Stage 5 Industrial Technology – Engineering: Practical Projects Guide

Overview

Term	Project	Main Focus	Key Skills	Approx. Duration
Term 1	Water Tower Challenge	Structural design, stability, load testing	Teamwork, sketching, building, failure analysis	~3 weeks
Term 1	Concrete Beam Casting & Test	Material strength; compressive vs tensile forces	Measuring and mixing, casting, curing, testing compressive vs tensile strength	~2 weeks
Term 1	Corrosion & Damp-Proofing Experiments	Corrosion processes, capillary action, protective measures	Planning experiments, data collection, comparing treatments	~2 weeks
Term 1	Tensegrity Phone Holder	Tensegrity structures and force balance	Measurement, knot-tying, adjusting tension, spatial reasoning	~1 week
Term 2	Tabletop Hydraulic Digger	Fluid power, lever linkages	Designing lever arms, constructing hydraulic circuits, measuring force and efficiency	~4 weeks
Term 3	Geared Lolly Dispenser	Compound gears, cams/ratchets, reliability	Gear ratio calculation, mechanism construction, reliability testing	~4 weeks
Term 3	Mechanism Experiments	Simple machines: gears, levers, cams, pulleys	Measuring velocity ratio & mechanical advantage, plotting results	~1 week
Term 4	Project Refinement	Optimising and improving mechanisms	Design evaluation, problem solving, iteration	~2 weeks
Term 4	Folio & Evaluation	Documentation and reflection	Organisation, technical writing, critical thinking, presentation skills	~2 weeks

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Term 1 – Structures and Materials

Water Tower Challenge

Key objectives

Objectives	Materials	Concepts & Skills	Safety
Design and build a tower that supports a water reservoir and withstands a load test	Light wood (balsa, dowels), glue, string, base board, container for water	Brainstorming, sketching, building trusses, understanding tension vs compression	Wear safety glasses and gloves when cutting or load testing

Steps

1. Understand the brief: plan the height and load requirements for your tower.
2. Brainstorm several designs and choose one with good stability (triangular bracing and wide base).
3. Draw a scale diagram and list the lengths of each member.
4. Cut and assemble the base and vertical supports; add cross-braces to strengthen joints.
5. Create a platform for the reservoir and attach it securely.
6. Check for weak points, reinforce if needed.
7. Gradually add weight (water or sand) to test load capacity; record the point of failure.
8. Discuss why the tower failed and redesign if time allows.
9. Document your design, build process, and test results with photos and sketches.

Concrete Beam Casting & Destructive Test

Key objectives

Objectives	Materials	Concepts & Skills	Safety
Cast small concrete beams and test them under bending load until failure	Cement, sand, aggregate, water, molds, optional reinforcement	Measuring and mixing, casting, curing, testing compressive vs tensile strength	Wear gloves, dust mask and goggles; caution during load tests

Steps

1. Prepare molds and apply a release agent.
2. Measure and mix concrete (e.g. 1 part cement : 2 parts sand : 3 parts aggregate).
3. Fill molds halfway; insert reinforcement if using; fill to the top and tap to release air bubbles.
4. Cover to cure; remove beams after 24 hours and keep them damp for several days.
5. Set up a simple bending test rig with two supports and a central loading point.

6. Apply load at the centre gradually until the beam cracks; record the load and observe where cracks develop.
7. Compare different beams (with/without reinforcement) to see how reinforcement affects strength.
8. Capture photographs of cracks and note which part of the beam was in tension and compression.
9. Reflect on results and document your findings.

Corrosion & Damp-Proofing Experiments

Key objectives

Objectives	Materials	Concepts & Skills	Safety
Explore how different conditions cause corrosion and how to prevent it; demonstrate rising damp and damp-proofing	Steel nails or wool, jars, water, salt water, vinegar, oil, paint, porous blocks, waterproof membrane	Planning fair tests, observing and recording changes, comparing treatments	Label jars; handle liquids carefully; wash hands after handling chemicals

Steps

1. Decide on conditions to test (plain water, salt water, acid, coated vs uncoated, sealed vs open).
2. Prepare identical metal samples; apply coatings or seal some samples.
3. Place each sample in its jar with the chosen solution; set up dry-air tests by sealing the jar.
4. Observe the samples each day, noting when rust appears and its severity.
5. Discuss why certain solutions accelerate corrosion and how coatings help.
6. Demonstrate rising damp by standing a brick or paper towel in water; observe capillary rise.
7. Test damp-proofing by applying waterproof cream to one half of a block or inserting a membrane; note how water is stopped.
8. Summarise your observations and suggest how these lessons apply to real buildings.

Tensegrity Phone Holder

Key objectives

Objectives	Materials	Concepts & Skills	Safety
Build a small tensegrity structure that balances compressive struts and tensile strings to hold a phone	Two platforms, 3–4 struts, thread, screws or hooks	Measurement, knot-tying, adjusting tension, spatial reasoning	Use a drill carefully; check stability before placing the phone

Steps

1. Learn the principle of tensegrity: struts in compression connected by strings in tension.
2. Decide positions for struts and threads on both platforms.
3. Cut struts to equal lengths and drill pilot holes in the platforms.
4. Fix one end of each strut to the top platform.
5. Tie threads to the loose end of each strut and attach them to the bottom platform; adjust length so the top floats.
6. Tension the strings evenly to keep the top platform level.
7. Test the structure with a phone and adjust strings if it leans or collapses.
8. Decorate or paint if desired and document the final geometry.

Term 2 – Fluid Power and Mechanical Systems

Tabletop Hydraulic Digger

Key objectives

Objectives	Materials	Concepts & Skills	Safety
Build a miniature excavator using syringes and linkages; measure force and efficiency	Wood or cardboard arms, bolts or hinges, syringes and tubing, water or oil	Designing lever systems, constructing hydraulic circuits, measuring mechanical advantage	Avoid air bubbles in syringes; secure joints; wear goggles during testing

Steps

1. Review Pascal's law and how fluid pressure transmits force.
2. Sketch the boom, stick, and bucket; decide where to attach cylinders.
3. Cut and assemble the base and arm pieces; attach pivots so they move freely.
4. Prepare and fill syringes; connect them with tubing and eliminate air bubbles.
5. Mount syringes at strategic points on the arms (base-to-boom, boom-to-stick, stick-to-bucket).
6. Test movement by pushing and pulling the input syringes; note how different cylinder sizes change force and distance.

7. Measure the load the digger can lift and calculate theoretical vs actual mechanical advantage.
8. Modify cylinder positions or lever lengths to improve performance and efficiency.
9. Document design, test results, and reflections.

Term 3 – Mechanisms and Machines

Geared Lolly Dispenser

Key objectives

Objectives	Materials	Concepts & Skills	Safety
Design a machine that dispenses one candy per turn using compound gears and optional cams or ratchets	Frame material, gears (store-bought or cut), axles, hopper, crank	Calculating gear ratios, designing cams or ratchets, building for reliability	Use tools safely; ensure moving parts are enclosed; avoid pinch points

Steps

1. Define the dispensing mechanism (rotating scoop or sliding gate) and design a hopper for your chosen candy shape.
2. Decide on gear sizes to connect the handle to the dispensing wheel; calculate the total gear ratio.
3. Create the frame and drill holes for axles; ensure proper spacing for gears to mesh.
4. Cut or mount gears; attach them to axles and secure them in the frame.
5. Add a cam or ratchet if needed to control the motion and prevent backsliding.
6. Mount the hopper and guide so only one candy enters the mechanism at a time.
7. Attach a crank to the input shaft and test by turning it; adjust gear spacing or hopper shape if multiple candies fall or it jams.
8. Record the number of handle turns per candy and compare to the theoretical gear ratio.
9. Keep a reliability log: how many times can you dispense without jamming? Note improvements made.

Mechanism Experiments

Key objectives

Objectives	Equipment	Concepts & Skills	Notes
Measure mechanical advantage, velocity ratio, and efficiency of simple machines	Simple gear pair, lever with fulcrum, pulley block, cams and followers	Data collection, ratio calculations, graphing, understanding energy loss	Keep loads within safe limits; record multiple trials for accuracy

General procedure

1. Assemble a simple device (gear pair, lever, cam, or pulley) with known dimensions.
2. Measure input force and distance (effort) and corresponding output force and distance (load).
3. Calculate velocity ratio (distance input ÷ distance output) and actual mechanical advantage (load ÷ effort).
4. Compute efficiency (AMA ÷ VR × 100 %).
5. Repeat with different loads and record results in a table.
6. Plot effort vs load to see if the relationship is linear.
7. Write a short reflection on how the device trades force for distance or speed.

Use the simple gear train diagram above when studying gear ratios. Refer back to the mechanical advantage formulas table when recording your data.

Mechanical advantage formulas

Mechanism	Velocity Ratio (VR)	Mechanical Advantage (MA)
Spur gear train	Number of teeth on driver ÷ number of teeth on driven	Load force ÷ effort force
Lever	Length of input arm ÷ length of output arm	Load ÷ effort
Pulley system	Number of supporting ropes	Load ÷ effort
Hydraulic cylinder pair	Output cylinder area ÷ input cylinder area	Load ÷ effort (assuming no losses)

Term 4 – Refinement and Evaluation

Project Refinement

Key objectives

Objectives	Activities	Concepts & Skills	Notes
Improve a previous mechanism by addressing problems and optimising performance	Review design, research improvements, redesign parts, test modifications	Critical analysis, problem solving, iteration, precision fabrication	Keep detailed notes on changes and their effects

Guidelines

1. Review data and observations from your original project and identify issues.
2. Research possible solutions (e.g. different gear ratios, better materials, smoother cam profiles).
3. Plan modifications with sketches and a parts list.
4. Build new components and integrate them with the existing mechanism.
5. Test the improved system, measuring the same metrics as before.
6. Compare performance before and after modification.
7. Iterate further if time allows.
8. Reflect on what you learned about the engineering design process.

Folio & Evaluation

Key objectives

Objectives	Contents	Concepts & Skills	Notes
Compile a comprehensive portfolio documenting the year's projects and reflect on your learning	Introduction, design documentation, test data, evaluation, reflection, real-world links	Organisation, technical writing, critical thinking, presentation skills	Use headings, lists, diagrams and tables for clarity

Guidelines

1. Introduce each project briefly and state its purpose.
2. Include drawings, notes, material lists, safety considerations, photos and data tables.
3. Present test results in graphs or charts and summarise your findings.
4. Evaluate how well each project met its criteria and what you would improve.
5. Reflect on teamwork, time management and risk management; note any challenges and how you overcame them.
6. Relate the projects to real engineering applications and mention possible career paths.
7. Make sure your folio is well organised and clearly presented; use captions for images and tables.
8. Be ready to present your refined project and answer questions about its design and performance.

Additional Learning Scaffolds

Experiment Data Recording Table

To organise measurements for mechanism experiments, use the following table (fill in your own data):

Trial	Load (N)	Effort (N)	Output distance (m)	Input distance (m)	Velocity ratio	Actual MA	Efficiency (%)
1							
2							
3							

Design & Evaluation Template

Use this template to plan and evaluate your projects. Add or remove rows to suit your needs.

Section	Description / Notes
Project Title	
Brief & Criteria	
Materials & Tools	
Safety Considerations	
Construction Steps	
Testing & Measurements	
Results & Analysis	
Reflection / Improvements	