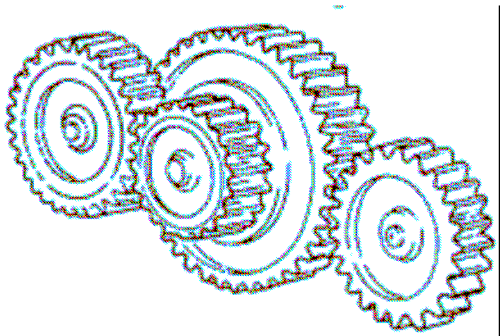
GEARS

Are fastened to axles or shafts to transmit motion and torque from one shaft to another

are used to :

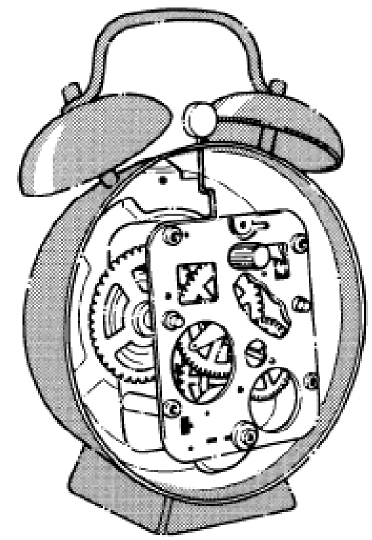
- **Maintain / change the direction of rotation;**
- **Increase / decrease speed of rotation;**
- **Change the angle of rotation;**
- **Change the rotational motion to linear motion and vice versa**
- **Increase / decrease torque (turning force);**
- **Provide Mechanical Advantage**

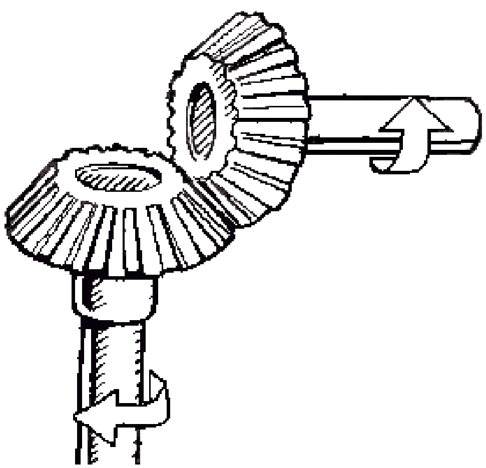
Types of gears



Spur gears

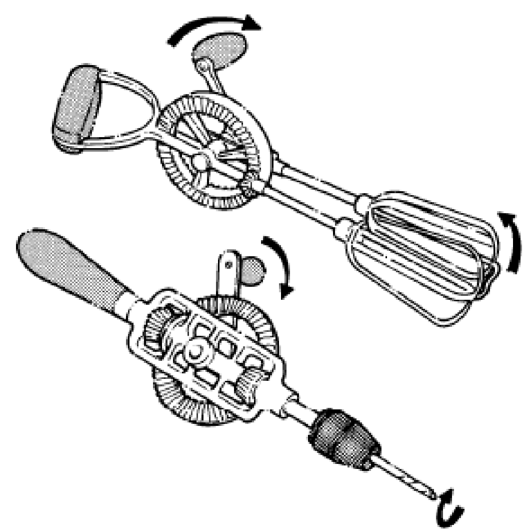
Multiple gears can be connected together to form a gear train. If there are an odd number of gears, the output rotation will be the same direction as the input. If there is an even number, the output will rotate in the opposite direction to the input. In a simple type of gear train, the number of teeth on the intermediate gears does not affect the overall velocity ratio, which is governed purely by the number of teeth on the first and last cog.

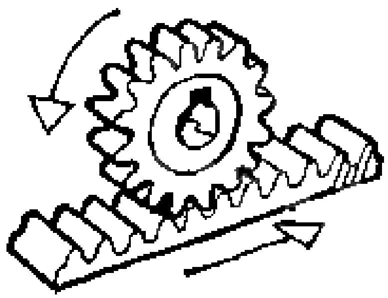




Bevel gears

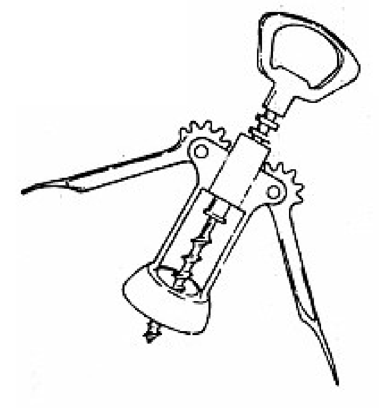
Bevel gears are used to change rotational movement through an angle of 90°. Bevel gears will provide some mechanical advantage or increase in velocity ratio.

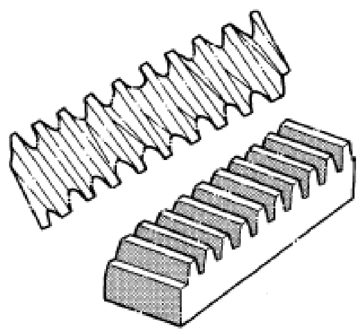




Rack-and-spur gears

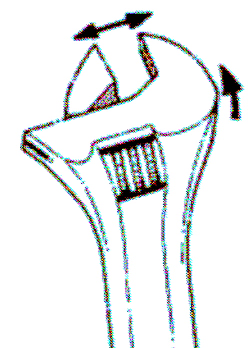
The rack-and-spur gear is used to convert between rotary and linear motion. Often the spur rotates in a fixed position and the rack is free to move. Alternatively, the rack may be fixed and the spur rotates moving up and down the rack. This latter arrangement on two-handled cork-pullers.

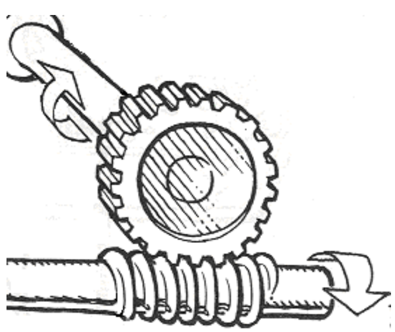




Rack-and-worm gears

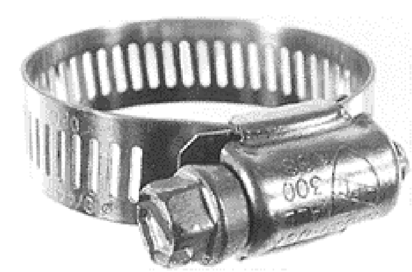
The rack-and-worm gear changes rotational movement into linear movement. In a shifting spanner, the rack-and-worm system is used to adjust the position of the jaw of the spanner—to make the gap wider or narrower. The worm is turned to adjust the position of the spanner. So for each revolution of the worm, the rack advances the distance between two consecutive teeth on the rack.

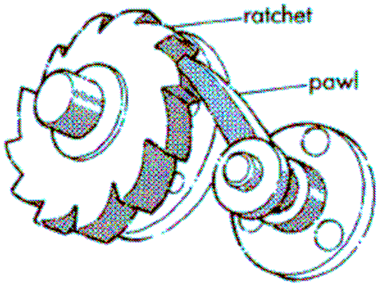




Worm-and-spur gears

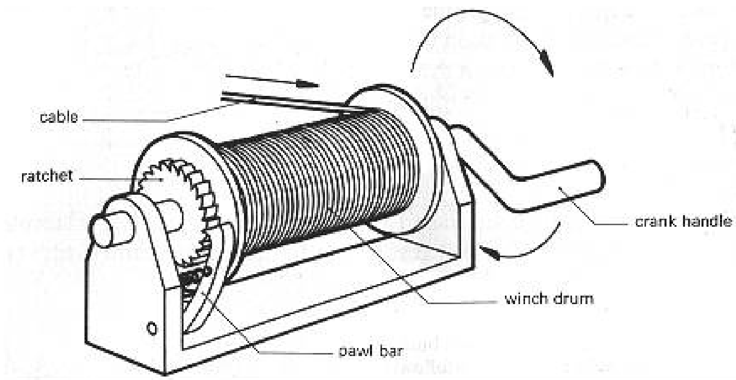
A worm-and-spur gear is often used when a large speed reduction is required and not much power is needed. Unlike ordinary gears, the motion is not reversible, a worm can drive a gear to reduce speed but a gear cannot drive a worm to increase it. The velocity ratio of two adjacent cogs can be calculated by dividing the number of teeth on the driven gear by the number of teeth on the driving gear. The velocity ratio of a worm-and-spur gears is easily calculated because the worm has only one tooth. The worm gear is always the drive gear. For example, if the wheel gear has 60 teeth and the worm gear has 1 tooth, then the velocity ratio is 1/60 = 1:60

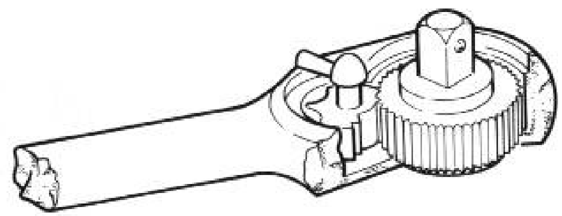


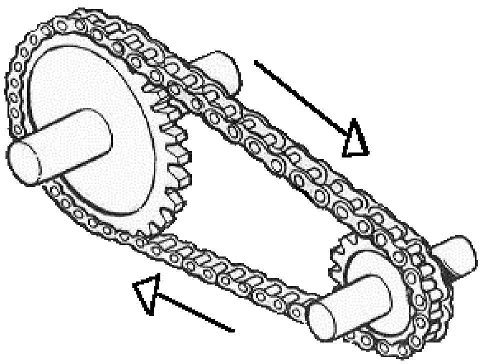


Pawl and ratchet

A ratchet mechanism is based on a wheel that has teeth cut out of it and a pawl that follows as the wheel turns. Studying the diagram you will see that as the ratchet wheel turns and the pawl falls into the 'dip' between the teeth. Ratchets are used widely in lifting equipment to lock the motion and prevent reverse rotation when the input force is remove. Ratchets can also be used to drive a motion in one direction and allow free-wheeling in the reverse direction.



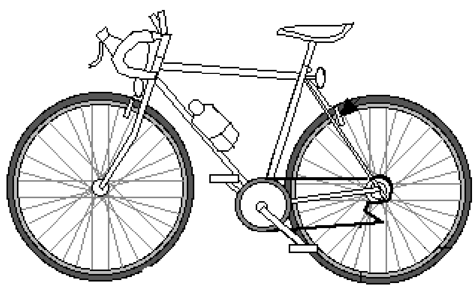




Chain and sprocket

A chain is made up of a series of links with the links held together with steel pins. This arrange makes a chain a strong, long lasting way of transmitting rotary motion from one gear wheel to another.

Chain drive has one main advantage over a traditional gear train. Only two gear wheels and a chain are needed to transmit rotary motion over a distance. With a traditional gear train, many gears must be arranged meshing with each other in order to transmit motion.

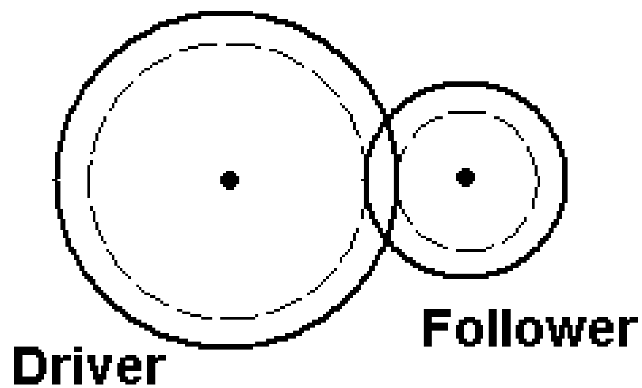


Direction of rotation

A series of intermeshing gears is called a **gear train.**

Intermeshing gears turn in opposing directions.

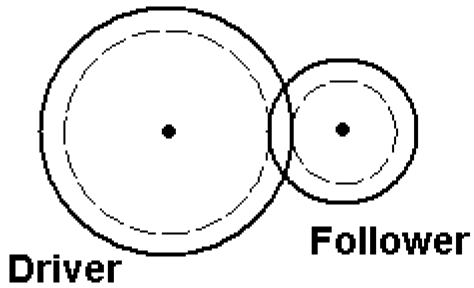
In a gear train we have a gear known as the ***driver*** and one known as the ***follower***.

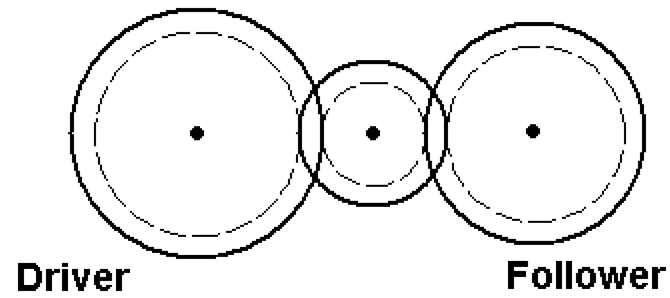


Driver - is the gear that has the force or motion input.

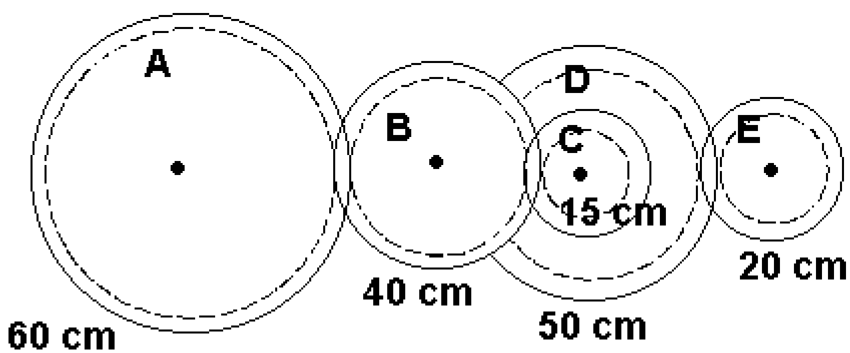
Follower - is the gear that results in the force or motion output.

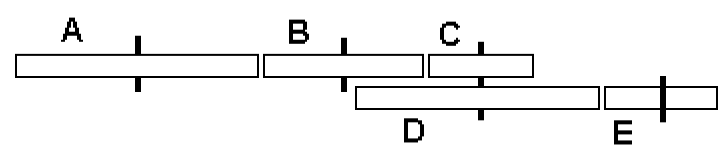
In **simple gear trains**, each gear is on its own axis.





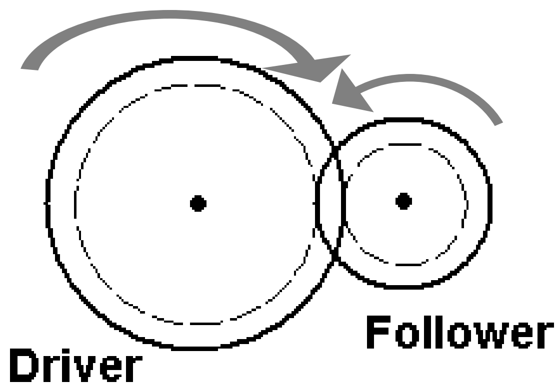
In **compound gear trains**, some gears share an axis.



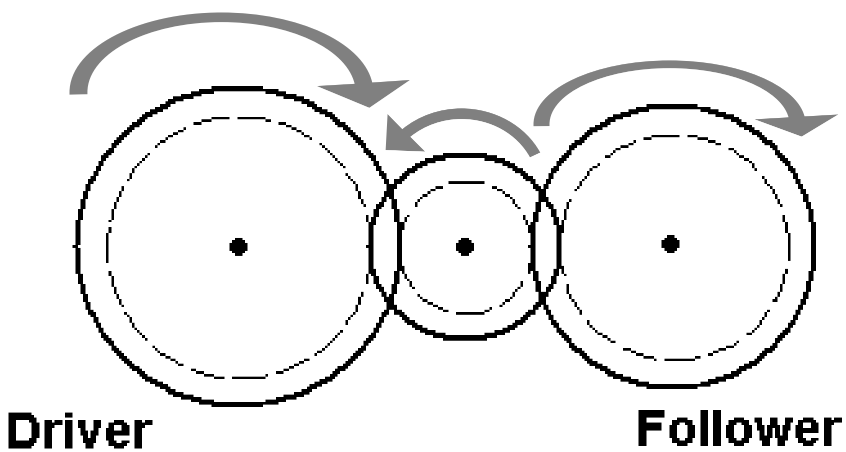


Side view of the compound gear train

Changing the direction of motion (1)



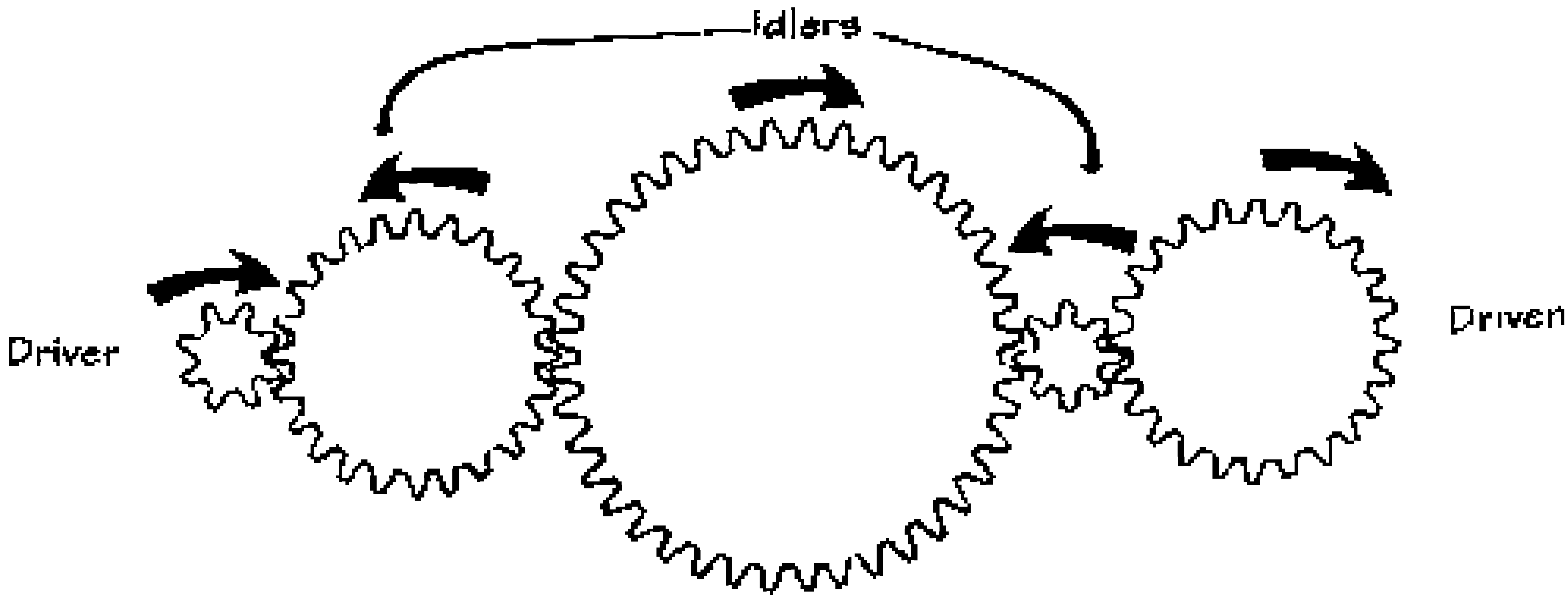
Adjacent gears on a gear train rotate in **opposite directions**. Notice how the driver rotates clockwise while the follower rotates anticlockwise.



The addition of a third gear (**idler**) makes the follower and driver rotate in the same direction.

Meshed Gears

The diagram below shows five meshed gears. The first gear that the force is applied is called the driver gear. Notice that the arrows show how the gears are turning. Every other gear is turning clockwise. The very last gear is the driven gear. All of the gears in between are called idlers.



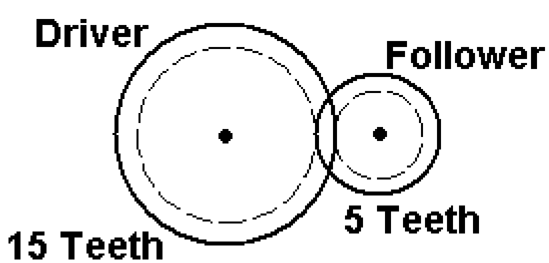
Sizes of gears

Gear ratio = **Comparing the size of gears**

The gear ratio of a gear train can be determined by:

1) **Dividing** the number of teeth on the **follower**, by the number of teeth on the **driver**.

$$\textbf{Gear Ratio} = \frac{\textbf{No. teeth on follower (output)}}{\textbf{No. teeth on driver (input)}}$$



In this gear train the driver has **15 teeth** while the follower has **5 teeth**.

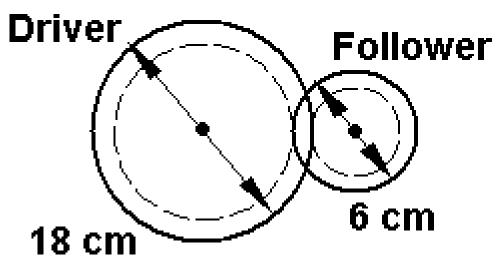
$$\text{Gear Ratio} = \frac{\text{No. teeth on follower (output)}}{\text{No. teeth on driver (input)}}$$

$$\text{Gear Ratio} = \frac{5}{15} = \frac{1}{3}$$

Gear Ratio = 1 : 3

2) Dividing the diameter of the **follower**, by the diameter of the **driver**.

$$\text{Gear Ratio} = \frac{\textbf{Diameter of follower (output)}}{\textbf{Diameter of driver (input)}}$$



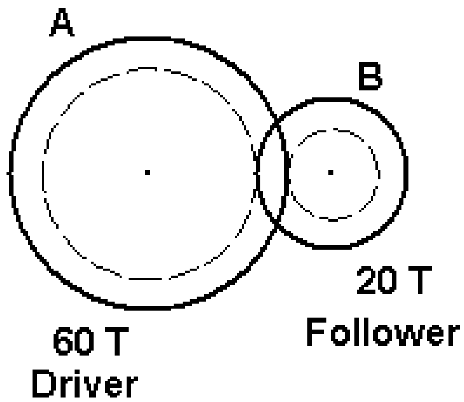
In this gear train the driver has a **diameter of 18 cm** while the follower has a **diameter of 6 cm**.

$$\text{Gear Ratio} = \frac{\text{Diameter of follower (output)}}{\text{Diameter of driver (input)}}$$

$$\text{Gear Ratio} = \frac{6}{18} = \frac{1}{3}$$

Gear Ratio = 1 : 3

Big Driver

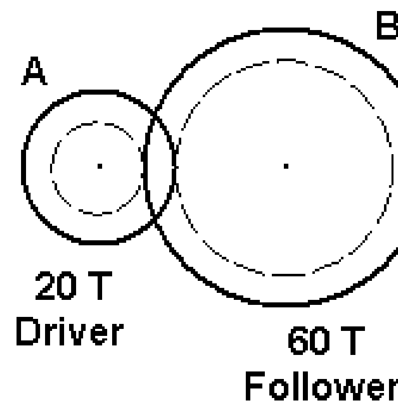


$$GR = \frac{\text{\# teeth on follower}}{\text{\# teeth on driver}}$$

$$= \frac{20}{60} = \frac{1}{3}$$

$$\boxed{GR = 1 : 3}$$

Small Driver

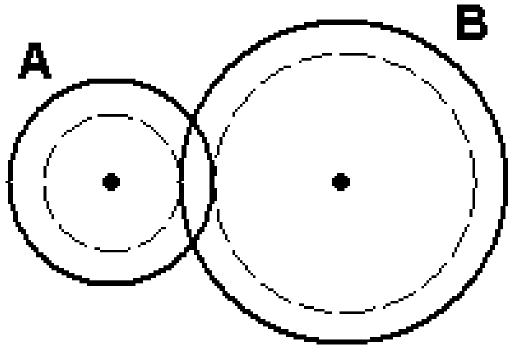


$$GR = \frac{\text{\# teeth on follower}}{\text{\# teeth on driver}}$$

$$= \frac{60}{20} = \frac{3}{1}$$

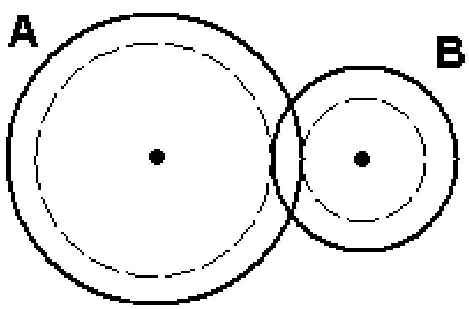
$$\boxed{GR = 3 : 1}$$

Exercises



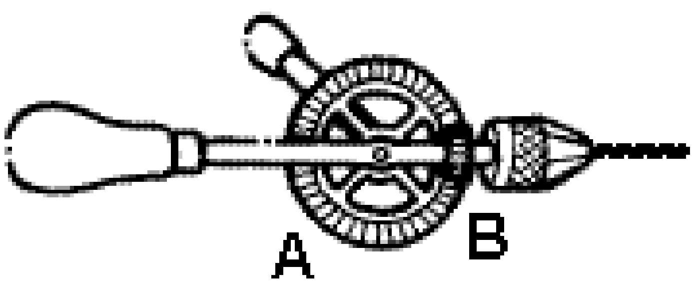
Look at the image on the left. Gear "B" has 36 teeth and gear "A" has 12.

Calculate the gear ratio of this gear train if "B" is the driver.



Look at the image on the left. Gear "B" has 12 teeth and gear "A" has 24.

Calculate the gear ratio of this gear train if "B" is the driver.

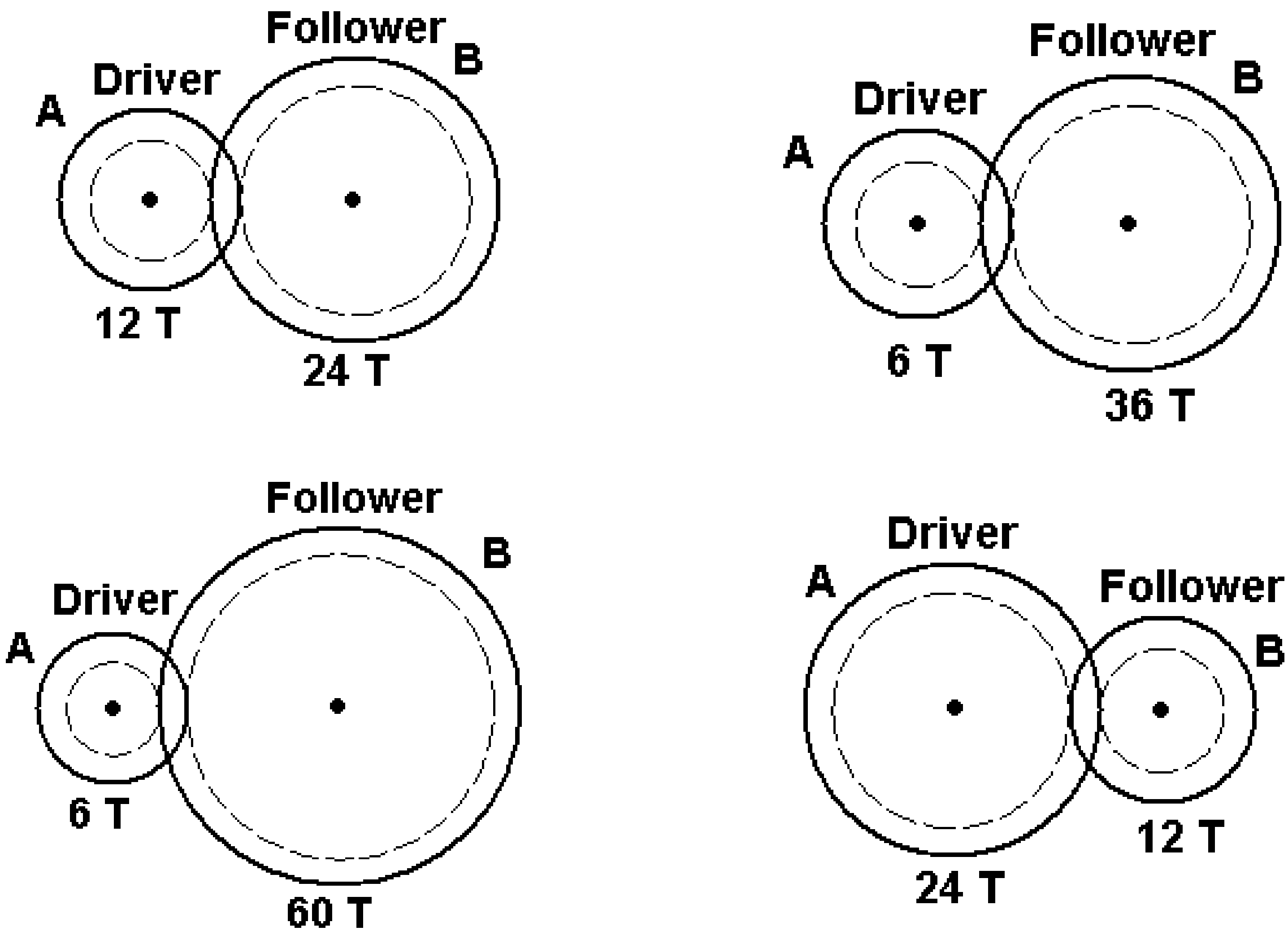


The hand drill on the left uses intermeshing bevel gears. Gear "A" has 80 teeth while gear "B" has 16.

Which one is the driver?

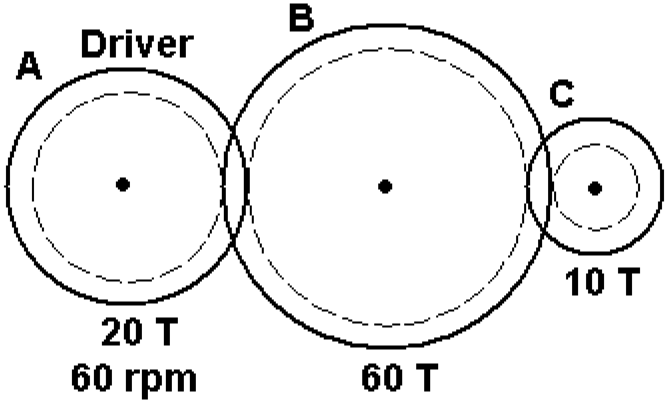
Calculate the gear ratio.

Calculate the gear ratios of these gear trains



Gear ratios and simple gear trains

What is the Gear ratio of the Gear Train $_{ABC}$?



$$GR_{ABC} = \frac{\text{Output B}}{\text{Input A}} \times \frac{\text{Output C}}{\text{Input B}}$$

$$= \frac{60\ T}{20\ T} \times \frac{10\ T}{60\ T}$$

$$= \frac{\cancel{B}}{A} \times \frac{C}{\cancel{B}}$$

$$= \frac{\cancel{60\ T}}{20\ T} \times \frac{10\ T}{\cancel{60\ T}}$$

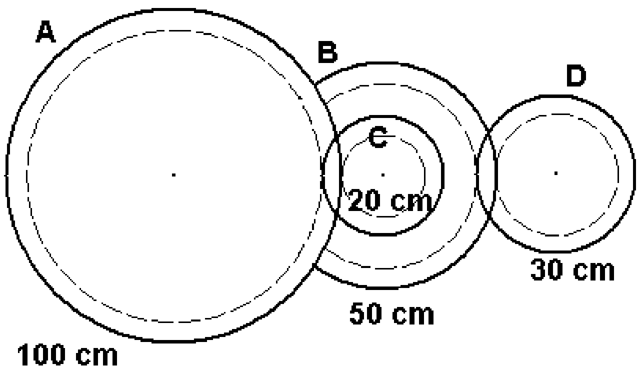
$$GR_{ABC} = \frac{\text{Output C}}{\text{Input A}}$$

$$GR_{ABC} = \frac{10\ T}{20\ T}$$

$$GR_{ABC} = 1 : 2$$

Gear ratios and compound gear trains

What is the Gear ratio of the Gear Train $_{ABCD}$?



$$GR_{ABCD} = \frac{\varnothing C}{\varnothing A} \times \frac{\varnothing D}{\varnothing B}$$

$$= \frac{20\ \text{cm}}{100\ \text{cm}} \times \frac{30\ \text{cm}}{60\ \text{cm}}$$

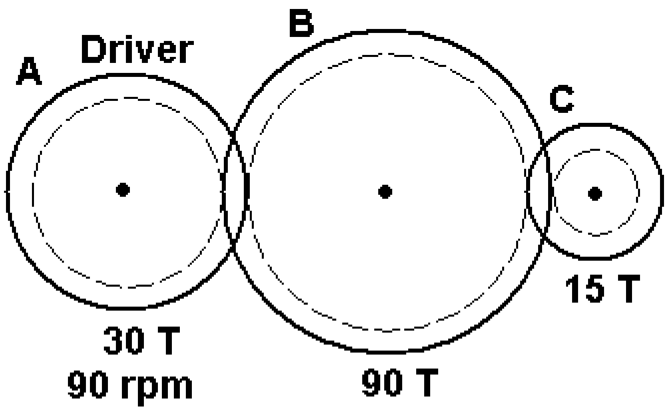
$$= \frac{1}{5} \times \frac{1}{2}$$

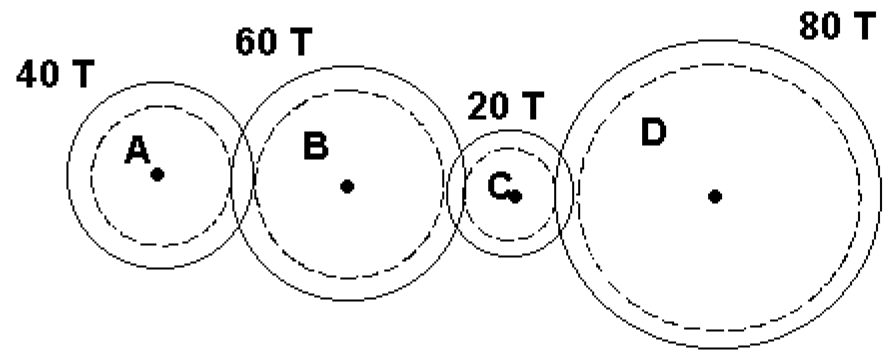
$$GR_{ABCD} = 1 : 10$$

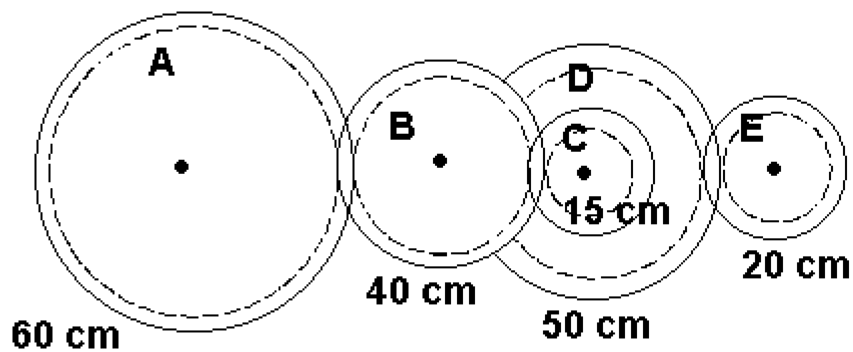
The ratio of the two gears on the same axis is not taken into account.

Gear C is the output to Gear A. Gear D is the output to gear B.

What is the Gear ratios of these Gear Trains?







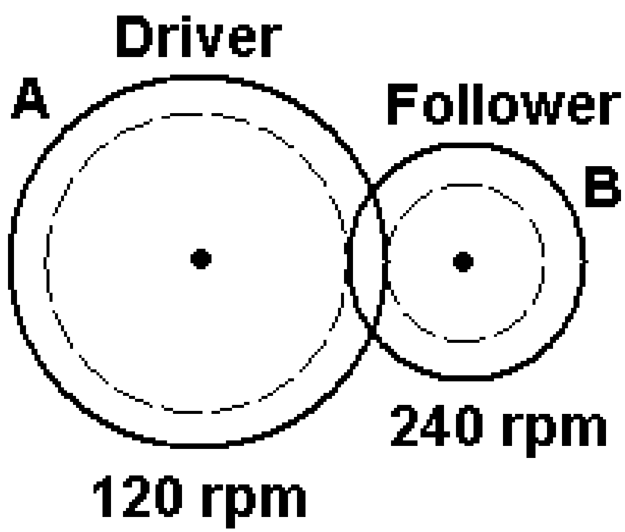
Speed of rotation

The Velocity ratio of a pair of gears is the **inverse** of the Gear ratio

Velocity ratio

= Comparing the rotational speed of gears

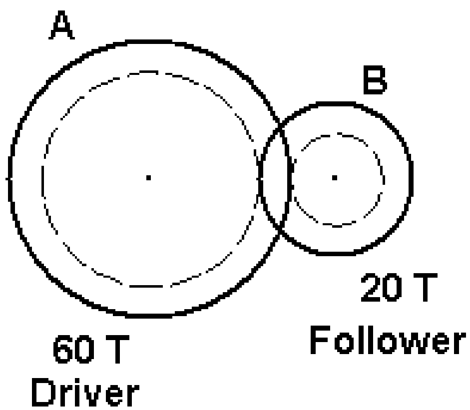
$$\text{Velocity Ratio} = \frac{\text{Velocity (rpm) of output}}{\text{Velocity (rpm) of input}}$$

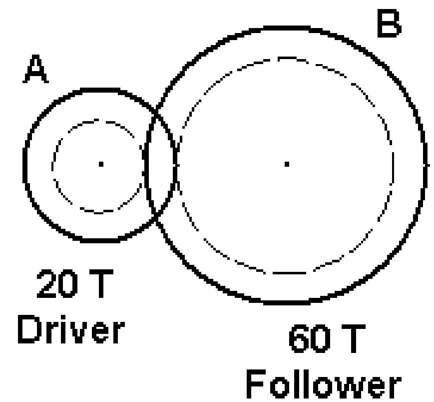


$$\text{Velocity Ratio} = \frac{240\text{ rpm}}{120\text{ rpm}}$$

$$VR = \frac{2}{1}$$

$$VR = 2 : 1$$





a 20-tooth follower will turn three times as fast as a 60-tooth driver.

(Speed ratio: 3 : 1)

This gear train can be used to **increase** **<u>speed</u>** and **decrease** **<u>force</u>.**

= Gearing **up**

Gearing up means the <u>follower</u> turns <u>faster</u> than the driver.

a 60-tooth follower will turn once for every three turns of a 20-tooth driver.

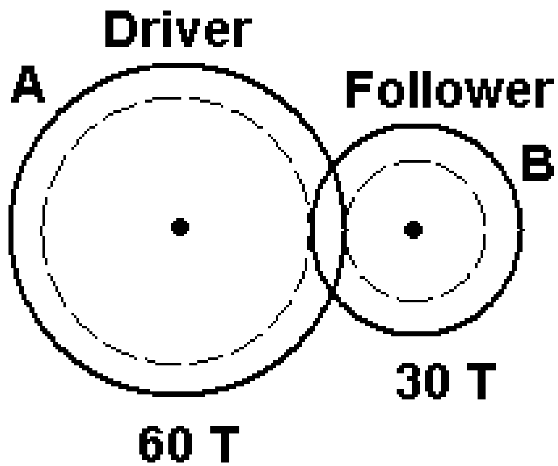
(Speed ratio: 1 : 3)

This gear train can be used to **decrease** **<u>speed</u>** and **increase** **<u>force</u>**.

= Gearing **down**

Gearing down means the <u>follower</u> turns <u>slower</u> than the driver.

Working out *revolutions per minute* (rpm)



If A revolves at 120 rpm, what is the rpm of B ?

Since gear B is smaller than gear A, it will rotate faster than gear A, therefore you have to multiply.

$$GR_{AB} = \frac{\text{\# teeth on follower}}{\text{\# teeth on driver}}$$

$$= \frac{30}{60}$$

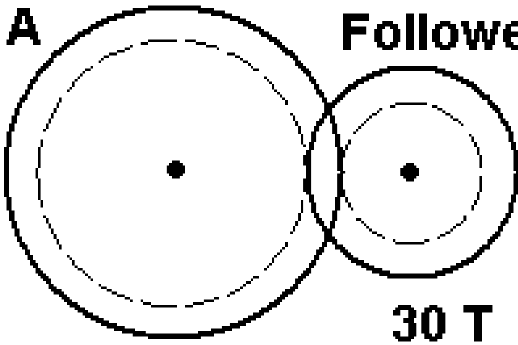
$$GR_{AB} = 1 : 2$$

rpm of B = rpm of A x 2

= 120 rpm x 2

rpm of B = 240 rpm

Working out *revolutions per minute* (rpm)



If A revolves at 120 rpm,
what is the rpm of B ?

VR = inverse of GR
therefore VR = 2 : 1

$$GR_{AB} = \frac{\text{\# teeth on follower}}{\text{\# teeth on driver}}$$

$$= \frac{30}{60}$$

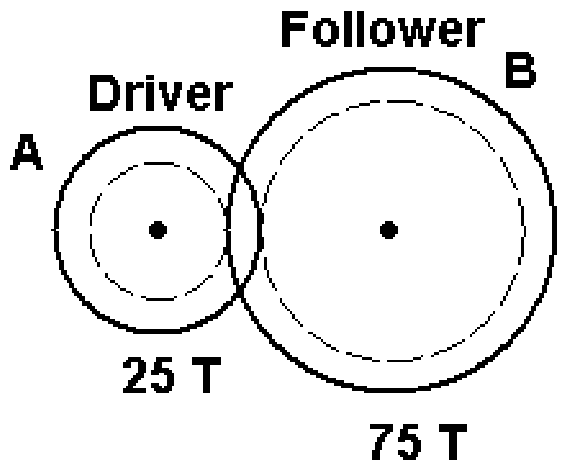
$$GR_{AB} = 1 : 2$$

rpm of B = rpm of A x VR

= 120 x 2

rpm of B = 240 rpm

Working out *revolutions per minute* (rpm)



If A revolves at 60 rpm,

what is the rpm of B ?

Since gear B is bigger than gear A, it will rotate slower than gear A, therefore you have to divide.

$$GR_{AB} = \frac{\text{\# of teeth on follower}}{\text{\# of teeth on driver}}$$

$$= \frac{75}{25}$$

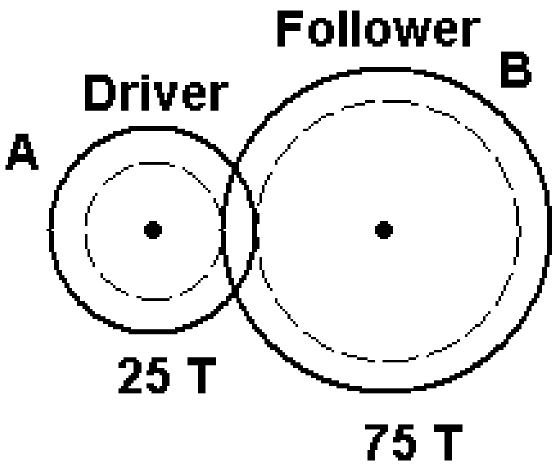
$$GR_{AB} = 3 : 1$$

$$\text{rpm of B} = \frac{\text{rpm of A}}{3}$$

$$= \frac{60}{3}$$

$$\text{rpm of B} = 20 \text{ rpm}$$

Working out *revolutions per minute* (rpm)



If A revolves at 60 rpm,

what is the rpm of B ?

VR = inverse of GR
therefore VR = 1 : 3

$$GR_{AB} = \frac{\text{\# of teeth on follower}}{\text{\# of teeth on driver}}$$

$$= \frac{75}{25}$$

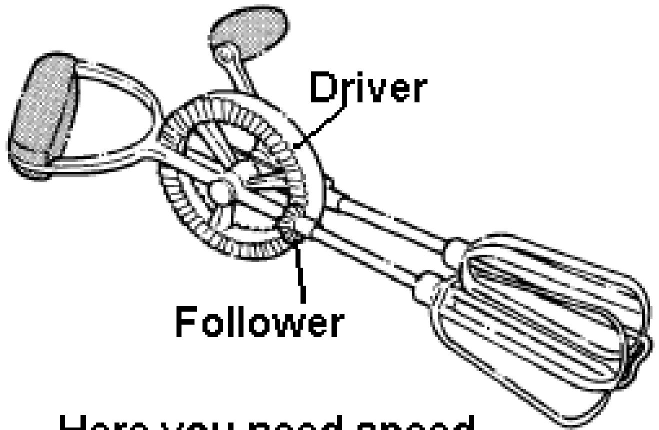
$$GR_{AB} = 3 : 1$$

rpm of B = rpm of A x VR

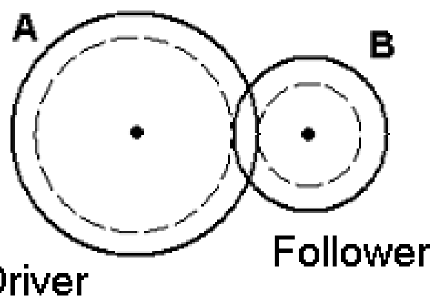
$$= 60 \times \frac{1}{3}$$

rpm of B = 20 rpm

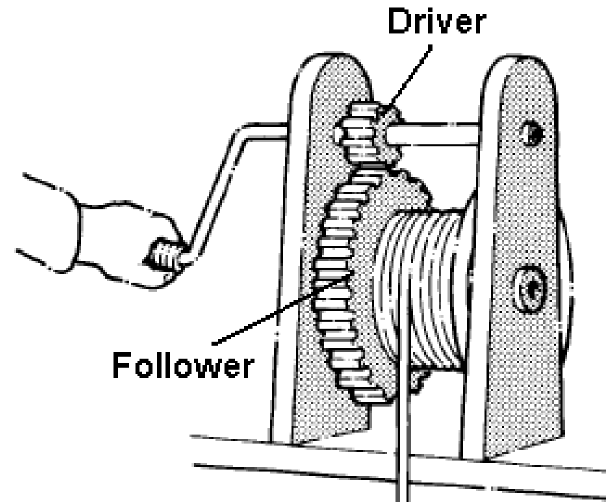
To summarize:



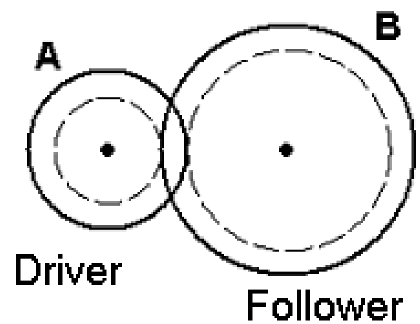
Here you need speed
to beat the eggs.



This gear train will **increase** **<u>speed</u>** and **decrease** **<u>force</u>.**



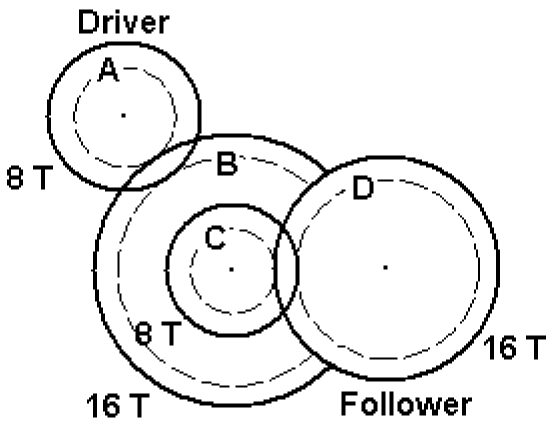
Here you need force
to lift the weight.



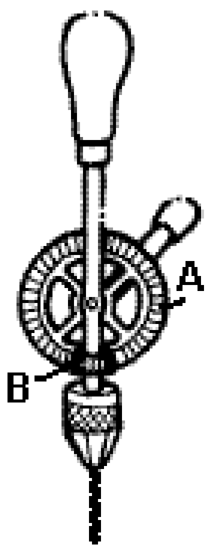
This gear train will **decrease** **<u>speed</u>** and **increase** **<u>force</u>.**

Question 1

For every revolution of the driver gear calculate the number of turns of the follower



Question 2



The hand drill on the right uses intermeshing bevel gears. Gear "A" has 80 teeth while gear "B" has 16.

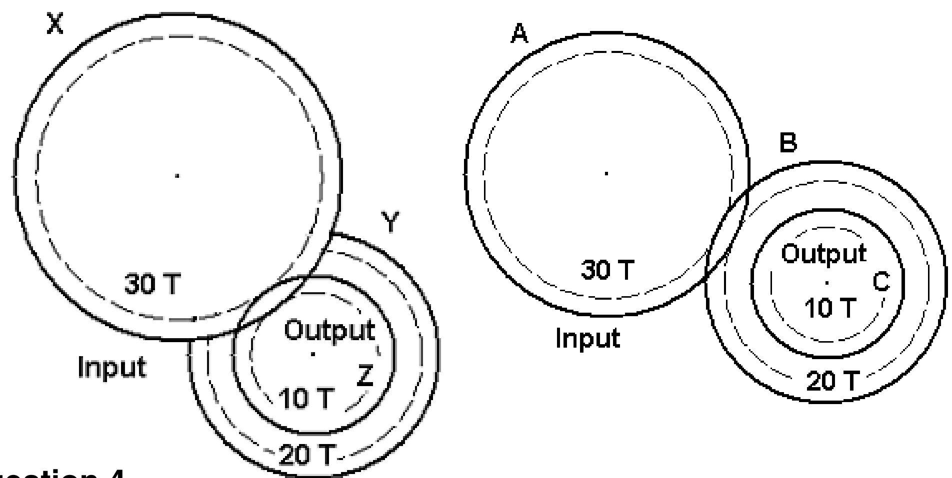
Calculate the number of turns the drill bit will complete if the handle is turned through 2 complete rotations?

Question 3

The input gear is connected to a motor that rotates at 3000 rpm.

Calculate the two possible velocity ratios.

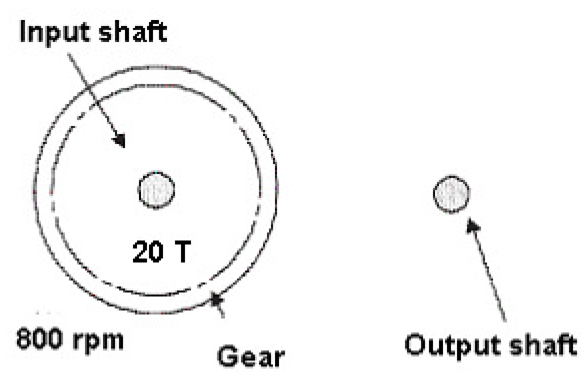
Calculate the two possible output speeds.



Question 4

Complete the gear system, to allow the output shaft to rotate at 400 rpm and in the same direction as the input shaft.

Indicate the number of teeth on each gear used in your solution.



Question 1

Two gears are used in a gear train. The radius of the driving gear is 20 cm. The radius of the driven gear is 10 cm. What is the velocity ratio of the system?

If the driving wheel makes 60 revolutions per minute, calculate how many revolutions the driven wheel makes each minute.

Question 2

The driving gear of a gear system has 42 teeth and the driven gear has 21 teeth. Calculate the velocity ratio of the gear system.

If the driving gear makes 120 revolutions per minute, calculate how many revolutions the driven gear makes each minute.

Question 3

A driving gear has a diameter of 36 cm. The driven gear travels at three times the number of revolutions of the driving gear. Find the diameter of the driven gear.

The driving gear in question turns at 100 rpm. Find the speed of rotation (rpm) of the driven gear.

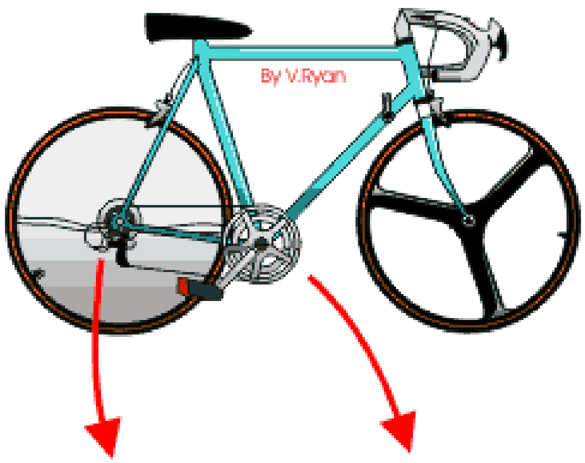
Question 4

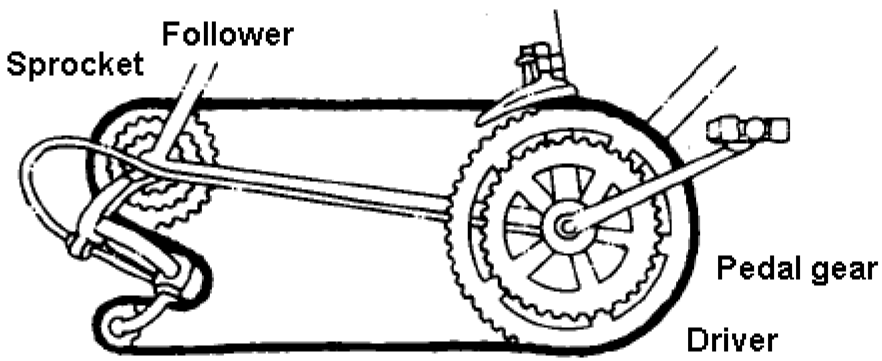
Find the velocity ratio of a gear train in which the driving gear has a diameter of 32 cm and the driven gear has a diameter of 8 cm.

Question 5

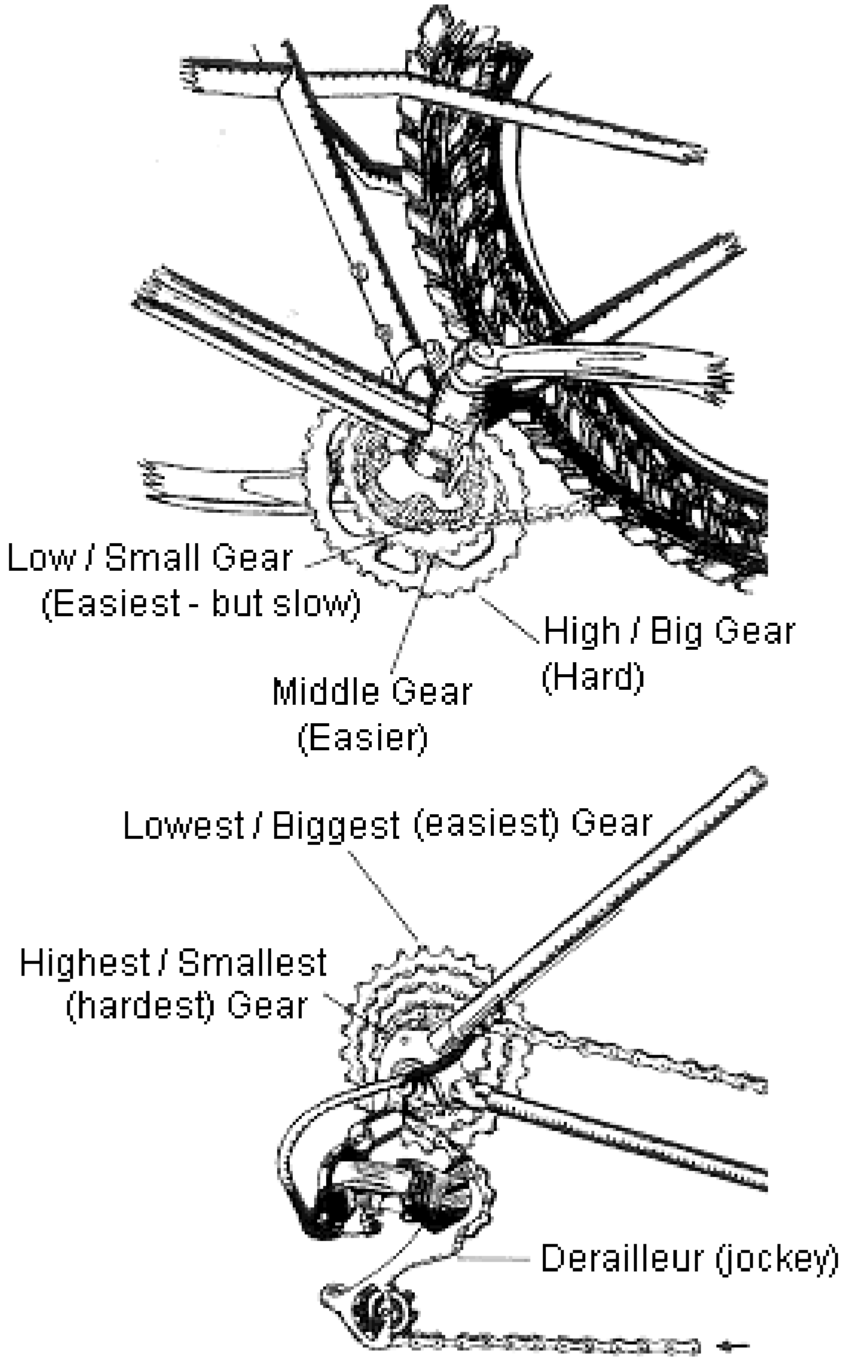
A gear system has 60 teeth on the driving gear and 20 teeth on the driven gear. Calculate the velocity ratio of the gear system.

Bicycles





Many machines use gears. A very good example is a bicycle which has gears that make it easier to cycle, especially up hills. Bicycles normally have a large gear wheel which has a pedal attached and a selection of gear wheels of different sizes, on the back wheel. When the pedal is revolved the chain pulls round the gear wheels at the back.



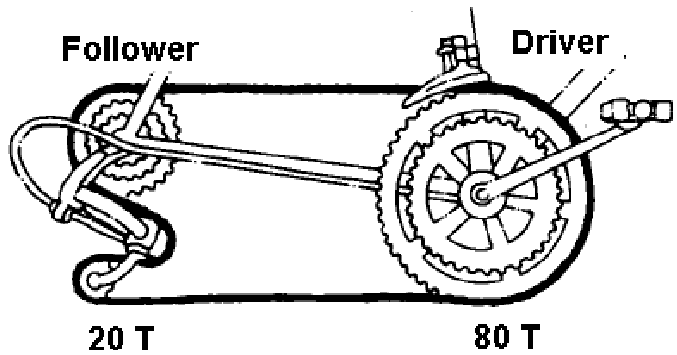
First time out, gears can be intimidating. Especially if mechanical gizmos do not weigh heavily in your background. And Bike gears are gizmos in every sense of the word.

I'm going to talk about gears as "hard" or "easy" instead of "big" or "small".

This is because "Big Gears" means different things, depending on where the gear is. A Big Gear in in back (at the rear wheel) is an easier gear. A Big Gear in front (at the pedals) is a harder gear.

A hard gear is difficult to pedal, but you go farther and faster with every turn of the crank.

An easy gear is, well, easier to pedal, but you go slow, and each turn of the cranks only moves the bike a little ways.



Highest gear: (downhill) is the largest front gear and the smallest back gear.

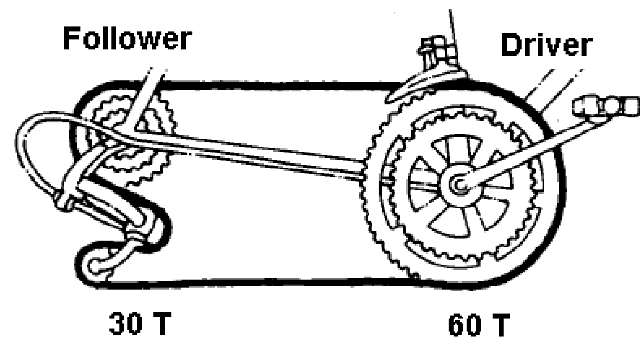
GR = 4 : 1

VR = 1 : 4

The smaller the follower - more speed & less force

= Gearing **up**

Gearing up means the <u>follower</u> turns <u>faster</u>.



Lowest gear: (uphill) that is the smallest front gear and the largest back gear.

GR = 2 : 1

VR = 1 : 2

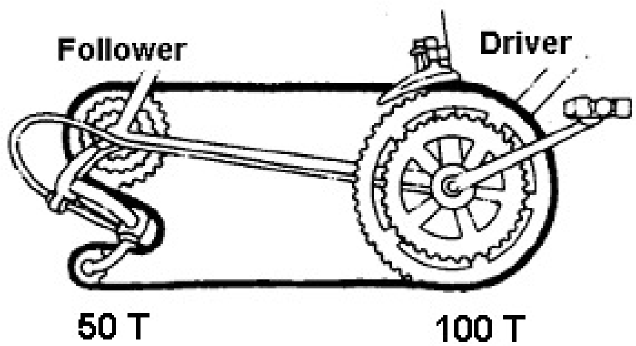
The bigger the follower - less speed & more force

= Gearing **down**

Gearing down means the <u>follower</u> turns <u>slower</u>.

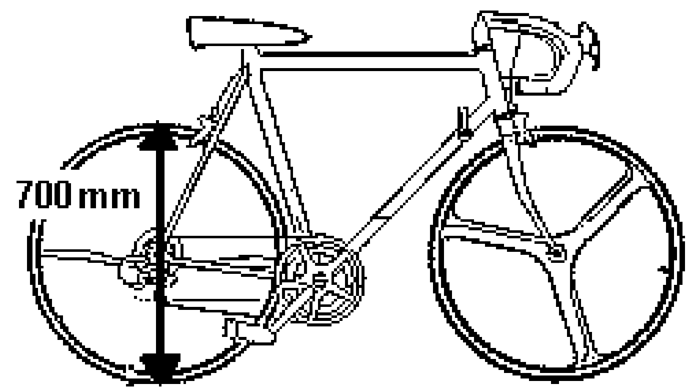
Question 1

If the pedal gear revolves once how many times will the sprocket gear revolve?

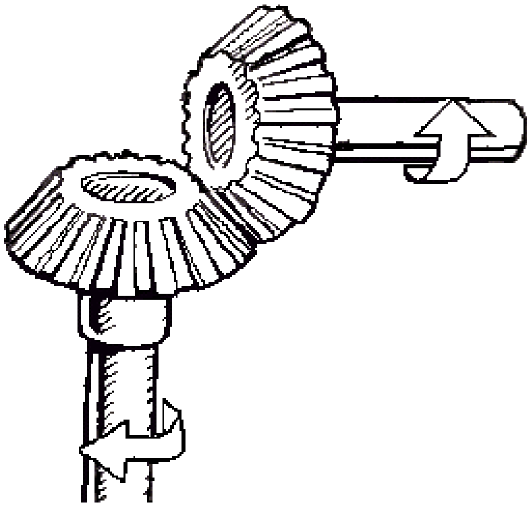


Question 2

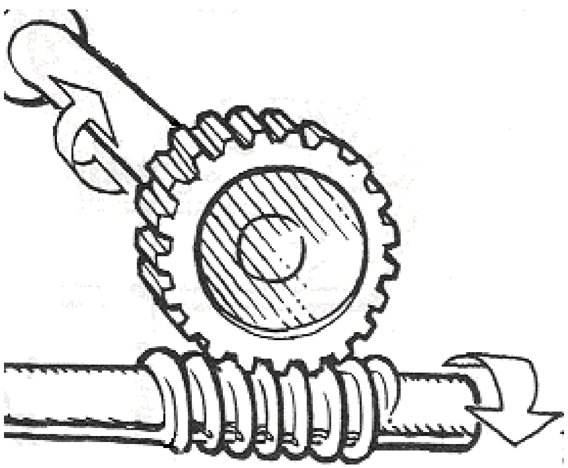
If the diameter of the wheel, including the tyre, is 700 mm, how far will the bicycle move for one revolution of the pedals, for a Gear Ratio of 40 : 20 ?



Changing the angle of motion



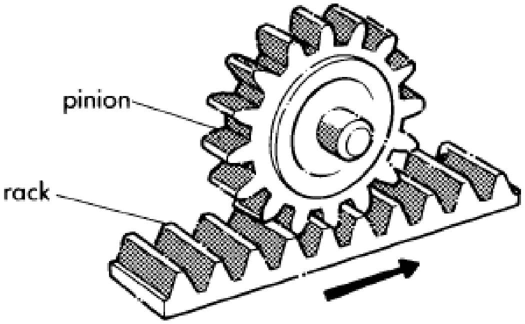
Bevel gears, intermesh and change the plane in which force is applied and rotary motion takes place.
They are used to transmit rotary motion and torque where the bevel gear shafts are at right angles (90 degrees) to each other.



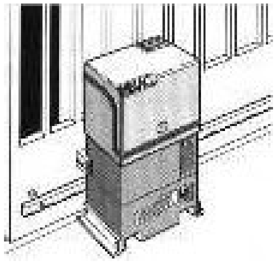
The worm and worm wheel also transmit torque and rotary motion through a 90° angle.

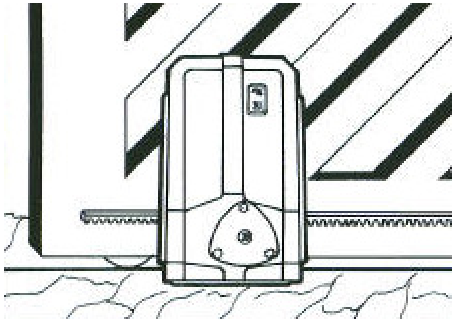
Changing the direction of motion (2)

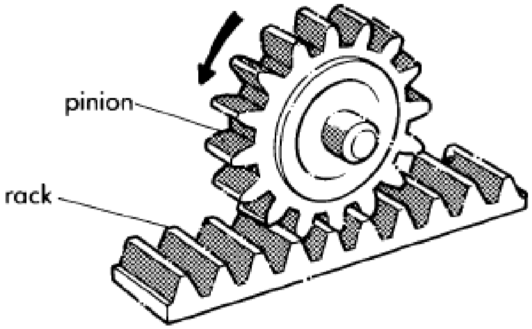
This gearing system is called a **rack and pinion.** **<u>Rotary</u>** motion is changed into **<u>linear</u>** motion and vice versa



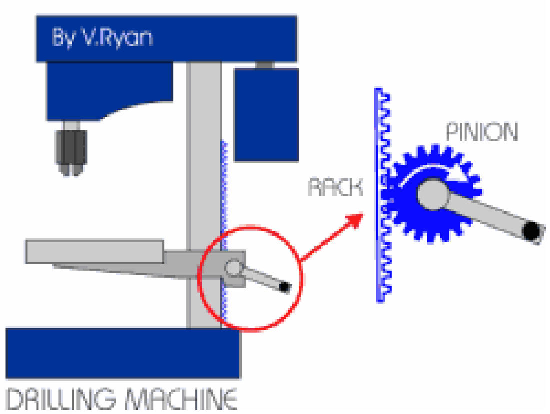
If the pinion rotates in a fixed position the rack moves in a linear motion.

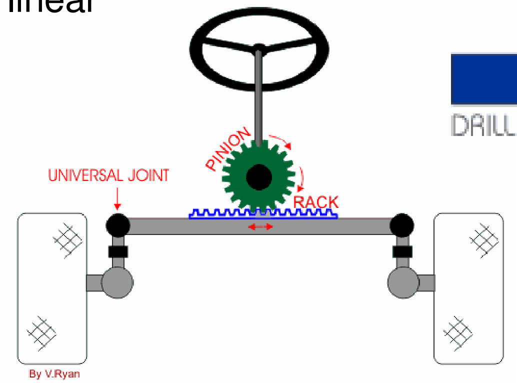






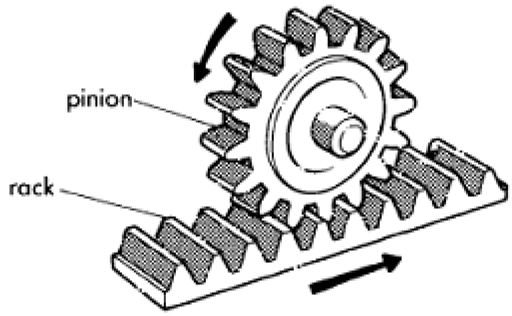
If the rack remains stationary the rotating pinion moves along the rack in a linear motion.





Movement of the rack & pinion

Note: the teeth on gears must mesh perfectly, therefore, for every tooth that the pinion rotates, one tooth of the rack will move linearly.



A pinion with 24 teeth rotates at 4 rpm; how far (in meters) will the rack move in 2 minutes? The rack has 2 teeth per cm.

The solution to this problem needs some initiative and logic. There are no formal equations to solve the problem.

If you know how many teeth is moved on the rack in 2 minutes, you can easily calculate the distance in meter; thus:

$$\text{distance moved measured in teeth} = \frac{24 \text{ teeth}}{\text{revolution}} \times \frac{4 \text{ revolutions}}{\text{minute}} \times 2 \text{ minutes}$$

$$= \frac{24 \text{ teeth}}{\cancel{\text{revolution}}} \times \frac{4 \cancel{\text{revolutions}}}{\cancel{\text{minute}}} \times 2 \cancel{\text{minutes}}$$

$$= 24 \times 4 \times 2$$

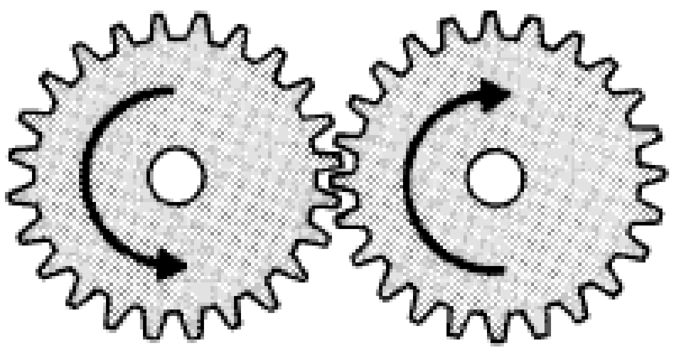
$$\text{distance moved measured in teeth} = 192 \text{ teeth}$$

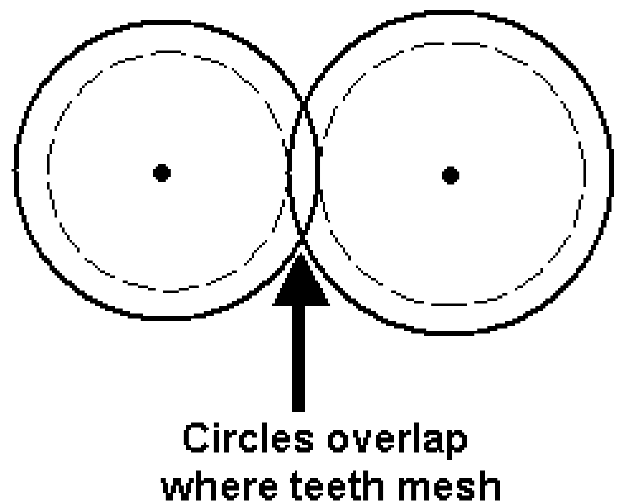
So, the rack will move 192 teeth in 2 minutes. At 2 teeth per cm, the following can be calculated:

$$\frac{192 \text{ teeth}}{2 \text{ teeth/cm}} = 96 \text{ cm} = 0.96 \text{ m}$$

DRAWING GEARS

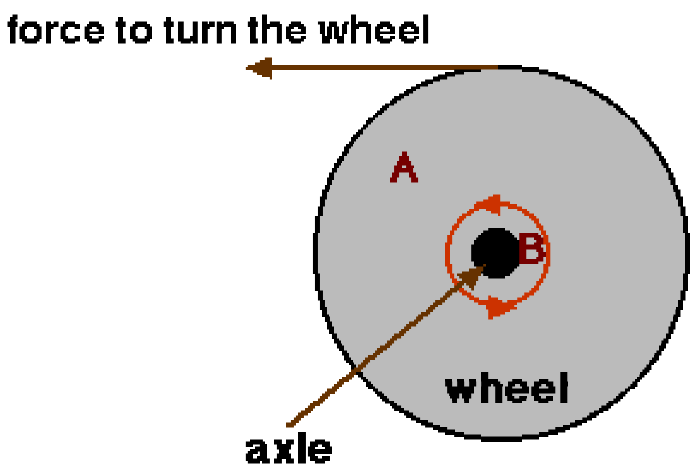
It would be very difficult to draw gears if you had to draw all the teeth every time you wanted to design a gear system. For this reason a gear can be represented by drawing two circles.





The Wheel Although they may seem very different, wheels and gears are closely related to levers. The wheel is essentially a rotating lever. Think of the diagram of the lever above as being bent into a circle. The center of the circle is the fulcrum. In math we call this the center point.

Wheel "A" is a circle. It is larger than wheel "B". The black circle. You will notice that "A" is larger than "B". The diameter of "A" is larger than "B". If you rotate "B"(the axle) it will move wheel "A". Since "B" is smaller than "A" and moves in a smaller circle than "A" you will use very little input you get a large output. The large ratio of the wheel radius to the axle radius is what makes it easy to turn the wheel at it's rim.



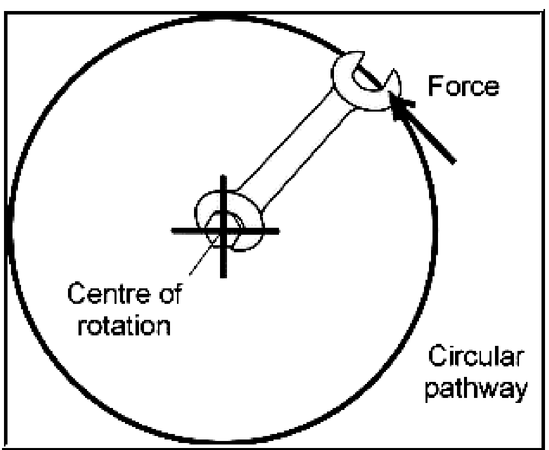
Torque

(Moment of force)

= a turning force

Torque (T) = Force x Distance

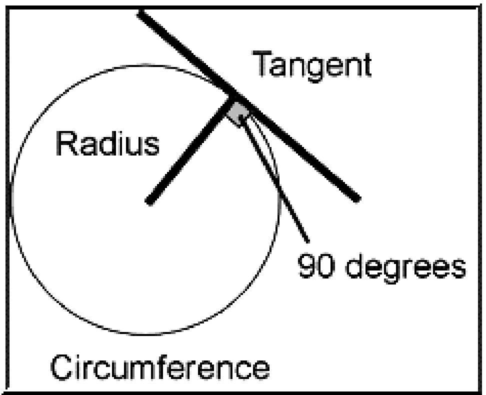
Depends on the **amount of force** and the **perpendicular distance** from the work-line of the force **to the fulcrum**, which in this case will be the centre of the gear. When working with gears, this perpendicular distance is equal to the radius of the gear. The direction of torque is said to be either clockwise or anti-clockwise.



A wheel is really a lever so the import things to know are the <u>size of the force</u> and the <u>distance from the fulcrum</u>.

Most people know from experience that it is easier to turn something, as the effort gets further away from the centre of rotation.

A spanner is a good example. It is easier to tighten and loosen the bolt if you push or pull the spanner right at the end.



To understand torque you need to know the words we use to describe circles.

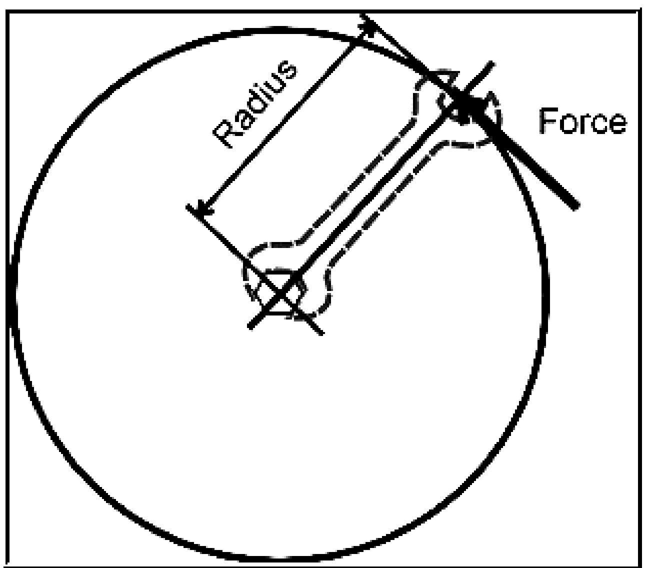
•The circumference is outside of the circle.

•The radius is a straight line from the centre to the circumference.

•A tangent is a straight line that touches the circumference.

•The angle between a tangent and the radius is always 90 degrees.

The force acts in a straight line



We always think of the force acting in a straight line and at the outside of the circular pathway.

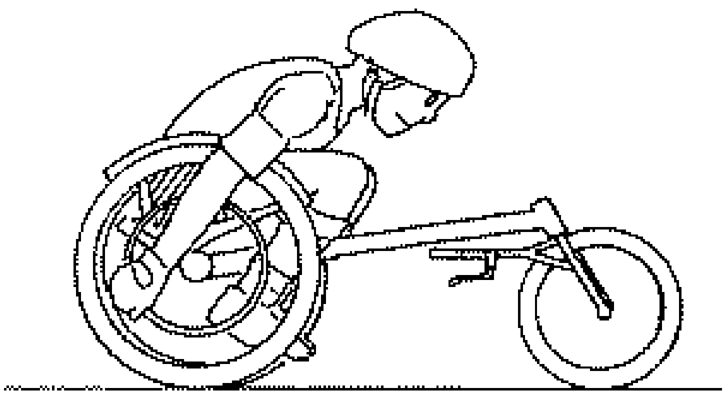
The angle between the force and the radius is always 90 degrees.

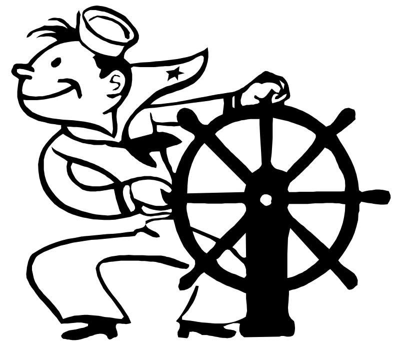
The torque or turning force is equal to the size of the force and the radius of the rotation. Simple mathematics is used to find the torque.

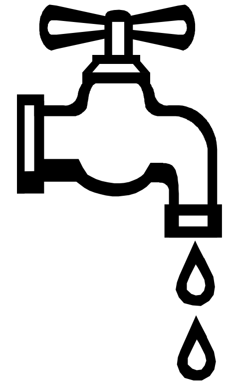
Torque = Force x radius of rotation (distance)

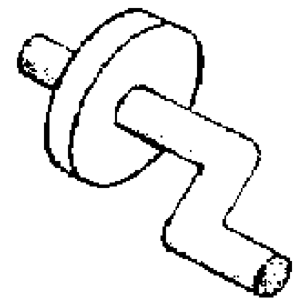
This explains why you should hold the end of the spanner rather than somewhere near the centre.

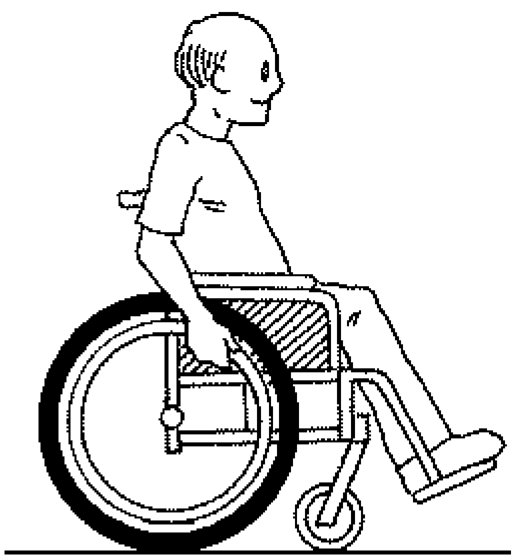
Discuss the use of torque in these pictures:

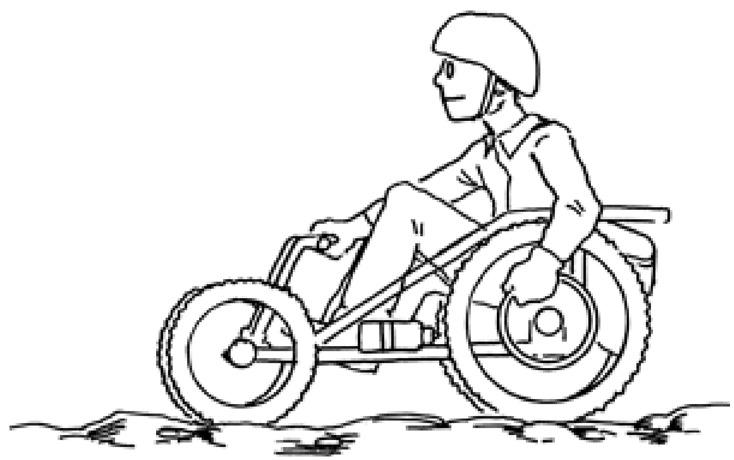


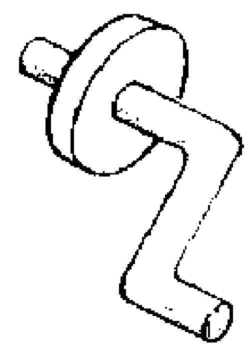










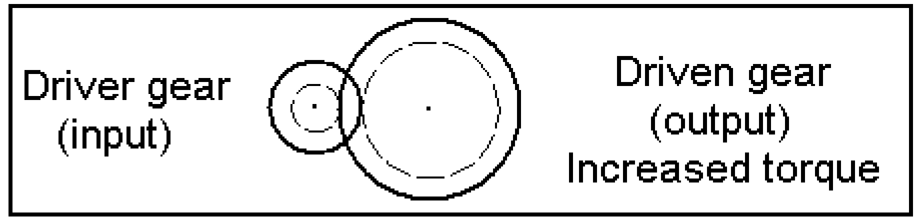


Gear torque rules:

Torque is a turning force: Torque = force x distance

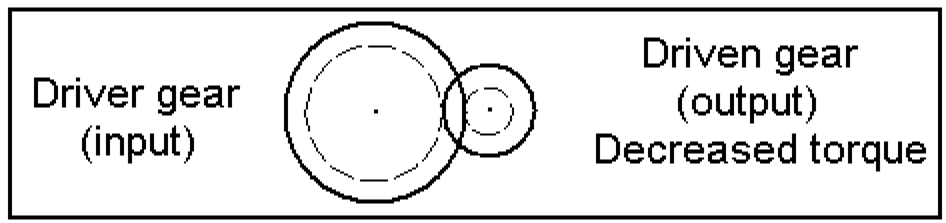
<u>Increasing torque</u>

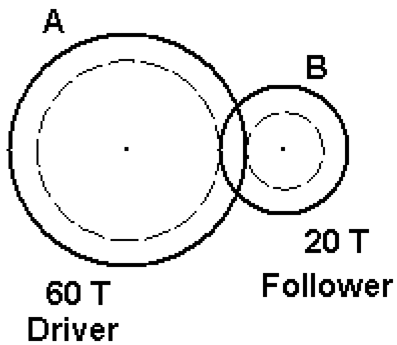
When the driven gear has more teeth than the driver gear the torque is increased at the output.



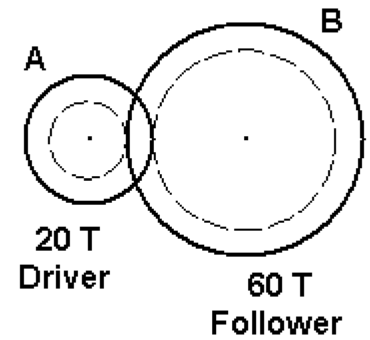
<u>Decreasing torque</u>

When the driven gear has fewer teeth than the driver gear the torque is reduced at the output.



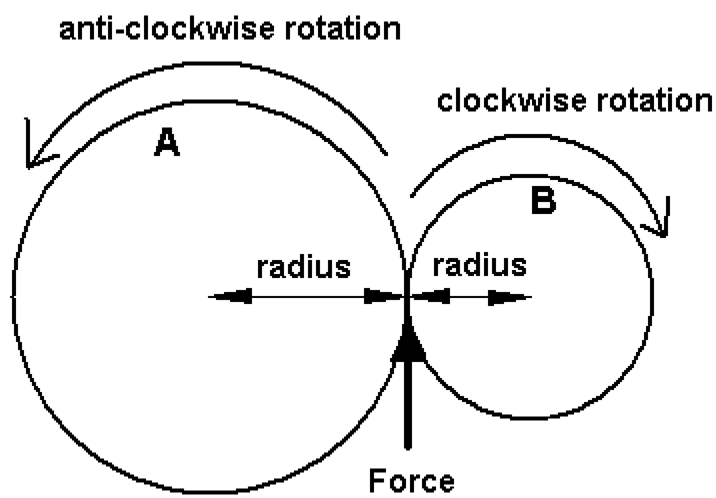


A big driver will reduce torque and increase speed of the follower.

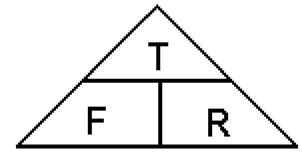


A small driver will increase torque and reduce speed of the follower.

When we work with simple gear trains, the **force** transmitted from one gear to the next is the **same.**



A simple gear train consists of two gears, gear A and gear B. The diameter of the input gear A is 20 cm and a force of 5N is transmitted to gear B. What must the diameter of output gear B be so that it produces a torque of 1.75 Nm. Draw a diagram of the gears.



$$\text{Radius} = \frac{\text{Diameter}}{2}$$

$$\text{Radius} = \frac{0.2\text{ m}}{2}$$

$$\therefore \text{Radius A} = 0.1\text{ m}$$

$$\text{Torque A} = \text{Force} \times \text{Radius}$$

$$= 5\text{ N} \times 0.1\text{m}$$

$$= 0.5\text{ Nm}$$

$$\text{Radius B} = \frac{\text{Torque}}{\text{Force}}$$

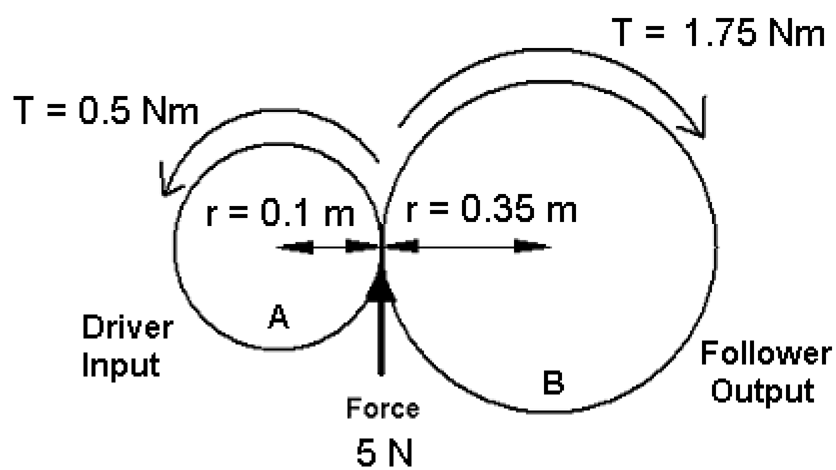
$$= \frac{1.75\text{ Nm}}{5\text{ N}}$$

$$\text{Radius B} = 0.35\text{ m}$$

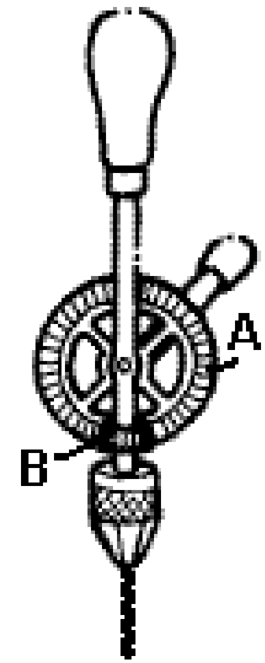
$$\text{Radius} \times 2 = \text{Diameter}$$

$$\text{Diameter} = 0.35\text{ m} \times 2$$

$$\therefore \text{Diameter B} = 0.75\text{ m}$$



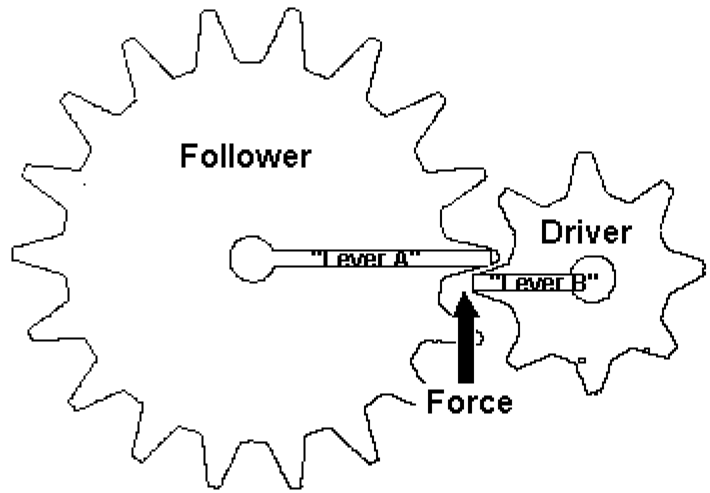
Look at the drill on the right.
The input gear rotates through a distance of 32cm. A output gear of the drill rotates a distance of 4 cm. What force is exerted by the drill bit if a force of 40N was applied to the gear train?



Mechanical Advantage

When two gears are meshed, as in the diagram on the right, they act in a similar fashion to levers. Each gear tooth can be regarded as the end of a lever with the fulcrum placed at the centre of the gear. The longer lever "A" is, the greater the force that is applied to the shaft of the follower.

We can make lever "A" longer by using gears with a greater number of teeth.
We can also make lever "B" smaller, therefore increasing the force exerted at the end of the lever.



Gears do not only increase speed and change the direction of motion but can multiply turning forces.

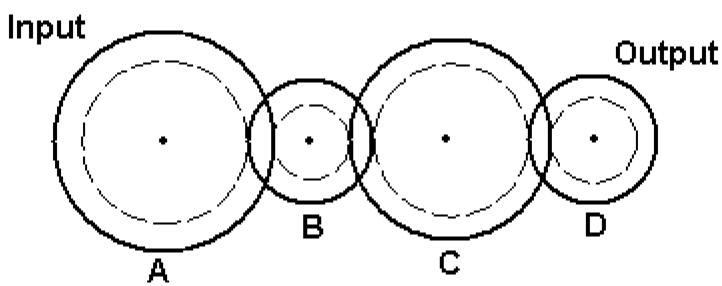
Mechanical Advantage

Mechanical advantage (MA) is the factor by which a mechanism multiplies the **force** put into it.

$$MA = \frac{\text{Output Torque}}{\text{Input Torque}}$$

Because the force that is transmitted from one gear to the next is the same, the MA is used to compare the output torque to the input torque of the whole system.

Given the following simple gear train, determine the MA for the system if the radius for A is 0.6 m, B is 0.3 m, C is 0.8 m, and D is 0.2 m. A force of 10 N is transmitted.



$$MA_{ABCD} = \frac{\text{Torque B}}{\text{Torque A}} \times \frac{\text{Torque C}}{\text{Torque B}} \times \frac{\text{Torque D}}{\text{Torque C}}$$

$$= \frac{\cancel{\text{Torque B}}}{\text{Torque A}} \times \frac{\cancel{\text{Torque C}}}{\cancel{\text{Torque B}}} \times \frac{\text{Torque D}}{\cancel{\text{Torque C}}}$$

$$= \frac{\text{Torque D}}{\text{Torque A}}$$

From the above we can see that the torque of the idler gears have no influence on the mechanical advantage. Therefore we only have to calculate the torque for gears A and D.

Torque A = F x r

= 10N x 0.6m

Torque A = 6Nm

Torque B = F x r

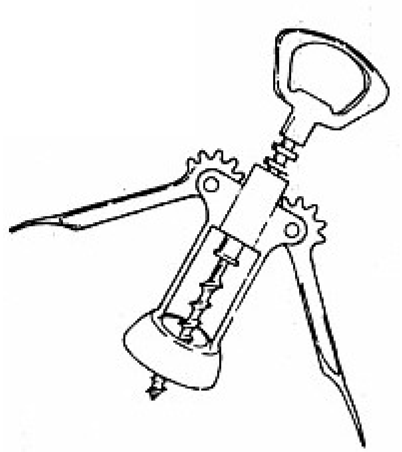
= 10N x 0.2m

Torque B = 2Nm

$$MA = \frac{2Nm}{6Nm} = \frac{1}{3}$$

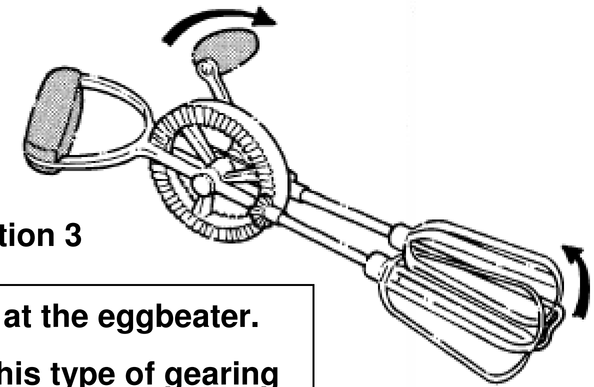
MA = 1 : 3

Question 1



Look at the image on the left of the gears of a wine bottle opener. What type of gear system is this? Is this simple machine a force multiplier or speed multiplier? How does this machine make it easy to uncork the wine bottle?

Question 3

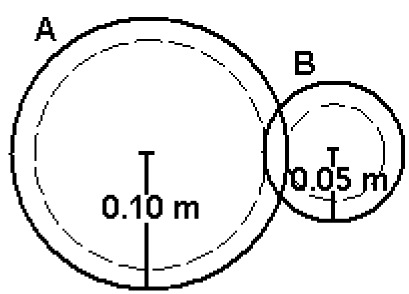


Look at the eggbeater.

Will this type of gearing produce speed or force multiplication. Explain.

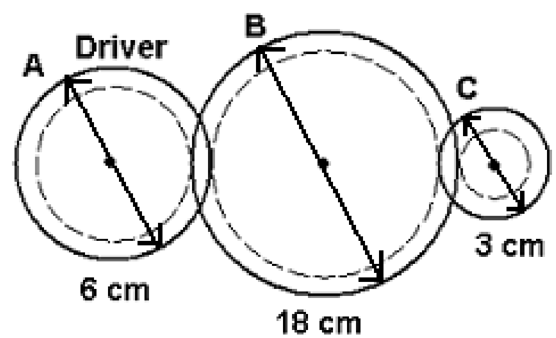
Question 2

Determine the MA for Gear train AB. A force of 5 N is transmitted.



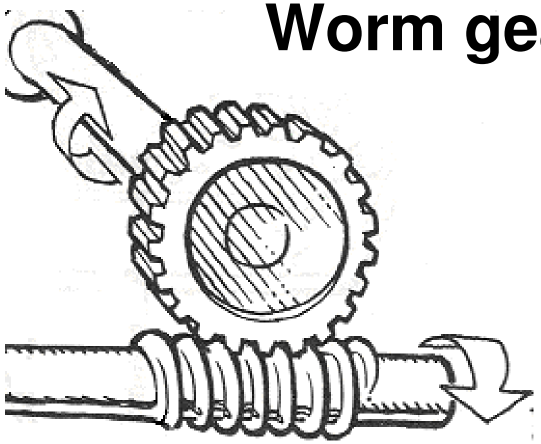
Question 4

Determine the MA for Gear train ABC. A force of 12 N is transmitted.



Reducing speed and increasing torque

Worm gear



The worm is always the driver.

The worm gear gives the highest decrease in speed and the highest increase in torque. This is because the number of teeth for the worm is one.

If the wheel of a worm gear system has 36 teeth, what will the gear ratio, velocity ratio, and mechanical advantage be?

$$GR = \frac{\#\text{ teeth of wheel (output)}}{1}$$

$$= \frac{36}{1}$$

GR = 36 : 1

VR = 1 : 36

The gear ratio will then be:

$$GR = \frac{\#\text{ teeth of wheel (output)}}{\#\text{ teeth of worm (input)}}$$

$$GR = \frac{\#\text{ teeth of wheel (output)}}{1}$$

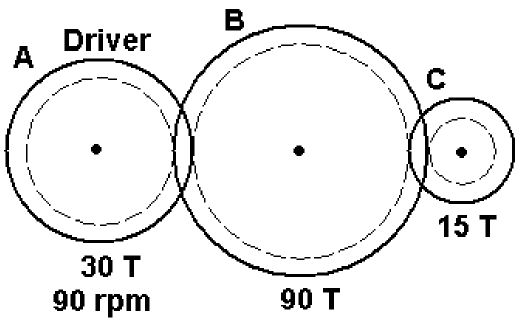
MA = GR

$$MA = \frac{36}{1} = 36$$

Answers p 12:

Answers p 13:

Answers p 16:

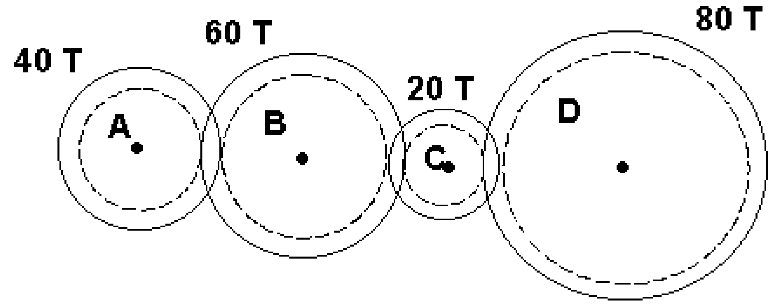


$$GR_{ABC} = \frac{\text{Output B}}{\text{Input A}} \times \frac{\text{Output C}}{\text{Input B}}$$

$$= \frac{\cancel{90\,T}}{\cancel{30\,T}_2} \times \frac{\cancel{15\,T}^{1}}{\cancel{90\,T}}$$

$$= \frac{1}{2}$$

$$GR_{ABC} = 1 : 2$$

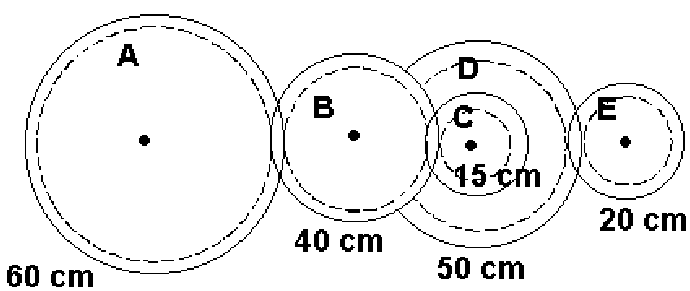


$$GR_{ABCD} = \frac{\text{Output B}}{\text{Input A}} \times \frac{\text{Output C}}{\text{Input B}} \times \frac{\text{Output D}}{\text{Input C}}$$

$$= \frac{\cancel{60\,T}}{\cancel{40\,T}_1} \times \frac{\cancel{20\,T}}{\cancel{60\,T}} \times \frac{\cancel{80\,T}^{2}}{\cancel{20\,T}}$$

$$= \frac{2}{1}$$

$$GR_{ABCD} = 2 : 1$$



$$GR_{ABCDE} = \frac{\text{Output B}}{\text{Input A}} \times \frac{\text{Output C}}{\text{Input B}} \times \frac{\text{Output E}}{\text{Input D}}$$

$$= \frac{\cancel{40}}{\cancel{80}_4} \times \frac{\cancel{15}^{1}}{\cancel{40}} \times \frac{\cancel{20}^{2}}{\cancel{50}_5}$$

$$= \frac{1}{\cancel{4}_2} \times \frac{\cancel{2}^{1}}{5}$$

$$= \frac{1}{10}$$

$$GR_{ABCDE} = 1 : 10$$

Answers p 24:

Answers p 25:

Answers p 29:

Answers p 41:

Circumference = diameter x 3.14

$$\text{Diameter A} = \frac{\text{Circumference A}}{3.14}$$

$$= \frac{32}{3.14}$$

Diameter A = 10.19

$$\text{Diameter B} = \frac{\text{Circumference B}}{3.14}$$

$$= \frac{4}{3.14}$$

Diameter B = 1.27 cm

$$\text{Radius A} = \frac{\text{Diameter}}{2}$$

Radius A = 5

$$\text{Radius B} = \frac{\text{Diameter}}{2}$$

Radius B = 0.64 cm

Torque A = Force x Radius

= 40N x 5cm

Torque A = 200 Nm

Torque B = Force x Radius

= 40N x 0.64cm

Torque B = 25 Nm

Answers p 44:

1. **Bevel Gears:**
   a. Have teeth parallel to each other.
   b. Change the direction of motion by 90°.
   c. Change the direction of motion by 45°.
   d. Change the direction of motion by 180°.

2. **When a large gear turns a smaller gear**
   a. The RPM of the smaller gear is faster than the large gear.
   b. The RPM of the smaller gear is slower than the large gear.
   c. The RPM of both gears is the same.

3. **When more than one set of gears are used together, they are called**
   a. A complex gear train.
   b. A compound gear train.
   c. A bevel gear train.
   d. A one-way gear train.

4. **When more than one set of gears are used together, the gear ratio for the entire train is computed by:**
   a. Multiplying the gear ratios of each set together
   b. Dividing the gear ratio of the first set by the gear ratio of the last set.
   c. Dividing the gear ratio of the last set by the gear ratio of the first set.
   d. Adding the gear ratios of each set together

5. **To increase the speed of a robot:**
   a. Increase the gear ratio on the motor output
   b. Increase the gear ratio on the motor input
   c. Decrease the gear ratio on the motor output
   d. Decrease the gear ratio on the motor input.

6. **Idler gears:**
   a. Can affect the total gear ratio.
   b. Can affect the rotational direction of the output gear.
   c. Can affect the total power available at the output gear.
   d. Can affect the rotational speed at the output gear

7. **A worm gear is special because:**
   a. It turns rotational motion into straight-line motion
   b. The direction of motion is not changed.
   c. It can only be located on the input axle.
   d. They provide a very small gear ratio

8. **The gear set that changes rotational motion into straight line motion is called:**
   a. Worm gear set
   b. Bevel gear set
   c. Spur gear set
   d. Rack and pinion gear set

9. Besides bevel gears, which other type of gear can change the direction of motion by 90°:

a. Worm and spur gears

b. Rack and pinion

c. Spur gears

d. Rack and worm gears

10. Where the teeth of a gear set, composed of different sized gears, mesh:

a. The rotational speed is the same

b. The rotational speed of the idler gear is slower

c. The rotational speed of the smaller gear is faster

d. The direction of rotation is the same

11. The larger the velocity ratio of a gear train:

a. The greater the speed

b. The greater the force

c. The greater the torque

d. The less the speed.

12. Gearing down your bicycle to increase its torque will:

a. Slow the bicycle down

b. Speed the bicycle up

c. Increase its force

d. Decrease its force

13. The input gear is 12 teeth, output 36 teeth. What is the gear ratio ?

a. 1:2

b. 1:3

c. 3:1

d. 3:4

14. A gear that is used to change direction is called…….. ?

a. Idler

b. Driver

c. Multiplier

d. Driven

15. What type of gear has only one tooth?

a. Compound gear trains

b. Worm gears

c. Bevel gears

d. Worm gears or bevel gears

16 . A gear train has two gears. The driven is 90mm wide and the driver is 30mm wide. What is the VR?

a. 1 : 3

b. 3 : 1

c. 1 : 60

d. 60 : 1

Answers
p. 54 - 55
1. b
2. a
3. b
4. c
5. a
6. b
7. d
8. d
9. a
10. c
11. a
12. c
13. c
14. a
15. b
16. a