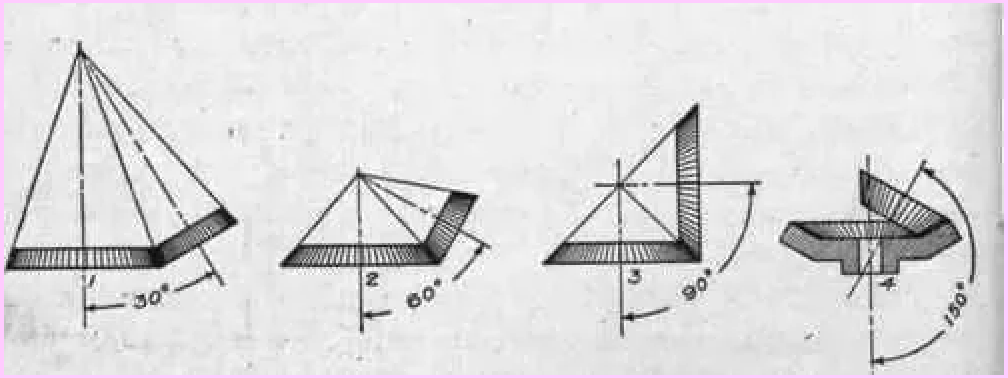
## Why are bevel gears used?

Transfer motion through **various angles**.

Motion often transferred through **90˚**.

Other angles can be achieved.

Two bevel gears of equal size (**1:1 ratio**) are called **mitre gears**




Learning objectives:

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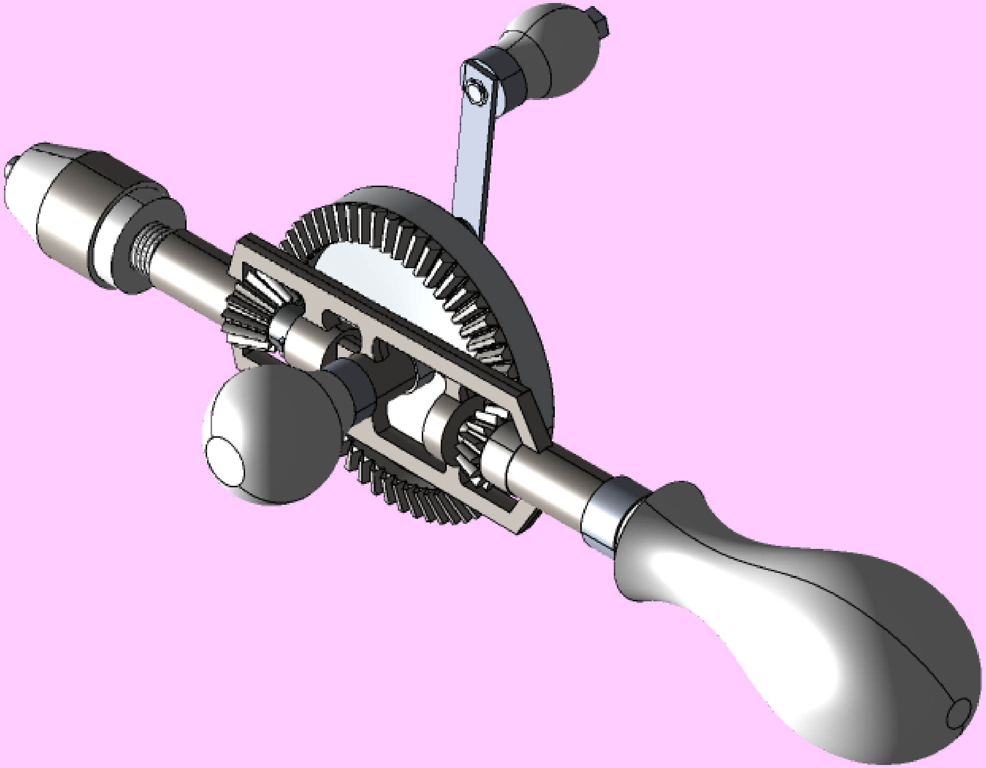
# Explanation

**What are the applications of bevel gears?**



Learning objectives:

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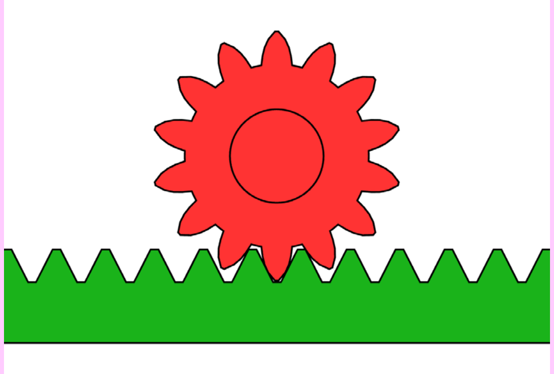
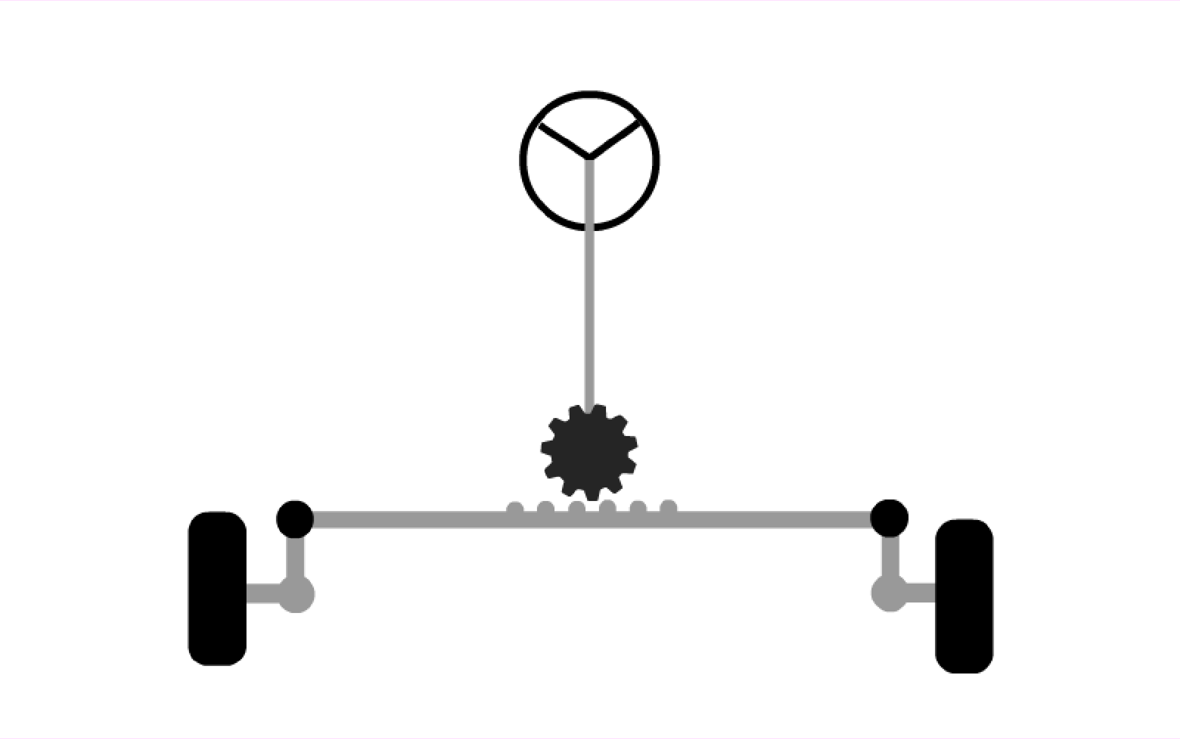
Explanation

**What are the applications of a rack and pinion?**





Learning objectives:

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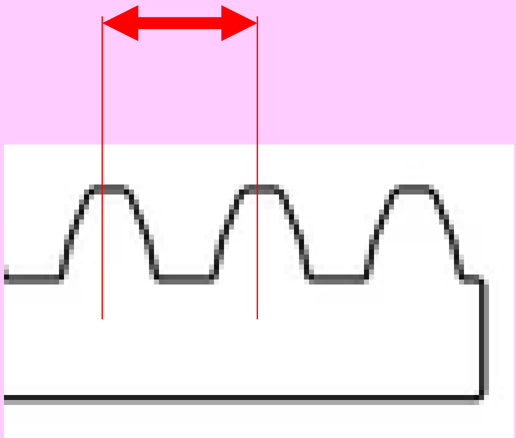
# Explanation

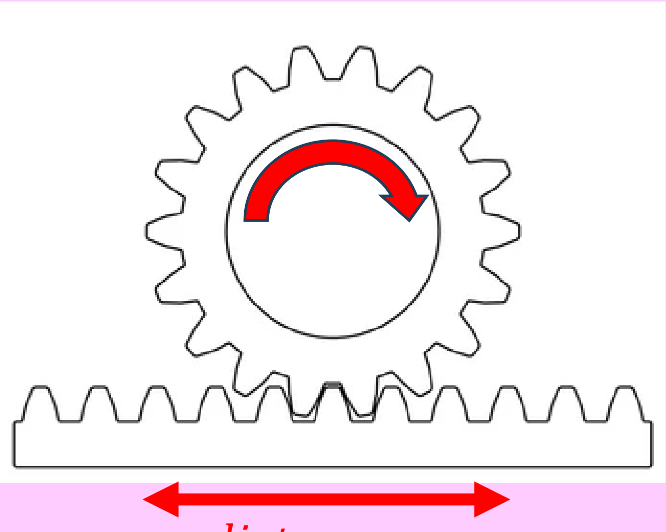
## How do we work with a **rack and pinion**?

Changes motion from **rotary to linear**.

**Rack tooth pitch=3mm**



**Pinion 18 teeth**



$distance\ x$

If the pinion rotates **half a revolution** how far would the rack move?

$$distance\ x = rack\ tooth\ pitch\ \times number\ of\ teeth\ moving\ over\ rack$$

$$distance\ x = 3 \times 9$$

$$distance\ x = 27mm$$

Learning objectives:

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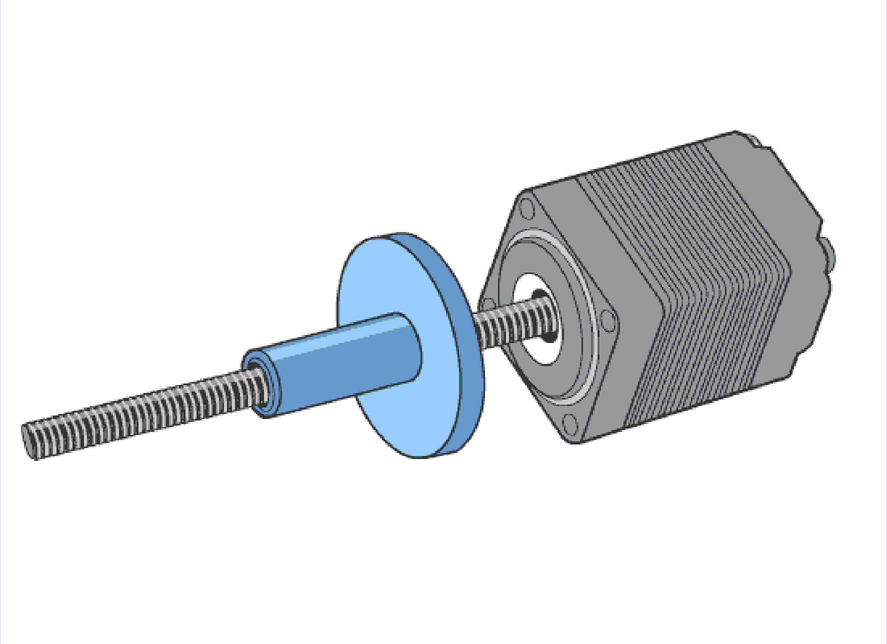
# Explanation

## What are the applications of a leadscrew?



Learning objectives:

- ❑ What is a mechanism?
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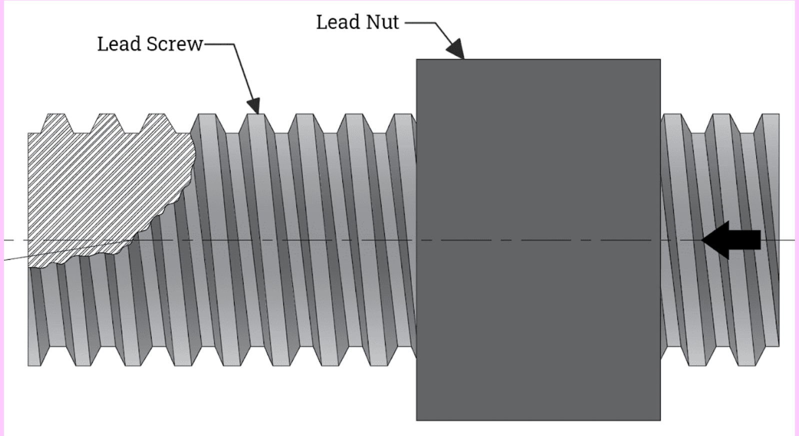
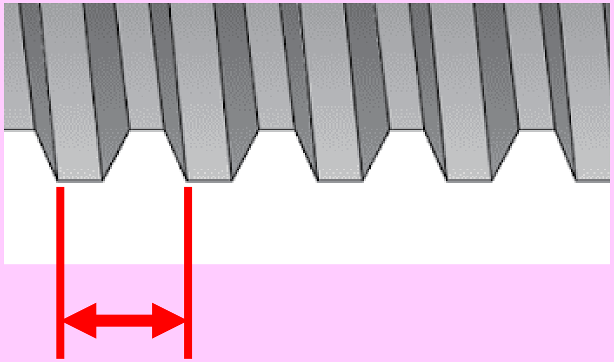
# Explanation

## How do we work with a <u>leadscrew</u>?




What is the **pitch**?



*pitch*

Changes motion from **<u>rotary</u>** to **<u>linear</u>**.

If the leadscrew makes **20 revolutions** and the **pitch is 2mm** how far would the lead nut move?

$$distance\ moved = 20 \times 2$$

$$\boldsymbol{distance\ x = 40mm}$$

Learning objectives:

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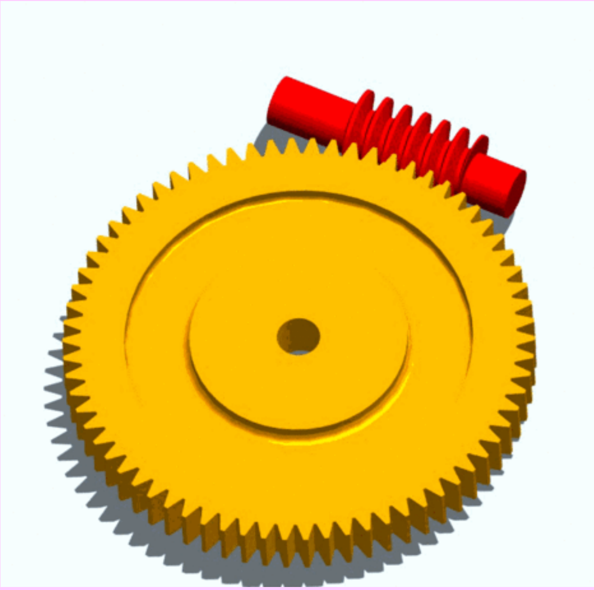
Explanation

# What are the applications of worm drives?



Learning objectives:

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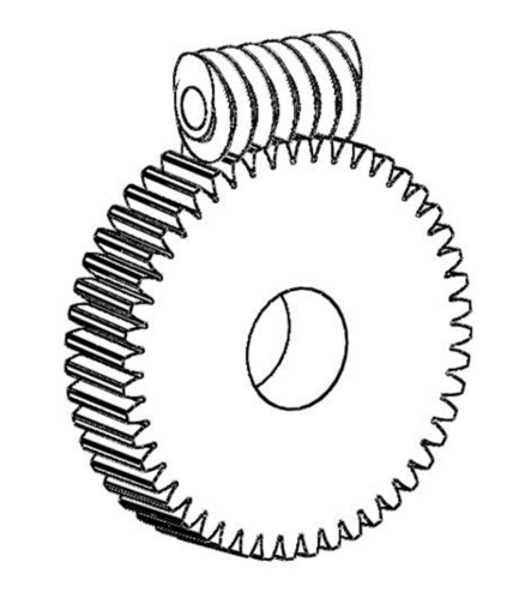
# Explanation

## How do we work with <u>worm drives</u>?

**Worm (driver)**
**1 tooth**



**Worm wheel (driven)**
**50 teeth**

Worm has a <u>**single tooth/thread**</u>

Each rotation of the worm causes the wheel to advance one tooth

$$\boldsymbol{Gear\ ratio} = \frac{number\ of\ teeth\ on\ \boldsymbol{driven}\ gear}{number\ of\ teeth\ on\ \boldsymbol{driver}\ gear}$$

$$Gear\ ratio = \frac{50}{1}$$

$$Gear\ ratio = \frac{50}{1}$$

$$Gear\ ratio = 50$$

Learning objectives:

- ❑ What is a mechanism?
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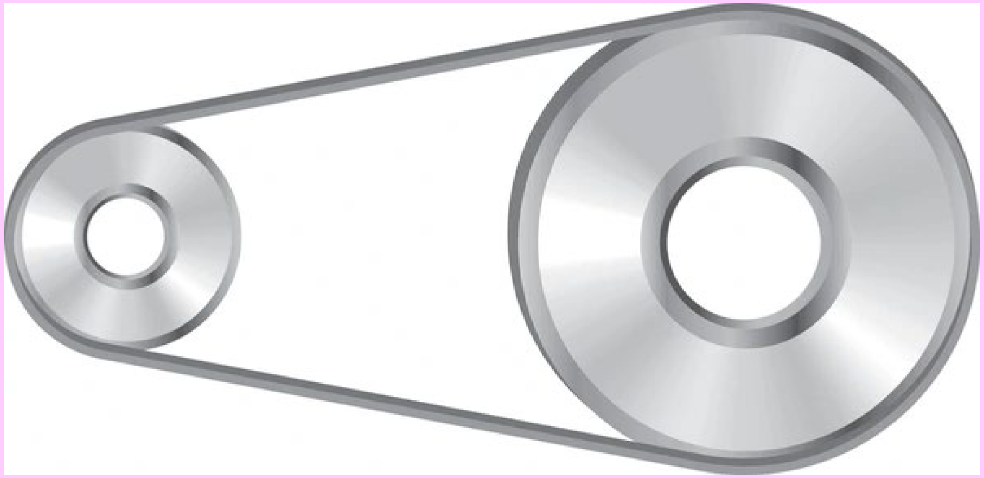
Explanation

# Calculating gear ratio with belt drives?

50mm
dia
(driver pulley)



150mm
dia
(driven pulley)

$$GR = \frac{diameter\ of\ \mathbf{driven}\ pulley}{diameter\ \mathbf{driver}\ pulley}$$

$$GR = \frac{150}{50}$$

$$GR = 3$$

Learning objectives:

- ❑ What is a mechanism?
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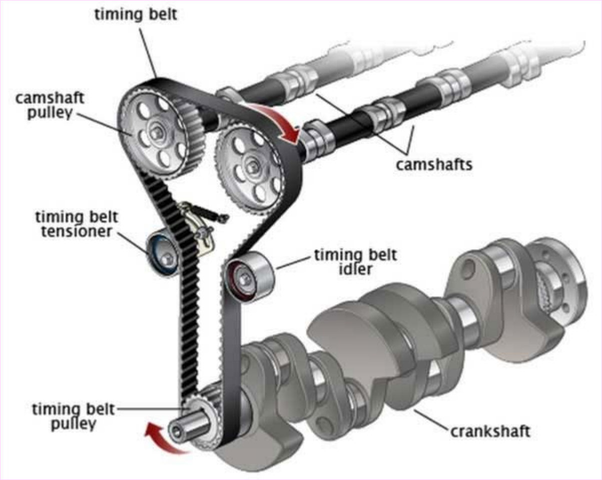
# Explanation

## What are the types of belt drive?

Toothed belt

Used where it is important that the belt does not slip





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# Explanation

## What are the types of belt drive?

V-Belt

-Large surface area in contact

-Less chance of belt slipping


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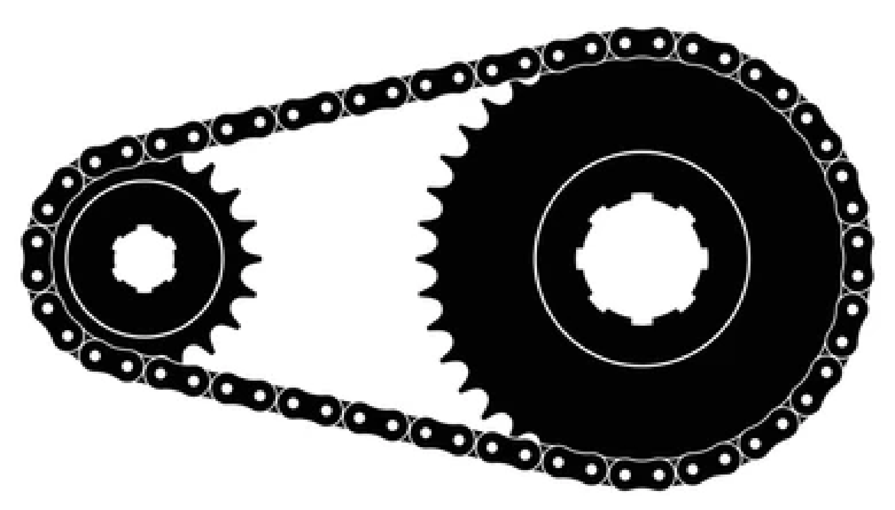
# Explanation

## Calculating gear ratio with chain drives?

20 teeth
(driver sprocket)



120 teeth
(driven sprocket)

$$GR = \frac{number\ of\ teeth\ on\ \boldsymbol{driven}\ sprocket}{number\ of\ teeth\ on\ \boldsymbol{driver}\ sprocket}$$

$$GR = \frac{120}{20}$$

$$GR = 6$$

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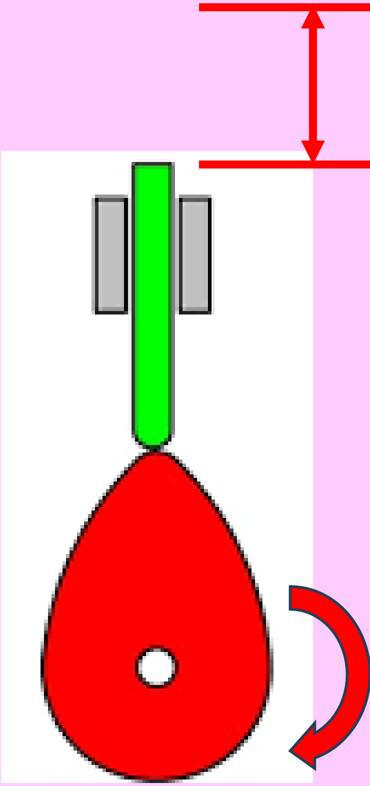
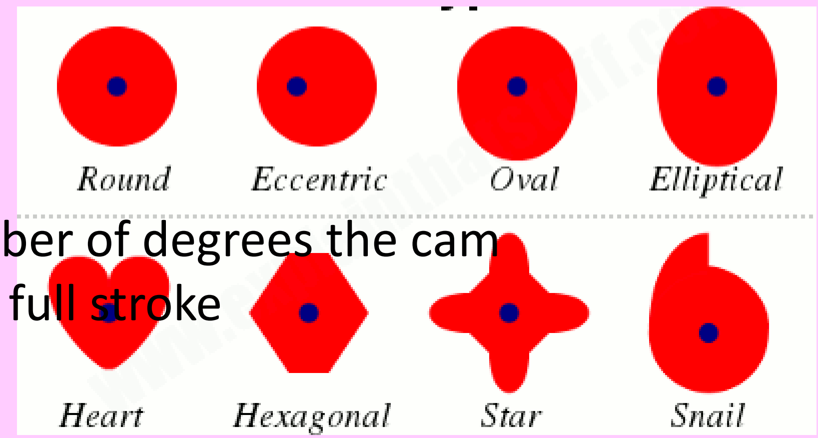
# Explanation

## How do we work with Cams?



**Stroke:** The maximum distance the follower rises

**Dwell:** The number of degrees during which no follower movement occurs




**Rise interval:** The number of degrees the cam rotates to produce the full stroke

Learning objectives:

- ❑ What is a mechanism?
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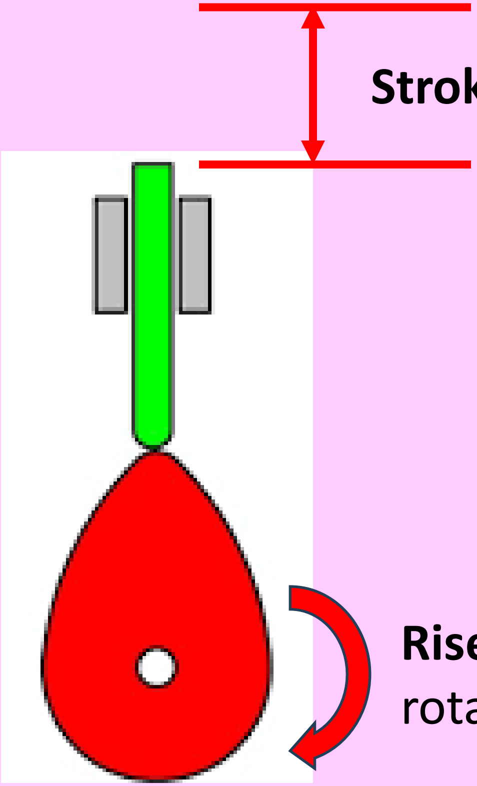
**Explanation**

# How do we work with Cams?



**Stroke:** The maximum distance the follower rises

**Dwell:** The number of degrees during which no follower movement occurs

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