1. Year Groups

Years 5/6

2. Aspect of D&T

Mechanical systems

Focus

Pulleys or Gears

3. Key learning in design and technology

Prior learning

- Experience of axles, axle holders and wheels that are fixed or free moving.
- Basic understanding of electrical circuits, simple switches and components.
- Experience of cutting and joining techniques with a range of materials including card, plastic and wood.
- An understanding of how to strengthen and stiffen structures.

Designing

- Generate innovative ideas by carrying out research using surveys, interviews, questionnaires and web-based resources.
- Develop a simple design specification to guide their thinking.
- Develop and communicate ideas through discussion, annotated drawings, exploded drawings and drawings from different views.

Making

- Produce detailed lists of tools, equipment and materials. Formulate step-by-step plans and, if appropriate, allocate tasks within a team.
- Select from and use a range of tools and equipment to make products that that are accurately assembled and well finished. Work within the constraints of time, resources and cost.

Evaluating

- Compare the final product to the original design specification.
- Test products with intended user and critically evaluate the quality of the design, manufacture, functionality and fitness for purpose.
- Consider the views of others to improve their work.
- Investigate famous manufacturing and engineering companies relevant to the project.

Technical knowledge and understanding

- Understand that mechanical and electrical systems have an input, process and an output.
- Understand how gears and pulleys can be used to speed up, slow down or change the direction of movement.
- Know and use technical vocabulary relevant to the project.

4. What could children design, make and evaluate?

fairground ride with gears or pulleys e.g. carousel, Ferris wheel
controllable toy vehicle with gears or pulleys e.g. dragster, off-road vehicle, sports car, lorry,
window display with moving parts e.g. lifting or turning items for sale other – specify

5. Intended users

peers siblings younger children
older children specific individuals
target groups company other – specify

6. Purpose of products

entertainment pleasure play
educational interests and hobbies
business other – specify

7. Links to topics and themes

Festivals Celebrations Travel and Tourism
Mini-enterprise Forces and Motion
Outdoor adventure Toys and Games
Our Community other – specify

8. Possible contexts

home school leisure enterprise
wider environment local community
engineering manufacturing other – specify

9. Project title

Design, make and evaluate a _____ (product) for _____ (user) for _____ (purpose).

To be completed by the teacher. Use the project title to set the scene for children's learning prior to activities in 10, 12 and 14.

10. Investigative and Evaluative Activities (IEAs)

- Investigate, analyse and evaluate existing everyday products and existing or pre-made toys that incorporate gear or pulley systems. Use videos and photographs of products that cannot be explored through first-hand experience.
- Use observational drawings and questions to develop understanding of each product in the collection e.g. *How innovative is the product? What design decisions have been made? What type of movement can be seen? What types of mechanical components are used and where are they positioned? What are the input, process and output of the system? How well does the product work? Why have the materials and components been chosen? How well has it been designed? How well has it been made?*
- Children could research and, if possible, visit engineering and manufacturing companies that are relevant to the product they are designing and making e.g. Jaguar Land Rover, JCB, local companies

11. Related learning in other subjects

- **Spoken language** – ask relevant questions, formulate and express opinions, give well-structured descriptions and explanations. Use relevant strategies to build their vocabulary.
- **Computing** – use search technologies for research purposes and be discerning when evaluating digital content.

12. Focused Tasks (FTs)

- Using a construction kit, investigate combinations of two different sized pulleys to learn about direction and speed of rotation e.g. *How many times does the smaller pulley turn each time the larger pulley turns once? Do the pulleys move in the same direction? How can you reverse the direction of rotation?*

AND/OR

- Using a construction kit, explore combinations of two different size gears meshed together. Investigate the direction and speed of rotation focusing on how the size of the driver gear affects the speed of the follower gear. Ask the children to use the number of teeth on each gear to decide upon the gear ratios e.g. 10 tooth driver gear meshed with a 20 tooth follower gear produces a ratio of 2:1
- Build a working circuit that incorporates a battery, a motor and a handmade switch, such as a reversing switch. Demonstrate the accurate use of tools and equipment including cutting and stripping wire, and making secure electrical connections. Remind children about the dangers of mains electricity. Draw a pictorial representation of the circuit or draw a circuit diagram using correct symbols.
- Develop measuring, marking, cutting, shaping and joining skills using junior hacksaws, G-clamps, bench hooks, square section wood, card triangles and hand drills to construct wooden frames, as appropriate. Demonstrate the accurate use of tools and equipment.

13. Related learning in other subjects

- **Spoken language** – ask relevant questions, formulate and express opinions, give well-structured descriptions and explanations. Use relevant strategies to build their vocabulary.
- **Mathematics** – understand ratios. Apply understanding and skill to carry out accurate measuring using standard units i.e. cm/mm.
- **Science** – apply knowledge and understanding of circuits, switches, conductors and insulators. Recognise that some mechanisms, including pulleys and gears, allow a smaller force to have a greater effect.

14. Design, Make and Evaluate Assignment (DMEA)

- Develop an authentic and meaningful design brief with the children.
- Children generate innovative ideas by carrying out research including surveys, interviews and questionnaires and develop a design specification for their product, carefully considering the purpose and intended user for their product.
- Communicate ideas through detailed, annotated drawings from different views and/or exploded diagrams. The drawings should indicate the design decisions made, including the location of the mechanical and electrical components, how they work as a system with an input, process and output, and the appearance and finishing techniques for the product.
- Produce detailed step-by-step plans and lists of tools, equipment and materials needed. If appropriate allocate tasks within a team.
- Make high quality products, applying knowledge, understanding and skills from IEAs and FTs. Children should use a range of decorative finishing techniques to ensure a well finished final product that matches the intended user and purpose.
- Evaluate throughout and the final product in use, comparing it to the original design specification. Critically evaluate the quality of the design, the manufacture, functionality, innovation shown and fitness for the intended user and purpose.

15. Related learning in other subjects

- **Computing** – use search technologies for research purposes and be discerning when evaluating digital content.
- **Art and design** – use and apply drawing skills. Use techniques with colour, pattern, texture, line and shape.
- **Science** – apply knowledge and understanding of circuits, switches, conductors and insulators in the design of the final product.
- **Mathematics** – understand ratios. Apply understanding and skill to carry out accurate measuring using standard units i.e. cm/mm.

16. Possible resources

videos, photographs and everyday products or toys with pulleys or gears

batteries, battery holders, wires, crocodile clips, motors, switches, aluminium foil, paper fasteners, paper clips, card, motors, motor stands, dowel, paper sticks

consumable and construction kit pulleys or gears of different sizes, elastic bands

junior hacksaws, glass paper, G-clamps, bench hooks, hand drill, automatic wire strippers

PVA glue, sticky pads, masking tape, dowel, double-sided tape, card triangles, square section wood, card, corrugated plastic, finishing media

17. Key vocabulary

pulley, drive belt, gear, rotation, spindle, driver, follower, ratio, transmit, axle, motor

circuit, switch, circuit diagram

annotated drawings, exploded diagrams

mechanical system, electrical system, input, process, output

design decisions, functionality, innovation, authentic, user, purpose, design specification, design brief

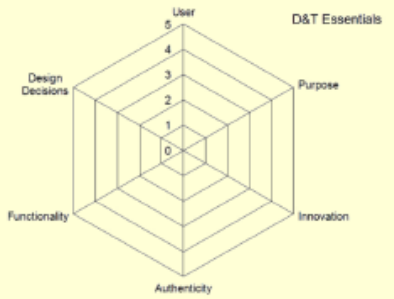
18. Key competencies

problem-solving teamwork negotiation
consumer awareness organisation motivation
persuasion leadership perseverance
other – specify

19. Health and safety

Pupils should be taught to work safely, using tools, equipment, materials, components and techniques appropriate to the task. Risk assessments should be carried out prior to undertaking this project.

20. Overall potential of project



Years 5/6

Mechanical systems

Pulleys or gears

Instant CPD



Tips for teachers

- ✓ Sourcing existing products with gears or pulleys can sometimes be difficult. Example products using construction kits or consumable materials can be premade for children to investigate.
- ✓ When beginning designing and making, ensure children are focused on making the mechanical system work, rather than the decoration.
- ✓ Focused tasks should concentrate on exploring combinations gears or pulleys using construction kits. If you do not have construction kits, attach bought pulleys and gears to cardboard using paper fasteners.
- ✓ Gears require more accuracy than pulleys at the making stage but make it easier for children to understand the concept of ratio by counting the number of teeth on each gear.
- ✓ The key to success in these units is to use components that are compatible with each other e.g. components purchased should have the same diameter holes.
- ✓ When children are making, zone areas of the classroom so resources can be easily found and replaced independently.
- ✓ Investigate alternative methods of evaluating. Try making video or photographic diaries that help develop ongoing evaluation.
- ✓ Don't be afraid of incorporating any failed designs into displays of final products. Include evaluations of why designs didn't work and how children would make them work. This links to design in the real world and the concept that designs don't always work first time around.
- ✓ Do not use rechargeable batteries.

Useful resources from www.data.org.uk:

- **Let's Get Practical Gears and Pulleys**
- **Let's Get Practical Developing Handmade Switches**
- **Fairgrounds**
- **CPD Resources Primary Inset Guides**

Other useful web-based resources:

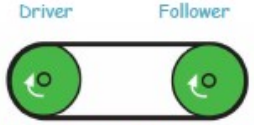
- **http://education.staffordshire.gov.uk/Curriculum/Subjectareas/DesignandTechnology/Primary/Support/Datafile/**
- **MWnet Crossover Project**

D&T Association publications:

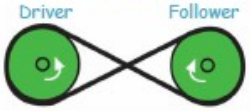
- **Primary Helpsheets – Units 6C and 6D**
- **Primary Lesson Plans – Units 6C and 6D**

Please note that these publications are based on previous National Curricula.

Developing understanding of gears and pulleys



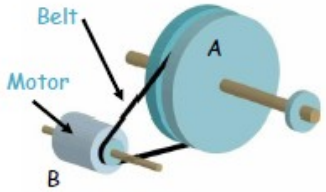
The pulleys rotate in the same direction



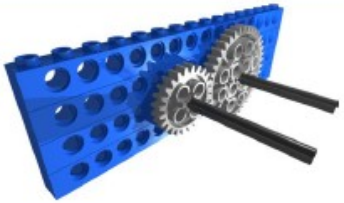
The pulleys rotate in different directions

Using construction kits, ask children to explore gear ratio using combinations of two gears e.g.

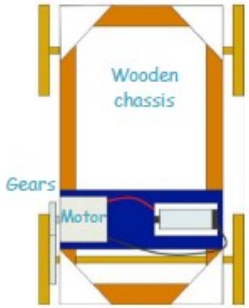
No. teeth	*Ratio*
8, 16	*2:1*
8, 40	*5:1*
8, 24	*3:1*
40, 40	*1:1*

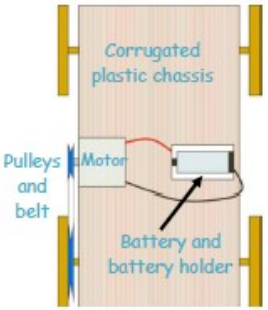


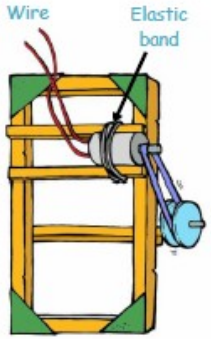
The small pulley (B) rotates much more quickly than the large pulley (A)



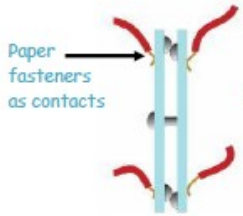
Building gears or pulleys into children's products

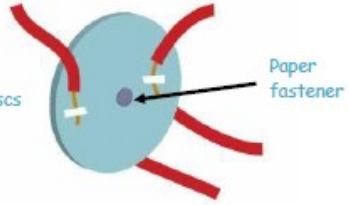






An example of a handmade reversing switch





Designing, making and evaluating a new toy vehicle for children in a particular age range

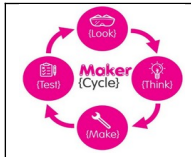
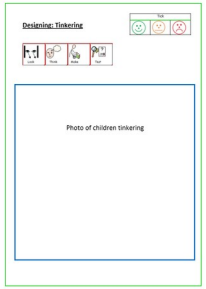
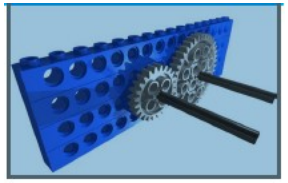
An iterative process is the relationship between a pupil's ideas and how they are communicated and clarified through activity. This is an example of how the iterative design and make process *might* be experienced by an individual pupil during this project:

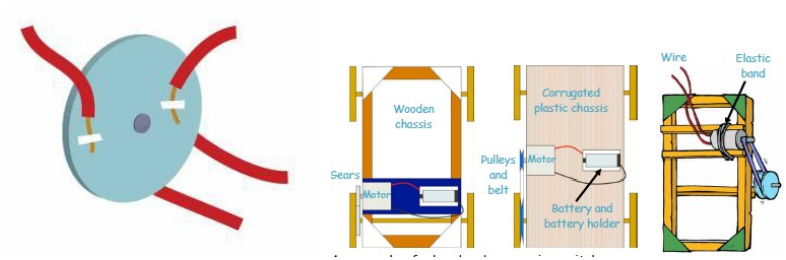
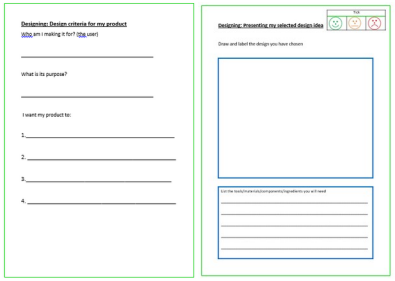
THOUGHT	ACTION
What type of toy vehicle shall I make? What will be its purpose? Who will use it?	Discussing ideas, drawing annotated sketches or exploded diagrams Generating a simple design specification
What electrical and mechanical components shall I use?	Discussing, modelling and evaluating different systems using mechanical and electrical components
Which materials will I use to make it? How will I make fit for purpose?	Investigating and trialling possible materials and components
How will I make the body shell for my toy vehicle?	Discussing, exploring and evaluating prototypes
What tools and materials will I need? What order will I work in? What constraints am I working to?	Negotiating, developing and agreeing a step-by-step-plan
Do I need to change anything?	Discussing, testing and modifying the design
Will my product meet the needs, wants and interests of the user group?	Evaluating the product with the intended user group and against the original design specification

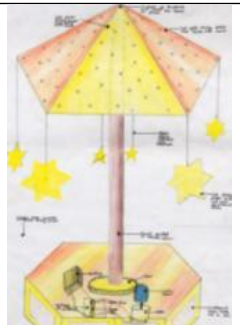
Glossary

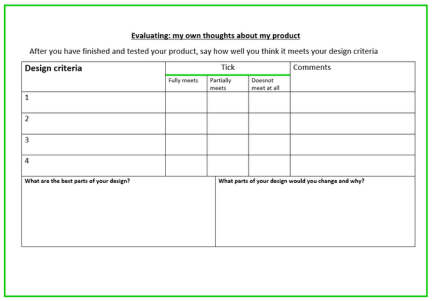
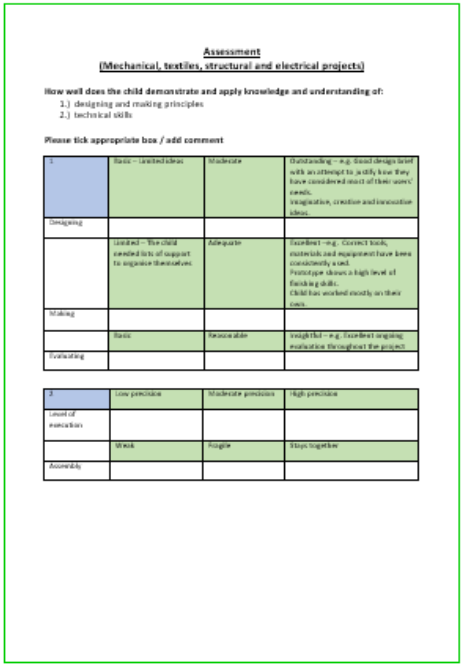
Pulley – a grooved wheel over which a drive belt can run.
Gear – a wheel with teeth around its circumference.
Drive belt – the belt which connects and transfers movement between two pulleys.
Gearing up or down – changing the rotational speed of a product by the use of pulleys or gears. When a small pulley or gear is used to drive a larger one the rotational speed is reduced and the product has been geared down.
Mechanical system – a set of related parts or components used to create movement.
Driver – the gear or pulley that provides the input movement to the system.
Follower – the gear or pulley that provides the output movement to the system.
Mesh – the point where two gears join together and transfer movement.
Motor spindle – the rod on the end of the motor onto which a gear or pulley is attached.

Session	Learning objective	Activity/outcome	Assessment	Vocabulary
1 Look LI: Give an opinion on a pre-existing product 		<u>Task: Research and explore existing products</u> Introduce the project: Select from: fairground ride with gears or pulleys e.g. carousel,, Ferris wheel, controllable toy vehicle with gears or pulleys e.g., dragster, off-road vehicle, sports car, lorry, window display with moving parts e.g. lifting or turning items for sale    **Investigative and Evaluative Activities (IEAs)** • Investigate, analyse and evaluate existing everyday products and existing or pre-made toys that incorporate gear or pulley systems. Use videos and photographs of products that cannot be explored through first-hand experience. • Use observational drawings and questions to develop understanding of each product in the collection e.g. *How innovative is the product? What design decisions have been made? What type of movement can be seen? What types of mechanical components are used and where are they positioned? What are the input, process and output of the system? How well does the product work? Why have the materials and components been chosen? How well has it been designed? How well has it been made?* • Children could research and, if possible, visit engineering and manufacturing companies that are relevant to the product they are designing and making e.g. Jaguar Land Rover, JCB, local companies	• Who do you think the product has been designed and made for? • What do you like about the product? • What works well?  Children complete page from booklet	functionality, innovation, authentic, user, purpose,design specification
2 Test LI: Test out ideas		**<u>Tinkering session</u>** **<u>The teacher should:</u>** • Explain to the children that they are going to make a (select from) fairground ride with gears or pulleys e.g. carousel,, Ferris wheel, controllable toy vehicle with gears or pulleys e.g., dragster, off-	• What ideas do you have? • How could you join those things together? • How is it going to work? • How could you make it better? • How can you make sure it is	pulley, drive belt, gear, rotation, spindle,, driver,, follower, ratio, transmit,, axle, motor, circuit,

	road vehicle, sports car, lorry, window display with moving parts e.g. lifting or turning items for sale • Provide the children with a wide range of resources to explore making the product - see possible resources on planner • Act as a facilitator – observe the children and provide support if necessary. • Encourage children to think about the **Makers Cycle – Look, think, make, test** • Observe misconceptions and support children to rectify these • Pupils should be encouraged to evaluate what they are doing	strong enough? • Does it move smoothly?  	switch,, circuit
3 Think/Test LI: Learn a new skill 	**<u>Skill builder session</u>** Teacher should lead a skill builder session where they teach their class a new skill. **Focused Tasks (FTs)** • Using a construction kit, investigate combinations of two different sized pulleys to learn about direction and speed of rotation e.g. *How many times does the smaller pulley turn each time the larger pulley turns once? Do the pulleys move in the same direction? How can you reverse the direction of rotation?* AND/OR • Using a construction kit, explore combinations of two different size gears meshed together. Investigate the direction and speed of rotation focusing on how the size of the driver gear affects the speed of the follower gear. Ask the children to use the number of teeth on each gear to decide upon the gear ratios e.g. 10 tooth driver gear meshed with a 20 tooth follower gear produces a ratio of 2:1  • Build a working circuit that incorporates a battery, a motor and a handmade switch, such as a reversing	<u>Technical knowledge:</u> <u>Pupils should:</u> • know about different pulleys and switches • Know about different gears • use the correct technical vocabulary for the projects they are undertaking • Can you work safely? • Can you work accurately?	pulley, drive belt, gear, rotation, spindle,, driver,, follower, ratio, transmit,, axle, motor, circuit, switch,, circuit diagram, annotated drawings,, exploded diagrams, mechanical system,, electrical system, input,, process, output

	switch. Demonstrate the accurate use of tools and equipment including cutting and stripping wire, and making secure electrical connections. Remind children about the dangers of mains electricity. Draw a pictorial representation of the circuit or draw a circuit diagram using correct symbols. • Develop measuring, marking, cutting, shaping and joining skills using junior hacksaws, G-clamps, bench hooks, square section wood, card triangles and hand drills to construct wooden frames, as appropriate. Demonstrate the accurate use of tools and equipment. 		
4 Make LI: Design a prototype 	<u>Task: Design the prototype (e.g. draw a diagram, write a list of equipment)</u> **<u>Design, Make and Evaluate Assignment (DMEA)</u>** • Develop an authentic and meaningful design brief with the children. • Children generate innovative ideas by carrying out research including surveys, interviews and questionnaires and develop a design specification for their product, carefully considering the purpose and intended user for their product. • Communicate ideas through detailed, annotated drawings from different views and/or exploded diagrams. The drawings should indicate the design decisions made, including the location of the mechanical and electrical components, how they work as a system with an input, process and output, and the appearance and finishing techniques for the product.	• Can you think of ideas and plan what you want to do? • Can you choose the best tools and materials? • Can you give a reason why these are best? • Can you describe their design by using pictures, diagrams, models and words? 	diagram, annotated drawings,, exploded diagrams, mechanical system,, electrical system, input,, process, output, design decisions,, functionality, innovation,, authentic, user, purpose,, design specification,, design brief

	 • Produce detailed step-by-step plans and lists of tools, equipment and materials needed. If appropriate allocate tasks within a team.		
5 Make LI: Make a prototype 	Task: Make a prototype **Design, Make and Evaluate Assignment (DMEA)** • Make high quality products, applying knowledge, understanding and skills from IEAs and FTs. Children should use a range of decorative finishing techniques to ensure a well finished final product that matches the intended user and purpose.   Children should: • select from a range of tools and equipment, explaining their choices • select from a range of materials and components according to their characteristics Mini plenary: What have you found out? What have has worked well? What might you want to change?		process, output, design decisions,, functionality, innovation,, authentic, user, purpose,, design specification,, design brief

5 Look/Think LI: Evaluate the prototype  	<u>Task: Evaluate your prototype</u> • Evaluate throughout and the final product in use, comparing it to the original design specification. Critically evaluate the quality of the design, Share your design. Why have you designed it that way? <u>Children should:</u> • talk about their prototype • make simple judgements about their product against design criteria • suggest how their products could be improved	• Was your product successful? • What went well with your work? • How could you make it better? • If you did it again, what would you want to improve? 	evaluate
Assessment Teachers should use the following document to assess pupils against. Please complete one for HAP, AAP and LAP pupil/attach to their booklets before handing to Nadia.			

Evaluating: my own thoughts about my product

After you have finished and tested your product, say how well you think it meets your design criteria

Design criteria	Tick			Comments
	Fully meets	Partially meets	Doesnot meet at all	
1				
2				
3				
4				

What are the best parts of your design?	What parts of your design would you change and why?

Assessment
(Mechanical, textiles, structural and electrical projects)

How well does the child demonstrate and apply knowledge and understanding of:
1.) designing and making principles
2.) technical skills

Please tick appropriate box / add comment

	Basic – Limited ideas	Moderate	Outstanding – e.g. Good design brief with an attempt to justify how they have considered most of their users' needs. Imaginative, creative and innovative ideas.
Designing			
	Limited – The child needed lots of support to organise themselves	Adequate	Excellent –e.g. Correct tools, materials and equipment have been consistently used. Prototype shows a high level of finishing skills. Child has worked mostly on their own.
Making			
	Basic	Reasonable	Insightful – e.g. Excellent ongoing evaluation throughout the project
Evaluating			

	Low precision	Moderate precision	High precision
Level of execution			
	Weak	Fragile	Stays together
Assembly			