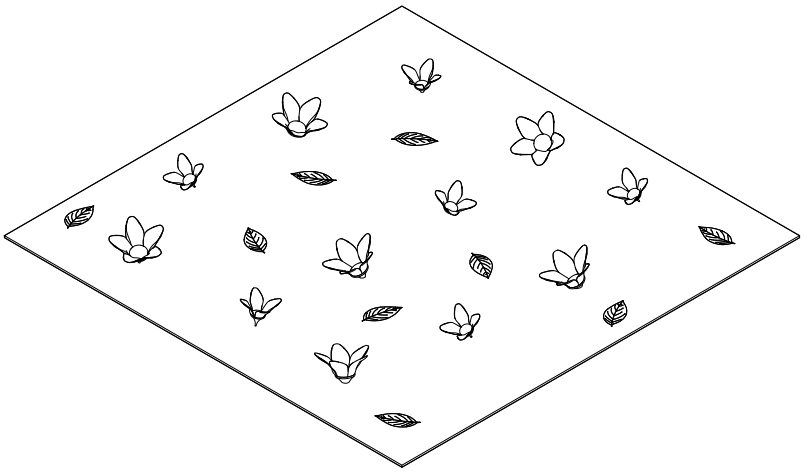


PAPER MANUFACTURING WORKSHEET

GETTING STARTED

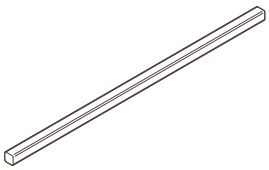
5-10m

Did you ever wonder where paper comes from? Most paper is made from cellulose fibres found in wood. All plants use the energy of the sun to make chemicals like sugars and complex carbohydrates. One of these complex carbohydrates is called 'cellulose'. Plants use cellulose to make their limbs and trunks strong and stiff. Without it, they would not be able to stand. Cellulose can be made into many different products like paper, cardboard, rayon fabric, and insulation.

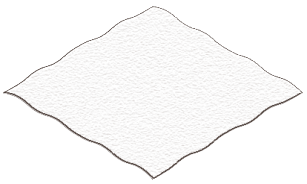
The average UK family throws away six trees-worth of paper in their household bin a year. Luckily, two-thirds of paper is recycled, making it one of the main materials recycled in the UK.

This session will show you how to take waste paper and turn it into a new and unique product to be used again.

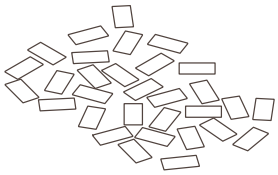
YOU WILL NEED



Balsa wood
8 lengths



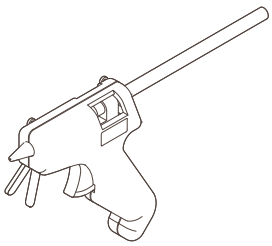
Muslin cloth
50x50cm



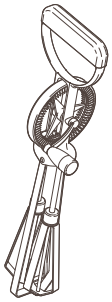
Shredded paper
4-5 A4 sheets

Food colouring or
natural dyes

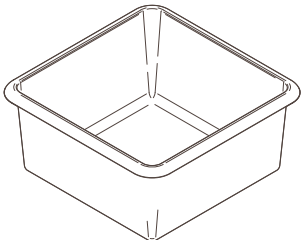
Decorative dried flowers,
leaves or seeds



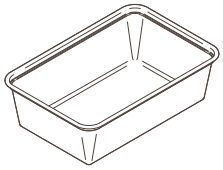
Glue gun
1



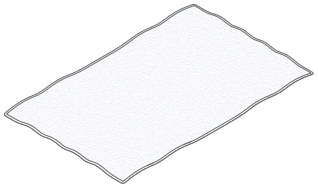
Rotary beater (whisk)
or blender
1



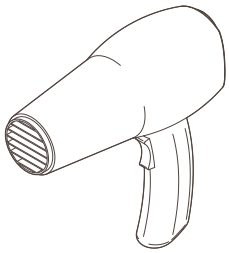
Washing up bowl or tray
1



Mixing bowl or container
1



Old towel
1



Hair dryer
1

DID YOU KNOW?

Many centuries ago – as early as the 3rd millennium BC – people in Egypt made a kind of paper from the papyrus plant. This is where the word 'paper' comes from. But it was later, in China 105 AD, that paper made from wood cellulose was first invented.

VOCABULARY

Cellulose - A chemical which makes up most of the cell wall of plant cells and keeps a plant in shape.

Solution - A special type of mixture where one substance is dissolved into another.

Gears - Mechanical parts with cut teeth designed to fit with teeth on another part so as to transmit or receive a force.

Drive Wheel - The toothed wheel causing other toothed wheels to rotate in a gear.

Bevel Pinion - The smaller of the two toothed wheels in a gear.

Hue - A colour or shade.

Filter - A device to remove unwanted material, similar to a sieve.

Evaporation - The change of state from liquid to gas.

Particle - Tiny bits of matter that make up everything in the universe.

WARM-UP ACTIVITIES

A

10-15m

Paper is the most recycled waste item in the UK. Different regions have different systems for how they recycle household waste. Do you know the procedures in your local area? Or how waste is recycled at your school?

Consider and investigate the following:

- How are different materials recycled where you live?
- Are there any materials that can not be recycled yet?
- What might happen to materials that are not recycled?

Thinking about where your waste goes will help you understand why recycling is so important.

B

20-30m

You can make your paper product unique by adding dyes and decorative details.

It is possible to create many different coloured dyes using natural products such as flowers, vegetables, seeds and spices.

Research and experiment with different options to see if you can create beautiful colours without the need for synthetic chemicals.

Decorative touches such as leaves, dried flowers and seeds can also be added to your paper products. So take some time outdoors to see what you can find to make your paper extra special.

MAIN CHALLENGE

3 x 30m sessions

Manufacturing your own paper is a great way to get you thinking about how to recycle your waste products.

We have provided you with instructions for making a simple sheet of paper. Before you begin you should decide on the different dyes and decorative additions you will use to make your paper product unique.

Once you have mastered this process you could try moulding the paper pulp into different shapes. For example, could you engineer a way to make paper cups or bowls?

Every time an engineer is faced with a problem, they approach it using the Engineering Design Process, shown here.

Ask - What is the problem?
Imagine - Choose a solution.
Plan - Design and choose materials.
Create - Make it.
Test - Test your creation.
Improve - Redesign as needed.

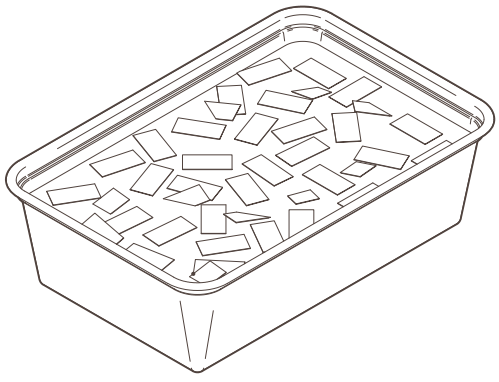
Using this design process, see if you can create strong and well-designed paper products. Good luck!

MANUFACTURING THE PAPER

Follow these steps to make your own recycled paper!

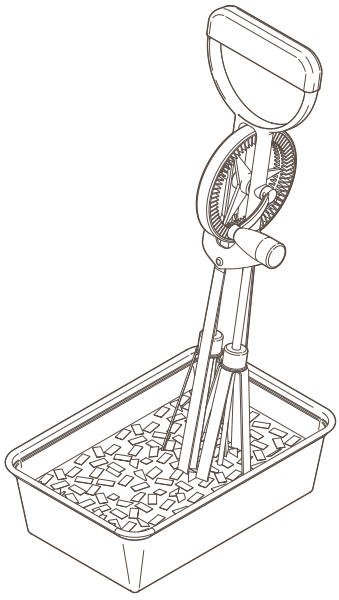
A

First, you need to turn the used paper you find in your house into paper pulp. Keep in mind that the colour of the papers you use and the amount of dark ink on the paper will affect the colour of the paper you create. Begin by shredding some paper (about 4-5 A4 sheets) into small pieces no larger than 1cm by 2cm. Then cover the shredded paper with warm water and leave to soak overnight. The warm water helps to soften the paper and begins to break down the cellulose fibres.



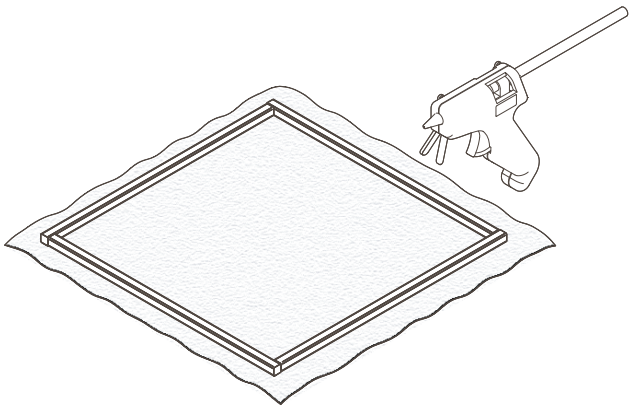
B

The following day, the shredded paper will be much softer. Now you can begin to break the fibres apart manually using a rotary beater. The rotary beater transfers the action of whisking into gears, which saves a lot of effort. Turning the handle cranks the large double-sided drive wheel which transmits the motion to the two smaller bevel pinions that spin the beaters much more quickly than you can turn the handle. Keep whisking the mixture until the pulp becomes smoother and there are no larger pieces of paper visible. By this point some of the paper particles have become so small they have formed a solution with the water.



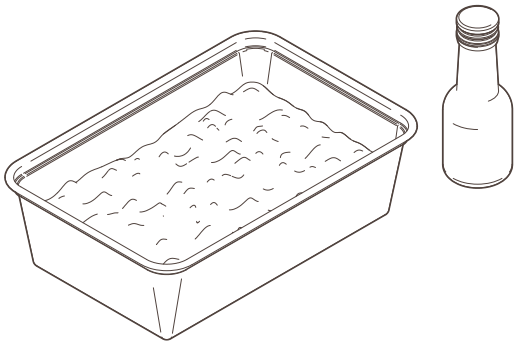
C

While the paper pulp is soaking, you can make your screen. First, you will need four lengths of balsa wood arranged into a square. Glue each corner with a hot glue gun so it creates a strong frame. Then take your muslin cloth and stretch it tightly over the frame. Glue it down securely on each side with the hot glue gun. Keeping the muslin stretched tightly over the frame is important if you want to create flat pieces of paper. Finally, glue another four pieces of balsa wood to the other side of the frame. This will give you a straight edge to push the pulp up to so you have a neat finished product.



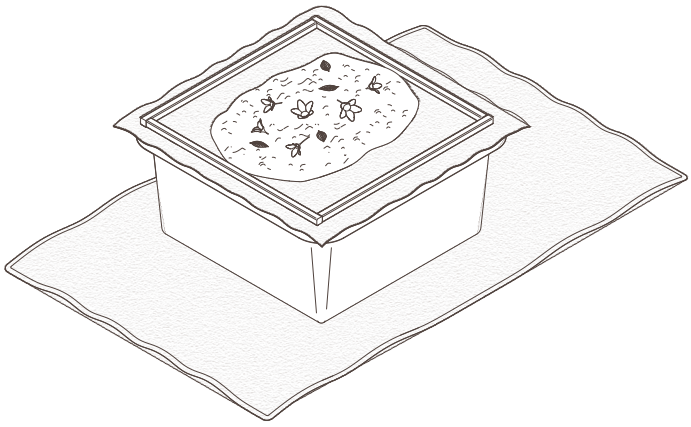
D

Now you can really get creative! You can change the hue of your paper with a few drops of food colouring. Alternatively, you could try experimenting with natural dyes which can be found in spices, vegetables or plants.



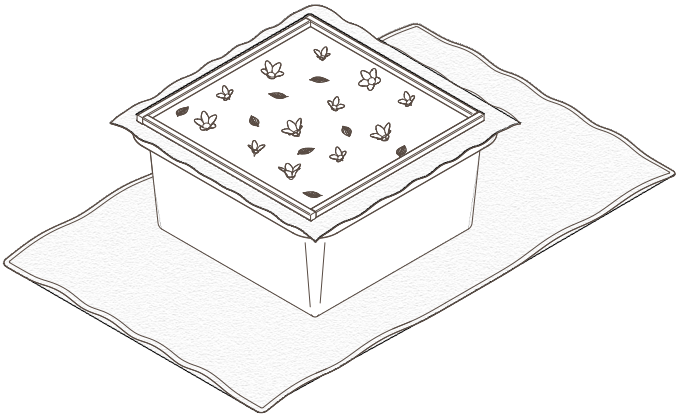
E

Next, transfer your paper pulp onto the screen you made earlier. The screen will act as a filter, allowing the smaller water particles to pass through the small holes but not the larger fibres from the paper. You will need a washing up bowl or tray underneath to catch the excess water as it drips through. An old towel to soak up any spills would also be useful. At this point, you can add some further decorative details to your recycled paper. Dried flowers, leaves, seeds or small shreds of a contrasting coloured paper can all look great!



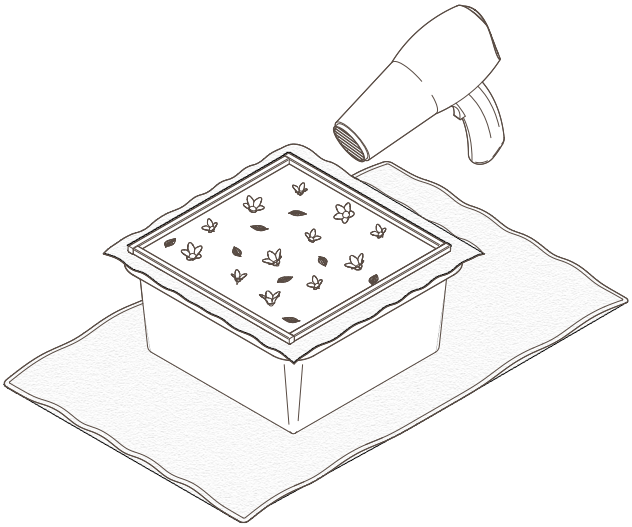
F

Next, spread the paper pulp over the screen in a thin and even layer. Push the pulp right up to the edge of the frame so your finished paper has a neat edge.



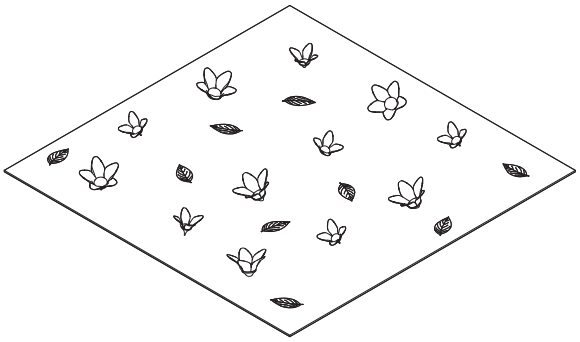
G

Your paper will now need time to dry. As the last of the water evaporates from the paper pulp, the cellulose fibres join together once more creating a solid piece of paper. You can speed up the evaporation process by leaving your paper in a warm place to dry or by using a hair dryer.



H

When the paper is fully dry, carefully peel it off of the frame. You can now decide how to use your recycled paper. The unique designs you have created would make wonderful greetings cards, decorations or notebooks.



DID YOU KNOW?

Paper can go through the recycling process 5-7 times before it must be permanently discarded. The process of paper recycling causes the natural wood fibres to become shorter and weaker. Aluminium, on the other hand, can be recycled indefinitely.

PAPER MANUFACTURING

HARNESSING THE STRENGTH OF PLANTS

KS2 UNDERSTAND THE SCIENCE

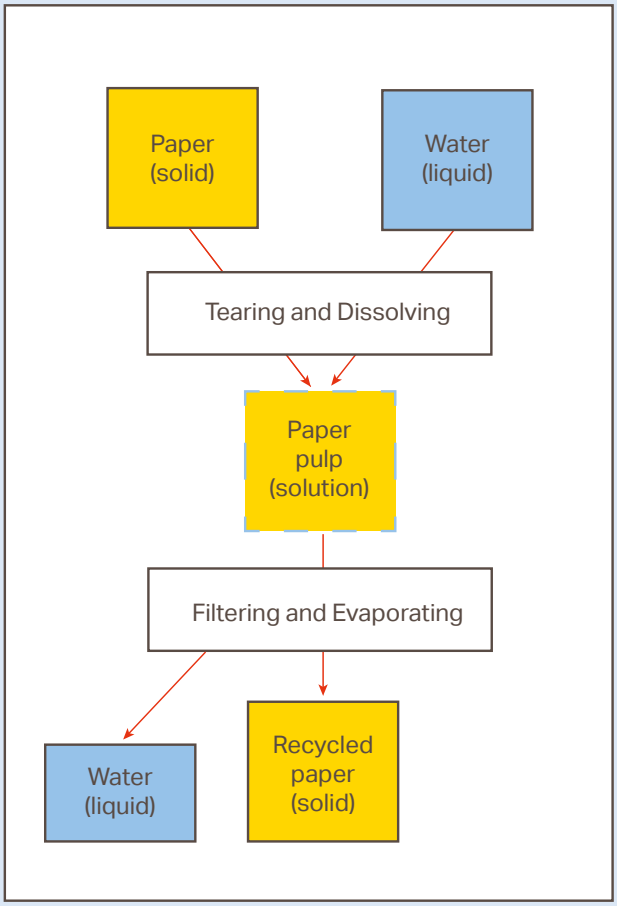
10-15m

Thinking about properties of materials and states of matter can help us to understand what is happening in the paper recycling process.

The original waste pieces of paper that we collected were solid. Solids are rigid, have a fixed shape and a fixed volume. The other ingredient in our paper pulp was water. Water is a liquid which means it flows and has no fixed shape.

When we tore the paper, we started to break the single solid object into lots of smaller pieces. Then, when the water was added to the torn paper, the pieces started to break down into even smaller pieces. The mechanical action of the whisk encouraged even more breaking up of the paper. As the paper pieces became smaller and smaller, some of them became so small they were no longer visible. Instead we could see a new material – paper pulp, which is a solution. A solution is a special type of mixture, that is made when one substance dissolves and mixes fully with another.

To turn our liquid paper pulp into useful solid paper we needed to remove the water. We began this process using the muslin material as a filter. Some of the water passed through the muslin because the water particles were small enough to fit through the tiny holes in the cloth. The paper fibres were left behind because they were larger. But the pulp left on the cloth was still too wet to use.



Finally, we left the frame in a warm place to dry. As the water in the pulp heated up, it changed from a liquid to a gas called 'water vapour'. This change in state from liquid to gas is called evaporation. Gases flow, have no fixed shape and no fixed volume which is why they can be found in the air all around us. We sometimes see water vapour gas in steam if we boil a kettle or have a hot shower.

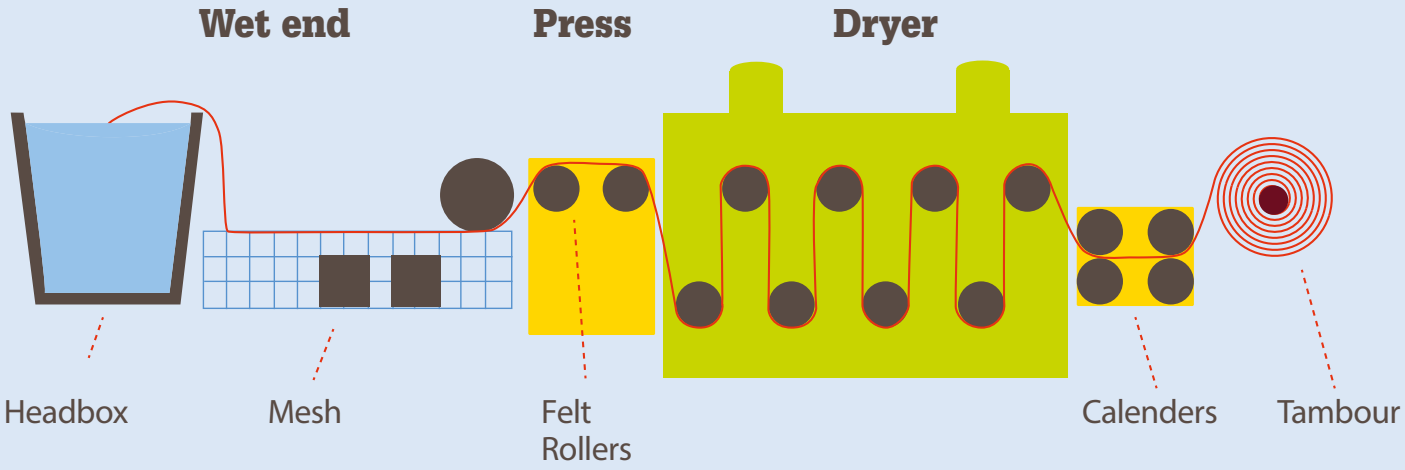
Once the water from the pulp had evaporated, only the solid paper was left behind. Once the paper was solid again, it was rigid, had a fixed shape and can be reused.

KS3 DEEPER LEARNING

10-15m

How is paper made on an industrial scale?

The best known type of paper making machine is called a Fourdrinier machine, named after the two English brothers who invented it at the start of the 19th century. Fourdrinier machines are vast. For example, each roller in the Dryer Section can have a diameter of several metres, the width of a finished reel of paper can be 10 metres long and from the Head Box to the Calenders could cover the distance of a football field!



The first section of the Fourdrinier machine is typically known as the wet end. Pulp enters the machine at the headbox and is fed onto wire mesh rollers with jets of pressurised water to make the fibres in the pulp face the same way. Aligning the fibres gives the paper strength and a smooth finish. Suction driers hold the pulp to the mesh and also help to remove excess water. When the pulp enters the machine, it's water content is 99%. As it travels along the belts, water is removed and by the end of this section the pulp has a water content of 75%.

The second section of the Fourdrinier machine is the press section, which removes the most water. The paper is fed over huge felt covered rollers that spin and squeeze the pulp under high pressure to remove the water. Excess water is also removed by the felt through absorption.

In the Dryer section, steam heated rollers stretch the paper and cause further water removal through evaporation. At this stage resins, glue, or starch, can be added to the paper to improve its strength and texture. If a glossy paper is required, such as that used for magazines or photo printing, then a layer of china clay is added at this stage too.

The fourth section is called the Calender section and consists of a number of counter rotating rollers. Pressure and heat are applied to the passing paper to make the paper surface extra smooth and glossy. It also gives it a more uniform thickness.

Finally, the finished product is wound onto a roll called a Tambour, and stored for final cutting and shipping.

QUIZ

10-15m

How is paper recycled?

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How do plants make cellulose?

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How does adding warm water help with the pulping process?

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.....

Why does the rotary beater make the pulping process easier?

.....

.....

What is a solution?

.....

.....

QUIZ

Why does the water pass through the muslin filter but not the paper?

.....

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Why does using a hair dryer increase the rate of evaporation?

.....

.....

What is added to the paper to give it a glossy surface in industrial manufacturing?

.....

.....

How many times can paper be recycled?

.....

.....

When was paper first invented?

.....

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