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Cleaning up the Environment

Inspired by Industry · JCB

THE BIG PROJECT PICTURE

- You are designing a prototype that responds to a real **environmental problem** — inspired by JCB engineering.
- You will investigate air, water and land pollution — causes, effects, who it harms.
- You will learn how levers, linkages and hydraulics change movement and force.
- You will model a working cardboard litter picker, sketch solutions, and choose the best with Pugh's Matrix.
- You will build a final model in timber and plastic with a mechanical, electrical or hydraulic system — then test it against the specification.

Designer responsibility: designers and engineers are responsible for their impact on people, society and the environment. Solve a pollution problem without creating new waste.

KS3 D&T CURRICULUM LINKS

In this project you are learning to:

- Research real problems and users
- Develop creative design ideas
- Communicate with sketches and models
- Select suitable materials and tools
- Understand mechanisms and material properties
- Make prototypes safely and accurately
- Test and evaluate against a specification
- Consider impact on people, society and the environment

THE DESIGN THINKING CYCLE — YOUR PROJECT JOURNEY

1. EMPATHISE →	2. DEFINE →	3. IDEATE →	4. PROTOTYPE →	5. TEST
Understand pollution — what causes it and who it affects.	Choose a clear environmental problem and set your specification.	Sketch ideas and model mechanisms in cardboard; select with Pugh's Matrix.	Build the final model in timber/plastic and add a working system.	Check it solves the problem safely and effectively — then improve it.

Iteration: if a test shows a problem, go back a stage, improve, test again. Your litter picker v1 → test → refine is iteration in action.

MECHANISMS — HOW MACHINES CHANGE MOVEMENT AND FORCE

Mechanism	How it works	Examples
Lever	A rigid bar moves a LOAD using EFFORT around a PIVOT (fulcrum)	Scissors, pliers, litter picker, see-saw
Linkage	Connected arms transfer or change movement: input movement → linkage arm → output movement. Can reverse direction or turn it 90°	Litter-picker jaws, digger arm, toolbox linkages
Mechanical advantage	Making a job easier by multiplying force. Effort further from the pivot = more force (but a bigger movement)	Crowbar, wheelbarrow, JCB boom
Hydraulic system	Liquid pressure transfers force: push syringe → liquid down tube → output syringe moves. Liquids can't be squashed	JCB rams — small lever movement, huge bucket force
Electrical system	Power (battery) + control (switch) + output (motor, LED, buzzer)	Motorised sweeper, warning light on your prototype

Lever diagram: EFFORT ↓ ———————— ▲ ————— ↑ LOAD (▲ = pivot/fulcrum)

Mechanical advantage = load force ÷ effort force. e.g. 10 N effort lifting 20 N at the jaws → MA = 2. In your cardboard models, split pins are the pivots and string carries the pull.

INDUSTRY LINK: JCB

- JCB is a British company making diggers, loaders and waste-handling machines used worldwide.
- Its machines are giant systems of levers, linkages and hydraulics — a small lever movement creates a huge force at the bucket.
- JCB engineers use the same design thinking cycle you use — and work on cutting pollution too, including hydrogen-powered engines.

LEVER CLASSES AT A GLANCE

Class	Order along the bar	Example
1st	Effort — PIVOT — Load	Scissors, see-saw
2nd	Pivot — LOAD — Effort	Wheelbarrow, bottle opener
3rd	Pivot — EFFORT — Load	Tweezers, litter-picker trigger

3rd class levers give less force but a bigger, faster movement — ideal for a litter picker's jaws.

KEY VOCABULARY

Key term	Simple meaning	Project link
Pollution	Harmful substances entering air, water or land	The problem your prototype responds to
Sustainability	Meeting needs today without harming the future	Guides your material choices and purpose
Design thinking	Problem-solving cycle used by industry	Empathise → Define → Ideate → Prototype → Test
Lever	Bar that moves a load with effort around a pivot	The core of your litter picker
Linkage	Connected arms that transfer/change movement	Makes your jaws, arms or rake move
Mechanical advantage	Multiplying force to make a job easier	Why a picker grabs litter with little effort
Prototype	Early model made to test ideas	Cardboard models + final timber model
Specification	Measurable points a design must meet	Your environment spec — used in testing
Pugh's Matrix	Table scoring ideas against criteria	How you choose your strongest design
Iteration	Improving by repeating the design cycle	Litter picker v1 → test → refine
Hydraulic system	Liquid pressure transferring force	Syringes + tubing — like JCB rams
Electrical system	Battery + switch + output in a circuit	Motors, LEDs, switches on your prototype
Material properties	How a material behaves (strength, weight…)	Why you choose pine, MDF or acrylic
ACCESS FM	Evaluation checklist (8 headings)	The framework for your final evaluation
Evaluation	Judging a design against the specification	Honest testing, with evidence
Kaizen	Small improvements, made continuously	Always find the next refinement

ENVIRONMENTAL DESIGN KNOWLEDGE

- **Pollution types:** land (litter, landfill), air (fumes, smoke), water (plastics, chemicals).
- Products cause pollution when they are made, used and thrown away — designers must think about the whole life of a product.
- Good design can reduce waste: pick up litter, sort recycling, use fewer materials, last longer.

A good environmental design is…
Useful · Safe · Durable · Easy to use · Low waste · Designed for a REAL problem

DESIGNING & CHOOSING IDEAS

- **Sketch** in 2D and 3D; **render** to show form and materials.
- **Annotate** — explain what each part does, how it pivots/moves, materials and user benefit. Labels just name; annotations explain.
- **Specification** — measurable targets, e.g. "picks up a can without the user bending".

Pugh's Matrix compares your ideas against criteria so you choose the strongest design with evidence — not just the one you like.
Criteria: effectiveness · safety · ease of use · cost · strength · environmental impact. Score each idea per criterion; highest total wins.

MATERIALS, TOOLS & SAFETY

Material / tool	Used for	Safety / quality tip
Cardboard + split pins + string	Fast working models; split pins = pivots, string = pull	Cut on a mat; loose pivots swing freely; keep string taut
Craft knife	Accurate cardboard cuts	Mat down, fingers behind blade, cut away from the body
Coping saw	Curves in timber and acrylic	Clamp work; fingers clear of the blade line
Tenon saw	Straight cuts in timber	Bench hook; mark out with rule and set square first
Files / sandpaper	Shaping and finishing edges	Never file without a handle; coarse → fine grit; mask for MDF dust
Pillar drill	Accurate holes for pivots/fixings	Goggles, hair tied back, work clamped, guard down, permission first
Timber (pine/MDF)	Main structure of the prototype	Plan cuts to reduce waste — that's sustainable design
Acrylic / plastic	Scoops, guards, detail parts	Cut edges are sharp — file and sand them smooth
Syringes + tubing	Modelling hydraulic systems	Water only; wipe spills at once; remove air bubbles for crisp movement
Motors / LEDs / switches	Electrical systems, if they help your design	Correct voltage only; never short a battery; check polarity first

TESTING YOUR PROTOTYPE

Test against the cleaning-up-the-environment specification:

- **Does it help clean up the environment?** Try a real task.
- **Does the mechanism work?** Every pivot and linkage moves — repeatedly, not just once.
- **Is it strong enough?** Survives repeated use.
- **Is it safe?** No sharp edges or finger traps.
- **Is it easy to use?** Works first time, no instructions.
- **Are the materials suitable?** Right property, right place.

Kaizen = small improvements over time. After testing, find at least three small, specific improvements.

ACCESS FM — EVALUATION

A — Aesthetics	Does it look purposeful and well made?
C — Cost	Affordable? Material wasted?
C — Customer/User	Who uses it — does it suit them?
E — Environment	Does it truly help — without creating new waste?
S — Size	Right size for the user and the waste it handles?
S — Safety	Safe to operate? No pinch points?
F — Function	Does the mechanism grab/lift/sort as intended?
M — Materials	Chosen for their properties, used well?

"It works" is not evidence — show what you tested and what happened.

QUICK RETRIEVAL — ANSWER FROM MEMORY, THEN CHECK

1. What is pollution? Name the three main types.
2. What are the three parts of every lever?
3. What does a linkage do in a mechanism?
4. What is mechanical advantage? Write the formula.
5. Why can hydraulic systems transfer force so well?
6. What three parts does every electrical system need?
7. What is a Pugh's Matrix used for?
8. Why is testing against a specification important?
9. Give one property of MDF and one of acrylic.
10. What does Kaizen mean?