DT -Pneumatic Toys

Year 3

Essential Knowledge

By the end of this unit children will know

Key Objectives

:

- How mechanisms work.
- A mechanical system can allow us to move something more easily.
- Mechanical systems can have more than one mechanism that moves to make them work.
- Mechanical systems are often hidden in products to make them look more appealing.
- Pneumatic systems can be found in everyday objects.
- Pushing air can be used to move a mechanism.
- Pivots can be used to create more movement in a mechanical system.
- A combination of mechanisms can improve a product.

-

Vocabulary

Diagram, evaluate, feedback,
Housing, linkage, mechanical system,
Mechanism, pivot, pneumatic system,
thumbnail sketch

Intentions

- Define a mechanism as a system of parts working together to create movement and a pneumatic system can be used as part of this.
- Describe how a pneumatic system forces air over a distance to create movement and identify pneumatic systems in a range of everyday objects.
- Describe different types of drawings used in design to explain ideas clearly and explain why one may be more useful for a particular situation.
- Develop design criteria from a design brief.
- Begin to draw different types of diagrams to generate suitable ideas.
- Recall different types of pneumatic systems used to design a toy and create one for a specific movement.
- Build secure housing for a pneumatic system, consider sustainable resources and work with materials to create different effects by cutting, creasing, folding, etc.
- Evaluate how well the design, materials and equipment help to achieve the design brief.

Session 1

Focus: To explore how pneumatic systems create movement within mechanisms.

- Success Criteria: I can define a mechanism as a system of parts working together to create movement.
- I can recall that a pneumatic system can be used as part of a mechanism.
- I can identify pneumatic systems in a range of everyday objects.
- I can describe how a pneumatic system forces air over a distance to create movement.

Main Activity

Hand out the *Activity: Exploring pneumatics* (one set pre-cut per group of four), which shows various ways pneumatics have been used throughout history. Ask the children to discuss how air has been used to create movement.

Presentation: Pneumatics throughout history

Display the *Presentation: Pneumatics throughout history* and use the timeline to discuss the pupils' answers to the questions on the cards and review the significant development in pneumatics by clicking on each point:

1. **Blowgun:** how is squashed air being used to move something? (A deep breath is blown through the tube, which pushes the dart or other projectile out the other end.)
2. **Bellows:** what movement is needed to make the air move through? (Opening and closing the handles moves air into the space in the middle and pushes it out the nozzle.)
3. **Aeolipile:** what will move up the tubes when the water is heated? (Steam.) How could this move the ball on its axle? (As the steam pushes through the narrow tubes and escapes, it causes the ball to spin around.)
4. **Vacuum pump:** if the air is taken out of a metal ball, do you think the two sides will stay together or fall apart? (When air is taken out of the ball structure, there is more pressure or push from the air outside, which firmly holds the two halves together.)
5. **Water wheel:** what movement is causing the wheel to turn? (The flow of water.) How is this movement automatic? (For example, if the wheel is positioned over a river, water movement happens without anyone adding any effort.)

6. **Pneumatic tube:** how could air be used to send messages around a building or even a town? (Air can push a lightweight paper message from one place to another.) How could you make sure messages get to the right place? (Tubes provide a specific pathway for the messages.)
7. **Pneumatic drill:** why might someone want this drill instead of a hammer? (It would be less tiring to use and is stronger.) Are there any downsides to using this device to break rocks? (It requires electricity; it is more dangerous; it is larger and heavier than a hammer.)
8. **Modern pneumatics:** can you think of other things that use air to move something? (Inflating tyres, airbrush spray paint, nail guns or pneumatic drills.)

Highlight to the class that an **input** movement causes the overall **output** movement in each example.
Ask the children:

- **Is electricity always needed as an input to make a machine work?** (No, as human energy or the energy from wind and water can also make machines work.)
- **Do you think air has power?** (Ask the children to consider things blown by the wind, such as windmills and wind turbines that make electricity. The examples from the activity and presentation also show how air has the power to move something.)
- **How do you think pneumatic machines have helped people?** (Answers may include that humans can do larger and stronger tasks with pneumatic inventions or that the automatic nature of some pneumatic machines makes it easier for humans to operate.)

Play the video on the link: BBC - What is a pneumatic device? to further explain pneumatic devices and introduce modern applications. Ask the class:

- What does it mean when he says 'the inflated balloon has a higher pressure'? (The air trapped inside has a greater force or outward push.)
- **How can you tell that air is being pushed out of the balloon?** (When there is an opening, the balloon deflates and gets smaller; if you put your hand in front, you can feel the escaping air pushing against your skin.)
- **Which device surprised you by using air to make something move?**

Demonstrate pneumatics

Demonstrate two different ways in which syringes and tubing can create motion and transmit force (as demonstrated in the *Teacher video: Exploring pneumatics*):

1. Attach the ends of two syringes of equal volume with a tube. When one syringe is pressed all the way in, the other will move all the way out as the air transfers from one syringe to the other. Highlight how the distances the syringe plungers move are comparable.
2. Attach the ends of two syringes of different volumes with a tube. When the smaller syringe is pressed all the way in, the large one will move out slightly. When the large syringe is pushed all the way in, the small end will pop straight out of the syringe, sometimes with quite some force (see Cautions). This is because there is insufficient space for all the air from the large syringe in the small one.

Ask the children:

- **What happens when you lift the plunger on a single syringe?** (The syringe fills with air.)
- **How is this different when two syringes are joined with tubing?** (The syringe still fills with air; however, the air is trapped and pulled from one syringe to another.)
- **Why does the first syringe move when you push the plunger in on the second one?** (The first syringe's plunger will go up as it is pushed by the air moving from the second tube. The air has nowhere else to go except through the tube and into the other syringe.)
- **If the plunger did not move, what might be the problem?** (Look for air leaking from the system, such as where the tubing connects with a syringe.)

Presentation: Exploring pneumatics

Arrange the children in small groups and hand out equipment for the syringe exploration (see Have ready). Display the *Presentation: Exploring pneumatics* to prompt them with questions to consider while experimenting. Allow the children to play with and observe the different examples of pneumatic systems to help them consider how they could be used to cause movement. Remind them of the safety hazard of pushing the plungers hard and keep them pointed away from each other's faces.

Questions

- **What happens when you cover the end of a syringe and push the plunger down?** (You can push in a little bit but it is harder to push as the air gets compressed or squashed.)

- **What happens when you let go of the plunger?** (The plunger shoots back up and then stops.)
- **Why do you think this happens?** (The squashed air pushes harder against the walls of the syringe so that when you let the plunger go, the air spreads back out.)
- **How should the plungers be set up so the air can move back and forth between the two syringes?** (One syringe must start with its plunger out and the other with the plunger in.)
- **What do you think will happen if one syringe is a different size?** (A larger syringe can push out more air.)
- **Do you think the size of the syringes affects how far the plungers move?**

Pupils needing extra support

Could have the challenges and experiments repeated or have the equipment set up before them to make it easier to repeat and follow during the Main event; could be grouped with a confident reader when completing the *Activity: Exploring pneumatics* and reading through the prompt questions in the Main event syringe exploration; could refer to the *Knowledge organiser* when summarising a pneumatic system to support spellings and examples.

Pupils working at greater depth

Could be encouraged to explore how the syringes can cause movements in further directions by considering pivots and linkages; should explain in more depth what causes the air movement at the beginning of their chosen example (input), where the air is moving and how this causes an overall movement (output).

Session 2

Focus: To use different types of diagrams to summarise information.

Success Criteria:

- I can recall that different types of drawings are used in design to explain ideas clearly.
- I can describe different types of diagrams.
- I can explain when one type of diagram may be more useful for a particular situation.
- I can begin to draw different types of diagrams.

Main Activity:

Display slide 1 of the *Presentation: Sketches and diagrams,* hand out whiteboards and pens and ask the children to imagine a cheese and tomato sandwich.

Presentation: Sketches and diagrams

Ask the children:

- **Why might a drawing be helpful when planning a meal for someone?** (Not everyone has the same idea of what a cheese and tomato sandwich will look or taste like. The exact types of ingredients may not be the same either.)

Ask the children to draw some quick sketches of what the sandwich may look like on the whiteboard. Allow a short amount of time and then compare the sketches produced. Click through the presentation to reveal some variations in cheese and tomato sandwiches, highlighting the choice of cheese and bread or how the bread is cut or heated.
Display slide 2 and ask the children why a quick sketch can be useful in the early planning stages (as they do not take as long, they allow more time for creativity and sharing ideas to decide how to move forward in the design process).
Display slide 3 and allow the children to discuss in pairs the differences between the two types of drawing. Click the detailed drawing to display some key differences between the two.
Hand out the *Activity: Different diagrams* (one each), display slide 4 and ask the children to choose from the three suggested products. Allow a short time to produce quick thumbnail sketches of variants for the chosen product, for example, differently shaped Matryoshka or different types of toppings on a pizza. Emphasise that the sketches should be thumbnails rather than detailed drawings. Give the children a time limit, such as one minute of thinking and two minutes of drawing time per idea.
Allow the children a few minutes to choose one of their designs and to draw it in more detail, ensuring labels and key details are included.

Display slide 5 and explain that different types of detailed diagrams are used for different purposes. Ask the children to consider in small groups what is useful about each type of diagram and what may be less useful or a disadvantage. Explain that they should make notes on their whiteboards. Discuss as a class and click on the diagrams to reveal key points about each.

Referring to the final diagram, emphasise that diagrams showing the inside of a product can be helpful for the client, customer and especially the builder in knowing how to put the pieces together. Share a real-world example illustrating how different parts of a product fit together using the link: IKEA - Anilinare stationery holder assembly.
Use slide 6 to talk through how to create an exploded diagram:

1. Begin with a list of all the required parts. Imagine taking the product apart and letting the pieces float in the air in sequence.
2. Spread out the outermost parts as much as possible (in this case, the two slices of bread should be as far apart as possible).
3. Keep the inner parts closer to the middle.
4. Consider the order of the parts and where they should be positioned.
5. Add arrows to show how the parts fit together.
6. Add labels to make all the parts of the diagram clear.

Return to slide 4 and ask the children to continue with the *Activity: Different diagrams* to produce a technical drawing, such as a cross-sectional or exploded diagram. If time allows, the children could produce both to compare how the product can be viewed.

Pupils needing extra support:
Could use the *Knowledge organiser* to refer to when drawing different types of diagrams; could have the *Activity: Different diagrams* printed larger to allow more room for annotations and sharing ideas.
Pupils working at greater depth:
Should draw with detail and accuracy, labelling the parts and materials in their diagrams; could be offered the *Resource: Isometric template* and explore how the grid pattern can be used to draw three-dimensional diagrams of a product; could choose their own product with internal and external features when drawing different types of diagrams.

Session 3

Focus: To design a toy that uses a pneumatic system.

Success Criteria:

- I can develop design criteria from a design brief.
- I can generate suitable ideas using different types of diagrams.
- I can recall different types of pneumatic systems I can use to design my toy.
- I can consider sustainable resources when designing my toy.

Main Activity

Explain to the class that they will watch clips demonstrating how simple pneumatic systems can cause movement.

Presentation: Inspiring pneumatic toys

Play each video one at a time from the *Presentation: Inspiring pneumatic toys* and after each, ask the children:

- **How could this movement be turned into a toy?**

Encourage group discussion about each movement and **idea blast** as a class, noting suggestions on the board for the children to refer to during the lesson. It may be preferable to organise the notes into different categories of pneumatic movement to help the class with their planning, for example:

- **Inflating a balloon between a folded paper plate:** a clam shell, a monster or an animal's face, for example, a frog.
- **Inflating a balloon inside a lidded box:** a mouse in a house with a door, a Jack in the box, an animal or a monster's face.
- **Two syringes connected by tubing:** someone playing peekaboo, a rabbit and a hare racing each other or two kangaroos jumping side-by-side.
- **A syringe with a pivot and linkage system:** a waving figure or a crane with a moving load.

Sketches and diagrams

Ask the pupils to sketch three ideas for a pneumatic toy using one of the demonstrated movements on their design sheet.

Emphasise that the sketches should be thumbnails rather than detailed drawings. Give the children a time limit, such as one minute of thinking and two minutes of drawing time per idea.

Ask the children to choose one of their designs to develop further. Allow time for the children to draw a more detailed or technical drawing of the selected design; depending on time and skill level, the children can choose to do a cross-sectional diagram, an exploded diagram or even both. Encourage the class to add labels to their diagram showing materials, air flow, input and output.
Leave some suggested equipment and materials out to one side for the children to plan around what is available and to test whether a particular movement is achievable. Further support strategies for generating and drawing ideas can be found in Adaptive teaching.

Pupils needing extra support:
Should have access to the *Resource: Generating ideas for a pneumatic toy* to help come up with ideas; should be encouraged to keep their ideas simple so that they can focus on creating a high-quality end product; could have the opportunity to look through available materials earlier or repeatedly to support design ideas; could remove the time constraint suggestions on thumbnail sketches; should use the paper plate or hinged box and balloon mechanisms as these are simpler to achieve; could use the *Activity: Designing a pneumatic toy: support version* with prompts to complete the design criteria and outlines of simple pneumatic mechanisms to plan around; could use the *Knowledge organiser* to support diagram completion; could have the *Presentation: Sketches and diagrams* from *Lesson 2: Drawing diagrams* displayed to support their diagram completion.
Pupils working at greater depth:
Should be challenged to draw with detail and accuracy, labelling the parts and materials in their design; should consider the input movement required, airflow and output movement when labelling their diagram; could consider using pivots or linkages as part of their mechanism as this applies prior learning to the pneumatic mechanism.

Session 4

Focus: To create a pneumatic system for a moving toy.

Success Criteria:

- I can create a pneumatic system to create a chosen movement.
- I can build secure housing for a pneumatic system.
- I can recall that syringes and balloons can create different pneumatic systems.
- I can recall how to use these components to make a functional and appealing pneumatic toy.

Main Activity

Hand out the children's *Activity: Designing a pneumatic toy* with sticky note feedback from *Lesson 3: Designing a pneumatic toy.* Ask them to review their design and the feedback provided. Instruct them to explain exactly how their design will work to a partner and describe the expected movement. The children should consider the practicality of their designs and chosen materials before making their toys.

Show the children a range of boxes and other materials for **housing** their pneumatic toy. Offer suggestions for modifying the boxes and demonstrate methods for inserting the tubing. Show how to create linkages using pivots (see *D&T, Year 2, Making a moving monster, Lesson 2: Making linkages*).

If required, display the *Presentation: Example pneumatic toys* to provide further inspiration on how to turn the mechanisms observed in the last lesson into functional pneumatic toys.

Presentation: Example pneumatic toys

Questions

- **What cutting equipment is most suitable for this build?** (Scissors are most suitable for cutting the materials and packaging; piercing holes should be made using a sharp pencil positioned over modelling dough, keeping fingers out of the way.)
- **What joining equipment is most suitable for this build?** (Masking tape is a sustainable and practical solution for holding packaging and card in place; PVA glue or glue sticks are suitable for sticking paper; split pins join parts together and allow movement through the pivot point.)

Ensure the children understand how to move around the room with scissors. Demonstrate how to cut safely and pierce holes using a sharp pencil and modelling dough. Remind the children working with syringes not to push too hard, especially when using syringes of different sizes (see Cautions).

Arrange the children on tables according to the type of **pneumatic system** they are building (for example, those using balloons and those using syringes) so they can share materials and support each other in troubleshooting (see Teacher knowledge). Instruct the children to collect the necessary materials to create their pneumatic system and connect the parts with masking tape where required.

Allow the children to build and test their mechanisms to ensure they work. Encourage them to gather the materials for their **housing** (cardboard packaging or card to meet the sustainability criteria) and remind them that they can draw their own nets for bespoke shapes if needed.

Instruct the children to mark clearly where each part of their mechanism will attach. Ensure they fit the balloon or syringes before attaching the moving parts of their toy. Once the attachment points are finalised, ask the children to cut the necessary card pieces for hinges or moving parts. Explain the importance of holding the mechanism to test that it works within the housing before fixing it.

Pause construction at points throughout the lesson to ask the class to test their mechanisms. Support the children in tweaking their mechanisms to ensure they run smoothly and discuss common problems and how to fix them as a class.

Pupils needing extra support:

Should keep their toy simple, for example, using balloons instead of syringes for their pneumatic toy, using boxes with hinged lids or folded paper plates and using pre-made shapes; could be provided with an example pneumatic mechanism structure to copy before adapting into their own toy; could have the *Presentation: Example pneumatic toys* available during the lesson to inspire and support construction.

Pupils working at greater depth:

Should apply their knowledge of stability and linkage systems to make a more complex pneumatic toy; could create their own nets on card for the housing or additional structures.

Session 5

Focus: To test and finalise ideas against design criteria.

Success Criteria:

- I can describe why materials are chosen due to how they work and look.
- I can recall how to work with materials to create different effects by cutting, creasing, folding, etc.
- I can evaluate how well the design, materials and equipment help to achieve the design brief.

Main Activity

Display the *Presentation: Pneumatic toy design brief* and select the design criteria on slide 3.

Presentation: Pneumatic toy design brief

Ask the class:

- **Does your pneumatic toy meet all of the design criteria at this stage?**
- **If it does not, what can you do to make sure that it does?**

Remind the children that while they finish building their toys, they must continually test the mechanism to ensure movement still happens as expected while parts and decorations are added.

Remind the class about the materials and equipment available for building, joining, cutting and decorating.
Allow time for the children to complete their pneumatic toy mechanisms and housing. They can use the remaining time to add some decorations to fulfil the 'appealing' element of the design criteria. Circulate the room to support the children in testing the efficiency of their mechanisms, fulfilling the design criteria and troubleshooting difficulties.

Pupils needing extra support:
Could make simple decorative features using suggested materials; could use a model to help them decorate their design; could be given pre-made features (such as arms, eyelashes, curled pipe cleaners, etc.) to help decorate their pneumatic toys.
Pupils working at greater depth:
Should experiment with their use of materials, independently reaching their own conclusions about how to make and finish their toys.

Session 6

Focus: To evaluate a design

Success criteria:

- I can identify if I have met the design brief.
- I can identify what works well.
- I can identify if there are any problems and how to fix them.

Main Activity

Children will be guided through the process of evaluating their completed or ongoing design work. They will reflect on how well their design meets the original brief, identify successful elements, and constructively assess areas for improvement. This supports the development of critical thinking and iterative design skills.