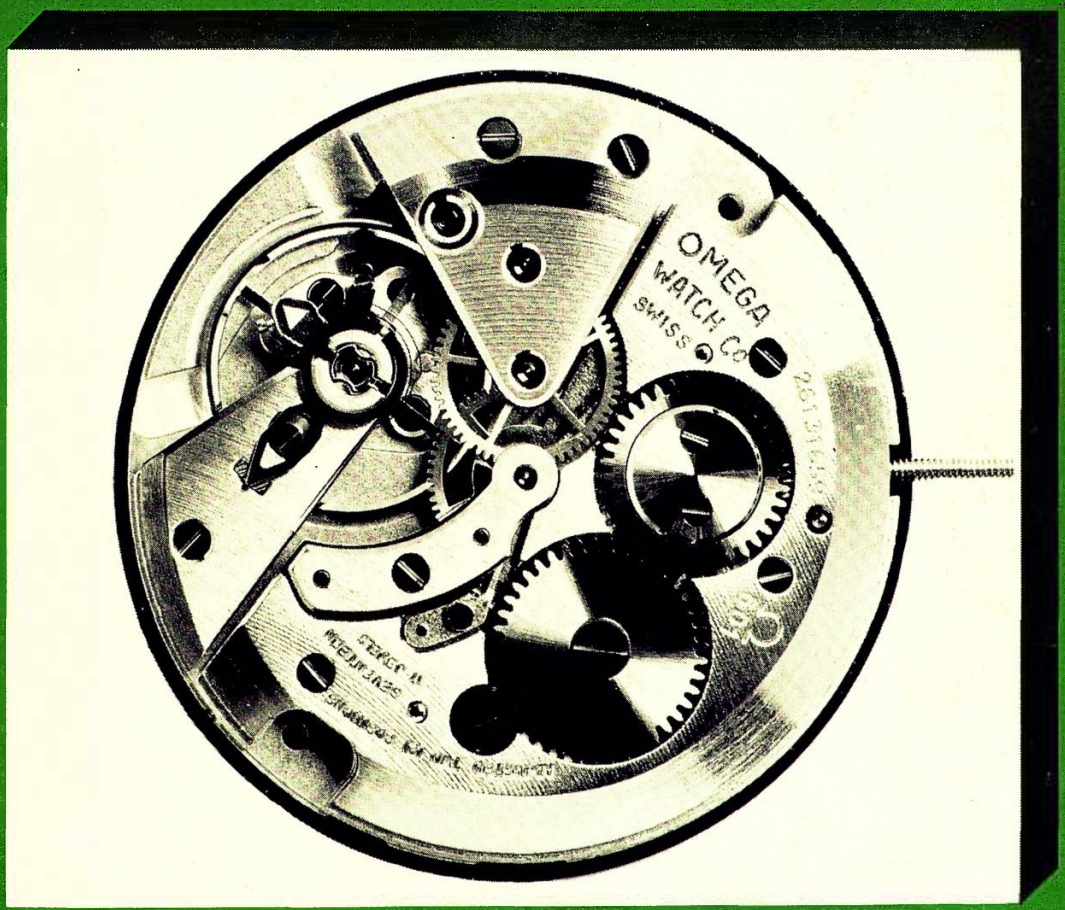
SCIENCE AT WORK



Gears and Gearing

SCIENCE AT WORK

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ABCDEF 79

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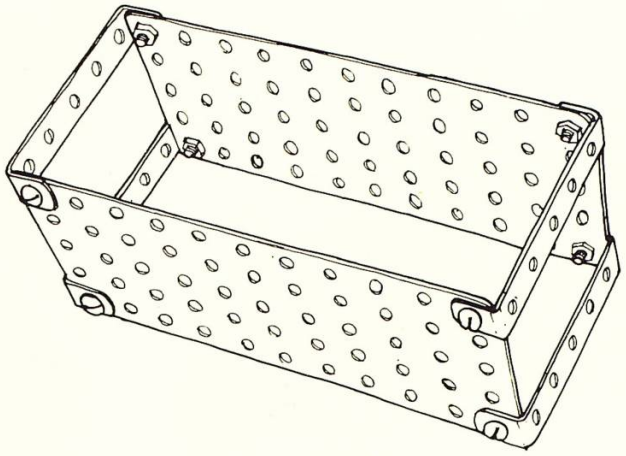
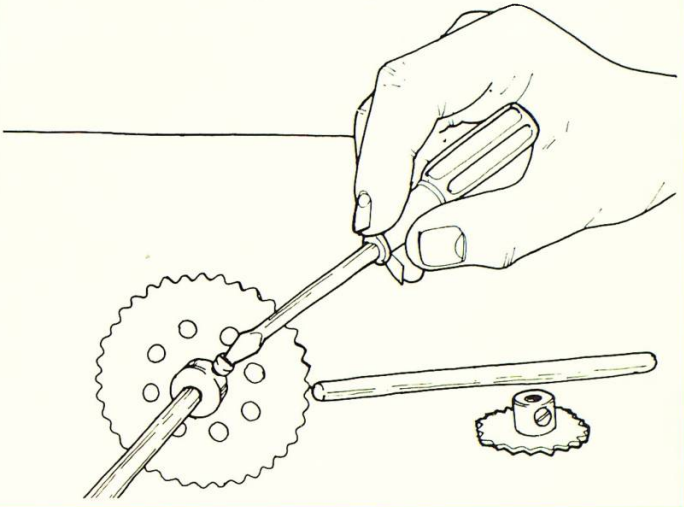
★ 2 flat plates ★ 4 double angle strips ★ 2 axle rods and collars ★ spanner
★ 25 mm sprocket gear ★ 50 mm sprocket gear ★ nuts and bolts
★ length of chain ★ screwdriver

You are going to make a chain drive and find out how it works.

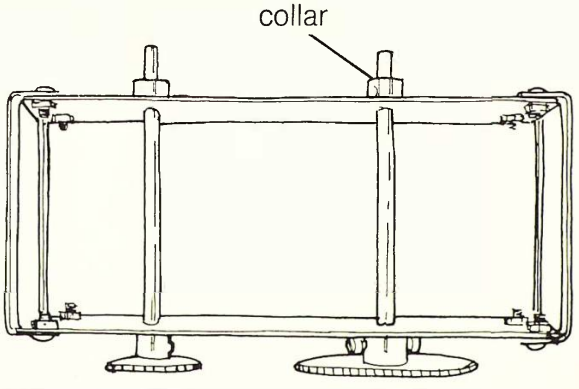
A Make a box, as shown. Use 2 flat plates and 4 double angle strips.



B Screw each sprocket gear to an axle.

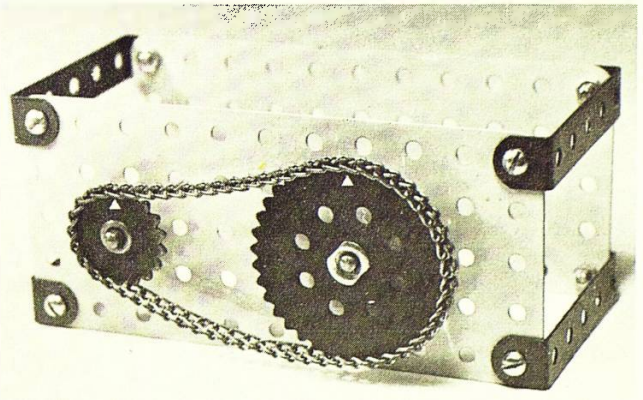


C Push the axles through the sides of the box. Fix a collar to each axle.



top view

D Put a length of chain around the 2 sprocket gears. Put a pencil mark at the top of each gear.



E Count the teeth on each gear. Turn the axle of the small gear. Watch what happens to the large gear. Then turn the axle of the large gear.

Q1 Which axle is easier to turn?

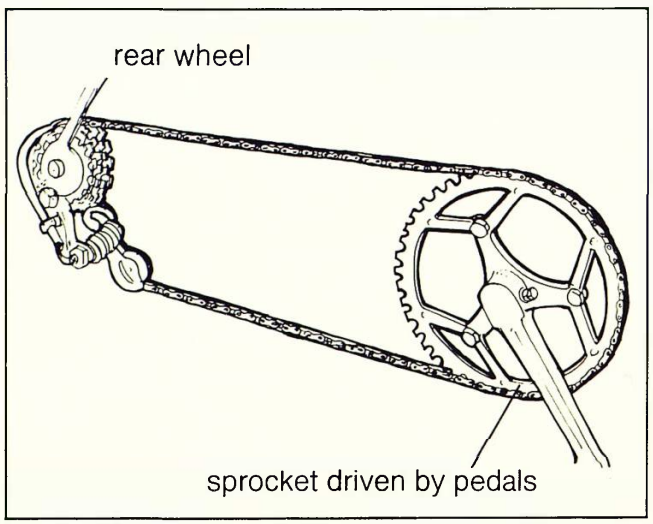
Q2 Which axle turns faster?

Q3 How many times do you need to turn the axle of the small gear to make the large gear go round once?

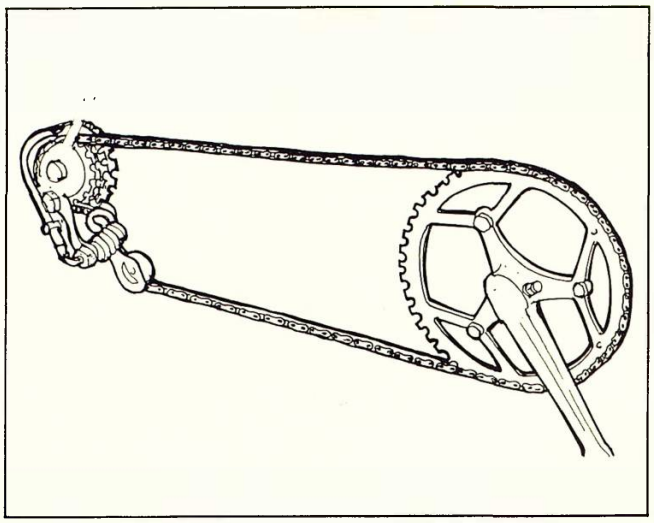
Chain drives

Information: Chain drives in everyday use

The bicycle uses a chain drive. It is the larger sprocket gear which is driven by the rider. If the bicycle has different gears, the rider can change gear as he travels along. If he rides up a hill, he will change gear and use a larger sprocket on the rear wheel hub. To ride quickly on a flat surface, he will choose a smaller sprocket on the rear wheel hub. A bicycle with 5 different size sprockets on the rear wheel has 5 different **gear ratios.**

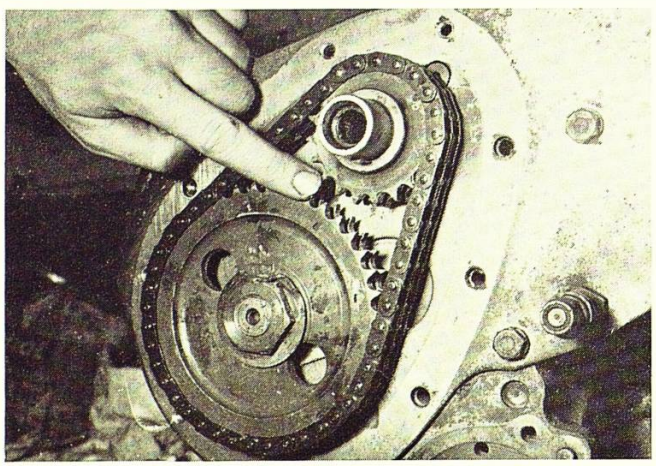


Bicycle in low speed gear for climbing hills.

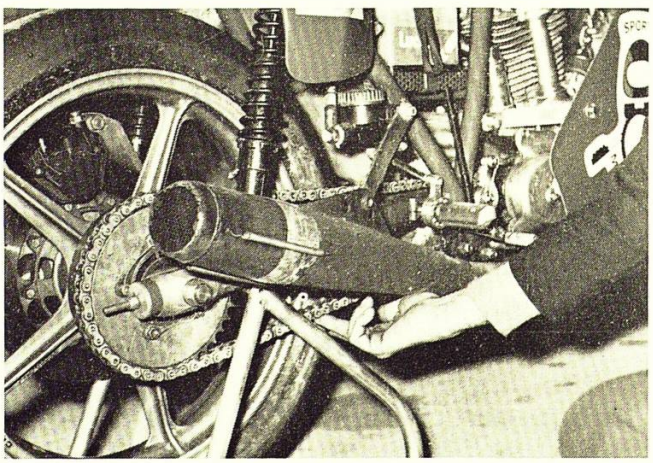


Bicycle in high speed gear for travelling quickly on flat ground.

Sometimes bicycles are fitted with 2 different sprocket gears connected to the pedals. If a bicycle also has 5 different sprocket gears on the rear wheel hub, it has a total of 10 possible gear ratios.



The timing chain on a car connects the **crankshaft** of the engine to the **camshaft.** There are usually twice as many teeth on the camshaft sprocket as on the crankshaft sprocket.



A chain drive connects a motorcycle's engine and rear wheel. A motorcycle has a gearbox with a more complicated gear system than a bicycle.

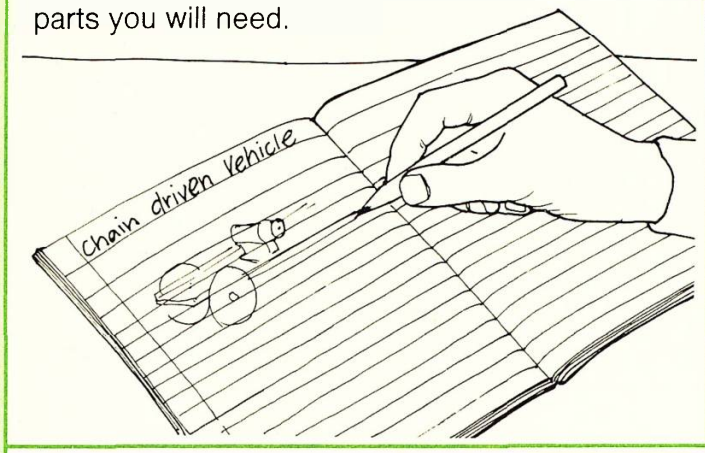
Project: Designing and making a chain-driven vehicle

Apparatus

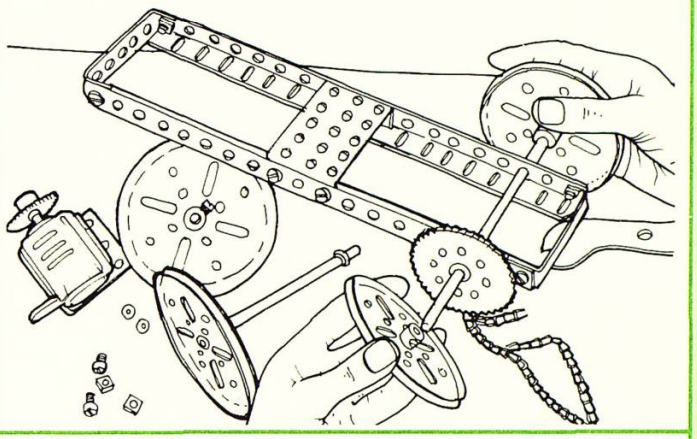
★ Meccano parts ★ electric motor ★ dry cell batteries ★ length of chain
★ nuts and bolts ★ spanner ★ screwdriver

You are going to design and make a chain-driven vehicle.

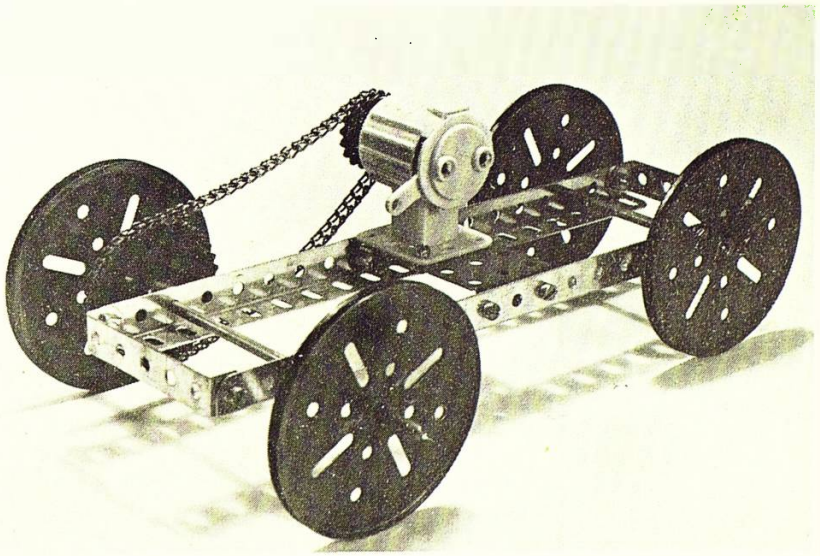
A Design a vehicle with an electric motor, chain drive and large sprocket on the axle. Write down the parts you will need.



B Make the vehicle from your design. Change the design if the model does not work at first.



C Here is an idea for the model:



Q4 Write down how you designed and made your model. What changes did you make in your design?

Q5 Make a drawing of your model.

Q6 Why is it better to have the smaller sprocket gear fixed to the motor?

Q7 Is it possible to make the model go backwards?

2 Belt drives

Making and investigating a belt drive

Apparatus

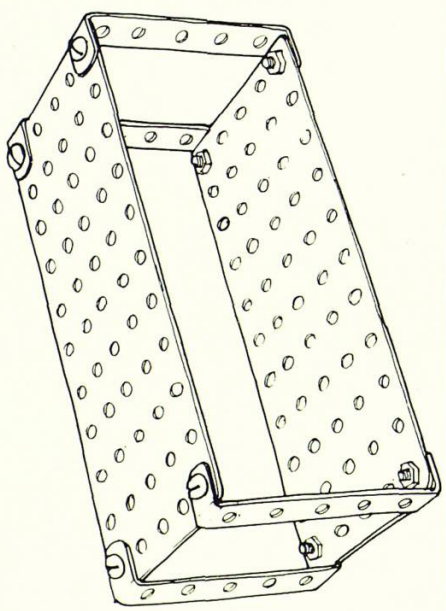
★ 2 flat plates ★ 4 double angle strips ★ 4 different pulleys labelled W, X, Y and Z
★ 2 axle rods with collars ★ drive belt ★ nuts and bolts ★ spanner
★ screwdriver ★ ruler

You are going to make a belt drive and find out how it works.

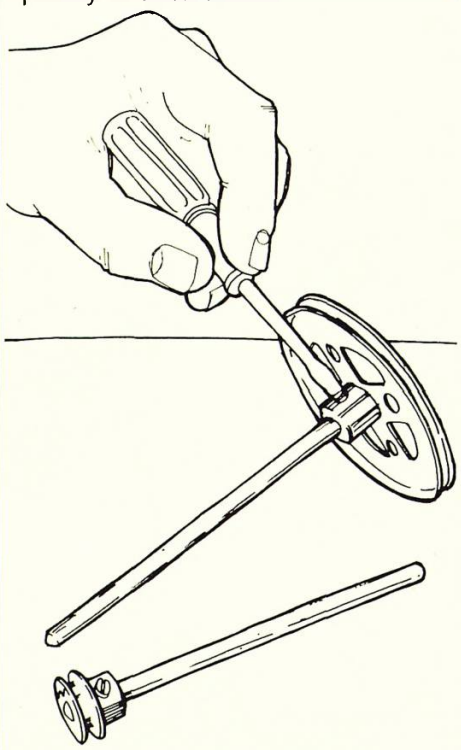
Q1 Copy this table.

First pulley	Diameter of first pulley (mm)	Number of times first pulley is turned	Second pulley	Diameter of second pulley (mm)	Number of times second pulley turns
W		10	X		
Y		10	Z		
W		10	Z		
W		10	Y		
X		10	Z		
Y		10	X		

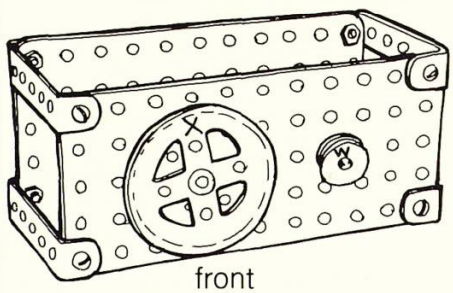
A Make a box, as shown. Use 2 flat plates and 4 double angle strips.

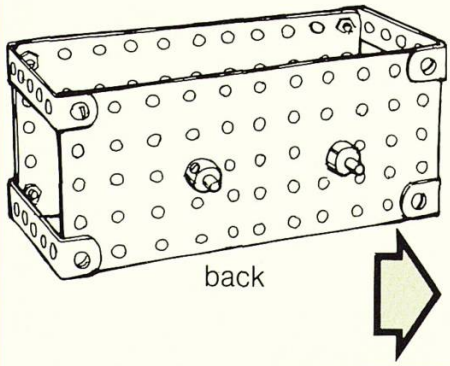


B Screw pulley W and pulley X onto axles.

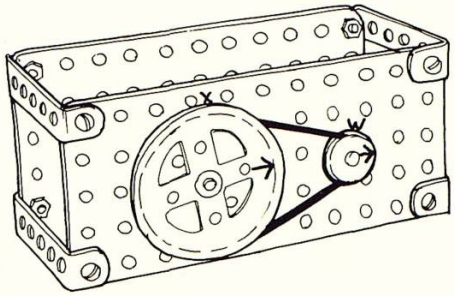


C Push the axles into the box. Fix a collar to each axle.

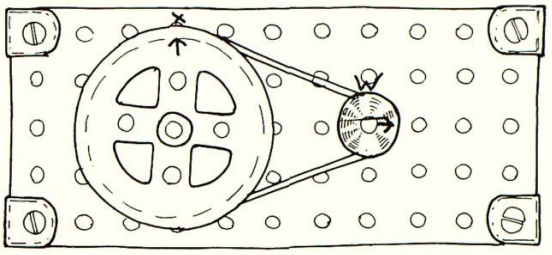




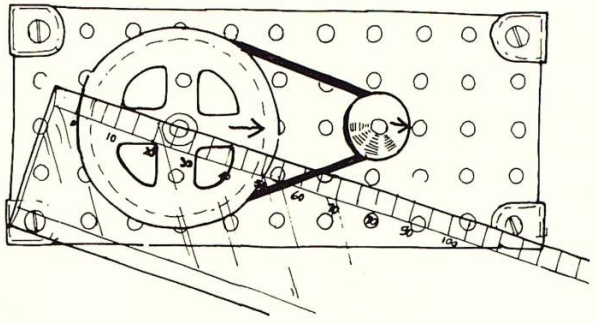
D Put a belt drive over the 2 pulleys. Put a pencil mark (arrow) on each pulley, as shown.



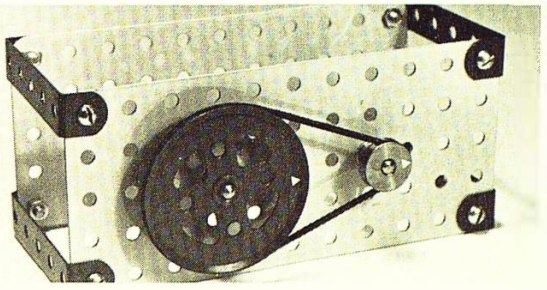
E Turn pulley W round 10 times. Count how many times X goes round. Record your results in the table.



F Measure the **diameter** of both pulleys. Record your results in the table.



G Repeat steps B to G with the other pulleys listed in the table. Each time, record your results in the table.



Q2 What happens to a large pulley when it is driven by a small one?

Q3 If you turn one pulley **clockwise,** which way does the other pulley turn?

Q4 How many times would pulley X turn if pulley W had been turned 100 times?

Q5 Look at your table of results. When pulley W is turned 10 times what do you notice about the diameters of pulleys X, Y and Z and the number of times they turn?

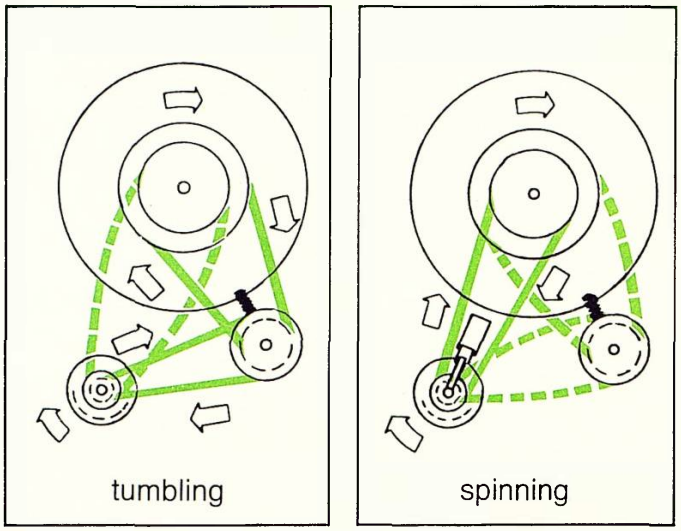
Q6 Copy this table. Then fill in the missing numbers.

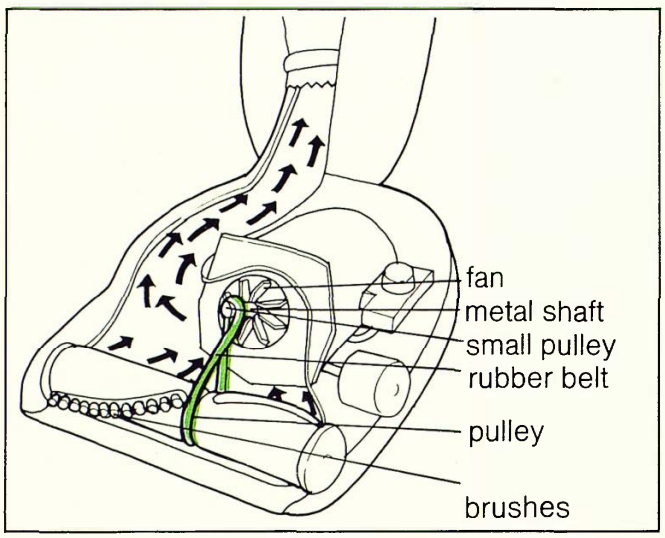
First pulley	Diameter of pulley (mm)	Number of times first pulley is turned	Second pulley	Diameter of pulley (mm)	Number of times second pulley turns.
P	25	10	L		20
Q	10	10	M	50	

Belt drives

Information: Belt drives in modern machines

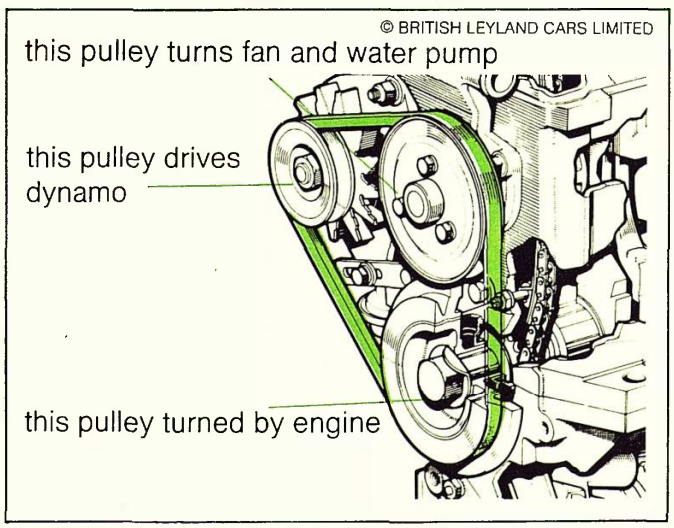
Belt drives are often used in modern machines. One of the pulleys is attached to a motor. The second pulley is attached to something that needs to be turned.
The drum of a washing machine is turned by an electric motor. The motor is connected to the drum by pulleys and a drive belt.



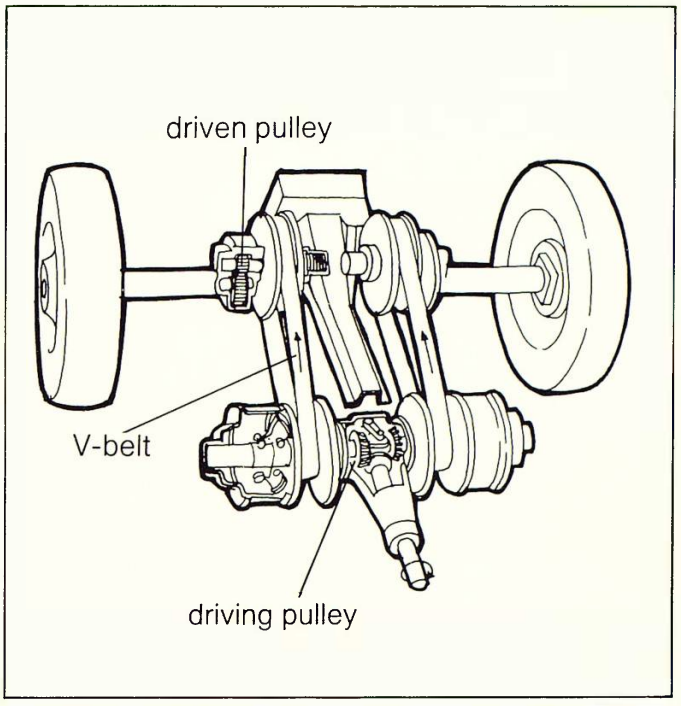


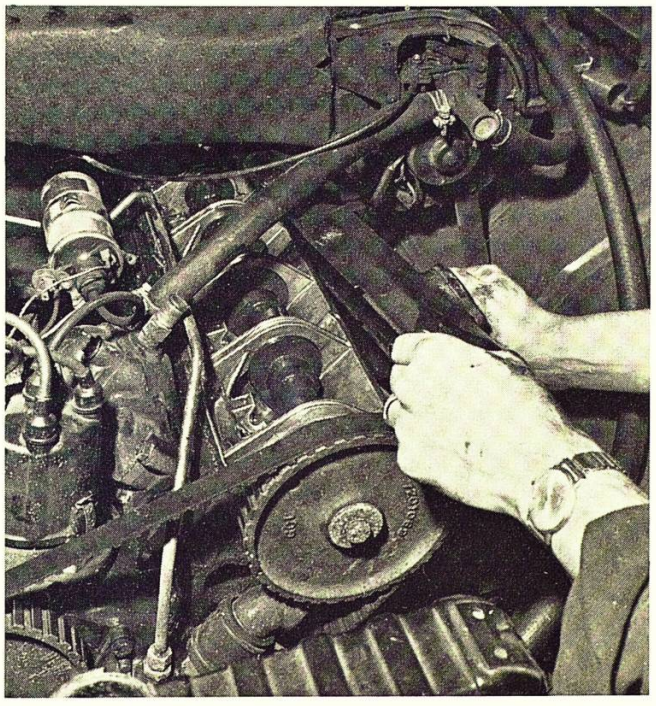
Some vacuum cleaners have belt drives. An electric motor turns a metal shaft. The metal shaft has a fan and a pulley on it. The fan sucks the dirt into a bag. The pulley is connected to the brushes by a thick rubber belt. The belt drives the brushes which beat the dust and dirt out of the carpet.

The fan belt in a car is driven by the engine. It goes round 2 other pulleys. One pulley turns both the fan and the water pump. They help to stop the engine overheating. The other pulley is part of the **dynamo** or **generator.** This provides the car with electricity.
If the fan belt snapped the car would soon overheat and break down.



The DAF Variomatic car has a belt drive instead of a gearbox. The pulleys change diameter as the car moves. The car changes gear without the driver doing anything.





In some car engines, a belt with teeth on it is used instead of a chain to drive the camshaft. The teeth on the belt fit exactly into the slots on the pulleys.

Q7 If the pulley turned by the engine of a car is smaller than the dynamo pulley, which will turn faster?

Q8 What are the advantages of belt drives?

Q9 What are the disadvantages of belt drives?

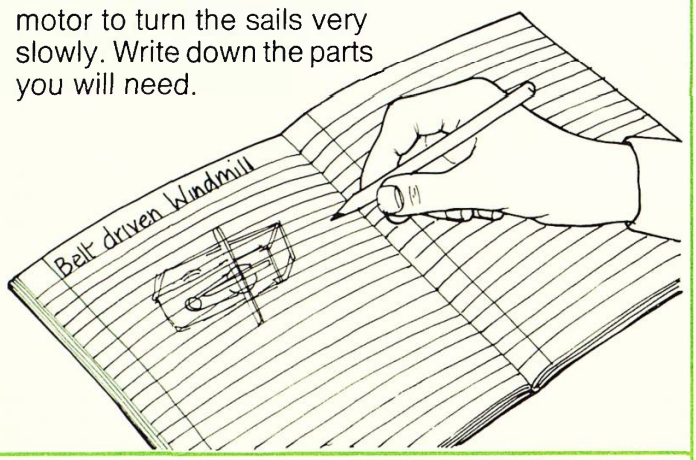
Project: Designing and making a model windmill

Apparatus

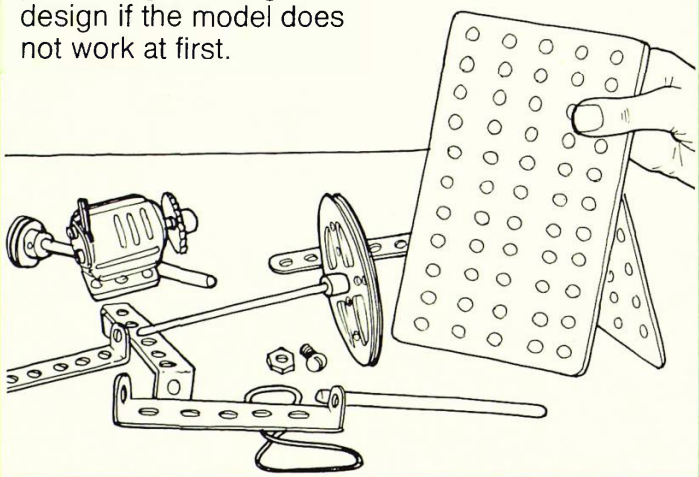
★ Meccano parts ★ electric motor ★ dry cell batteries ★ pulleys
★ nuts and bolts ★ spanner ★ screwdriver

You are going to design and make a model windmill.

Design a very simple model windmill. Use a belt drive from the electric motor to turn the sails very slowly. Write down the parts you will need.



Make the windmill from your design. Change the design if the model does not work at first.



Q10 Write down how you designed and made your model. What changes did you make in your design?

Q11 Make a drawing of your model.

Q12 How could you change your design to make the sails turn as fast as the pulley on the motor?

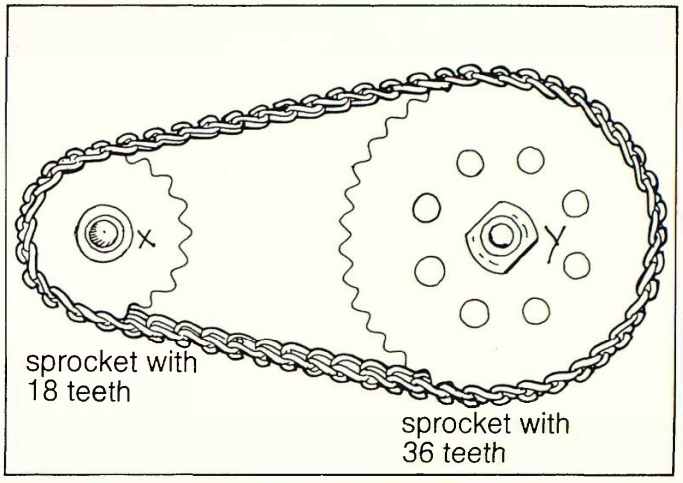
Q13 How could you make the sails turn the other way by making a simple change to the drive?

Information: Gear ratios in chain and belt drives

The **gear ratio** in a chain drive is the number of teeth on the larger sprocket divided by the number of teeth on the smaller sprocket. The smaller sprocket is usually the one turned by the motor, or even by hand.

Axle X turns twice to turn axle Y once.

The gear ratio is
$\frac{36}{18} = \frac{2}{1}$
or two to one.

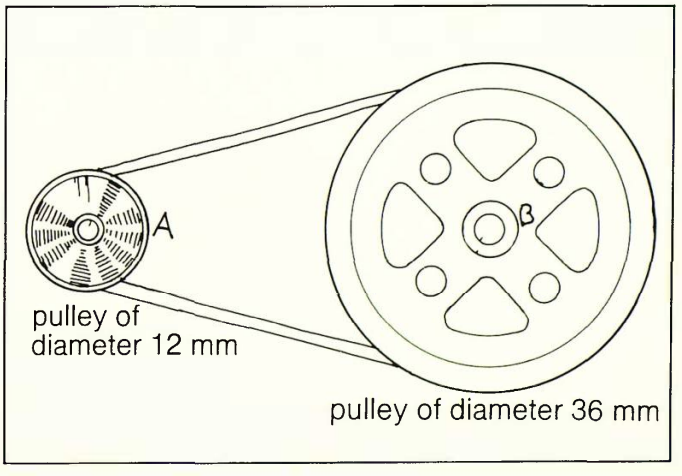


If a motor is attached to a small sprocket or pulley, it turns the larger one more easily. The higher the gear ratio the more **leverage** the engine will have. The engine of a car must work hard to start the car moving. A car is started in **first gear** with a ratio of about 14:1 overall. This means the engine's crankshaft turns 14 times for every 1 turn of the road wheels. When cruising at 100 kph in **fourth gear,** the overall gear ratio is about 4:1.

In a belt drive, there are no teeth. The gear ratio is worked out by measuring the **diameters** of the pulleys. The larger diameter is divided by the smaller to give the gear ratio.

To turn axle B once, axle A must be turned about 3 times. (Actually, it must be turned a little more than 3 times.)

The gear ratio is
$\frac{36}{12} = \frac{3}{1}$
or three to one.



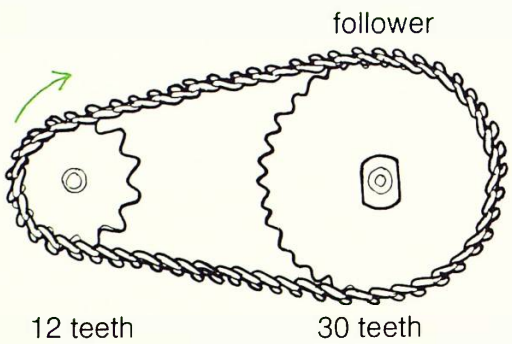
Q14 If sprocket X in the top diagram had 9 teeth, what would the gear ratio be?

Q15 If pulley A in the bottom diagram had a diameter of 9 mm, what would the gear ratio be?

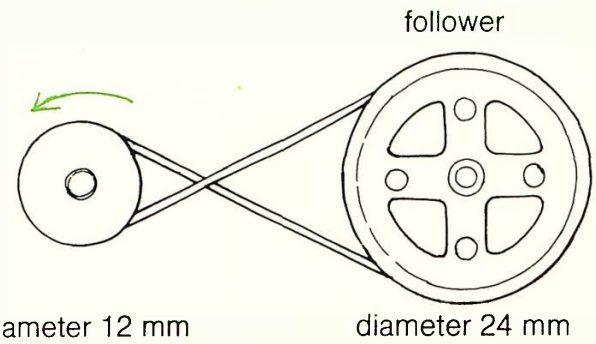
Belt drives

Q16 Copy the diagrams of chain and belt drives. Mark on your diagrams the direction the **follower wheel** will turn in each case.

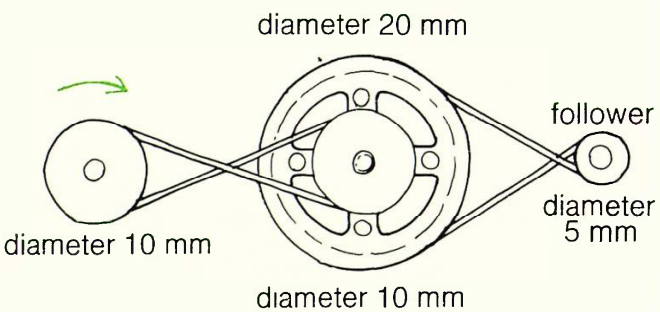
A



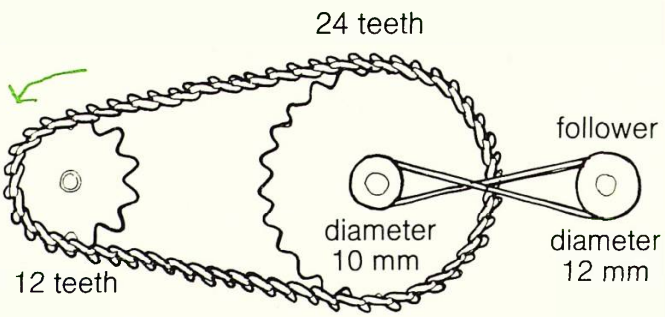
B



C



D



Q17 Work out the gear ratios for each diagram.

3 Spur gears

Investigating spur gears

Apparatus

★ 2 flat plates ★ 4 double angle strips ★ 2 axle rods and spring clips
★ 4 spur gears: W = 12 mm, X = 38 mm, Y = 17 mm, Z = 32 mm ★ spanner
★ nuts and bolts ★ screwdriver

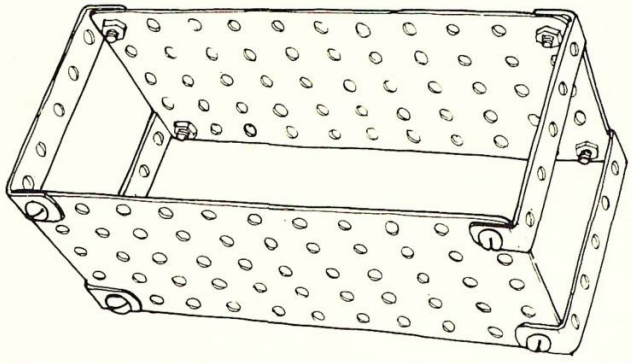
You are going to find out how spur gears work.

Q1 Copy this table.

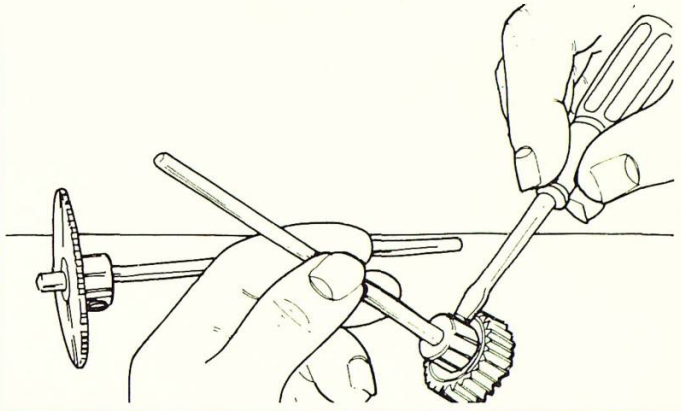
Gear	Number of teeth on gear.	Number of times the gear is turned.
W		10
Y		10

Gear.	Number of teeth on gear.	Number of turns the gear makes if other is turned 10 times.
X		
Z		

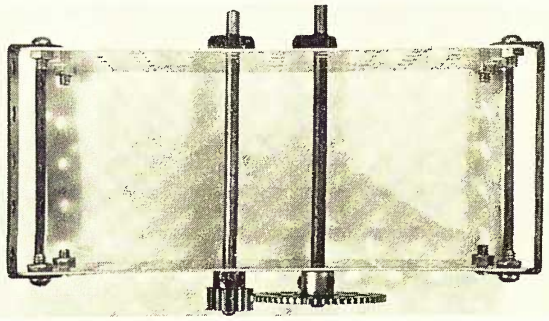
A Count the teeth on the spur gears and record them in your table. Make a box, as shown.



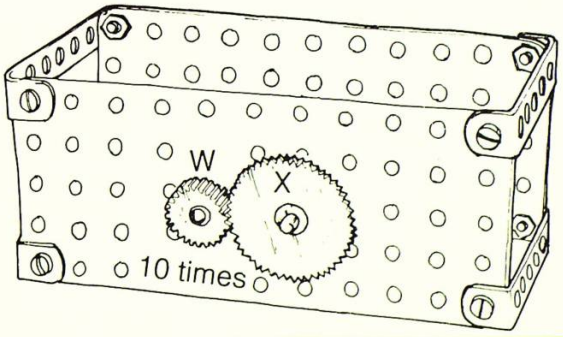
B Screw spur gear W and spur gear X onto axles.



C Push the axles into the box so that the gears **mesh** with each other. Fix them in place with spring clips.



D Turn gear W 10 times and count the number of times gear X turns. Record the results in your table. Repeat steps B to D with gears Y and Z.

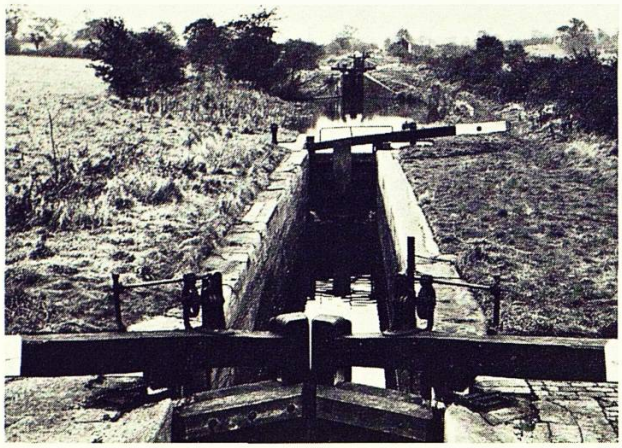


Q2 From your results, work out the gear ratios of W:X and Y:Z. (No. teeth on X ÷ No. teeth on W.)

Q3 What would the gear ratio be of 2 spur gears with 15 and 45 teeth?

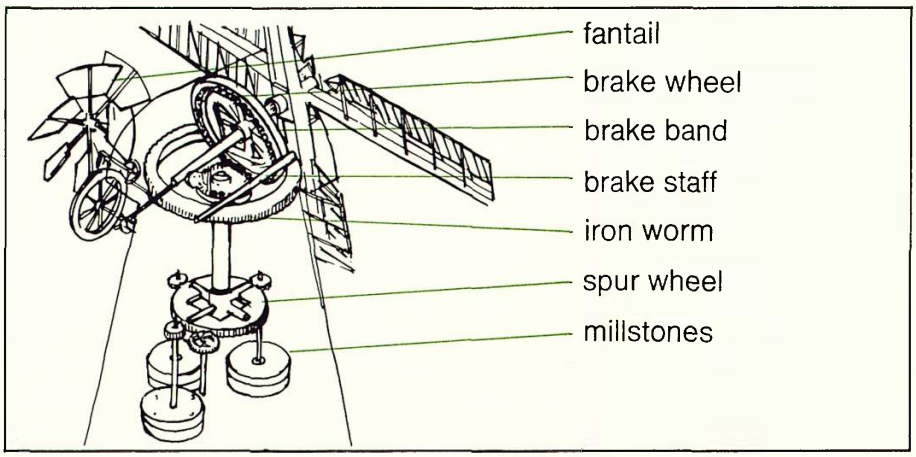
Spur gears

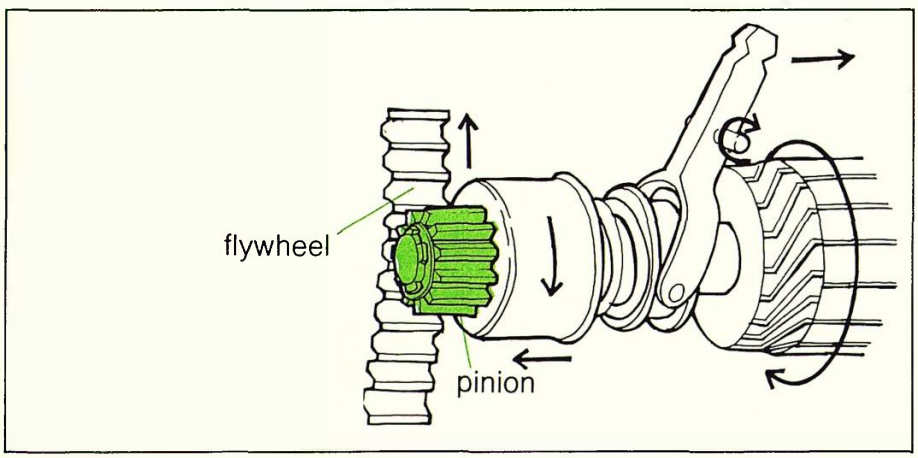
Information: Spur gears past and present



The **sluice gates** on canal locks can be opened by hand. Spur gears are used to give more leverage in opening the gates. The gear ratio means the handle has to be turned many times to open the sluice gate just a little.

Wind and water mills use natural forces to drive giant spur gears. The mills were mostly used to grind cereals such as corn.





The **starter motor** in a car has a small spur gear. When the engine is started, the gear connects with a ring of spur gear teeth on the **flywheel.** After the engine has started, the spur gear disconnects on its own. The gear ratio is usually about 10:1.

Q4 What are the disadvantages of a wind-powered machine?

Q5 If the gear ratio was less than 10:1, would the starter motor turn the engine more or less easily?

4 Compound spur gears

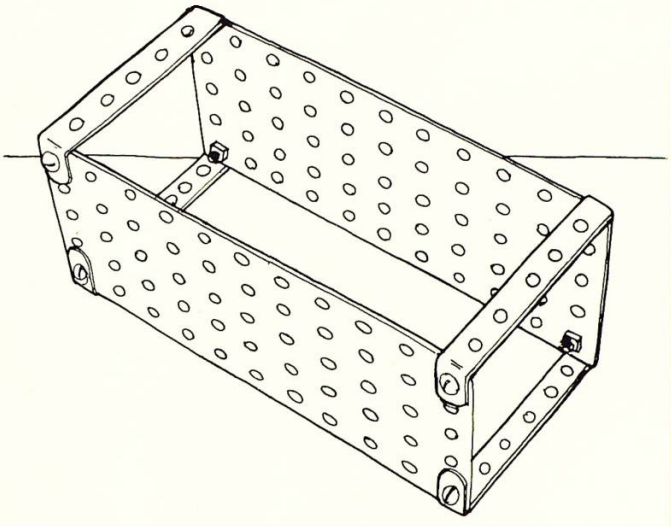
Making and investigating a compound gearing system

Apparatus

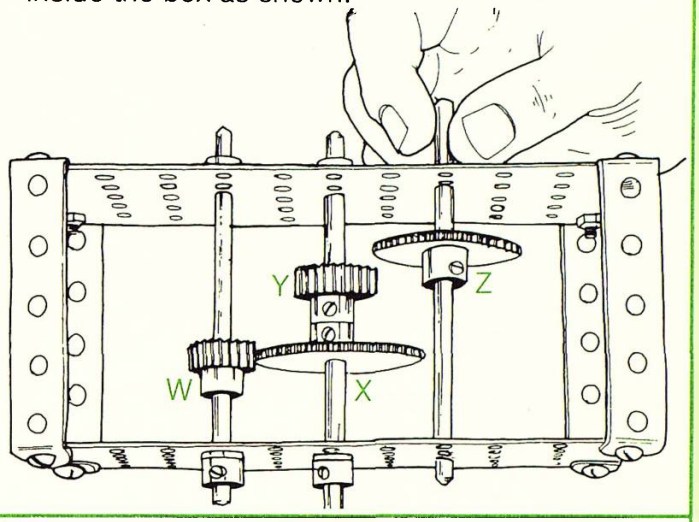
★ 2 flat plates ★ 4 double angle strips ★ 3 axle rods ★ 6 collars with screws
★ 4 spur gears: W = 12 mm, X = 38 mm, Y = 17 mm, Z = 32 mm ★ spanner
★ nuts and bolts ★ screwdriver

You are going to make a compound gearing system and find out how it works.

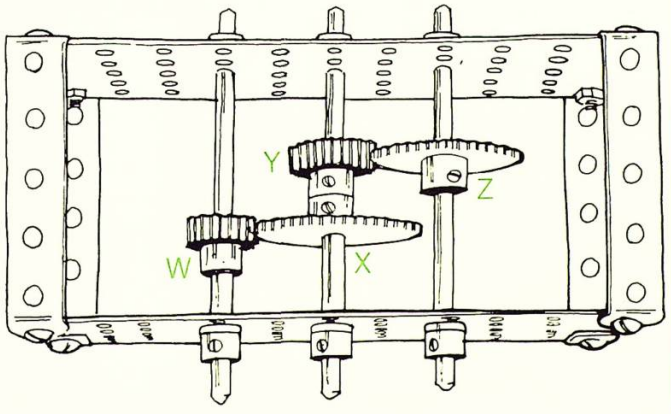
A Make a box, as shown.



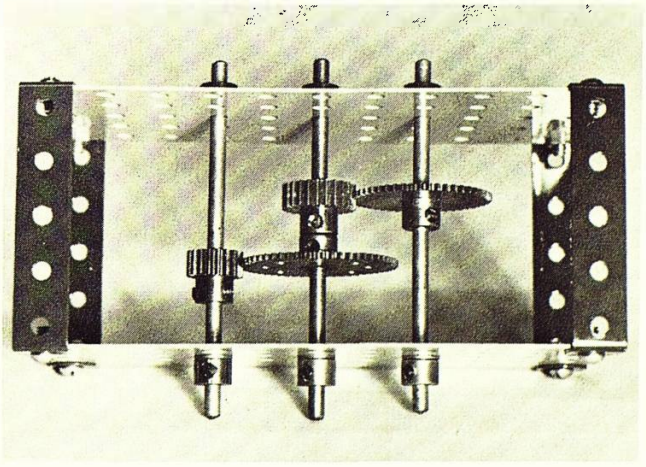
B Push 3 axles into the box. Fit 4 spur gears inside the box as shown.



C Push the axles through to the other side of the box so that the gears mesh, as shown.



D Fix the rods in position with collars. Try turning the axles.



Q1 How many times does gear Y turn when Z is turned once?

Q2 How many times does gear W turn when X is turned once?

Q3 How many times does gear W turn when Z is turned once?

Compound spur gears

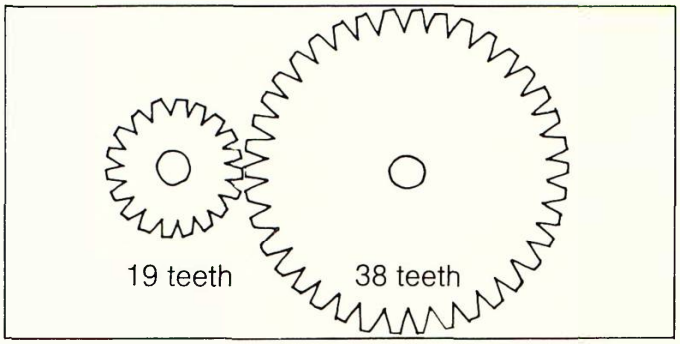
Information: Gear ratios in compound gears

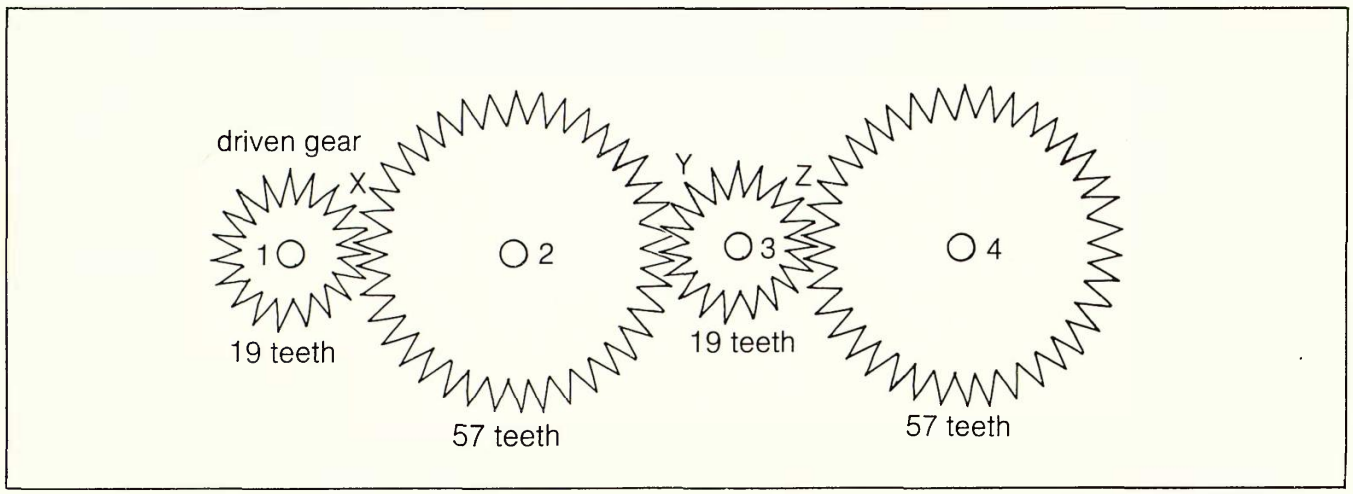
In simple gearing systems, the gear ratio is worked out by dividing the number of teeth of the larger gear by the number of teeth of the smaller gear.

For example, in the diagram

38 teeth ÷ 19 teeth = $\frac{2}{1}$

or a 2:1 gear ratio.





If there are more than 2 gears, then the **overall** gear ratio should be worked out. The way to do this is to work out the gear ratios of connecting gears first. Start from the driven gear.

Gear 1 has 19 teeth Gear 2 has 57 teeth

Gear ratio X is 57:19 = 3:1 or $\frac{3}{1}$

Gear 2 has 57 teeth Gear 3 has 19 teeth

Gear ratio Y is 19:57 = 1:3 or $\frac{1}{3}$

Gear 3 has 19 teeth Gear 4 has 57 teeth

Gear ratio Z is 57:19 = 3:1 or $\frac{3}{1}$

The overall gear ratio is ratio X × ratio Y × ratio Z

In this case: $\frac{3}{1} \times \frac{1}{3} \times \frac{3}{1} = \frac{9}{3} = \frac{3}{1} = 3:1$

The overall gear ratio is 3:1

Q4 If you made a compound gear system where gear 1 has 10 teeth, gear 2 has 30 teeth, gear 3 has 20 teeth and gear 4 has 60 teeth, how many times would gear 1 turn if gear 4 was turned only once.

Finding gear ratios

Apparatus

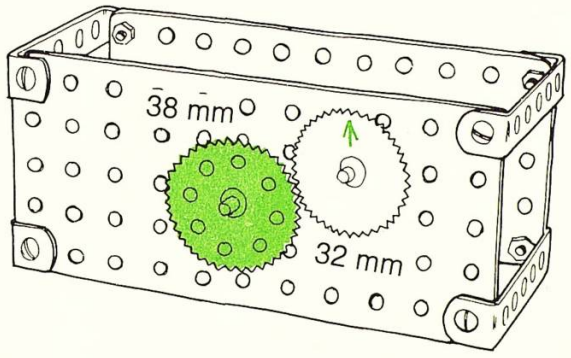
★ 2 flat plates ★ 4 double angle strips ★ 3 axle rods and collars ★ spanner
★ 12 mm spur gear ★ 32 mm spur gear ★ two 38 mm spur gears
★ nuts and bolts ★ screwdriver

You are going to make some models using spur gears and work out their gear ratios.

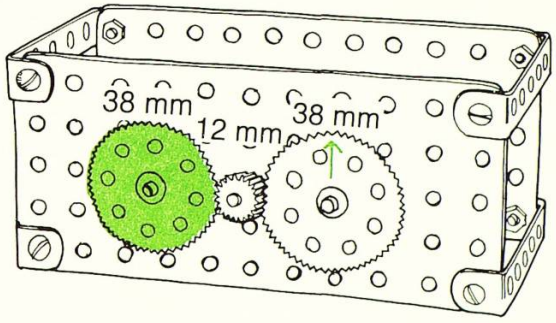
Q5 Copy this table.

Model	Coloured gear (mm)	Number of times coloured gear is turned	gear with arrow (mm)	Number of times gear with arrow turns
A		10		
B		10		
C		10		

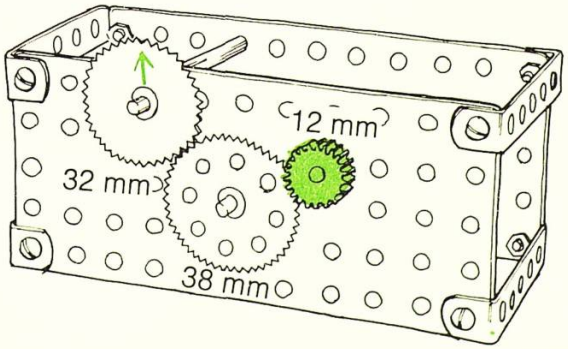
A Make a model, as shown. Turn the coloured gear 10 times. Count how many times the gear with the arrow turns. Record the results in your table.



B Make a model, as shown. Turn the coloured gear 10 times. Count how many times the gear with the arrow turns. Record the result in your table.



C Make a model, as shown. Turn the coloured gear 10 times. Count how many times the gear with the arrow turns. Record the result in your table.



Q6 What is the gear ratio of model A?

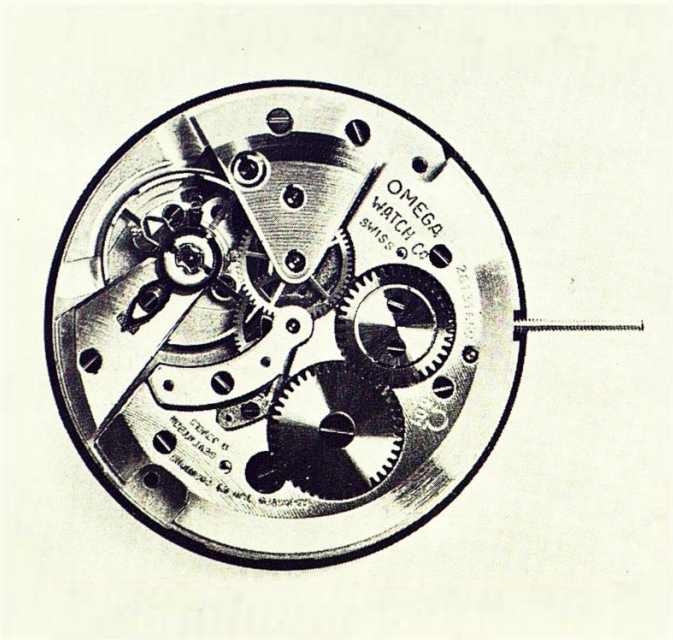
Q7 What is the gear ratio of model B?

Q8 What is the gear ratio of model C?

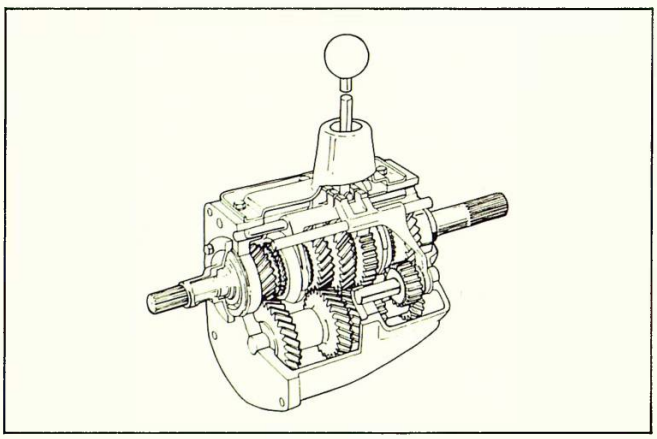
Q9 The 12 mm gear in step B is known as an **idler gear.** How does this affect the way in which the last gear turns?

Compound spur gears

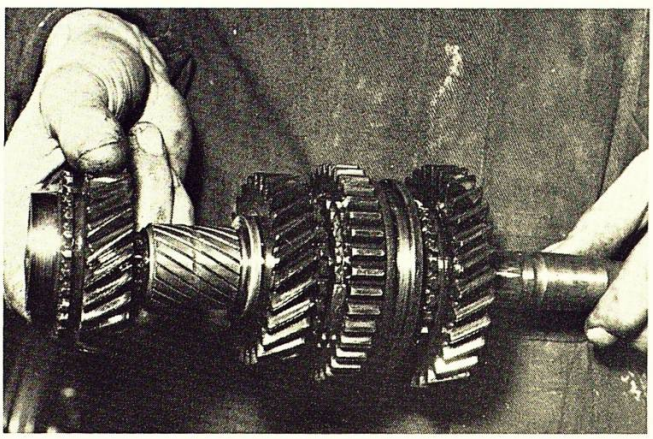
Information: Compound spur gears in action



Compound spur gears are used in mechanical watches. The energy to make the gears turn is stored in a spring. As it unwinds, the spring turns the gears. The tiny axles are sometimes held in place by **jewels,** such as **rubies.** These are very hard and take a long time to wear out.



The gear box in a modern car is usually just behind the engine. Sometimes it is underneath (Mini), or in front (Renault 16). It is joined to the engine by a **clutch.** Inside the gearbox there are compound gears. There are usually 4 forward gears and a reverse.



The gears themselves are **crossed helical.** This means that the teeth are curved and slanted. The reverse gear (and sometimes first gear) has spur gears which are straight. A gearbox made of spur gears would work very well but would be very noisy.

Q10 Why are jewels used in watches?

Q11 Look at the second diagram on page 14.
Draw a diagram of 4 gears meshed together in a line – gear 1 = 10 teeth, gear 2 = 20 teeth, gear 3 = 30 teeth, gear 4 = 90 teeth. Work out their overall gear ratio.

5 Worm gears

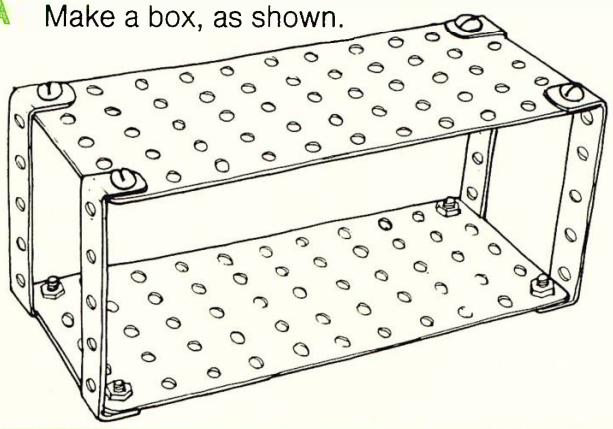
Investigating the worm and pinion

Apparatus

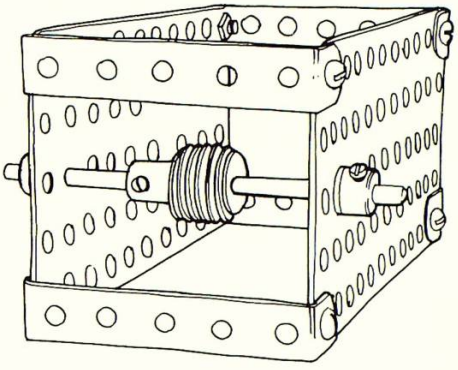
★ 2 flat plates ★ 4 double angle strips ★ 38 mm spur gear ★ worm gear
★ 165 mm axle rod ★ 90 mm axle rod ★ 4 collars ★ nuts and bolts
★ spanner ★ screwdriver

You are going to find out how a worm and pinion works.

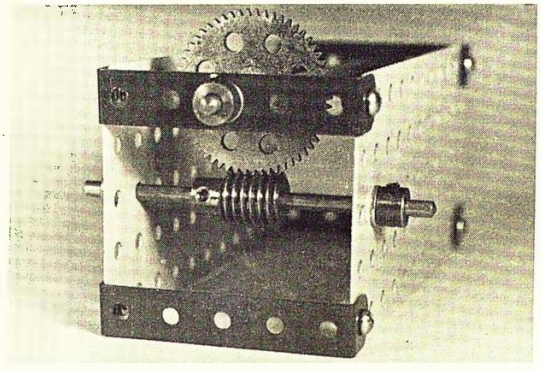
A Make a box, as shown.



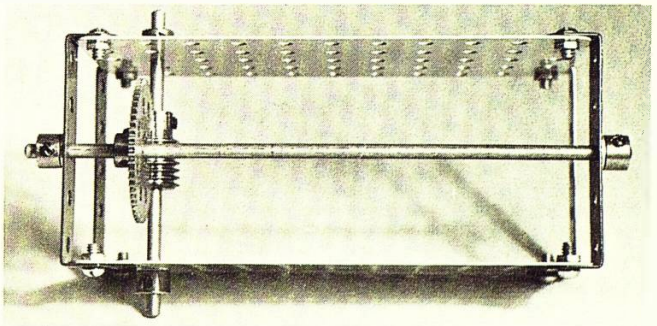
B Fix a worm gear in place, as shown.



C Fix a 38 mm spur gear in place, as shown.



D Put collars on the axles to complete the model. Turn the axles.



Q1 Make a drawing of your model. Put arrows on your drawing to show which way the gears turn. Label the worm and pinion (spur) gear.

Q2 How many teeth are there on the pinion gear?

Q3 How many times must the worm gear turn in order to make the pinion gear go round once?

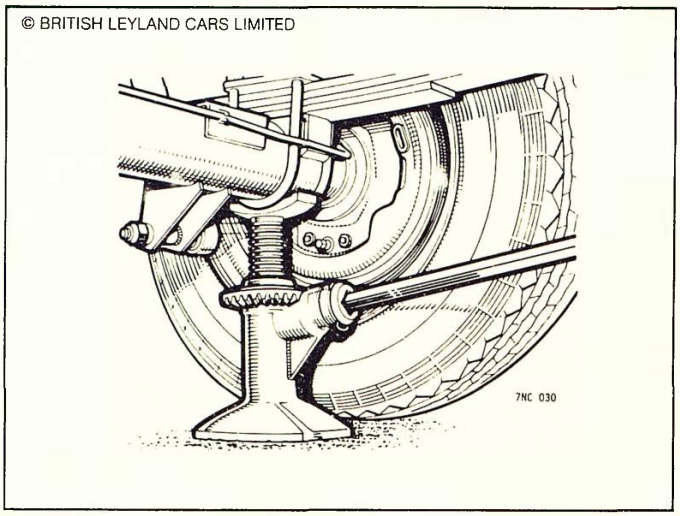
Q4 Can the pinion gear make the worm gear turn?

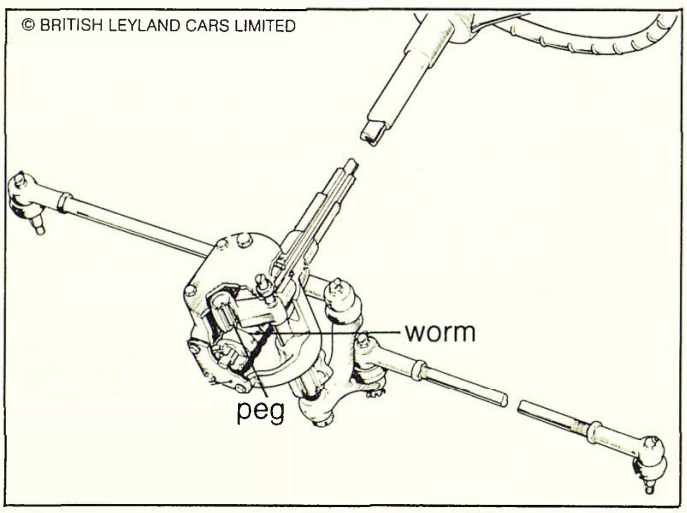
Q5 How many teeth does the worm gear have?

Q6 What is the gear ratio of the model?

Information: Worm gears in cars

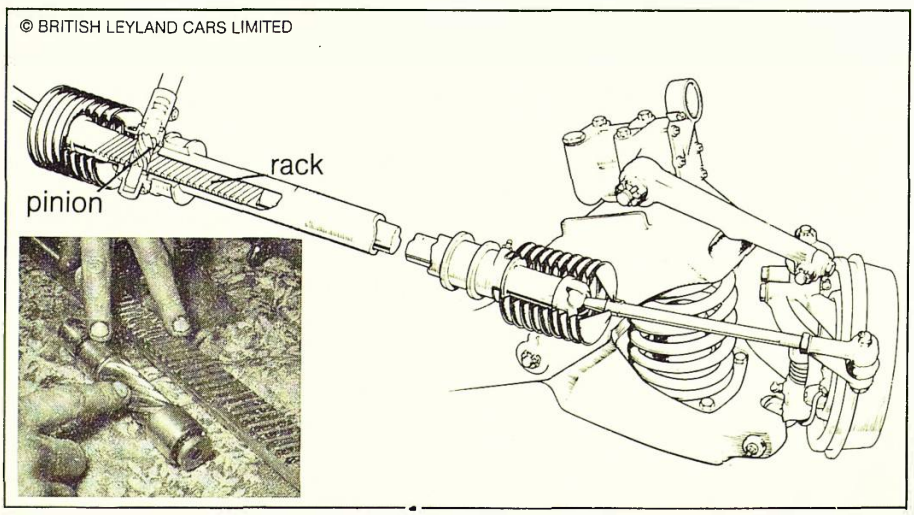
The worm gear will turn the pinion easily. The pinion **cannot** turn the worm gear. This gearing system can be used to lift heavy loads. It is used in car jacks.
The worm gear has only **one** tooth. The gear ratio is worked out in the usual way. If the pinion has 10 teeth, the ratio is 10:1.



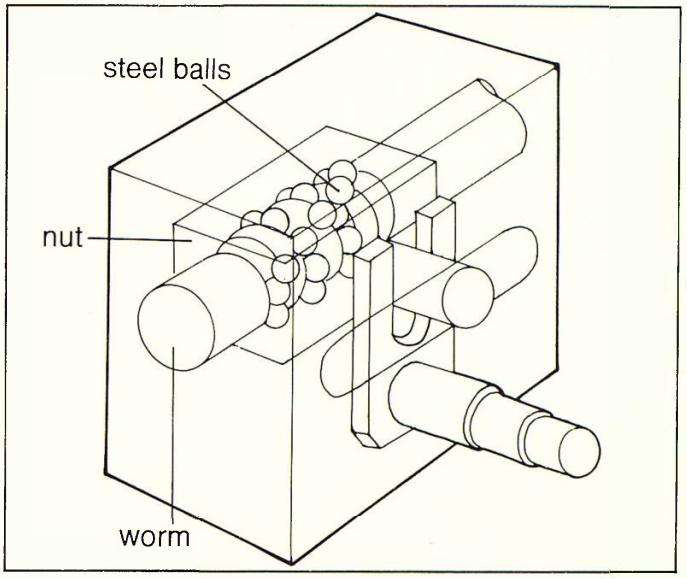


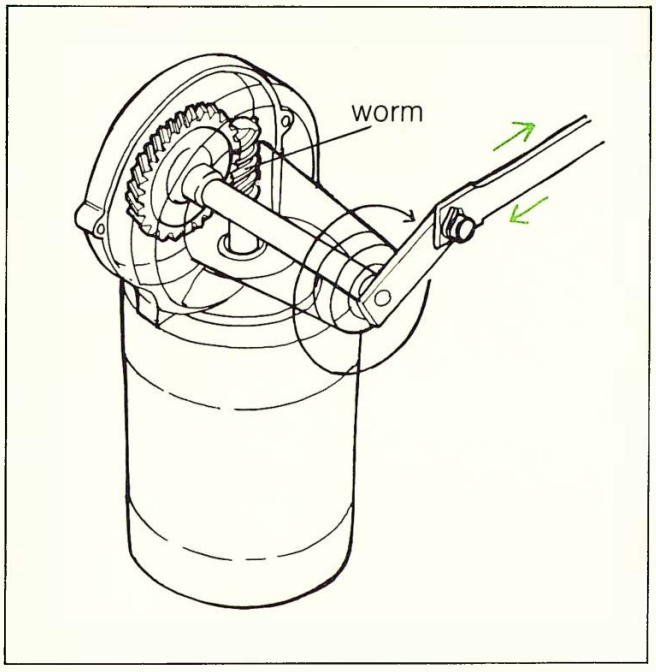
The worm gear is not always used with a pinion. In some older cars, **worm and peg** steering was used. The worm gear was attached to the steering column and the peg fitted into the groove of the worm gear. As the driver turned the steering wheel the peg moved up or down the groove. The peg was attached to the front wheels by various steel rods.

Most modern cars have a pinion in the steering gear. This is meshed with a **rack.** A rack is a straight piece of metal with gear teeth on it. The pinion is attached to the steering column. As the driver turns the steering wheel the rack is forced to move. As it moves it turns the front wheels of the car.

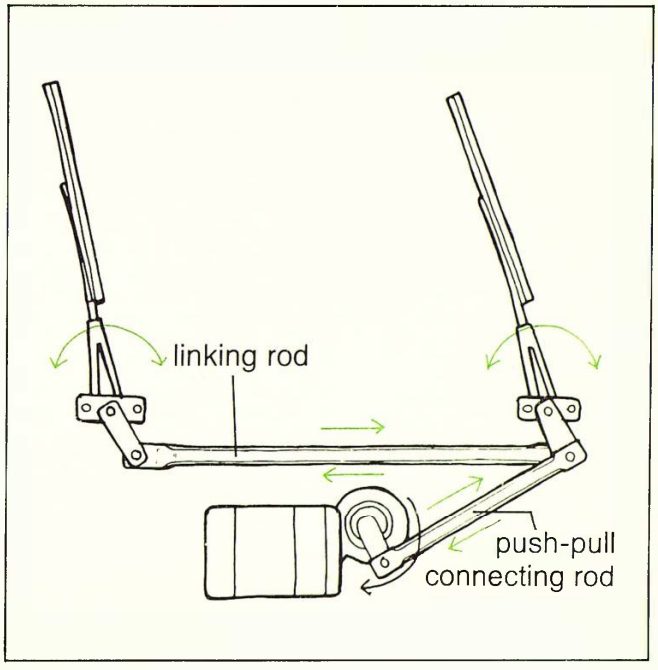


Another type of steering which uses a worm gear is the **worm and nut** system. The worm gear works like a giant screw moving the nut. Ball bearings are used to reduce the **friction** between the worm gear and the nut.





A windscreen wiper motor uses a worm and pinion gear. A motor turns the worm quickly to drive the pinion.



The pinion is joined to the wipers by a special mechanism. This mechanism changes the circular motion to a push-pull motion.

Q7 If a worm gear was attached to an electric motor, which would turn faster, the worm or pinion?

Q8 If a pinion had 28 teeth, what would be the gear ratio in a worm and pinion system?

Q9 Why does there have to be a push-pull mechanism attached to the pinion gear in a windscreen wiper?

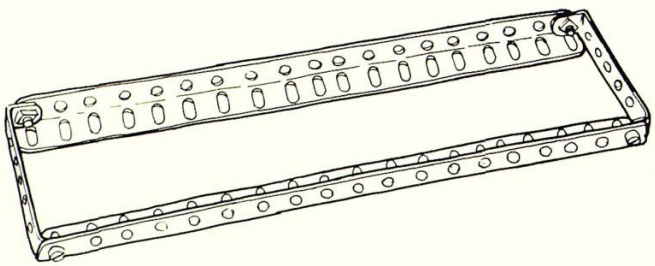
Project: Designing and making a vehicle with worm and pinion gearing

Apparatus

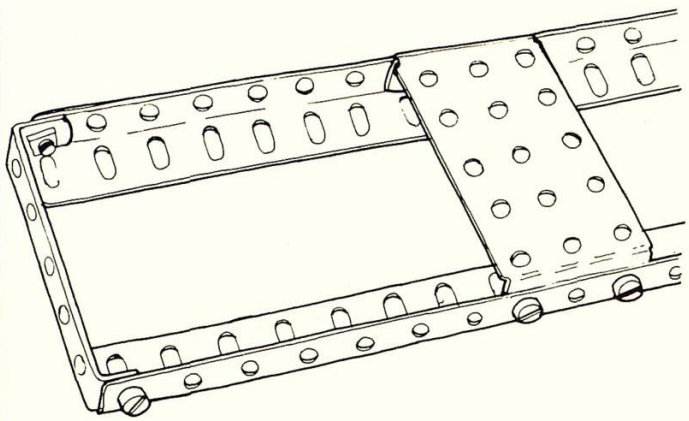
★ flanged plate ★ 4 flat trunions ★ worm gear ★ spur gears ★ 3 axle rods ★ collar
★ 2 long angle girders ★ 3 double angle strips ★ 4 large wheels ★ nuts and bolts
★ electric motor and power supply ★ spanner ★ screwdriver

You are going to design and make a vehicle with worm and pinion gearing.

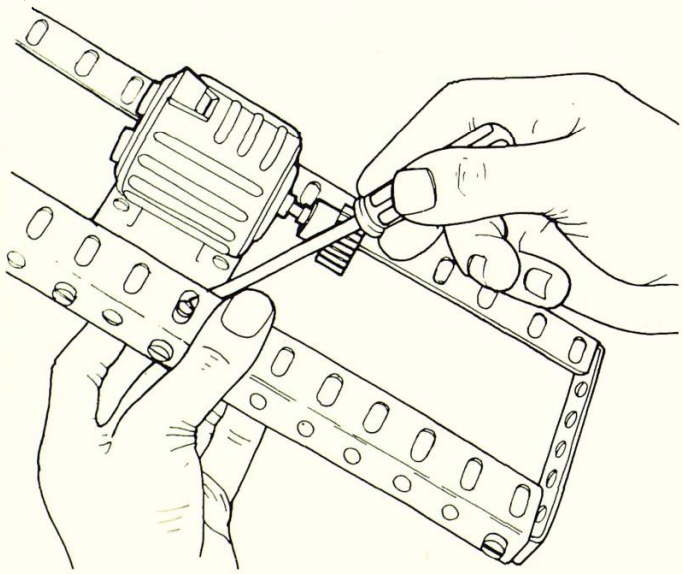
A Join 2 long angle girders to 2 double angle strips.



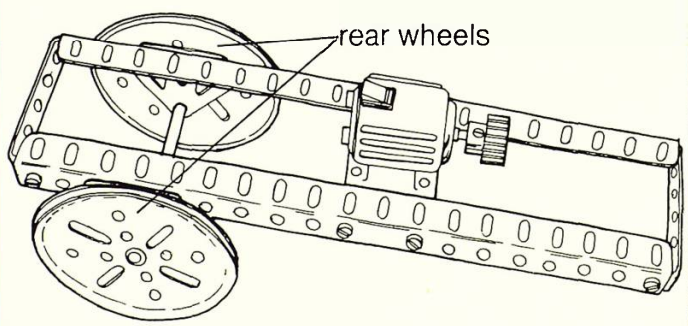
B Bolt on a flanged plate a little more than halfway down the frame.



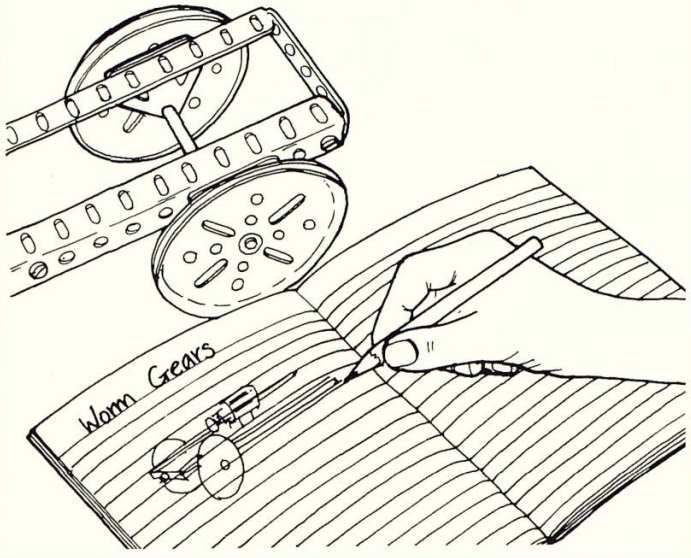
C Screw the electric motor onto the flanged plate.



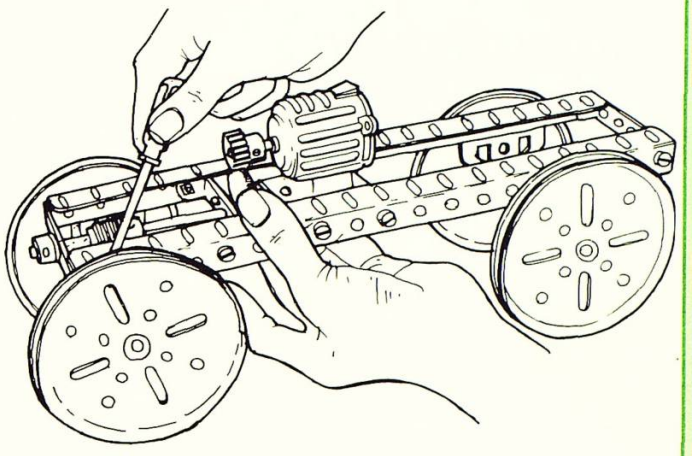
D Attach 2 rear wheels to the vehicle.



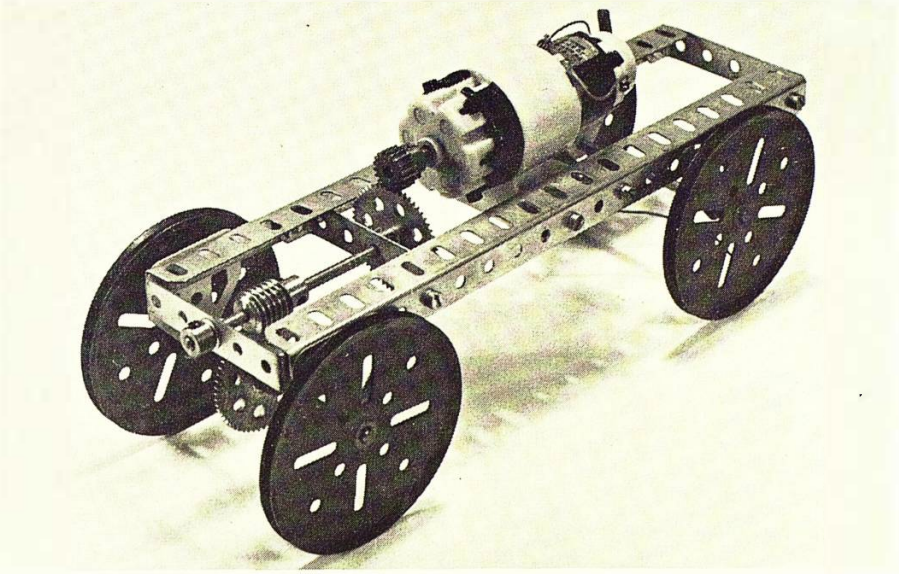
E Design a worm and pinion gearing system to drive the front wheels. You may need other parts to support the gears and wheels.



F Finish making your model. See if it works. Change your design if it doesn't work at first.



G If you changed your design and the gearing system still didn't work, try to build this gearing system into the vehicle.



Q10 Make a drawing of your working model.

Q11 Describe any problems you had with your design, and how you solved them.

Q12 Work out the overall gear ratio from the motor drive shaft to the rear axle. (Remember, a worm gear has only **one** tooth.)

6 Contrate and helical gears

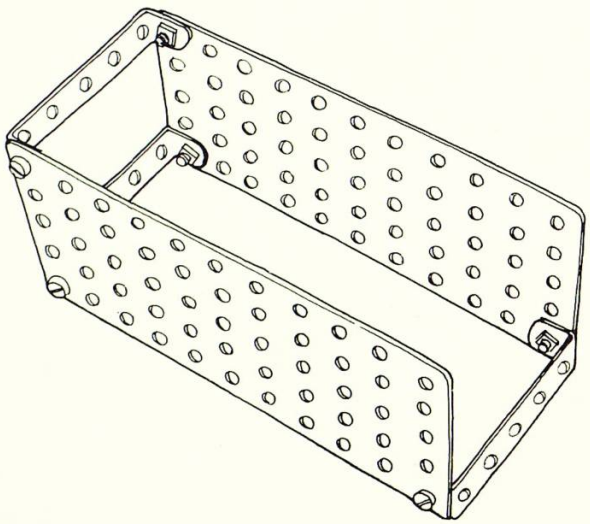
Investigating contrate gears

Apparatus

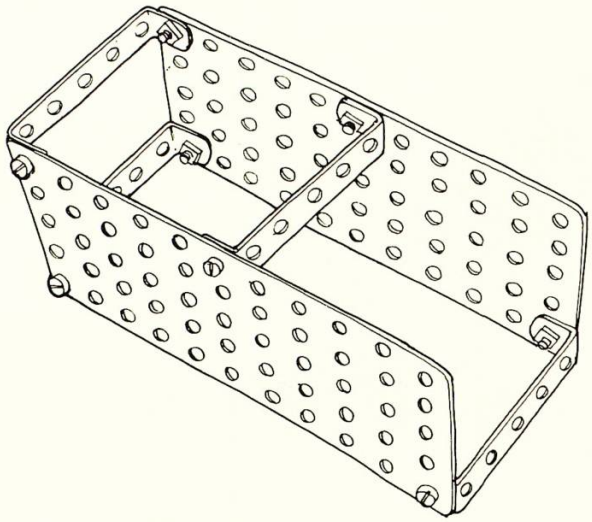
★ 2 flat plates ★ 4 double angle strips ★ 2 axle rods and spring clips
★ two 12 mm spur gears ★ 38 mm contrate gear ★ nuts and bolts
★ spanner ★ screwdriver

You are going to find out how contrate gears work.

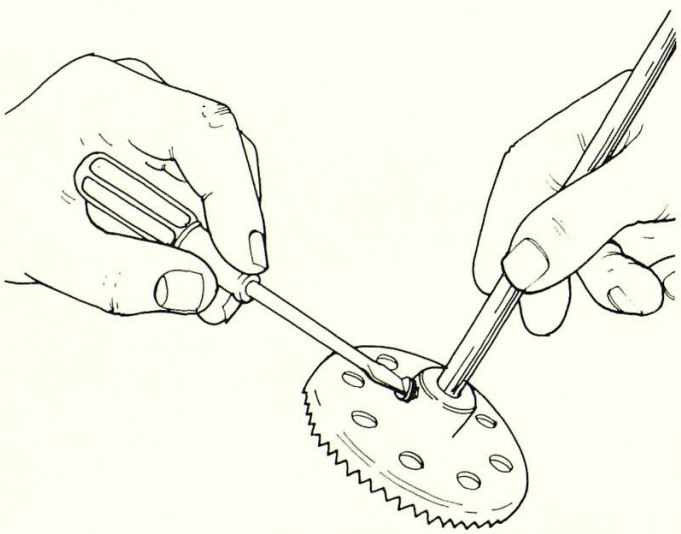
A Join 2 flat plates together at 3 corners. Do this by screwing 3 double angle strips to the flat plates on the **inside.**



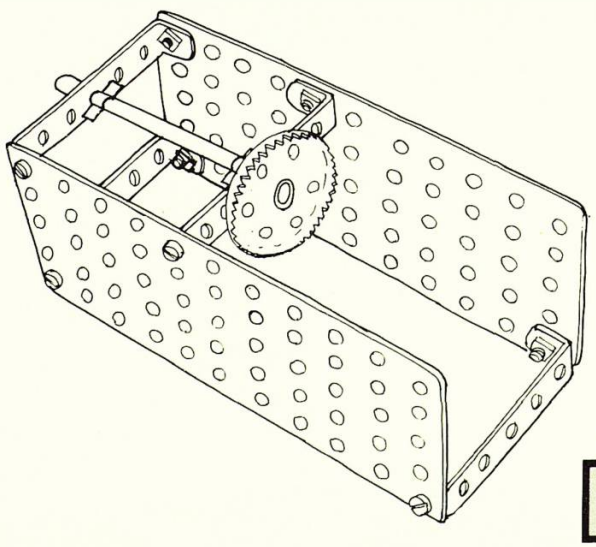
B Screw a fourth double angle strip in the position shown.



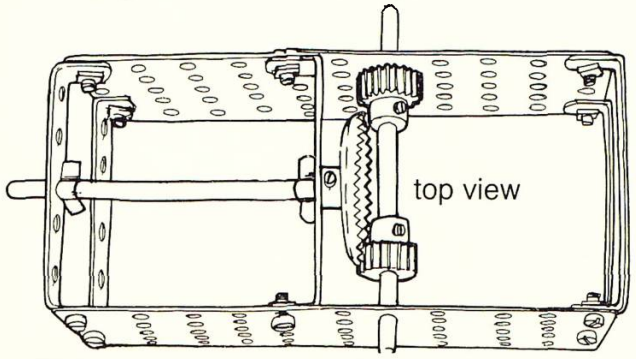
C Screw a 38 mm contrate gear to the end of an axle rod.



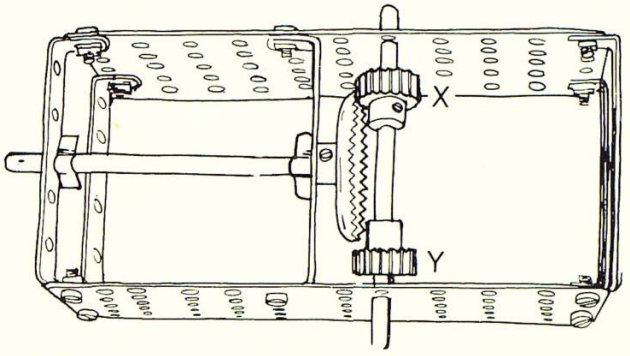
D Slide the contrate gear into the box as shown. Use 2 spring clips to hold it in place.



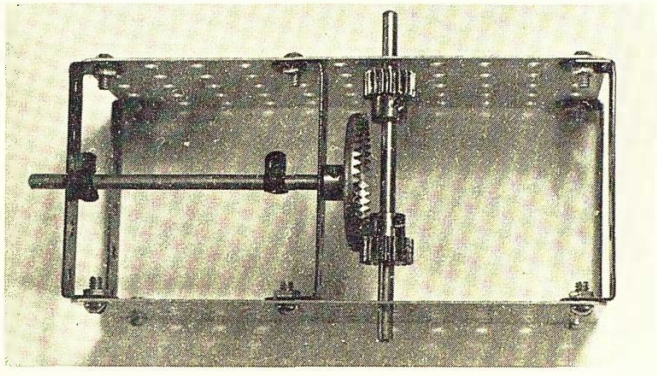
E Slide two 12 mm spur gears onto another axle. Slide the axle across the box so the spur gears can engage with the contrate gear.



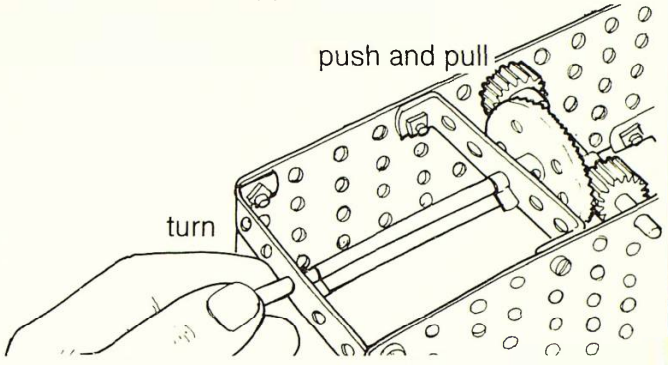
F Tighten the screws on the spur gears so that one gear (X) engages but the other does not.



G Make sure the other spur gear (Y) can be engaged by sliding the axle across.



H Turn the contrate gear one way only. Change gear from X to Y by pushing and pulling the axle rod. Watch what happens.



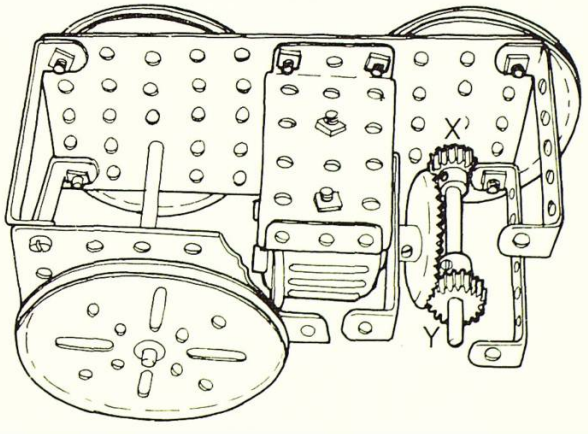
Q1 Make a drawing of your model. Draw an arrow to show which way you turned the contrate gear. Draw arrows to show which way gears X and Y turned.

Q2 What is the gear ratio of X and the contrate gear?

Q3 What is the gear ratio of Y and the contrate gear?

Q4 In this diagram, the contrate gear is driven by a motor and the other axle is attached to the wheels. What would happen to the movement of the vehicle if the spur gear is changed from X to Y?

(One wheel and part of side removed to show gears)



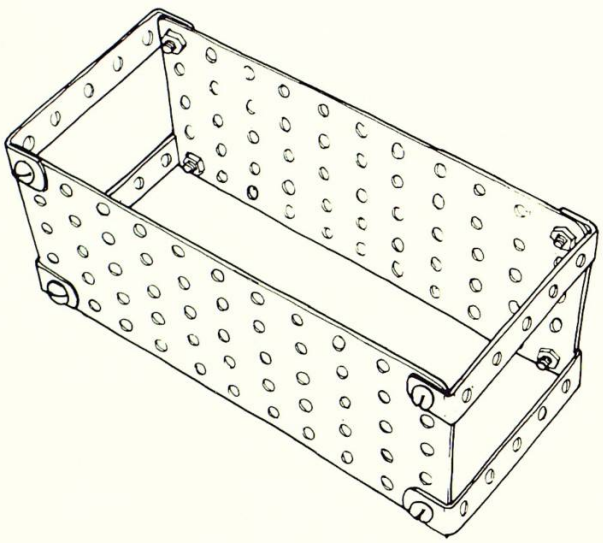
Investigating helical gears

Apparatus

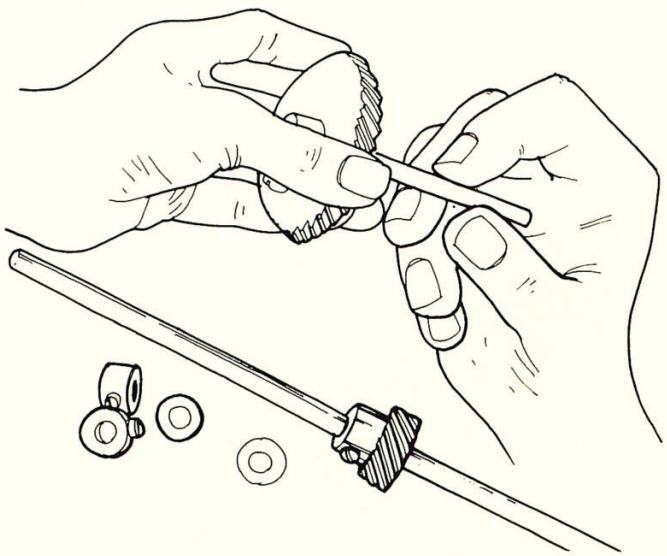
★ 2 flat plates ★ 4 double angle strips ★ 165 mm axle rod ★ 90 mm axle rod
★ 12 mm helical gear ★ 38 mm helical gear ★ 4 collars ★ nuts and bolts
★ spanner ★ screwdriver

You are going to find out how helical gears work.

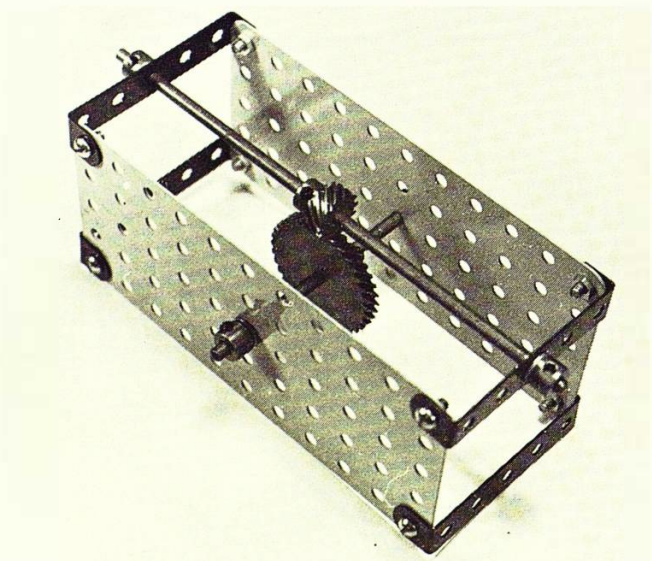
A Make a box, as shown.



B Slide a 12 mm helical gear onto an axle. Slide a 38 mm helical gear onto another axle.



C Turn the gears through a 90° angle and fix into the box as shown. Turn the axles.

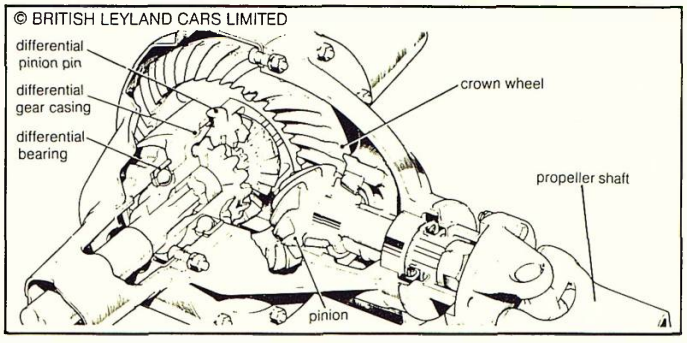


Q5 Which of the 2 helical gears turns more easily, the small one or the large one?

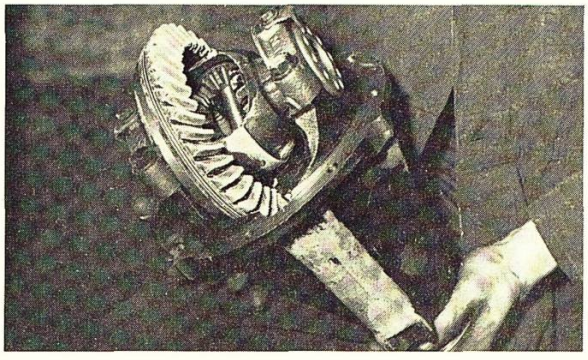
Q6 What is the gear ratio of the model?

Information: Contrate and helical gears

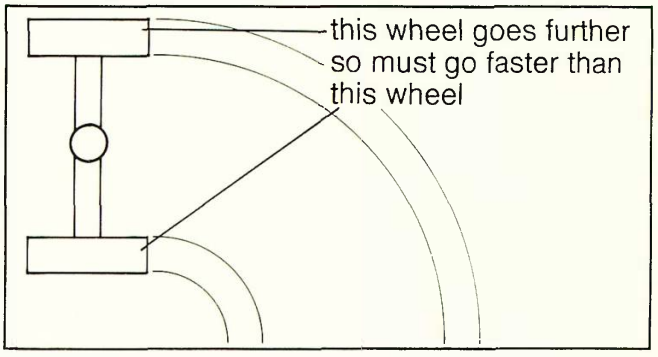
The differential



A contrate gear is also known as a **crown** gear. There is a crown gear called a **crown wheel** inside the **differential** of a car. The crown wheel is driven by a smaller gear called a pinion. The pinion is turned by the **propeller shaft.** The propeller shaft is connected to the gearbox.

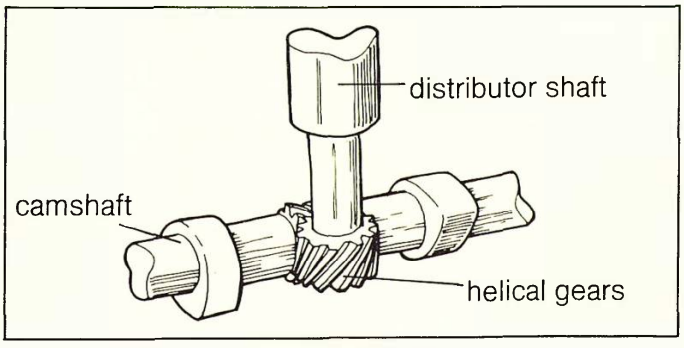


The differential gearing system lets one back wheel turn faster than the other as the car goes round a bend.



This system works on a bend of up to a 90° angle. There is a great deal of friction between the gears. The differential is filled with oil to reduce the friction.

The distributor drive



The **distributor** in a car is driven by the camshaft. The distributor drive shaft in this car is at a 90° angle to the camshaft. The helically cut gears have a ratio of 1:1.

Q7 Where would you find helical gears in a modern car?

Q8 What might happen if there was no oil in the differential?

Q9 The gear on the end of a distributor drive has 14 teeth. How many teeth would there be on the camshaft gear which drives it?

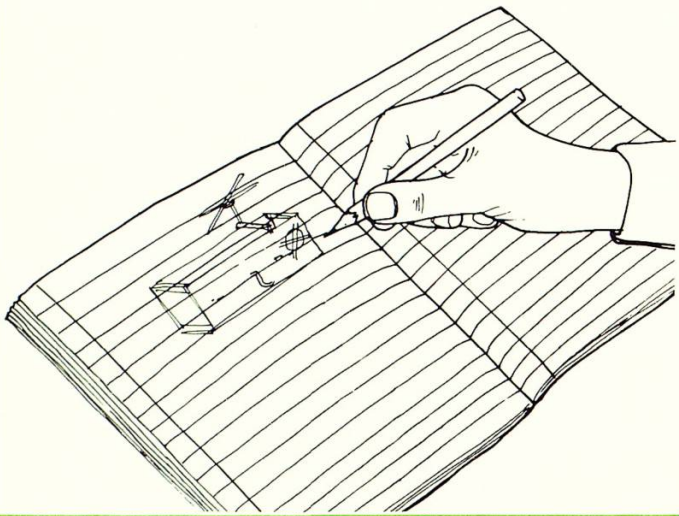
Project: Designing and making a model helicopter

Apparatus

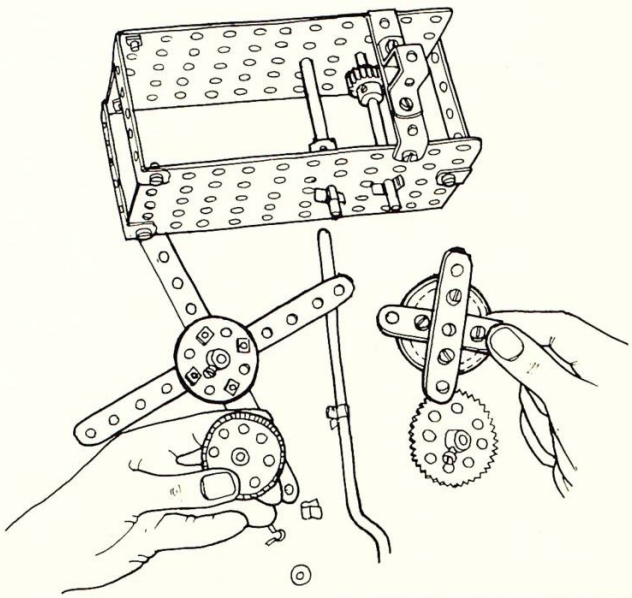
★ Meccano parts ★ contrate or helical gears ★ spur gears ★ nuts and bolts
★ spanner ★ screwdriver

You are going to design and make a model helicopter.

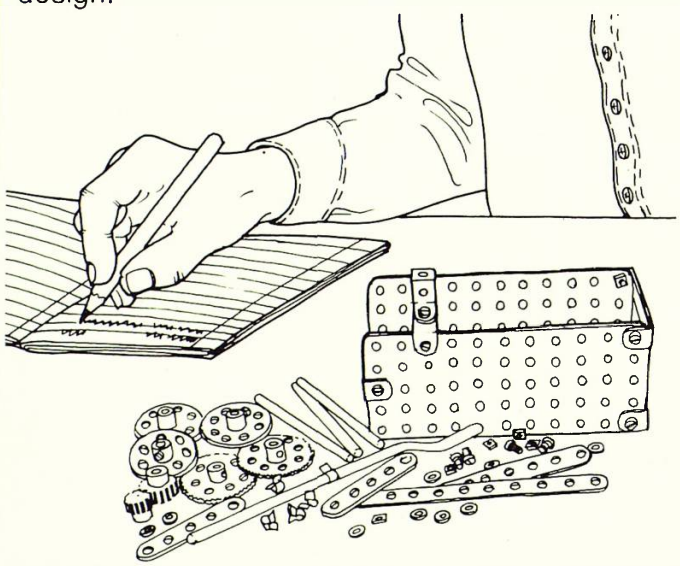
A Design a simple model helicopter. The wheels should turn the rotor blades using gears. Pulleys could be used to make the rear propeller turn at the same time.



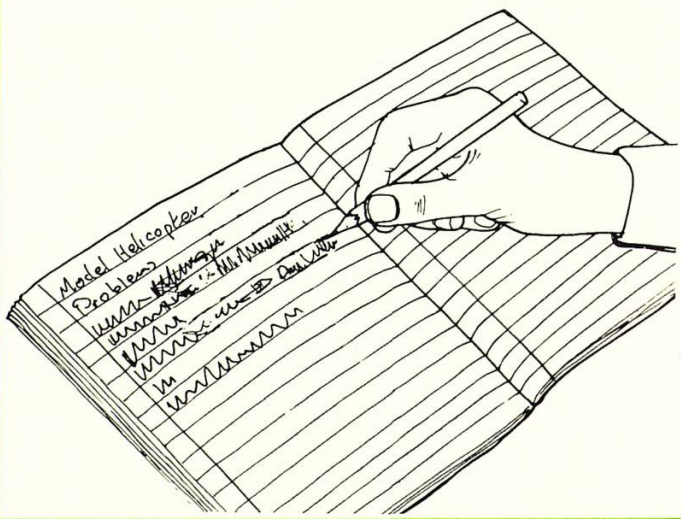
B Try to build your model.



C If the model does not work, change your design.



D Write down what problems you had and how you solved them.



Q10 Make a careful drawing of your model. Show all the gears and pulleys you used.

Q11 How could you make the rotor blades turn twice as fast as the ground wheels?

7 Cams

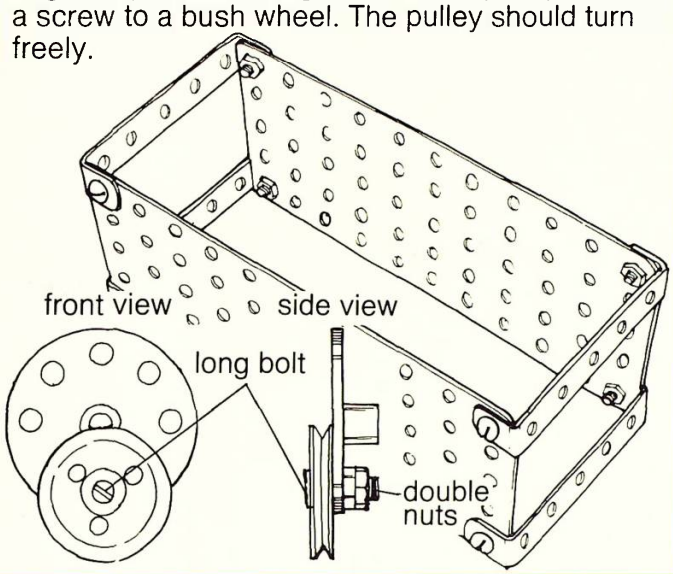
Investigating the action of a cam

Apparatus

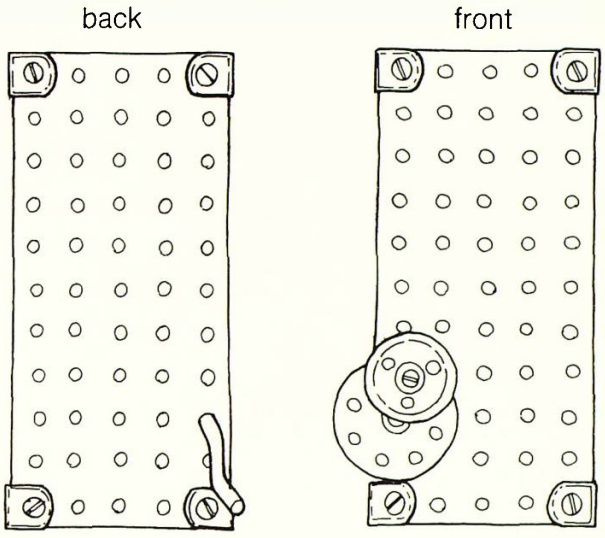
★ 2 flat plates ★ 4 double angle strips ★ double bracket ★ nuts and bolts
★ 14 cm perforated strip ★ rod and strip connector ★ two 9 cm axle rods
★ 13 cm crank handle ★ 34 mm bush wheel ★ 25 mm pulley with screw
★ 25 mm pulley without screw ★ 3 spring clips ★ two 15 mm bolts ★ ruler
★ 2 spanners ★ screwdriver ★ small rubber band ★ washers

You are going to find out how a cam works.

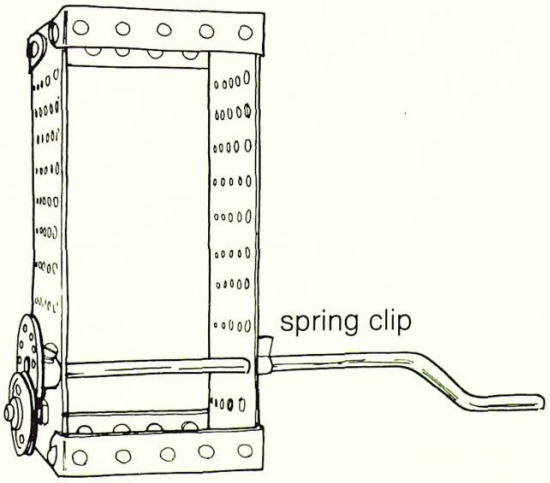
A Make a box with 2 flat plates and 4 double angle strips. With a long bolt, attach a pulley without a screw to a bush wheel. The pulley should turn freely.



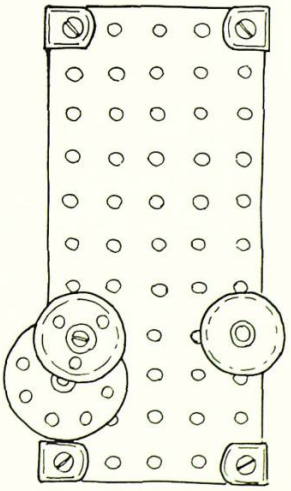
B Put a crank handle into the box. Screw the **cam** (bush wheel) to it.



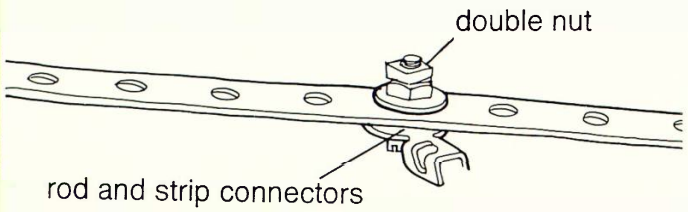
C Make sure the cam can be turned easily with the crank handle. Use a spring clip to hold the crank handle in place.



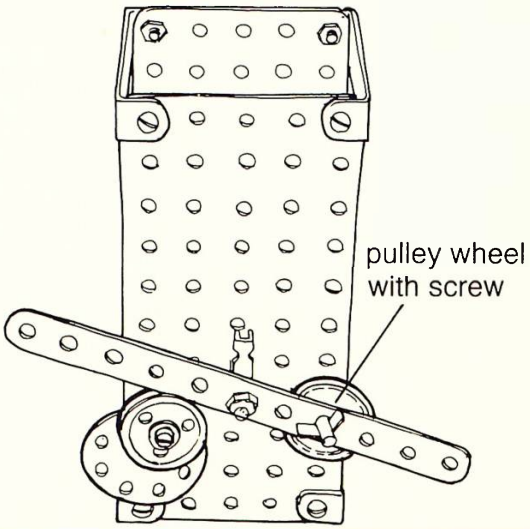
D Screw a pulley wheel with a screw to an axle. Put this into the box as shown. Hold it in place with a spring clip.



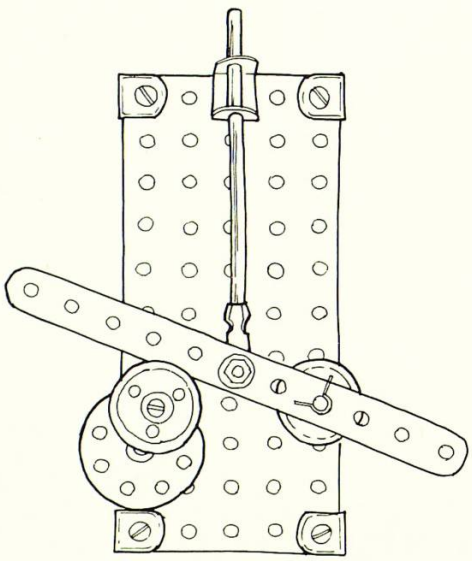
E Screw a rod and strip connector to a 14 cm perforated strip. Use a double nut so the connector is held loosely.



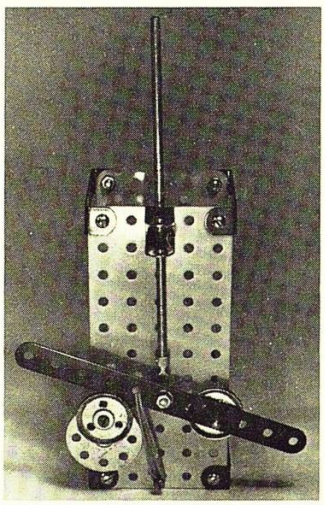
F Let the strip rest in the groove of the cam wheel. Attach the other end of the strip, through the 4th hole, to the axle. Hold in place with a spring clip.



G Fix a double bracket to the top of the box. Slide an axle through the bracket into the connector.



H Screw a long bolt with a washer on it into the box as shown. Put a rubber band through the perforated strip and attach it to the long bolt. Turn the crank handle.

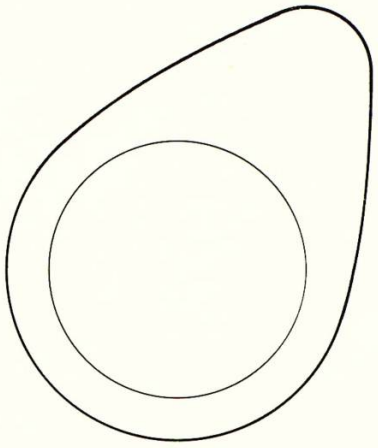


Q1 What happens to the **vertical** (upright) axle when you turn the handle?

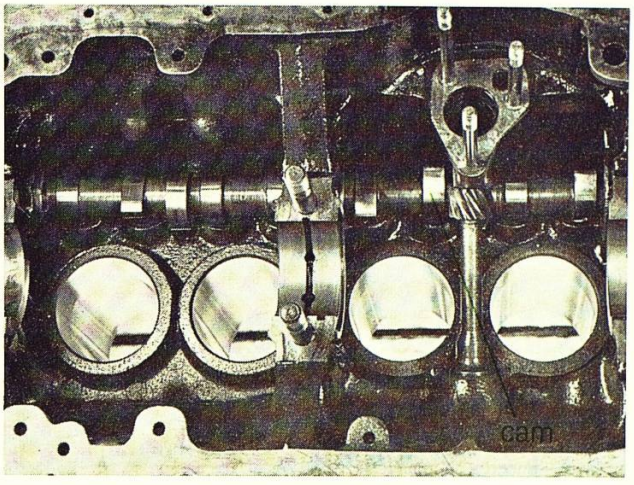
Q2 With a ruler, measure how far the vertical axle moves. Record the result in your book.

Q3 Do you think the vertical rod would move the same distance if it was attached to the last hole of the perforated strip?

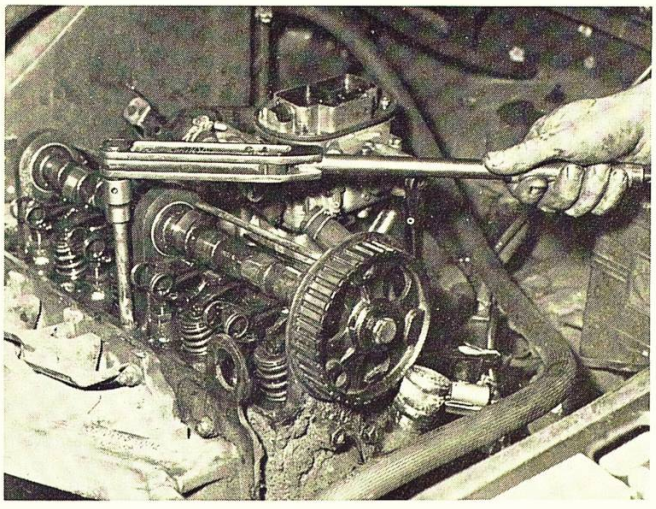
Information: Cams in a car engine



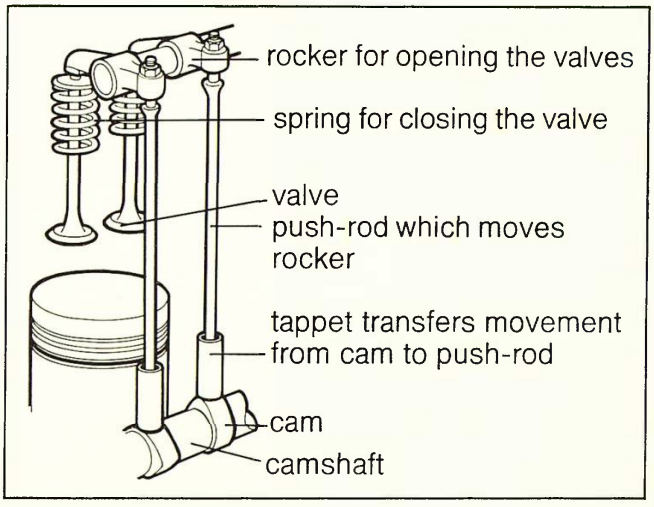
A cam is shaped like this. The shape is called **eccentric.** There are many cams in the engine of a modern car.



A 4-cylinder engine has 8 cams on a shaft known as a camshaft. The cams are solid and made in one piece with the shaft.



A camshaft is used to open the valves in a car's engine. Powerful springs close the valves. In some cars the camshaft is above the valves. This is known as an overhead camshaft.



Some cars have the camshaft under the valves. The action is like a see-saw. The cam pushes a rod up. The rod forces a rocker to push down onto the valve stem. This opens the valve.

Q4 How many cams are there on the camshaft of a 4-cylinder engine?

Q5 What does the valve spring do?

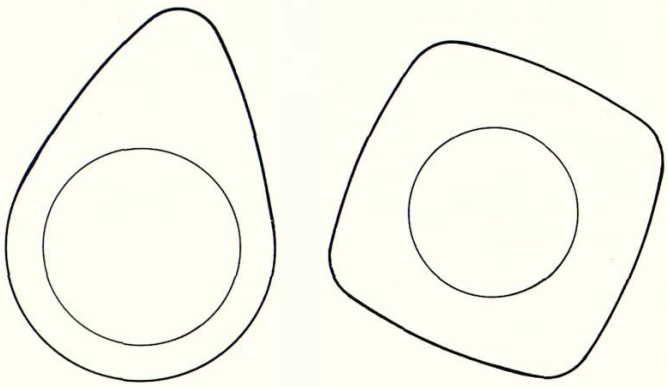
Q6 What is the name of the part of the engine which opens the valve by pushing down on it?

Cams

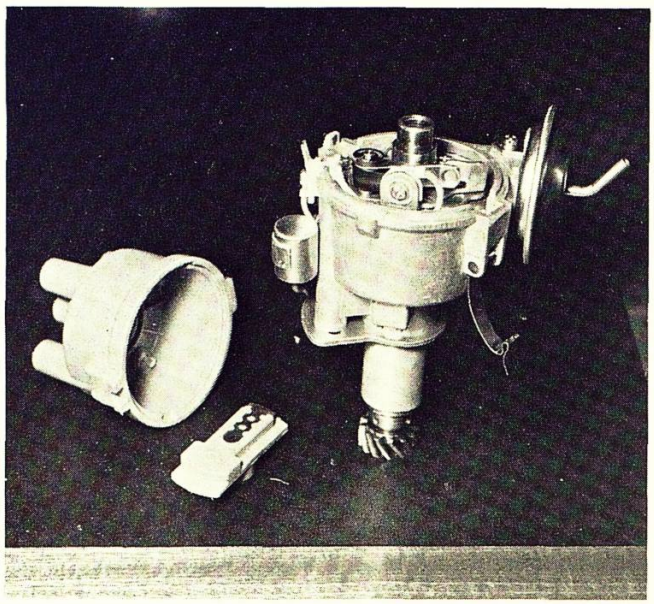
Information: The distributor cam

simple cam – 1 lobe

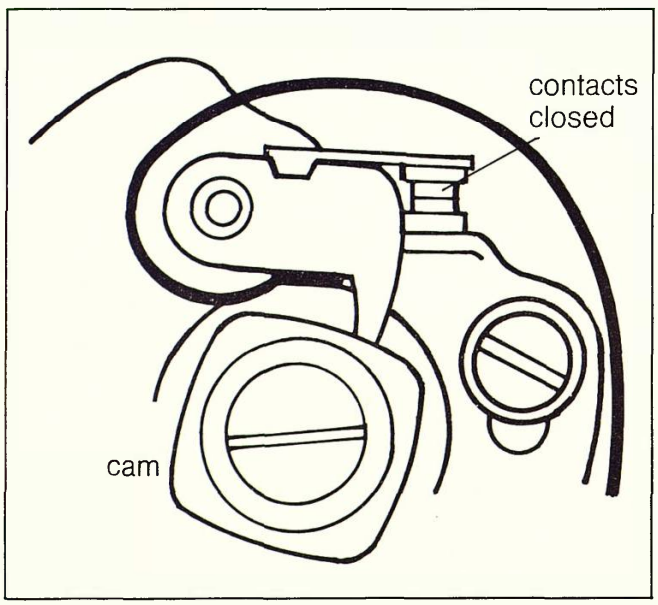
4 cylinder distributor cam – 4 lobes



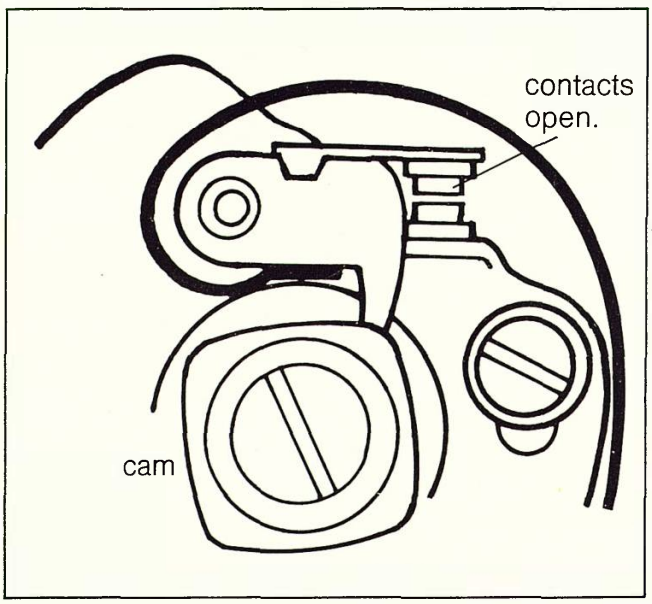
The cam in a distributor of a car is a different shape from a simple cam on a camshaft. It has 4 **lobes** on it. It has one lobe for each cylinder of the car's engine.



The cam in a distributor acts as a switch. It is used to open the **contact breakers.** When the car is moving it opens the contact breakers many times in one second.



The cam goes round and each lobe in turn pushes on the contact breaker. The contact breaker opens 4 times when the cam goes round once.



Every time the contacts open, the electricity stops flowing. This means a small, high voltage current is made in the **coil.** This current makes a spark in a **spark plug** which lights the fuel to make the car go.

Q7 How is a distributor cam different from a simple cam on a camshaft?

Q8 How many lobes would the distributor cam of an 8 cylinder car have?

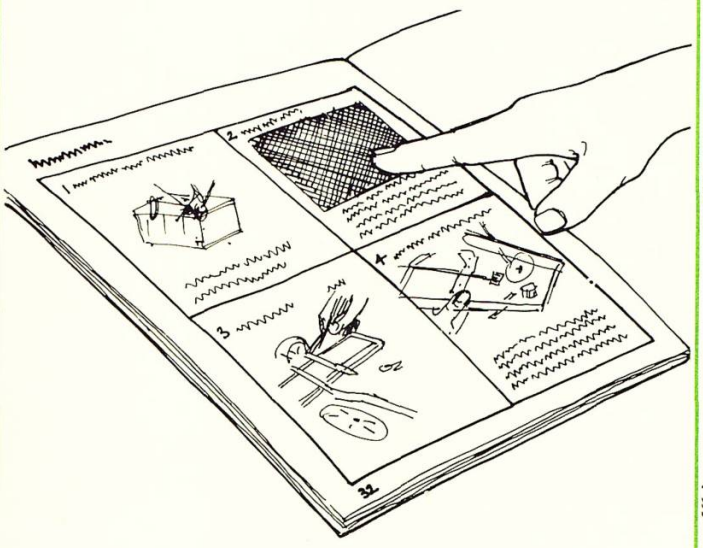
8 Design and build problems

Apparatus

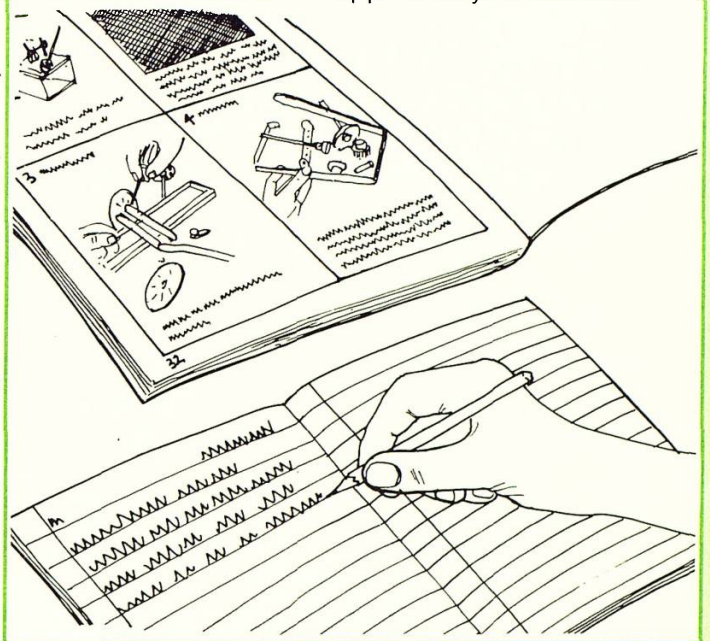
★ Meccano parts ★ nuts and bolts ★ spanner ★ screwdriver

Choose a gearing problem and try to solve it by making a working model.

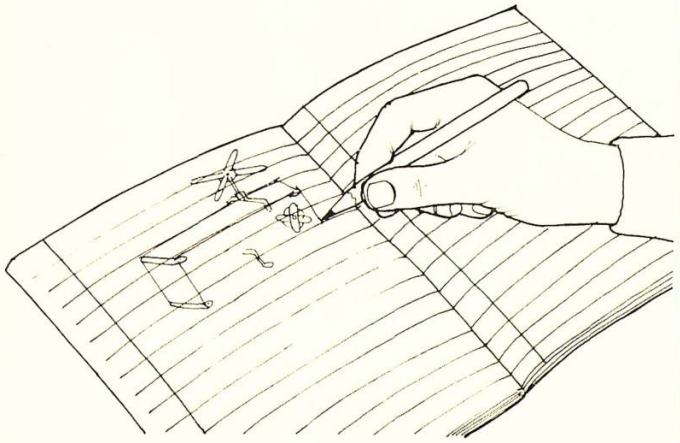
A Choose a problem from page 32.



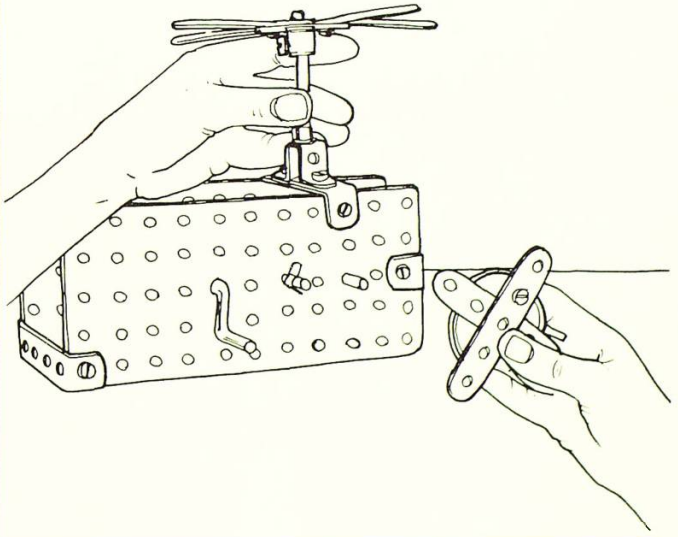
B Look at the problem. Think about how you will solve it. List all the apparatus you will need.



C Draw a diagram of the model you will make to solve the problem. Try to solve the problem by making the model.



D If the model does not work, change it. If it still does not work, try and make the model simpler.



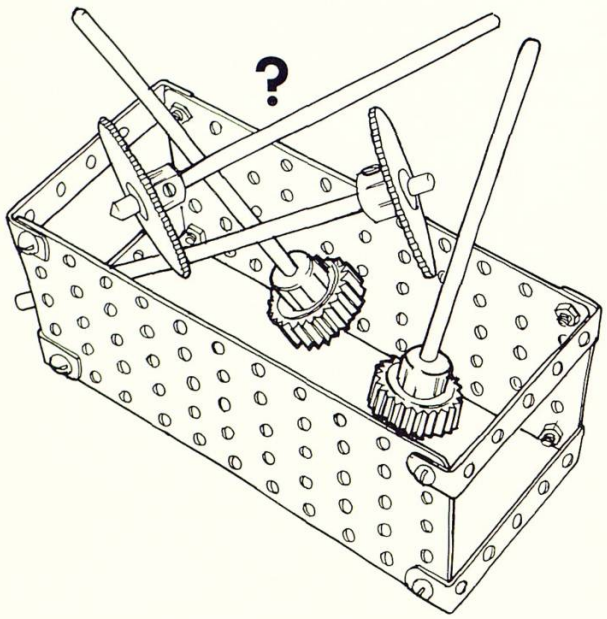
Q1 Write down any problems you had making your model.

Q2 Write down any changes you made to your model.

Design and build problems

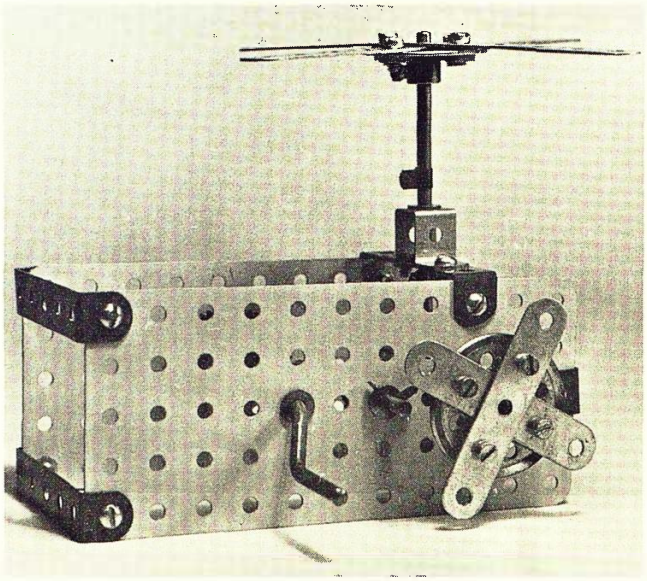
Choose your problem from those given below.

1 Maximum and minimum gear ratios.



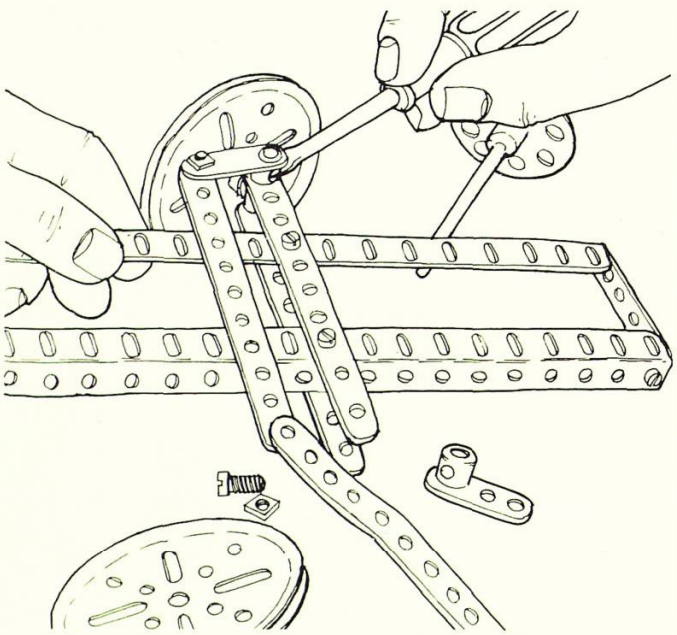
Choose 4 spur gears. Make a box to hold the gears in place. Use the gears to give the highest possible overall gear ratio. Then use the gears to give the lowest possible overall gear ratio.

2 Making a drive turn through 90° and 180°.



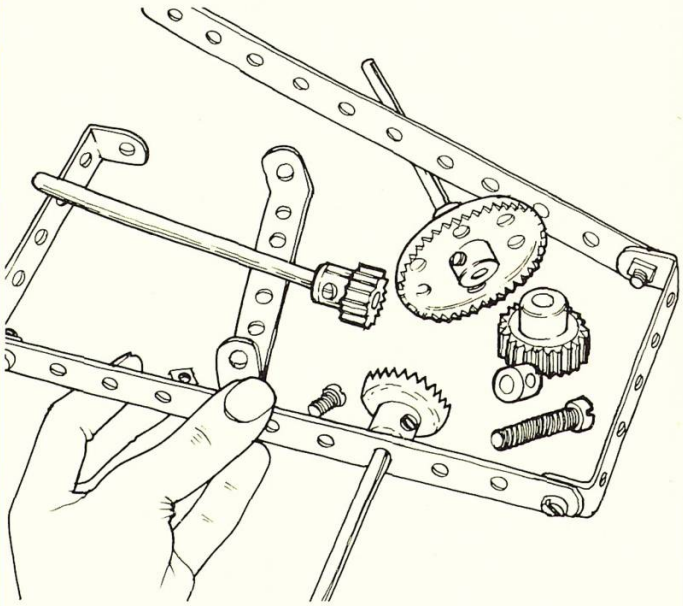
Make a gear system in a box to drive 2 fans at the same time. One fan should be next to the driven axle and turn the same way. The other fan should stick up in the air at 90° to the first axle.

3 A steering problem.



Make a vehicle with a steering wheel that turns the front wheels.

4 Differentials.



Look at the pictures of differentials on page 25. Try to make a model differential like them. When the propeller shaft is turned both wheels should go round. If one wheel is held still, the other wheel should go round when the propeller shaft turns.

Teachers' Guide to Gears and Gearing

SCIENCE AT WORK

Introduction

The units

Science at Work is a series of 18 science units for 14-16 year old, less able pupils. Each unit consists of a pupils' book and a teachers' guide. Each provides a complete half-term's course of study. The units are self-contained, and can be taken in any order.

The pupils' books

The pupils' books provide information, practical investigations and questions. Pupils are thus able to work from the books at their own pace; generally, the work becomes more difficult towards the end of each book and the weakest pupils are not expected to finish every unit. The material has been checked by a language specialist, who has ensured that the reading level is as low as possible.

INVESTIGATIONS

Each investigation begins with a list of the apparatus required. The purpose is then stated, and instructions for the investigation given (in words and pictures). Finally, the pupils are asked questions which help them record their results and draw conclusions. (Throughout the books a pupil is expected to make a written response each time a 'Q' appears.)

INFORMATION

Appropriate information from the real world follows most investigations, in most cases from the world of work. Questions are also asked about these information sections.

The teachers' guides

Each unit has a teachers' guide. This contains record sheets and information for the teacher.

RECORD SHEETS

Record sheets in the form of masters are provided in each guide. These sheets will save pupils copying tables, and will help them write answers to questions as complete sentences. One record sheet is provided for each chapter of the pupils' book. Teachers may decide to give record sheets only to those pupils who have difficulty with writing; alternatively, they may be given to all pupils.

OTHER RESOURCES FOR THE TEACHER

Each teachers' guide contains:
course and unit objectives
hints on introducing and teaching the unit
an apparatus list (for technicians)
safety procedures
new scientific words (which pupils may have difficulty reading)
answers to questions in the pupils' book
a resource list.
Specimen questions for a post-unit test are also included.

Examining the course

Science at Work is derived from a successful and well-proven modular scheme developed by teachers in Manchester LEA. Most of the pupils following the course in Manchester gain a CSE Mode III certificate in science. A paper giving information on CSE Mode III construction for this course is available from Addison-Wesley.

Aims of the course

1. To provide a flexible science course based on non-sequential study units. Though developed predominantly for less able pupils, the course can cater for pupils capable of CSE grade I by the addition of suitable extension work.
2. To develop pupils' thinking in scientific methodology and the approach to problem solving.
3. To give knowledge and understanding of science relevant to pupils' interests, environment, and future work and leisure needs.
4. To develop pupils' interest in science and enjoyment of science.
5. To provide a wide range of practical experiences and develop practical skills.
6. To develop the ability to work both independently and as a member of a team.

General objectives of the course

1. To develop the ability to carry out experimental procedures and written work according to instructions.
2. To develop manipulative skill in handling equipment and an awareness of safe practice.
3. To develop powers of accurate observation.
4. To develop the ability to check statements and assertions against tests of observation and experiment.
5. To develop skill in handling the interpretation of data.
6. To develop the ability to look for and make generalisations (this objective is likely to be achieved by only the ablest pupils).
7. To be able to understand and recall the factual content of the material.
8. To develop communication skills—verbal, written, and mathematical.
9. To develop the ability to apply knowledge gained.
10. To encourage pride in neatly and accurately produced work.
11. To develop awareness of the responsible use of science and technology.

Objectives of the Gears and Gearing unit

When they have completed this unit, the pupils will have practised the following skills:

using Meccano to construct models from written instructions and diagrams

using Meccano to construct models from the pupils' own designs

making Meccano models to investigate how chain drives, belt drives, spur gears, compound gear systems, worm and pinion gears, contrate and helical gears, and cams work

using Meccano models to understand gear ratios

the recording of observations in table form.

In their work on *Gears and Gearing* pupils will find out:

the relevant terminology associated with gears and gearing

the way that gear systems are applied in some common machines

the function and different uses of chain drives, belt drives, spur gears, compound gear systems, worm and pinion gears, contrate and helical gears, and cams

what gear ratios are and how to find them

how to apply the concept of gear ratios in solving problems.

Teaching the Gears and Gearing unit

Introducing the unit

It is suggested that the unit be introduced with an exhibition of gears from the following list: car, motorcycle, bicycle, vacuum cleaner, food blender, watch, clock, sewing machine. The unit has both structured experiments (where the pupils follow the instructions, then make measurements and answer questions) and open-ended "design and make" experiments. Since the main aim of the unit is to develop an understanding of the importance and application of gear systems these admittedly more difficult exercises are a crucial part of the unit.

Teaching the unit

The pupils' book contains 8 chapters. Most chapters have practical and information sections. There are sequential questions within each chapter: these indicate when a student has to write in a notebook. For slow readers and writers, there are record sheets to each chapter. The record sheets are copyright free and are contained within this teachers' guide (pages 7-15).

Samples of the type of questions that may be used for assessment when pupils have completed the unit are on page 16.

Equipment

3 kits are available to accompany this unit. Kit A contains enough Meccano for 3 groups, each working on a different chapter of the pupils' book.

If the projects on pages 3, 8 or 20-21 of the pupils' book are attempted, each working group will need Kit B (motor and leads). This motor works from a PP9 battery or a 12 V battery. Alternatively, pupils may use Kit C (transformer and plugs) to power the motor.

Science at Work Gears and Gearing Kits A, B and C are available from: Economatics, 411 Petre Street, Sheffield S4 8LL, Tel: (0742) 611471. In cases of difficulty, kits may also be obtained from: Watford Mail Order Service, PO Box 118, Watford WD1 5AZ, Tel: (01) 428 7443.

Kit A contains:

14 perforated strips
2 angle girders
1 double bracket
6 axle rods
10 pulleys (various sizes)
1 crank handle
1 bush wheel 34 mm
4 pinions
1 gear wheel 32 mm
2 gear wheels 38 mm
1 contrate gear 38 mm
2 contrate gears 19 mm
1 worm gear
2 spanners
8 spring clips
1 screwdriver
51 bolts
50 nuts
16 washers
1 double bent strip
4 double angle strips
1 flanged plate
6 collars
2 cranks
1 coupling
2 flat plates
2 curved strips
1 chain
1 sprocket wheel 50 mm
1 sprocket wheel 25 mm
4 flat trunions
2 pivot bolts
5 driving bands
2 helical gears
1 rod & strip connector

Detailed teaching notes

1 CHAIN DRIVES

MAKING AND INVESTIGATING A CHAIN DRIVE (pupils' book page 1)

Apparatus: 2 flat plates; 4 double angle strips; 2 axle rods and collars; 25 mm sprocket gear; 50 mm sprocket gear; length of chain; spanner, screwdriver; nuts and bolts
New Words: investigating, axle, sprocket, gear ratio, crankshaft, camshaft

The box is the basis of many of the experiments and could therefore be made and kept if there is enough Meccano and storage space.

PROJECT: DESIGNING AND MAKING A CHAIN-DRIVEN VEHICLE (pupils' book page 3)

Apparatus: Meccano parts; electric motor; power supply (dry cell batteries); length of chain, spanner, screwdriver, nuts and bolts
New Words: design, vehicle

The idea of the "design and make" projects is to encourage the pupils to plan and to link theory with practice. They should be encouraged to make a detailed design and to think of the problems in advance. The idea provided in step C is for those who find the exercise difficult–others should be encouraged to make an original design.

Q6 A smaller sprocket provides better 'leverage' (ie the motor turns the wheels more easily).

Q7 Yes–put the motor into reverse.

2 BELT DRIVES

MAKING AND INVESTIGATING A BELT DRIVE (pupils' book page 4)

Apparatus: 2 flat plates; 4 double angle strips; 4 different pulleys, labelled W, X, Y and Z; 2 axle rods with collars; drive belt; spanner; screwdriver; nuts and bolts; ruler
New Words: pulley, diameter, machinery, vacuum, shaft, dynamo, generator

The experiment is straightforward, the measurement is not necessarily so. Check that the pupils know what a diameter is. It is unlikely that the ratio of diameters will correspond exactly with the ratio of numbers of turns in this experiment. Alert pupils will ask how to take account of the thickness of the drive belt when measuring the diameters.

Q3 Clockwise.

Q5 The larger the diameter of the pulleys X, Y and Z, the slower they turn. The number of turns pulleys X, Y and Z make when being driven by W depends on the ratio of W:X, W:Y and W:Z.

Q7 Small pulley turns faster.

Q8 Advantages: slip when overheated rather than breaking, cheap, fairly quiet, no lubrication, flexible, etc.
Disadvantages: not as strong as chains, slip, stretch, etc.

PROJECT: DESIGNING AND MAKING A MODEL WINDMILL (pupils' book page 8)

Apparatus: Meccano parts; electric motor; power supply (dry cell batteries); pulleys; spanner; screwdriver; nuts and bolts
New Words: windmill, follower

Assuming the pupils have learnt how to go about "designing and making", this exercise is more open-ended. They are expected to realise that the relative diameters of the pulleys involved will determine how slowly the sails will turn.

Q12 Use pulleys with the same diameter.

Q13 Change the belt drive to a figure 8 rather than a simple loop.

Q14 4:1.

Q15 4:1.

Q17 5:2, 2:1, 1:4, 12:5.

3 SPUR GEARS

INVESTIGATING SPUR GEARS (pupils' book page 11)

Apparatus: 2 flat plates; 4 double angle strips; 2 axle rods and spring clips; 4 spur gears: W = 12 mm, X = 38 mm, Y = 17 mm, Z = 32 mm; spanner; screwdriver; nuts and bolts
New Words: mesh, sluice gate, cereal, starter motor, flywheel

Not all the combinations of spur gears will mesh using the box in step A. The experiment assumes the information on gear ratios has been understood–the information should be to hand.

Q2 W:X = 1:3, Y:Z = 1:2.
Q3 3:1 or 1:3.
Q4 Disadvantages: only works on a windy day–needs a lot of wind for small movement.
Q5 Less easily.

4 COMPOUND SPUR GEARS

MAKING AND INVESTIGATING A COMPOUND GEARING SYSTEM (pupils' book page 13)

Apparatus: 2 flat plates; 4 double angle strips; 3 axle rods; 6 collars with screws; 4 spur gears: W = 12 mm, X = 38 mm, Y = 17 mm, Z = 32 mm; spanner, screwdriver; nuts and bolts
New Words: compound, overall

The "gearbox" is sometimes stiff if the box is not correctly made.

Q1 Gear Y should turn twice when gear Z is turned once.
Q2 Gear W should turn 3 times when gear X is turned once.
Q3 Gear W should turn 6 times when gear Z is turned once.

FINDING GEAR RATIOS (pupils' book page 15)

Apparatus: 2 flat plates; 4 double angle strips; 3 axle rods and collars; 12 mm spur gear; 32 mm spur gear; two 38 mm spur gears; spanner; screwdriver; nuts and bolts
New Words: idler, jewel, rubies, clutch, helical

It should be explained to the pupils that the gears will only mesh if the models are made in the way the diagrams indicate.

Q7 57:50 or 1.14:1.
Q8 1:1.
Q9 50:19 or 2.63:1.
Q10 The idler gear reverses the direction of motion of the third gear in the train.
Q12 9:1.

5 WORM GEARS

INVESTIGATING THE WORM AND PINION (pupils' book page 17)

Apparatus: 2 flat plates; 4 double angle strips; 38 mm spur gear; worm gear; 165 mm axle rod; 90 mm axle rod; 4 collars; spanner; screwdriver; nuts and bolts
New Words: worm gear, pinion, jack, peg, rack, nut, friction, ball bearings

The pupils may have experienced stiffness in their spur and compound gear models and may try to force the pinion to turn the worm following the instruction in step D to turn the axles. Beware–adolescent brute force = broken apparatus!

Q2 57 teeth on 38 mm spur gear.
Q3 As many times as there are teeth on the pinion gear.
Q5 1 tooth.
Q6 1:57 or 57:1.
Q7 The worm.
Q8 28:1.

PROJECT: DESIGNING AND MAKING A VEHICLE WITH WORM AND PINION GEARING (pupils' book page 20)

Apparatus: flanged plate; 4 flat trunions; worm gear; spur gears; 3 axle rods; collar; 2 long angle girders; 3 double angle strips; 4 large wheels; electric motor and power supply; spanner; screwdriver; nuts and bolts
New Words: trunion, flanged plate

This experiment starts with the basic design and allows the pupils to finish it. The apparatus list implies the sort of design which will work but inventive pupils should be encouraged to make their own versions and to modify the basic design if necessary.

6 CONTRATE AND HELICAL GEARS

INVESTIGATING CONTRATE GEARS (pupils' book page 22)

Apparatus: 2 flat plates; 4 double angle strips; 2 axle rods and spring clips; two 12 mm spur gears; 38 mm contrate gear; spanner; screwdriver; nuts and bolts
New Words: contrate, engage

Emphasise to pupils that although, at first glance, the box looks the same as in previous experiments–it isn't. The brackets fit inside the box. The spur gears must be fitted carefully so that when one is engaged, the other isn't.
Q2 3:1.
Q3 3:1.
Q4 The motion is reversed.

INVESTIGATING HELICAL GEARS (pupils' book page 24)

Apparatus: 2 flat plates; 4 double angle strips; 165 mm axle rod; 90 mm axle rod; 12 mm helical gear; 38 mm helical gear; 4 collars; spanner; screwdriver; nuts and bolts
New Words: differential, crown, propellor shaft, distributor

Many pupils who have successfully completed other experiments will finish this experiment quickly and more work may be needed for a double lesson for them.
Q5 Should be the small one.
Q6 5:2.
Q7 In the gear box or on the distributor drive shaft.
Q8 It would get hot and the gear wheels might sieze up.
Q9 14 (gear ratio 1:1).

PROJECT: DESIGNING AND MAKING A MODEL HELICOPTER (pupils' book page 26)

Apparatus: Meccano parts; contrate or helical gears; spur gears; spanner; screwdriver; nuts and bolts
New Words: helicopter, rotor blades

In this experiment, gears, pulleys or chain drives could be used to solve the problems posed. A wide variety of gears and Meccano parts needs to be available if the open-ended instructions are to be followed by the pupils. The illustrations in the pupils' book shows a helicopter made with a simple box. However, it is possible to make a model which resembles a real helicopter.
Q11 By using a gear ratio of 2:1.

7 CAMS

INVESTIGATING THE ACTION OF A CAM
(pupils' book page 27)

Apparatus: 2 flat plates; 4 double angle strips; double bracket; 14 cm perforated strip; rod and strip connector; two 9 cm axle rods; 13 cm crank handle; 34 mm bush wheel; 25 mm pulley with screw; 25 mm pulley without screw; 3 spring clips; two 15 mm bolts; ruler; small rubber band; washers; 2 spanners; screwdriver; nuts and bolts
New Words: cam, crank handle, bush wheel, perforated, washer, vertical, lobe, rocker, contact breaker, coil, spark plug

The cam in the model does not look like a real cam. The two pulleys bolted together **do**, however, behave like a cam. Point out the difference to pupils between a real cam and the model.

Q1 Goes up and down.

Q3 No–it would move up and down, but it would move through a greater distance.

8 DESIGN AND BUILD PROBLEMS

(pupils' book page 31)

Apparatus: Meccano parts; spanner; screwdriver; nuts and bolts

These problems are supposed to be difficult. If there are pupils who are still having difficulty with the open-ended "design and make" experiments, then they should be helped with suggestions for models, or allowed to look at models in a Meccano book.

Reference books

AA Book of the car, Readers Digest
Various car workshop manuals

1 Chain drives

MAKING AND INVESTIGATING A CHAIN DRIVE (page 1)

Q1 The axle of the *small gear/large gear* is easier to turn.

Q2 The axle of the *small gear/large gear* turns faster.

Q3 To make the large gear go round once I have to turn the axle of the small gear ..... times.

PROJECT: DESIGNING AND MAKING A CHAIN-DRIVEN VEHICLE (page 3)

Q4 I designed and made my model in this way: .....

.....

.....

The parts I needed were: .....

.....

I had to make these changes: .....

Q5 Make a drawing of your model on the back of this sheet.

Q6 It is better to have the smaller sprocket gear fixed to the motor because .....

.....

Q7 It *is/is not* possible to make the model go backwards.

2 Belt drives

MAKING AND INVESTIGATING A BELT DRIVE (page 4)

Q1

First pulley	Diameter of first pulley (mm)	No. of times first pulley is turned	Second pulley	Diameter of second pulley (mm)	No. of times second pulley turns
W		10	X		
Y		10	Z		
W		10	Z		
W		10	Y		
X		10	Z		
Y		10	X		

Q2 If a large pulley is driven by a small one, the large pulley .....

.....

Q3 If I turn one pulley clockwise (↷), the other pulley turns .....

Q4 If pulley W had been turned 100 times, pulley X would turn ..... times.

Q5 When pulley W is turned the *larger/smaller* the diameter of pulleys X, Y and Z, the *faster/slower* they turn.

Q6

First pulley	Diameter of first pulley (mm)	No. of times first pulley is turned	Second pulley	Diameter of second pulley (mm)	No. of times second pulley turns
P	25	10	L		20
Q	10	10	M	50	

INFORMATION: BELT DRIVES IN MODERN MACHINES (page 6)

Q7 If the pulley turned by the engine of a car is smaller than the dynamo pulley, the pulley that will turn faster is .....

Q8 The advantages of belt drives are .....

.....

Q9 The disadvantages of belt drives are .....

.....

2 BELT DRIVES (CONTINUED)

PROJECT: DESIGNING AND MAKING A MODEL WINDMILL (page 8)

Q10 I designed and made my model in this way: .....

.....

.....

The parts I needed were: .....

.....

I had to make these changes: .....

Q11 Make a drawing of your model on the back of this sheet.

Q12 I could change my design to make the sails turn as fast as the pulley on the motor by .....

.....

Q13 To make the sails turn the other way I would change the drive by .....

INFORMATION: GEAR RATIOS IN CHAIN AND BELT DRIVES (page 9)

Q14 If sprocket X in the top diagram had 9 teeth, the gear ratio would be .....

Q15 If pulley A in the bottom diagram had a diameter of 9 mm, the gear ratio would be .....

Q16 Copy the diagrams of chain and belt drives onto the back of this sheet. Mark on each diagram the direction the follower wheel will turn.

Q17 The gear ratios for each diagram are:

diagram A ..... diagram B .....

diagram C ..... diagram D .....

3 Spur gears

INVESTIGATING SPUR GEARS (page 11)

Q1

Gear	No. of teeth on gear	No. of times the gear is turned	Gear	No. of teeth on gear	No. of turns the gear makes when the other is turned 10 times
W		10	X		
Y		10	Z		

Q2 The gear ratio of W:X is .....

The gear ratio of Y:Z is .....

Q3 The gear ratio of 2 spur gears with 15 and 45 teeth would be .....

INFORMATION: SPUR GEARS PAST AND PRESENT (page 12)

Q4 The disadvantages of a wind-powered machine are .....

Q5 If the gear ratio was less than 10:1 the starter motor would turn the engine *more/less* easily.

4 Compound spur gears

MAKING AND INVESTIGATING A COMPOUND GEARING SYSTEM (page 13)

Q1 When gear Z is turned once, gear Y turns . . . . . times.

Q2 When gear X is turned once, gear W turns . . . . . times.

Q3 When gear Z is turned once, gear W turns . . . . . times.

INFORMATION: GEAR RATIOS IN COMPOUND GEARS (page 14)

Q4 In a compound gear system where gear 1 has 10 teeth, gear 2 has 30 teeth, gear 3 has 20 teeth and gear 4 has 60 teeth, if gear 4 is turned once only, gear 1 would turn . . . . . times.

FINDING GEAR RATIOS (page 15)

Q5

Model	Coloured gear (mm)	No. of times coloured gear is turned	Gear with arrow (mm)	No. of times gear with arrow turns
A		10		
B		10		
C		10		

Q6 The gear ratio of model A is . . . . . .

Q7 The gear ratio of model B is . . . . . .

Q8 The gear ratio of model C is . . . . . .

Q9 The 12 mm gear in model B is known as an **idler** gear. The idler gear affects the way in which the last gear turns by . . . . . .

INFORMATION: COMPOUND SPUR GEARS IN ACTION (page 16)

Q10 Jewels are used in watches because . . . . . .

Q11 On the back of this sheet draw a diagram of 4 gears meshed together. Gear 1 = 10 teeth, gear 2 = 20 teeth, gear 3 = 30 teeth, gear 4 = 90 teeth.

The overall gear ratio is . . . . . .

5 Worm gears

INVESTIGATING THE WORM AND PINION (page 17)

Q1 On the back of this sheet make a drawing of your model. Put arrows on your drawing to show which way the gears turn. Label the worm and pinion (spur) gear.

Q2 There are . . . . . teeth on the pinion (spur) gear.

Q3 In order to make the pinion (spur) gear go round once, the worm gear must be turned . . . . . times.

Q4 The pinion (spur) gear *can/cannot* make the worm gear turn.

Q5 The worm gear has . . . . . teeth.

Q6 The gear ratio of the model is . . . . . .

INFORMATION: WORM GEARS IN CARS (page 18)

Q7 If a worm gear was attached to an electric motor the *worm/pinion* would turn faster.

Q8 If a pinion had 28 teeth, the gear ratio in a worm and pinion system would be . . . . . .

Q9 There has to be a push-pull mechanism attached to the pinion gear in a windscreen wiper because . . . .

. . . . . .

PROJECT: DESIGNING AND MAKING A VEHICLE WITH WORM AND PINION GEARING (page 20)

Q10 Make a drawing of your model on the back of this sheet.

Q11 I had these problems with my design: . . . . . .

. . . . . .

I solved the problems by: . . . . . .

. . . . . .

Q12 The overall gear ratio from the motor drive shaft to the rear axle is . . . . . .

6 Contrate and helical gears

INVESTIGATING CONTRATE GEARS (page 22)

Q1 On the back of this sheet, make a drawing of your model.
Draw an arrow to show which way you turned the contrate gear.
Draw arrows to show which way gears X and Y turned.

Q2 The gear ratio of X and the contrate gear was .....

Q3 The gear ratio of Y and the contrate gear was .....

Q4 In the diagram at the bottom of page 23, the contrate gear is driven by a motor and the other axle is attached to the wheels. If the spur gear is changed from X to Y, the effect on the movement of the vehicle would be .....

INVESTIGATING HELICAL GEARS (page 24)

Q5 The *small//large* helical gear turns more easily.

Q6 The gear ratio of the model is .....

INFORMATION: CONTRATE AND HELICAL GEARS (page 25)

Q7 In a modern car helical gears are found .....

Q8 If there was no oil in the differential this might cause .....

.....

Q9 If the gear on the end of a distributor drive has 14 teeth there would be ..... teeth on the camshaft which drives it.

PROJECT: DESIGNING AND MAKING A MODEL HELICOPTER (page 26)

Q10 On the back of this sheet, make a drawing of your model.

Q11 To make the rotor blades turn twice as fast as the ground wheels I would .....

.....

7 Cams

INVESTIGATING THE ACTION OF A CAM (page 27)

Q1 When I turn the handle it makes the vertical (upright) axle rod .....

Q2 The vertical axle rod moves ..... mm.

Q3 If the vertical rod was attached to the last hole of the perforated strip I *do/do not* think it would move the same distance.

INFORMATION: CAMS IN A CAR ENGINE (page 29)

Q4 There are ..... cams on the camshaft of a 4-cylinder engine.

Q5 The job of a valve spring is to .....

Q6 The part of the engine which opens the valve by pushing down on it is called the .....

INFORMATION: THE DISTRIBUTOR CAM (page 30)

Q7 A distributor cam is different from a simple cam because .....

.....

Q8 The cam of an 8-cylinder car would have ..... lobes.

8 Design and build problems

Page 31

Q1 The problems I had in making my model were .....

.....

.....

.....

Q2 The changes I made to my model were: .....

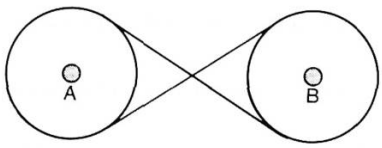
.....

.....

.....

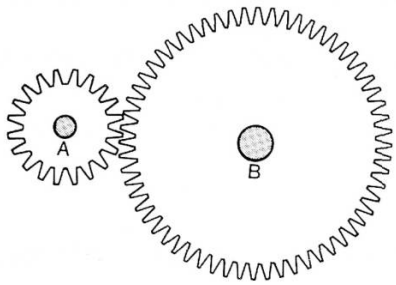
Specimen post-unit questions

1 In the diagram below, A is turning in an anticlockwise direction. Draw on B an arrow to show which way it is turning.



2 Why is a bicycle fitted with a chain drive and not a belt drive?

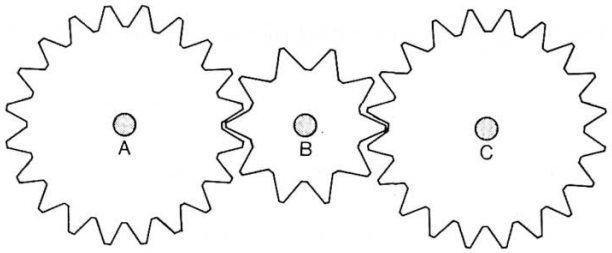
3 In the diagram below, gear A has 20 teeth and gear B has 60 teeth. How many times must A turn for B to turn once?



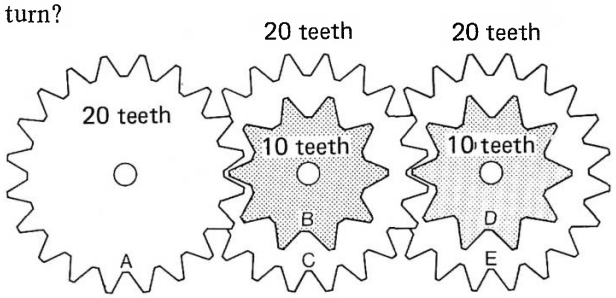
4 Which of these gears would you use on a motor car to climb a very steep hill? (Tick √ the right answer.)

a) 1st gear (3:1 ratio).
b) 2nd gear (2.2:1 ratio).
c) 3rd gear (1.5:1 ratio).
d) 4th gear (1:1 ratio).

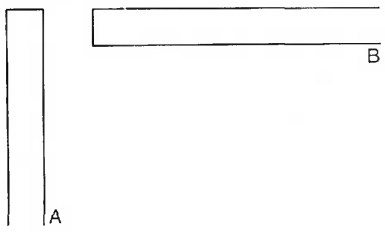
5 In the diagram below what is the name given to gear B? How does gear B affect the way in which gear A turns?



6 In the diagram below what is the gear ratio between gear A and gear E?
When gear A turns twice how many times does gear C turn?
When gear A turns once how many times does gear E turn?



7 Look at the diagram below. Draw a system of gears to join drive axle A to axle B.



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