Design a farming machine for a farm in 2040

Introduction

These materials are intended to provide lesson ideas for science, design and technology and English. The ideas and materials are suitable for children at KS1 and KS2 although some differentiation will be necessary for the youngest children.

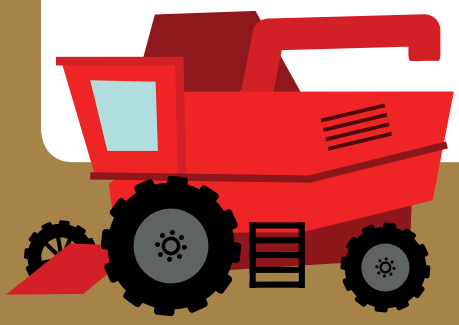
Throughout the project, children should work in pairs or groups of three. This will support dialogue and peer-teaching and reduce pressure on resources.

The suite of materials and ideas can be used flexibly in the classroom. It is essentially a creative thinking exercise to imagine and design a farm machine for 2040 drawing on science ideas and current farm machinery.

The project is spilt into four stages. You may choose which stages your children do dependent on their age, the time available and relevance to your curriculum and context. Suggestions for how activities may be simplified for younger learners is given within this guidance

Project overview

Stage	Time (mins)	Overview
Introduction	10	An introductory overview of the project for children to see the stages they will go through.
1: Machinery and friction	45-120	Presentation to show children how farmers use machinery to help them to do jobs on the farm. Children investigate factors that affect friction.
2: Levers gears and pulleys	45-60	Presentation to show children how levers, gears and pulleys are used in farm machinery. Children investigate a circus of activities using levers, gears and pulleys.
3: A farming machine of the future	60-90	Children use creative thinking and experience of current farming machinery to design a farming machine of the future.
4: Advertising and marketing	45-60	Children explore features of persuasive writing and are challenged to write a persuasive advert or speech that explains how their product solves a problem and why it should win. This could be presented as a speech video, PowerPoint, radio/ TV/ magazine/ stop motion advert, persuasive letter etc.



Stage 1: Machinery and friction

Suggested KS1 learning objectives: To explore how different surfaces affect friction.
To see examples of farm machinery and the jobs they do.

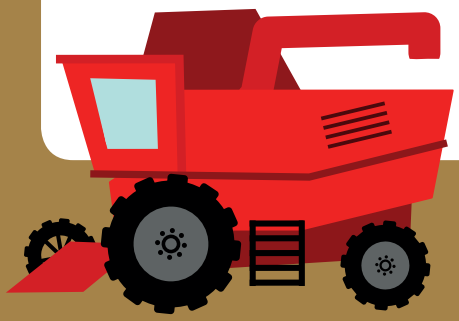
Suggested KS2 learning objective: To explore how one or more factors affect friction and relate ideas to farm machinery.

Suggested equipment and materials:

- Wooden block from a materials kit or similar
- String or screw hook to attach the block to a force meter
- 1 kg masses
- 0-10 N and 0-20 N force meters
- Non-absorbent surface
- Mixture of washing up liquid and water (50%) as a lubricant
- Cloths / paper towels to mop up spills

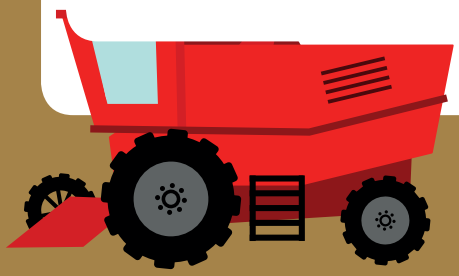
The presentation

Slide	Description
Slide 1	Landing slide
Slide 2	Farm machinery The plough was used in ancient Egypt from about 600 BC. Simpler implements such as digging sticks and hoes were used earlier than ploughs. Ploughs were originally pulled by people but, later, oxen, horses and mules were used. The Industrial Revolution brought steam-powered traction engines for ploughing from about 1850 and internal combustion engine tractors from about 1910.
Slide 3	Tractor-driven machinery Tractors are used with a variety of different implements. These fix to the tractor using strong, moveable arms and / or a hitch. The arms can lift some implements up for travelling. Some implements are driven by a shaft connected to the tractor.
Slide 4	A seed drill This farmer is planting seeds using a seed drill. The seed drill scrapes a small furrow in the soil, plants the seeds in the furrow and then covers them with soil.
Slide 5	A two-share plough A plough uses a sharp blade to cut through the earth and turn the soil over. This small tractor is pulling a two-share plough, but modern ploughs can have six or more shares.



Teacher guidance - 3

Slide 6	A disc harrow The disc harrow is used to break and turn soil that has already been ploughed. Ploughed land is usually harrowed before planting.
Slide 7	A carrot harvester Carrot harvesters lift carrots from the ground by their stalks, wheels knock off most of the soil and then blades cut off the stalks. The carrots then go to a hopper or waiting trailer by conveyor belt. See the video: https://www.youtube.com/watch?v=xDsZC-s6V9g
Slide 8	A potato harvester Potato harvesters do a similar job, but you can't pull potatoes from the ground by the stalks. A potato harvester digs up the potatoes with the soil and separates them. Some potato harvesters are self-propelled but the one shown here is pulled by a tractor.
Slide 9	A simpler potato harvester This potato harvester separates the potatoes from the soil and drops the potatoes on top. People must pick the potatoes up though!
Slide 10	A tractor-driven crop sprayer Some crops are sprayed with insecticides to kill insect pests. Some crops are sprayed with fungicide to prevent them from turning mouldy. Some crops are sprayed with herbicides to kill weeds. Many people don't know that crop spraying is also used in organic farming.
Slide 11	A round baler Famers use a baler to collect and compact hay (dry grass) and straw (stalks from wheat and barley). Hay is a food source for cattle and sheep in the winter months, and straw is used for animal bedding. Some balers fully wrap the bales in plastic to keep the rain off.
Slide 12	A manure spreader Crops remove nutrients from the soil and nutrients need replacing if the soil is to remain fertile. Manure from sheep and cattle contains many nutrients and is spread on fields with a manure spreader. The manure decomposes and returns nutrients to the soil.
Slide 13	Special machinery Some farm machinery does not need a tractor to pull or drive it: it is self-propelled.
Slide 14	The combine harvester The combine harvester cuts the wheat or barley and separates the grain from the stalks (straw). The grain goes straight into a trailer and the waste straw comes out at the back.
Slide 15	The pea harvester Peas need to be harvested as soon as they are ripe. This pea harvester cuts down the pea plants and pops the peas out of the pods. The peas are stored in the harvester which is emptied when it's full.
Slide 16	A self-propelled crop sprayer This self-propelled crop sprayer has a high clearance to spray tall crops without flattening them. It usually has wider spraying booms than a spraying implement for a tractor and has a larger tank for the liquids it sprays.



Slide 17	Friction Friction is a contact force that is useful in many cases. For example, if there was no friction, we would not be able to walk, and vehicles could not steer or brake. Objects would not stay on shelves or tables: they would slide off in a similar way to a marble rolling, if there were the slightest slope. Tractor tyres have a deep tread, which is designed to grip soft, wet ground.
Slide 18	Friction can be a nuisance We cannot sledge on grass because there is too much friction. We do not want friction between moving parts in machinery because friction causes heating and wear. Bearings and lubrication are two ways in which friction can be reduced. You could get children to rub their hands vigorously to feel the heat generated by friction and show how putting a liquid such as hand sanitiser or hand cream reduces friction and heating.
Slide 19	Friction on the farm Cutting and turning soil and harvesting crops require sharp implements to reduce friction. The farm is a tough environment for moving parts because dust and grit can cause unwanted friction and wear in machinery.
Slide 20	Investigating friction This slide introduces the investigation by showing children how they will measure the friction force by pulling a wooden block with a force meter. Explain that the block must be pulled at a steady speed in a straight line to measure the sliding friction force. Ideally you will show the children the equipment they will use, and how to measure the sliding friction force. Please note that it may be difficult for the children to read the force meter as they pull the block along: the reading may vary if they cannot pull the block smoothly and at a steady speed. Ask questions such as: • What might change the size of the friction force? • Why must the surface be level? • What question about friction would you like to investigate?

Background information

Friction is a contact force between two surfaces and the size of the force depends on several factors:

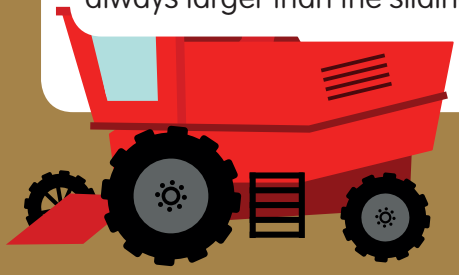
- Whether objects are stationary or moving
- The type of surface and the type of object
- The downward force (weight) acting on the object
- Whether or not the surface is lubricated

The size of the friction force is not affected by:

- The area of contact between the surface and the object
- The speed of movement of the object across a surface

Static or moving friction

The sliding friction force is the force needed to keep an object moving in a straight line at a steady speed on a level surface. The sliding friction force does not depend on the speed of movement. The static friction force is the force needed to start an object moving. The static friction force is always larger than the sliding friction force.



Friction is caused by lumps and bumps on each surface rubbing against each other. Even surfaces that appear to be smooth have lumps and bumps at a microscopic level. You can model friction using strips of corrugated card held together by a small weight. Starting the top card sliding requires a large force but, once the card is moving, a smaller force will keep it moving. Figure 1 shows the two strips of card. Figure 2 models how the surface lumps and bumps mesh when the surfaces are stationary.

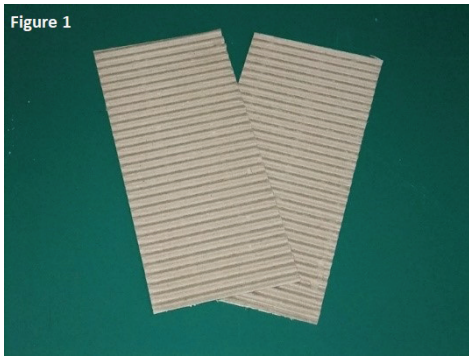


Figure 1

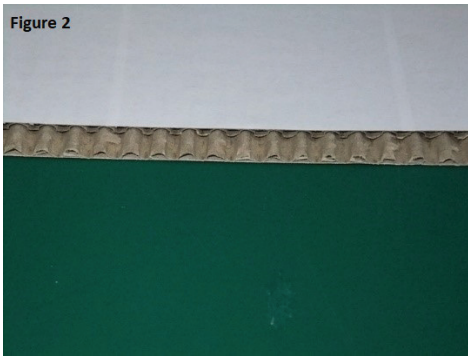


Figure 2

The investigation

Children can plan an investigation using the planning support sheet or you may wish to guide them to a specific investigation question and provide them with a suitable method. There is a second sheet that supports children with collecting, presenting and analysing data.

Suggested investigation questions

How does the speed of sliding affect the size of the friction force?

> A wooden block is pulled across the same surface using a force meter to measure the sliding friction force. The block is pulled at three different speeds, slow, medium and fast. Children control variables by using the same block placed on the same surface.

How does the surface area of a block affect the size of friction?

> A wooden block with three different sized faces is pulled across a surface on each of the three faces in turn, and the sliding friction force measured. Children control variables by using the same block on the same surface and pull the block at the same steady speed.

How does lubrication affect sliding friction?

> A non-absorbent block is pulled across a surface with and without lubricants. A 50:50 mixture of washing up liquid with water provides a less messy alternative to oils. Children control variables by using the same block on the same surface and by pulling the block at the same steady speed.

How does the weight of a block affect sliding friction?

A wooden block is pulled across the same surface using a force meter to measure the sliding friction force. Masses are added to the block to change its weight. Children control variables by using the same block placed on the same surface and by pulling the block at the same steady speed.

How does the type of surface affect sliding friction?

A wooden block is pulled across different surfaces using a force meter to measure the sliding friction force. Children test surfaces such as concrete, tarmac, a Formica table top, wooden table top, carpet, tiled floor and linoleum. Children control variables by using the same block and pulling it at the same steady speed.

Stage 2: Levers, gears and pulleys

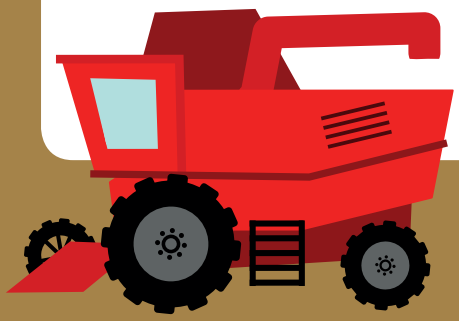
Suggested learning objective: To explore levers, gears and pulleys as simple machines and how they are used in more complex machines.

The PowerPoint presentation, Levers, gears and pulleys, provides children with information about the history of simple machines and the purpose of levers, gears and pulleys. It provides images of them in use without detailed explanation of why they are used.

The example of the excavator provides children with an opportunity to apply learning by identifying levers and pivots in the arm of an excavator.

Suggested resources, equipment and materials:

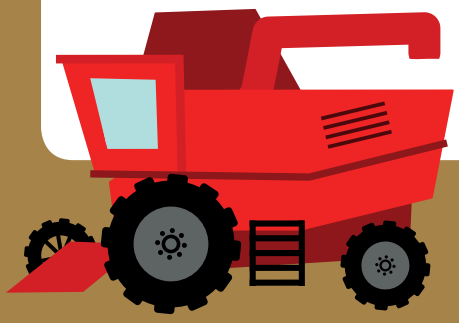
- PowerPoint presentation
- Investigation recording sheets
- Two single pulleys
- Two clamp stands, bosses and clamps
- Two G-clamps
- Four 500 g or 1 kg masses
- Four gear wheels (available from suppliers such as Rapid Electronics, Technology Supplies Ltd or Amazon)
- Four 25 mm nails
- Two pieces of wood or board on which to mount the gears
- Two metre rules
- Two triangular section pivot blocks
- 0-10 N force meter
- 0-50 N force meter
- Cloths / paper towels to mop up spills
- String



The presentation

These slide descriptions also appear on the 'notes section' on the relevant slide.

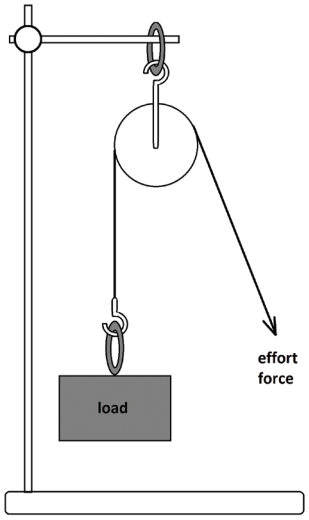
Slide	Description
Slide 1	Landing slide
Slide 2	Simple machines Simple machines have been used for thousands of years. The picture on the left shows a shadoof, a pivoting lever to help lift water from a well. The lever is weighted so that it only takes a small force to push the bucket down the well empty and the same small force to lift it back up full. It pivots so the bucket can swing to one side of the well. The shadoof has been used in the Middle and Far East since about 2000 BC. Hero of Alexandria (circa 10 AD to Circa 70 AD) identified pulleys as one of six simple machines used to lift weights in Ancient Greece. A pulley system with pulley blocks top and bottom is called a block and tackle. The picture on the right shows the top pulley block of a block and tackle on a sailing ship. A block and tackle with four pulleys (two at the top and two at the bottom) will roughly quarter the force needed to hoist a sail.
Slide 3	Gears This picture shows part of a gearbox with different sized gears meshing. Gear wheels change the direction and speed of rotation of shafts or axles.
Slide 4	Gears and chains Gears are often joined by a chain. Children may be familiar with bike chains that connect the pedals and chainwheel to the rear sprocket. Gear wheels connected by a chain rotate in the same direction but may turn at different speeds depending on their relative sizes.
Slide 5	Pulley and belt In machinery, pulleys are often connected using belts. The pictures both show double pulleys connected with 'vee' belts. Pulleys also commonly use flat belts or toothed belts. Pulley and belt systems work in a similar way to gear and chain systems. Pulley and belt systems are quieter and can run faster than gear and chain systems, but are not as strong.
Slide 6	Can you see the levers and pivots? The arm of an excavator such as the one shown is composed of a series of levers connected by pivots. Powerful hydraulic rams push and pull the levers to move the arms. Challenge the children to identify the pivots and levers on the excavator.
Slide 7	These are the pivots
Slide 8	These are the levers
Slide 9	And these are the hydraulic rams Explain that hydraulic rams use oil to push and pull steel pistons in and out of long cylinders. The piston and cylinder together make up a hydraulic ram. Hydraulic rams push and push the levers in the excavator arm to move the arm and bucket.



Slide 10	Land use in the UK Just over one third of the UK is grassland used for livestock such as cattle, sheep and pigs. It is also used for making hay to feed livestock during the winter months. Some grassland may be steeply sloping and is unsuitable for arable (crop) farming. About one third of UK land is used for arable farming: wheat, potatoes, rapeseed, sugar beet and barley are the top five arable crop products of the UK by value as reported by the Food and Agriculture Organisation in 2012. About one quarter of UK land is classed as natural: not built on or under agriculture. This land includes mountain and moorland areas. Surprisingly, less than one tenth of UK land is built on (roads, railways and buildings). However, this is very familiar to all of us as we spend most of our time in cities, towns or villages, or travelling between them on roads and railways.
Slide 11	How can we farm more land than we do now? The image shows a rice growing area in the Cordillera region of the Philippines. The steep mountainsides have been terraced to make flat areas for farming. The terraces also prevent soil erosion and collect rainwater. The UK currently produces just more than half the food we need and with the world's population rising, we need to make the best use possible of our land.
Slide 12	What might farming machines in 2040 look like? This slide introduces Stage 3 of this project: A farming machine of the future. The image imagines how robots might be used to work in a greenhouse in the future. It can be used to start a discussion about how farming might change over the next twenty years and what jobs we might want machines to do. Ideas may draw on current farming implements, how land is currently used in the UK and the need for countries such as the UK to grow more of the food we need.

Background information

Pulleys

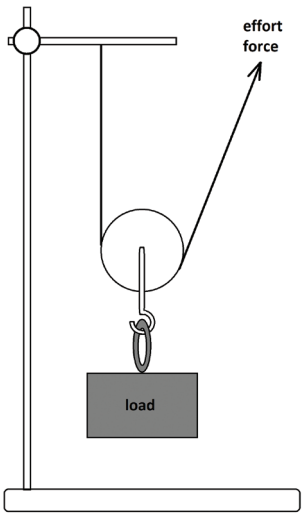


A single fixed pulley changes the direction of pull to lift an object.
In this example, the effort force acts downwards to lift the load upwards.

There is no reduction in the force needed to lift the load: it will take an effort force of 10 newtons to lift a 10 newton load. If there is friction in the pulley bearing, the effort force will be greater than the load force.

A single fixed pulley is used to make lifting a load more convenient: it is often better to stand up straight and pull downwards than it is to bend over and lift upwards.

A single moving pulley reduces the force needed to lift a load.



In this example, the effort force is half the load force.
The effort force acts in the same direction as the load force - upwards.

A single moving pulley reduces the force needed to lift a load. However, the effort force must move twice as far as the load force.

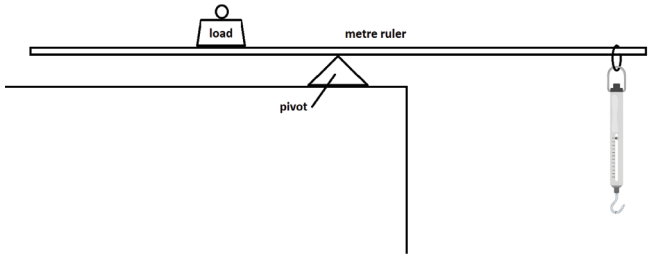
Very often, a single moving pulley is used with a single fixed pulley. Once again, the effort force is half the size of the load force, but the effort force is pulled downwards.

Double or triple pulleys are used in a block and tackle to further reduce the effort force needed, but the effort force must move much further than the load force moves.

Levers

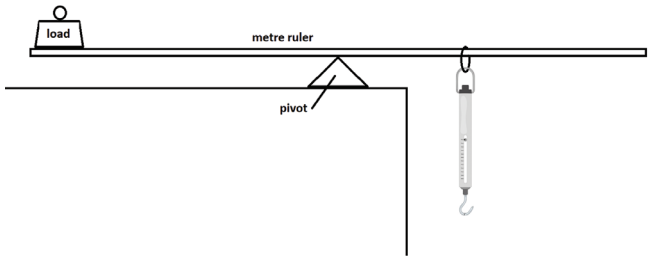
A seesaw is an example of a simple lever. Most children will have experience of playing on a seesaw with an adult who may weigh twice or three times as much as they do. To balance a seesaw, the adult must sit closer to the pivot.

Children investigate two levers: one with the load near to the pivot and one with the load a long way from the pivot.



In this case, the load force is placed about 20 cm from the pivot. The effort force is applied using a force meter placed about 45 cm from the pivot.

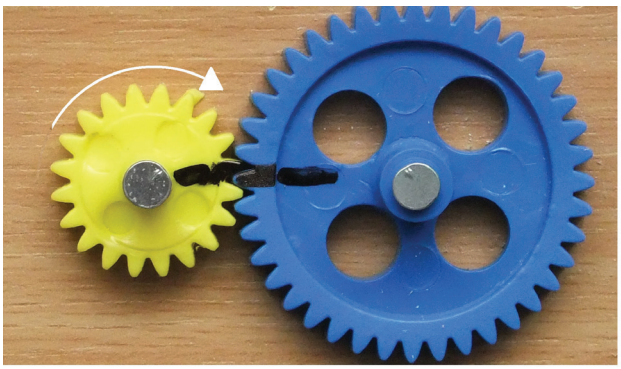
The effort force will be just less than half the load force. However, the effort force needs to move more than twice as far as the load moves. This is an example of a force multiplier.



In the second lever, the load force is placed about 45 cm from the pivot. The effort force is applied using a force meter placed about 20 cm from the pivot.
The effort force will be just more than twice the load force. However, the effort force moves less than half the distance that the load moves. This is an example of a distance multiplier.

Gears

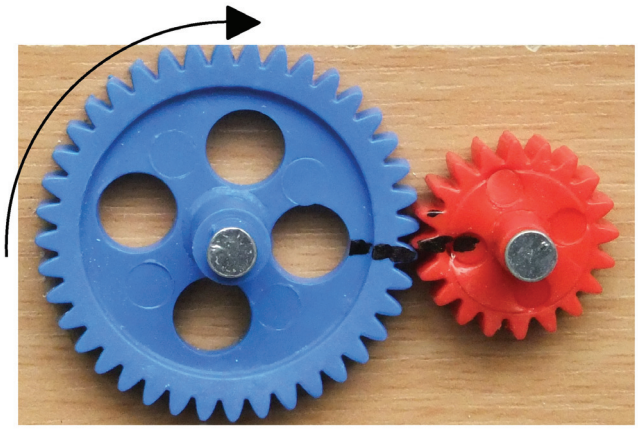
Simple gear pairs can be made by nailing gear wheels to blocks of wood with 25 mm nails. Ideally choose gears with a simple ratio of teeth. In the example pictures, the larger gear wheel has 40 teeth and the smaller has 20 teeth.



If a small gear drives a large gear, the large gear turns in the opposite direction and at a slower speed than the smaller wheel.

In the example here, the large wheel makes half a turn anticlockwise when the small wheel makes a full turn clockwise.

The turning force of the large wheel will be twtwice that of the small gear. This is an example of a force multiplier.



If a large gear drives a small gear, the small gear turns in the opposite direction and at a faster speed than the larger wheel
In the example here, the small wheel makes two turns anticlockwise when the large wheel makes a full turn clockwise.

The turning force of the small wheel will be half that of the large gear. This is an example of a distance multiplier.

The investigation

Set up the circus and provide children with recording sheets. The KS1 investigation has been simplified to avoid using force meters to measure force.

Give groups of children 5-6 minutes at each station to investigate the simple machine and record their findings.

Safety

For the pulley investigations, ensure that each clamp stand is fixed to the table with a G-clamp to prevent the stands from toppling. Table tops should be protected using hardboard or corrugated carboard. Pulleys, masses and force meters should ideally be tied to the string to reduce the risk of masses falling on children's feet.

For investigating levers, ensure that each mass is fixed to the metre rule with sticky tape. Warn children not to lift the load mass more than 2-3 cm off the table. Table tops should be protected using hardboard or corrugated carboard. Pivots can be fixed to the tables using sticky tack.

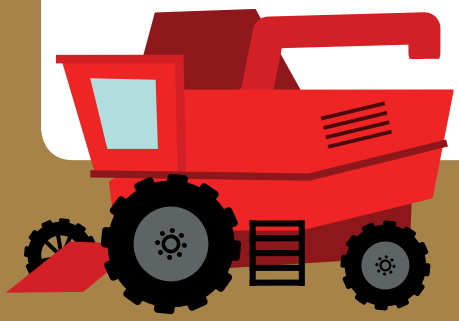
Stage 3: A farming machine of the future

Suggested learning objectives: To practice creative thinking, and design and technology design techniques. To imagine, design and refine a farming machine of the future.

Children use ideas from present farm machinery combined with creativity to imagine a farming machine of the future. The PowerPoint presentation in Stage 2 provides information and ideas about current farm machinery. The following reference provides information about additional agricultural machinery. Children can find out about individual pieces of agricultural machinery by hovering the cursor over the machinery names. Clicking on the names will hyperlink to a new web page dedicated to that machinery: https://en.wikipedia.org/wiki/List_of_agricultural_machinery

Suggested resources

- PowerPoint presentation
- Design support sheets



The design task

The design planning sheet is divided into six phases (five for KS1):

Initial phase: Evaluating an existing farm machine (KS2 only)

The purpose of this phase is to give children practice at evaluating an existing design. Children can draw, describe or stick a picture of their chosen machinery to their sheet. They are then asked to consider strengths, weaknesses and improvements to the existing machine.

Phase 1: Starting thoughts

In this phase, children use words and pictures to sketch out two or three different ideas for a farming machine. The assessment boxes at the bottom of the page are intended to be used for peer-evaluation of children's ideas. However, you may prefer children to self-assess.

Phase 2: Developing one of my ideas

Children develop their preferred idea further. They consider the uses and the purposes of the machine, how it works, how it is suitable for the intended uses and the important features it should have.

Phase 3: A labelled diagram / picture of my design

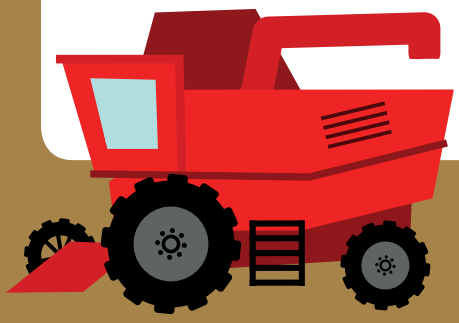
In this phase, children draw a diagram or picture of their preferred design idea. They should be encouraged to provide as much detail as possible through their picture / diagram and through explanatory labels.

Phase 4: Evaluation and improvements

In this phase, children identify strengths and weaknesses of their design and suggest improvements they could make to the appearance and working of their machine. This phase could be completed after peer-evaluation with verbal feedback, or through reflection and self-assessment.

Phase 5: A labelled diagram / picture of my final design

Children refine their design based on feedback or reflection.



The presentation

Slide	Description
Slide 1	Landing slide
Slide 2	You have seen examples of tractor driven farm machinery in use (Recap slide)
Slide 3	You have seen examples of special farm machinery in use (Recap slide)
Slide 4	You have seen examples of simple machines (Recap slide)
Slide 5	You have seen how we use land (Recap slide)
Slide 6	Design task This slide introduces the design task. Introduce and explain the design planning sheets to children before they start on the task.

Stage 4: Advertising and marketing

Suggested learning objective: To use persuasive language to advertise a product.

- PowerPoint presentation.
- Internet access.

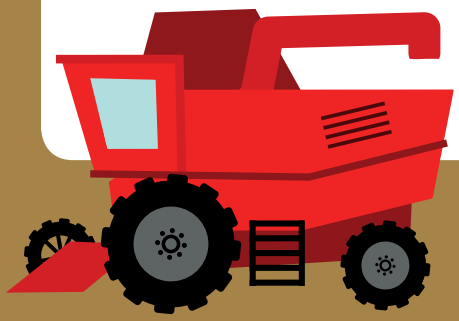
The short presentation describes key components of marketing and advertising.

Slide	Description
Slide 1	Landing slide
Slide 2	What is marketing?
Slide 3	What is advertising?
Slide 4	Features of a good advert

The marketing aspect of the activity could become an extended activity if you wish. For example, children could conduct market research about their farm machinery product using the internet. Dependent on outcomes from their market research, they could refine their product

The advertising activity is accessible for all children. Explore the features of a good advert. Children will suggest memorable adverts they have seen on billboards, online and on TV. Draw out why the adverts are memorable and why we remember snappy statements in adverts. Explore features of persuasive language: repeated words, alliteration, emotional language, strong arguments, rhetorical questions, humour and colourful, eye-catching fonts.

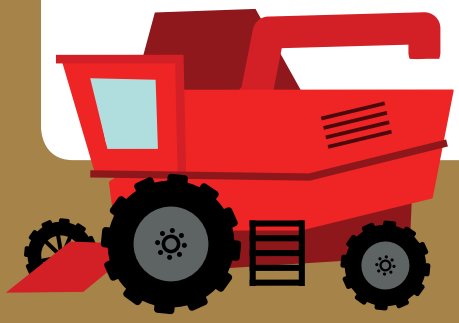
Children could take photographs of their design as the central image in the advert. Alternatively, they could draw new images. To help them to develop snappy statements, you may wish to explore features of some real adverts.



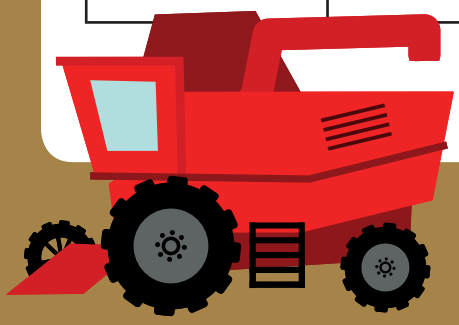
You may wish your children to explore other forms of advertising, for example, by making a recorded advert for radio, video advert for TV or a stop motion animation advert. Alternatively, you may wish them to explore other forms of marketing such as making a speech, producing a PowerPoint presentation or writing a persuasive letter.

Possible links to the national curriculum:

Key Stage/ Subject	Topic	National Curriculum statements
KS1 Science	Working Scientifically	• Asking simple questions and recognising that they can be answered in different ways. • Observing closely, using simple equipment. • Performing simple tests. • Using their observations and ideas to suggest answers to questions. • Gathering and recording data to help in answering questions.
KS1 Design and Technology	Design	• Design purposeful, functional, appealing products for themselves and other users based on design criteria. • Generate, develop, model and communicate their ideas through talking, drawing, templates, mock-ups and, where appropriate, information and communication technology.
	Make	• Select from and use a range of tools and equipment to perform practical tasks [for example, cutting, shaping, joining and finishing]. • Select from and use a wide range of materials and components, including construction materials, textiles and ingredients, according to their characteristics.
	Evaluate	• Evaluate their ideas and products against design criteria.
KS2 Science	Forces and magnets	• Compare how things move on different surfaces. • Notice that some forces need contact between two objects, but magnetic forces can act at a distance. • Explain that unsupported objects fall towards the Earth because of the force of gravity acting between the Earth and the falling object. • Identify the effects of air resistance, water resistance and friction, that act between moving surfaces. • Recognise that some mechanisms, including levers, pulleys and gears, allow a smaller force to have a greater effect.



	Working Scientifically	• Asking relevant questions and using different types of scientific enquiries to answer them. • Setting up simple practical enquiries, comparative and fair tests. • Making systematic and careful observations and, where appropriate, taking accurate measurements using standard units, using a range of equipment, including thermometers and data loggers. • Gathering, recording, classifying and presenting data in a variety of ways to help in answering questions. • Recording findings using simple scientific language, drawings, labelled diagrams, keys, bar charts, and tables. • Reporting on findings from enquiries, including oral and written explanations, displays or presentations of results and conclusions. • Using results to draw simple conclusions, make predictions for new values, suggest improvements and raise further questions. • Identifying differences, similarities or changes related to simple scientific ideas and processes. • Using straightforward scientific evidence to answer questions or to support their findings. • Planning different types of scientific enquiries to answer questions, including recognising and controlling variables where necessary. • Taking measurements, using a range of scientific equipment, with increasing accuracy and precision, taking repeat readings when appropriate. • Recording data and results of increasing complexity using scientific diagrams and labels, classification keys, tables, scatter graphs, bar and line graphs. • Using test results to make predictions to set up further comparative and fair tests. • Reporting and presenting findings from enquiries, including conclusions, causal relationships and explanations of and degree of trust in results, in oral and written forms such as displays and other presentations. • Identifying scientific evidence that has been used to support or refute ideas or arguments.
KS2 Design and technology	Design	• Use research and develop design criteria to inform the design of innovative, functional, appealing products that are fit for purpose, aimed at particular individuals or groups. • Generate, develop, model and communicate their ideas through discussion, annotated sketches, cross-sectional and exploded diagrams, prototypes, pattern pieces and computer-aided design.
	Make	• Select from and use a wider range of tools and equipment to perform practical tasks [for example, cutting, shaping, joining and finishing], accurately. • Select from and use a wider range of materials and components, including construction materials, textiles and ingredients, according to their functional properties and aesthetic qualities.



	Evaluate	• Investigate and analyse a range of existing products. • Evaluate their ideas and products against their own design criteria and consider the views of others to improve their work. • Understand how key events and individuals in design and technology have helped shape the world.
	Technical knowledge	• Apply their understanding of how to strengthen, stiffen and reinforce more complex structures. • Understand and use mechanical systems in their products [for example, gears, pulleys, cams, levers and linkages]. • Understand and use electrical systems in their products [for example, series circuits incorporating switches, bulbs, buzzers and motors]. • Apply their understanding of computing to program, monitor and control their products.