Royal Academy of Engineering

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1 Building a cliff railway

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Teacher sheet

Problem-based learning resources

The **Royal Academy of Engineering** is harnessing the power of engineering to build a sustainable society and an inclusive economy that works for everyone.

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Project brief and variations

Students will act as consulting engineers to explore the issues faced in the design, construction and maintenance of a cliff railway. The activities will include practical, investigative work in the workshop or lab, group work (e.g. team planning meetings) and a series of individual paper-and-pencil exercises (e.g. writing reports, mathematical exercises).

Design and Development (D&D) candidates will create a design for a cliff railway to match specifications they have identified by analysis of the presented scenario. They will engage in investigative practical work to derive a range of key values (e.g. an estimate of the electrical power needed to pull a given mass up a slope) that would drive the final system design and performance.

Maintenance, Installation and Repair (MIR) candidates will identify potential points of failure and key routine maintenance needs for an existing cliff railway or part of it to inform a suitable service strategy. They carry out exemplar repairs or replacements in the workshop to identify potential problems (e.g. safety issues working with large currents, extensive system downtime during repair and suggest ways to solve these.

Manufacturing, Processing and Control (MPC) candidates explore materials suitable for manufacturing a key component in the cliff railway and generate data which will inform this manufacture. They identify potential problems and suggest ways to solve this by optimising kit and materials delivery and deployment in the production line.

The projects are organised around a version of the engineering design process as shown in **Figure 1.** The CODIFY and PRESENT components are focused on clients and their circumstances while the PLAN, PERFORM and REVIEW processes tend to be internal to the engineering team. This process is often shown as a cycle (the output from one cycle providing an input to stimulate another) and, while the project resources are based around a global arc from CODIFY to PRESENT, teaching and learning will inevitably involve some smaller repeated cycles, or cycles with some components omitted for convenience, throughout the 30 hour project.

Exemplar tasks are mentioned to support students who might be finding it difficult to formulate a way forward, but these are only examples of what *might* be possible rather than *mandatory requirements*. Students should be encouraged to develop their own work plans, within the limits imposed by the relevant specifications and college timetables, to prepare them better for the world of work.

Project resources

Student resources

The Students booklet gives details of the proposed context and a series of forms to fill in during the project work. This will help to form a record of their progress.

Individual sheets offering support with particular topics or techniques are also available and can be made available at appropriate points in the project.

Teacher resources

The Teacher resources are provided in a single file and describe the teaching approach used to drive the project. Each context can be interpreted to support particular T-level qualifications (Design and Development (D+D), Maintenance, Installation and Repair (MIR) and Manufacturing, Process and Control (MPC). They equally work well with other technical qualifications. The following parts of the project are common to all three pathways and derive from the context:

- **Project overview:** a simple overview of the content in terms of the relevant core skills from the T-level engineering specifications with a suggested schedule.
- **Learning focus:** the purpose and emphasis of the project in general terms.
- **Success criteria:** illustrative success criteria at three levels for students.

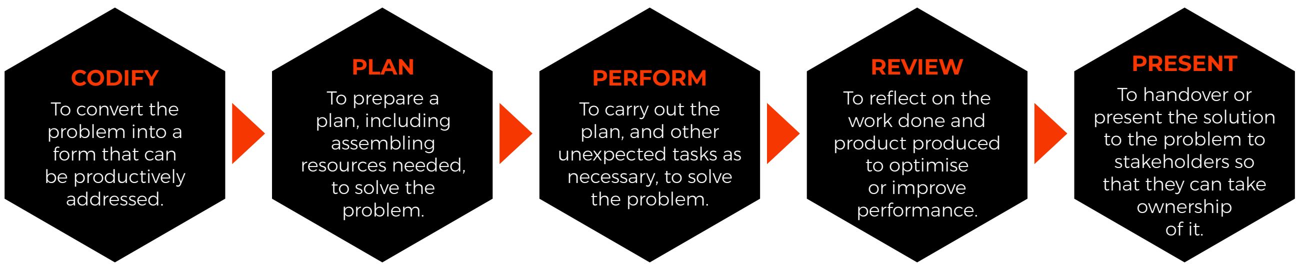

Figure 1: The Engineering Design Process

- **Exemplar tasks:** examples of the kinds of tasks suitable to deliver and demonstrate learning linked to the T-Level Core Skills.

The following extra details are supplied for the D+D pathway in the Building a Cliff railway project:

- **Teaching sequence:** advice on lesson management including suggestions for formal outputs that can evidence student achievement.
- **Resources:** materials to support particular tasks.

Project deployment

The full project is a time-consuming endeavour (roughly 30 hours of teaching time). This provides significant learning benefits, particularly in terms of student self-management, by giving time for greater exploration and optimisation. However, this is not always possible. Two options are possible to solve this problem:

1. Provide some of the material needed for the project directly to students, e.g. giving them a pre-built plan rather than asking them to develop their own, supplying experimental data to analyse rather than asking students to plan and carry out an investigation to generate their own. This allows the teacher to explore particular aspects of a project or try out interesting approaches without committing to the whole project.
2. Opting for a slightly modified project with a smaller scope. Again, these will not allow the full skill development of the whole project but can focus on particular aspects of the process where students need extra support. Examples are given in **Table 1** below.

Learning focus

This project will focus on students' abilities to:

- Audit and use their existing engineering knowledge and understanding to produce a viable solution to problems identified by the students, concerning the design, manufacture, installation and maintenance of a cliff railway.
- Conduct research as required to develop their existing engineering knowledge and understanding (e.g.forces acting on moving bodies, prioritising work schedules, diagnostic tests) in order to support sophisticated engineering problem-solving decisions (often containing compromises between different priorities).
- Develop a maintenance strategy which will ensure maximum system up-time and performance through identifying most likely

Table 1: Project deployment

Activity	Phases targeted	Brief description of the activity	Time / hrs
Planning a project	**CODIFY**	Ask students to review the possibility of installing a cliff railway at a local site or a well-known tourist spot.	6
	PLAN	Research into the circumstances locally can be done with visits to the site if required while a well-known tourist spot will be well-documented online. The planning should culminate in a clear statement of what is possible and desirable in the context with an outline of possible routes to achieve the objective.	
Commenting on a project	**REVIEW**	Ask students to review either the plan for a particular installation or the implementation of a project. The former could be created by other students while the latter could be documented online (e.g. Crossrail, HS2, the second Severn Crossing). It might be useful to choose a project that has gone well to act as a model to copy or one that has performed badly (over schedule, over budget and poor quality) to illustrate some of the issues that can arise in badly-run projects.	6
Testing materials	**PERFORM**	Ask students to design and carry out a test to assess the suitability of a material for a particular purpose. Characteristics investigated could include electrical conductivity, tensile strength etc. which would be related to the overall cliff railway context.	4

points of failure and mechanisms (skills, equipment and components) to ensure this.

- Work effectively in teams to identify and analyse a problem, create a plan of work to solve the problem and organise the delivery of this with others in a collaborative manner.

Success criteria

Assessment opportunities across the project will allow all candidates to practice key skills and gather evidence of success in the general competencies and their increasing background knowledge.

The statements in **Table 2** below are examples of the typical achievements at three levels of sophistication as they move from the left-hand column across to the right-hand side.

They can be edited and added to during the process and not all students will be expected to hit all outcomes – they should not be seen as a simple checklist to tick.

Table 2: Success criteria

INCREASING SOPHISTICATION →		
All students will:	**Most students will also:**	**A few pupils will also:**
Recognise a clearly-defined problem.	*Draw out the key issues in a scenario to codify a problem to be solved.*	Consider competing interests in formulating a problem so that multiple strategies to solve it can be suggested.
Use 'common sense' insights to solve a problem.	*Consciously and explicitly use their existing engineering knowledge and skills to solve a problem.*	Recognise gaps in their existing engineering knowledge and skills and explicitly seek to fill these in order to help with producing a valid solution to a problem.
Produce a rudimentary plan with a clear sequence of tasks	*Show tasks, resources and people needed to deliver work with key dates specified.*	Agree the plan with relevant parties in consultation and have potential back-up strategies available.
Collect data in an inquiry and modify this raw data as appropriate (e.g. calculating averages, graphing) prior to communicating the data in a report.	*Design a valid experimental procedure to generate valid, reliable and useful data.*	Modify their experimental procedures to solve problems as they emerge during the activity explaining why their new approaches will produce more useful, valid data.
Justify their strategy decisions by reference to collected data and the original project brief.	*Justify their strategy decisions by reference to their existing engineering knowledge and skills, collected data and the original project brief.*	Recognise that the first solution to a problem may not be the best and seek to optimise and finesse their initial ideas and products to improve performance. Make decisions between competing priorities (e.g. cost and performance of components, ease of replacement of components and waste production).
Contribute to a shared report taking personal responsibility for an identifiable component (e.g. digitising calculations with a spreadsheet, producing graphics or specific items of text).	*Present a report that is constructed to reflect the needs of the audience.*	Manage the delivery of the report answering questions and taking suggestions for future developments as appropriate.
Provide and receive respectful, honest and helpful feedback within their teams.	*Modify their behaviour / approach in the light of respectful, honest and helpful feedback.*	Support other team members as they seek to modify their behaviour or approaches.

Design and Development

Design and Development (D&D) candidates will create a design for a cliff railway to match specifications they have identified by analysis of the presented scenario. They will engage in investigative practical work to derive a range of key values (e.g. an estimate of the electrical power needed to pull a given mass up a slope, the properties of materials selected for the cables) that would drive the final system design and performance including safety features (**Table 3**).

Table 3: Design and development

Phase	D+D core skills from City and Guilds T-level specification (8714)	Exemplar tasks	Time / hrs
CODIFY	**Core Skill A: Planning and preparation** ▪ Interpreting and confirming project requirements.	Students explore the scenario and identify a suitable problem to solve. They produce a description of the problem to be solved in engineering terms and generate a proposal. Students carry out an initial survey of the proposed site and produce an initial design for the railway.	4
PLAN	**Core Skill A: Planning and preparation** ▪ Planning and scoping project parameters (e.g. timescales, resources, costs). ▪ Developing project plans.	Students draw up a detailed specification with relevant measurements including track length and gradient. Students plan an inquiry into the power requirements for the railway.	10
PERFORM	**Core Skill C: Developing proposals and concepts** ▪ Designing proposals to meet set requirements. ▪ Developing, modelling and revising concepts.	Students carry out their inquiry into the power requirements and carrying capacity of their proposed design to generate data which can be scaled up for the actual site. Students update their designs and specifications based on the data from their laboratory inquiry. Students design a power supply system for the railway showing typical loads, current draw and other factors they have identified as significant with full justification for their decisions.	10
REVIEW	**Core Skill D: Evaluation** ▪ Carrying out tests, evaluation and analysis. ▪ Evaluating how well project requirements have been met.	Students review their activity and comment on it showing how they used their engineering knowledge, any investigative activities and direct observation to inform the design of the system. Students reflect on their team's and their personal performance and consider options for improvement in the future.	4
PRESENT	**Core Skill B: Communication** ▪ Interpreting, using and producing engineering representations and drawings following graphical language and industry conventions. ▪ Interpreting and using technical information and media. ▪ Communicating with technical and non-technical audiences using technology.	Students present their cliff railway plans, data, calculations and risk analysis to the client with clear recommendations for the best way forward.	2

Teaching sequence

CODIFY (4 hrs)

Exemplar tasks

- Students explore the scenario and identify a suitable problem to solve. They produce a description of the problem to be solved in engineering terms and generate a proposal.
- Students carry out an initial survey of the proposed site and produce an initial design for the railway.

Teaching strategies

Introduce the project to students either by visiting a cliff railway or show them some images and videos of cliff railways – there are many available online. Draw out the notion that it uses a different track and drive mechanism to a normal railway – it's not just a normal railway on a slope!

When students are familiar with the context ask them to consider what engineers might do in a similar situation. Encourage them to think about possibilities, what might happen, as opposed to simply describing what they can see in the contextual material. Use this opportunity to draw out students' interests and encourage creativity. Typical examples of work that they might consider doing include:

- Designing a lifting mechanism for the car – this involves assessing the strength of cables, the load that will be acting on them and how they might degrade with use and over time.
- Designing a cable car – what materials might be most appropriate given the need to be lightweight yet strong and, of course, as cheap as possible!
- The two examples use different ways to power the railways. Students might consider possible alternative, more sustainable power sources. How could they make their chosen system resilient and efficient?

You can run this part of the session as a brainstorm or a series of small group exercises. The output could be used to form their projects or you may require them to do specific tasks for assessment purposes. By the end of this exercise, students should be clear about the project they are about to engage in and any expectations that you have that they need to build into their planning.

Ask students to carry out a survey of the proposed site or, if nowhere is suitable in your locality, use a simulated site created from examples of other sites in the world. Ensure that the simulated site has a vertical height to rise, a horizontal distance to travel and details about the land at the bottom and top of the slope. An alternative approach is to ask students to propose an upgrade to an existing cliff railway – how might they bring an older setup into the 21st century?

Ask the students what problem the railway is trying to solve – is it moving goods or people? Why might it be better or worse than alternative solutions like a set of stairs, a winding road or even a cable car? How could they estimate potential trade – if the railway does not yet exist how can they predict how much cargo or how many people would use it on completion? Remind them that this is an engineering problem and that they should use their engineering knowledge and skills to help solve it – this project is not asking them to simply suggest a few futuristic ideas about cliff railways and design a logo for the train.

Ask students to draw together the various aspects of the issue, revealed by research and their existing knowledge, to create a proposal for the local council or landowner. The proposal should demonstrate the need for the railway, identify its potential customers and estimate the cost of and schedule for construction. The proposal must include a rough design of the railway and a review of the environmental costs and benefits of the project.

Output and evidence

The output from this stage should be a clear statement of the problem to solve in engineering terms and an outline plan showing possible options for progress. This could be evidenced by:

- A proposal overview showing the key features of the proposed railway, its construction and estimated costs and schedules. This will need to be suitable for a non-specialist audience and should include at least one illustration, one mathematical diagram or charting no more than 500 words of text.
- A technical annexe showing detailed drawing with full justification, in terms of engineering knowledge and understanding, for all proposals in the proposal overview. It should be appropriate for a technical audience and include all calculations used and full background justification for the proposal components.

Useful resources

3: Environmental assessments. Considering the environmental impacts of a project (e.g. building a new gigafactory to make batteries) or change (e.g. a switch to EV cars) in the immediate and medium-term and for the local area and more widely.

10: Knowledge audit. Identifying the knowledge base appropriate to a project and the likely future needs.

19: Conducting site surveys. Conducting a site survey for a construction project (e.g. cliff railway, EV charging station, temporary building) or installation (e.g. installing a computer server, refrigeration unit) taking measurements of key features to produce a detailed map with significant measures clearly marked.

25: Engineering design cycle. Using the engineering design cycle to stimulate creative solutions to problems.

28: Creative thinking. Using divergent and convergent thinking skills to sharpen your creativity.

29: Constructing a project strategy. Developing the 'big picture' strategy to drive an engineering project.

PLAN (10 hrs)

Exemplar tasks

- Students draw up a detailed specification with relevant measurements including track length, gradient and estimated load.
- Students plan an inquiry into the power requirements for the cliff railway.

Teaching strategies

A key aspect of the project involves the power consumption of the railway. Ask students to design an investigation into the effects of a range of factors (e.g. gradient, mass of carriage, speed of ascent etc.) on the energy needed to move a mass up an inclined plane. The easiest way to explore these issues is to develop a simple model of the railway and measure the power needed by an electric motor to lift objects up the track. This apparent simplicity masks a range of issues with experimental design and the reliability of any data generated so ensure that students have identified and managed all relevant variables and are confident taking and recording measurements before they start to build their model. This may involve making sure they can use measuring equipment competently and safely – and without damaging the meter! One problem with student-generated inquiries is that they assume the availability of equipment or materials without planning their requirements in advance – use this opportunity to emphasise that planning involves both formulating a method and organising/ordering any kit required to implement it.

Again, stress to students that their engineering knowledge will help them when tackling this task and that they should mention it explicitly when justifying decisions. This may involve them carrying out research to gather more understanding or you may choose to provide extra content at various points to supplement their existing understanding.

As part of the planning process, students should identify and agree roles within the team. Take this opportunity to stress the fact that most engineers work in teams and depend on others making their contributions to complete their own work. Ask students to consider how workplaces can be organised to reinforce this team spirit – this provides a useful opportunity to discuss rights and responsibilities in the workplace – everything from punctuality to pay!

Students will need to use a variety of mathematical techniques to calculate key values, e.g.the length and slope of the track, the size of the stations at the base and top of the track, the number of supports for the track as it goes up the slope). These calculations should accompany their designs and demonstrate the feasibility of their suggestions.

Output and evidence

The output from this stage should be a clear plan that identifies key problems, strategies to solve them and roles and responsibilities of all in the team. The specific inquiry recommended for this project is to look at the power supply for the railway but other inquiries are possible depending on student choice and interest. This could be evidenced by:

- A detailed plan showing the tasks to be completed, the staff involved and the schedule. All decisions should be justified by reference to existing engineering knowledge and skills, the particular needs of the context and the characteristics of the proposed solution.

Useful resources

2: Risk analysis. Conducting a risk analysis for a process or project and identify key safety practices and equipment that would be necessary (legally) and advisable (good practice).

13: Setting SMART objectives. Reviewing the characteristics and use of objectives to drive development.

14: Avoiding crises. Identifying priorities and strategies for work.

15: Rights and responsibilities. Identifying key rights and responsibilities in the workplace and how they affect working life.

16: Managing meetings. Facilitating a meeting to explore possible solutions to a problem, generate a decision and a report with clear recommendations and their justification.

17: Working in teams. Developing strategies for successful team working – and suggesting behaviours which can undermine teamwork.

22: Responding to a brief. Developing a strategy to deliver on a brief or win a tender.

PERFORM (10 hrs)

Exemplar tasks

- Students carry out their inquiry into the power requirements and carrying capacity of their proposed design to generate data which can be scaled up for the actual site.
- Students update their designs and specifications based on the data from their laboratory inquiry.
- Students design a power supply system for the railway showing typical loads, current draw etc. with full justification for their decisions.

Teaching strategies

The students should be managing their own activities as much as possible during this task so the role of the teacher is as a facilitator supplying expert knowledge and skills when required and general encouragement. However, avoid simply telling or showing students how to complete a task at the first problem. Also, encourage the students to take responsibility for both the task completion and team cohesion so watch out for one or two members taking over and doing everything while the others are excluded – or complained about!

Inevitably engineering projects throw up problems and difficulties as they progress so encourage students to constantly review their methods to ensure success. At the same time, if a good approach does not work the first time because of unforeseen circumstances (e.g. staff or team absence) or bad luck (e.g. a piece of equipment is faulty) they should repeat the work rather than give up and try something else. In all cases, students should be able to justify their decisions about changes to their plan when challenged.

Students tend to carry out practical work but often fail to make full use of the data they collect to solve the original problem. Encourage accurate and complete record-keeping of the activities and keep pushing them to show how these results will inform their thinking and their solutions. Given the large amount of data produced by the experimental work it is now that a lack of mathematical skills could manifest so be ready to cover simple statistical techniques with the whole class as 'maths enhancement sessions'.

The nature of T-levels and Engineering implies workshop experience as students hone their practical as well as theoretical skills. This section of the project would be a good place to provide workshop activities that could showcase aspects of the Cliff railway challenge, e.g. fitting an electric motor, building a simple control circuit.

Output and evidence

The output from this stage should be a complete record of all relevant data, organised by appropriate statistical techniques, and a clear account of how this data was collected and how it will be used to inform the solution of the problem. A clear description of the proposed solution should be provided with any design decisions justified in terms of engineering knowledge and skills, the original problem definition and any supporting data from the practical work. This could be evidenced by:

- A detailed schematic or model showing the proposed solution – this could be provided as text but ideally would include digital elements (e.g. spreadsheet models for the calculations, visualisations of proposed structures and potentially animations of the mechanism in operation).
- A full account of the experimental work and all collected data with approbate data-management techniques shown. This could be in the form of a logbook, a presentation or a text-based document.

Useful resources

4: Working with triangles. Calculating unknown angles and side lengths in triangles for assessing engineering measurements.

5: Working with shape and space. Calculating volume, height, angles of corners, articulations of a 3D shape (e.g. an incubator, temporary building, storage containers) based on measured or published data.

6: Using mathematical formulae. Calculating safe working parameters for structural components (e.g. incubator trolley, temporary building roof or struts) based on measurements of properties of materials and published data.

7: Converting between units. Converting between different measuring units as appropriate (e.g. Celsius to Fahrenheit or Kelvin, meters to inches, metres to millimetres or kilometres) .

8: Calculating power usage. Calculating the power usage for a device or installation based on experimental measures and published data to plan a suitable power supply system.

17: Working in teams. Developing strategies for successful team working – and suggesting behaviours which can undermine teamwork.

18: Prioritising projects. Deciding which parts of a project or work package should be done first.

26: Planning a project. Creating a detailed plan for a project including resources needed, key dates and possible problems.

REVIEW (4 hrs)

Exemplar tasks

- Students review their activity and comment on it showing how they used their engineering

- knowledge, any investigative activities and direct observation to inform the design of the system.
- Students reflect on their team's and their personal performance and consider options for improvement in the future.

Teaching strategies

Remind students that there are two aspects to any review of work completed: a check that the task output is up to specification (e.g. 'is the pulley and cable system an appropriate size?', is the motor large enough to handle heavy traffic?') and a reflection on the performance of the individuals and team (e.g. did this person turn up on time and work hard, did the team work well together?). This 'task' and 'team' perspective is important and while the judgements must be clear and supported by evidence the emphasis should be on development and strategies for improvement rather than simply aiming for a 'met/not met' judgement about preset success criteria or a notional mark out of ten.

The review should compare the proposed solution with the original context and the problem codified by the team. To what extent have they met their original objectives and what compromises did they have to make? This is best done as a small group activity focusing on the impersonal aspects of the task rather than the performance of individual team members. This 'task' review will also provide material that can be fed into the presentation that forms the final part of the project.

Each student should also be asked to reflect on their personal performance and identify successes, surprises and scope for change. This can be quite intimidating for students with low self-esteem or confidence issues and, equally, can encourage the over-confident to bluster and assume they are doing very well! More formal structures at the start of the course can help to get students used to this type of activity and identify those that may need more support. Eventually all students should be able to reflect on their personal performance, give and receive respectful, helpful feedback and identify ways in which they can improve. Peer review activities are useful but should not be used until you know the class well – probably after they have also done some work on giving and receiving feedback.

Output and evidence

The output from this stage should be an assessment of the extent to which the problem has been solved or, if that has not been possible, clarified. The assessment should take into account the needs of the various stakeholders in the original context and identify any compromises or negative impacts that will occur if the proposed solution is implemented. As part of the process students should also engage in self-reflection, supported by peer and teacher comments as appropriate, to identify possible areas for development. This could be evidenced by:

- A personal statement, possibly in a logbook, of the lessons learned during the project including technical material (e.g. knowledge of electric motors, power calculation skills), team aspects (e.g. working with others, managing conflicts) and personal insights (e.g. 'I work better in the morning', 'I tend to put off work until the last minute and then panic'). This account should include a suggestion of a way to develop an aspect of their work in the coming project.
- A statement agreed within the team, and potentially by an external adjudicator, and related to the original context, the problem identified and any other relevant parameters (e.g. schedule, budget) about the degree of success of the project. The statement should be backed up by objective evidence.
- A laboratory or workshop logbook can provide a useful record of work done and support conversations about performance between teacher and students.

Useful resources

11: Providing and receiving feedback. Providing respectful, honest and helpful service to a colleague, subordinate on a product or service.

12: Reflecting on your performance. Reflecting on performance – how self-reflection can help development.

13: Setting SMART objectives. Reviewing the characteristics and use of objectives to drive development.

27: Keeping a logbook. Recording useful information to assist with reflection and review.

PRESENT (2 hrs)

Exemplar tasks

- Students present their cliff railway plans, data, calculations and risk analysis to the client with clear recommendations for the best way forward.

Teaching strategies

If the previous Review section was inward-looking for the team and individual this Presentation section is outward-looking and involves presenting the work to others. The work is best done in teams but ensure that all members of the team have a clear role and present an aspect of the project by themselves.

Presentations are typically digital, and students often waste more time on transitions, colour choices and digital tricks than the important content of the document. Encourage them to review the original scenario and problem and explain that the presentation must show how this problem has been solved and provide full justification for any decisions made – especially if they are surprising and forced on the work by new data (e.g. power consumption by an electric motor) or changes in circumstances (e.g. a rise in expected traffic on the railway or a change in budget).

Presentations should have a time limit which must be enforced – a one-minute warning can be helpful but stick to the time agreed. It is also helpful for students to offer a slide count limit as well – one slide per minute is reasonable, three slides per minute is impossible. The surest way to fail with a presentation is to have too many slides to fit into the time slot allocated and start rushing – inevitably, important information is left out!

The presentations can be to the remainder of the class, a senior member of staff, college visitors invited specifically for the task or a combination of all three. Experience of presenting to local employers is particularly valuable – but maybe towards the end of the course when students have had chance to hone their skills.

Output and evidence

The output from this stage should include a presentation and technical document created for a specific audience.

This could be evidenced by:

- A team-based presentation of the proposal, the research methods and data and the outcome (e.g. model, cliff railway component specifications). The exact specifications or this presentation (e.g. purpose, time limit, audience) needs to be specified in advance.
- A technical document (e.g. instruction manual, design specification) showcasing the proposed design or mechanism operation. Appendices within the document should include all relevant experimental data and calculations.

Useful resources

20: Making a pitch. Preparing a pitch or proposal for a piece of engineering work (e.g. a cliff railway, production facility).

21: Delivering a presentation. Present a pitch (e.g. a cliff railway, production facility) to a body that will make the decision on basis of needs, costs, suitability, sustainability.

24: Preparing reports. Understanding the nature of reports (content and structure) and prioritising what should be included.

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Maintenance, Installation and Repair

The Cliff railways context also provides extensive support for students following a MIR T-level. The table below provides an outline of suitable tasks that could structure a valid project. Many of the resources and activities specified for the D+D treatment would also be suitable. Note that the individual skills might be slightly different to other T-Level Engineering pathways (**Table 4**).

Students could develop a maintenance and repair strategy for a cliff railway to include sensing equipment to detect potential safety issues and a timetable for routine maintenance. The strategy should include a detailed maintenance schedule and guidance on how to ensure safety while keeping the railway running during normal hours as much as possible.

Table 4: Maintenance, Installation and Repair

Phase	MIR core skills from City and Guilds T-level specification (8712)	Exemplar tasks	Time / hrs
CODIFY	**Core Skill A: Analysing and interpreting** ■ Evaluate and confirm the brief with reference to context, objectives and constraints (eg requirements, resources, precedents, technical issues, costs, health and safety, regulations, possibilities).	Students explore the scenario and identify a suitable project to complete. They produce a description of the problem to be solved in engineering terms and generate a proposal. Students carry out an initial survey of the proposed site and identify limitations and potential.	4
PLAN	**Core skill B: Planning and preparation** ■ Propose and plan key activities, stages, methods, processes, techniques, documentation, resources (inc. types of tools and equipment) and risk assessments.	Students identify likely points of failure in a cliff railway describing the effects on the whole system of failures here. Students identify a number of components that need repair/ replacement and develop a plan to do this with minimum disruption to users. Students identify pre-emptive monitoring and maintenance activities to reduce unexpected failures.	10
PERFORM	**Core skill C: Implementing plan** ■ Propose maintenance, installation, and repair processes for achieving specific objectives and quality outcomes, using relevant techniques, and technology, within limits of own authority.	Students carry out some exemplar repairs or replacements of components including situations which require some disassembly of mechanisms. Students collect data on time to complete repair/replacement, ease of task and likely cost in terms of parts, labour and disruption to normal service. Students design a monitoring system / calendar for key points of failure	10
REVIEW	**Core Skill D: Evaluating and QA** ■ Investigate components and systems, to gather and evaluate relevant evidence and data, and to confirm the suitability of processes, actions and outcomes (including quality control and quality assurance activities).	Students review their proposed solution and comment on their work and performance (individually and as a team). Students prepare their work output for presentation to client.	4
PRESENT	**Core Skill E: Communication and presentation** ■ Record, report, communicate and present plans, proposals, processes, issues, risks and outcomes to both technical and non-technical audiences, across a range of suitable formats and media (eg diagrams; physical and digital records, presentations).	Students present their plans, data, calculations, and risk analysis to the client.	2

Manufacturing, Process and Control

The Cliff railways context also provides extensive support for students following a MPC T-level. The table below provides an outline of suitable tasks that could structure a valid project. Many of the resources and activities specified for the D+D treatment would also be suitable. Note that the individual skills might be slightly different to other T-Level Engineering pathways (**Table 5**).

Students could design and make a lightweight chair suitable for use in a cliff railway. The chair must be strong enough to take adult customers easily but light weight to ease the strain on the railway carriage.

Consider the wisdom of fitting seat belts and other safety devices and report on your safety strategy.

Table 5: Manufacturing, Process and Control

Phase	MPC core skills from City and Guilds T-level specification (8713)	Possible tasks	Time / hrs
CODIFY	**Core Skill A: Analysing and interpreting** ▪ Evaluate and confirm the brief with reference to context, objectives and constraints (eg requirements, resources, precedents, technical issues, costs, health and safety, regulations, possibilities)	Students review a specification for a cliff railway carriage and identify a component that they could manufacture (e.g. a chair, window opening, canopy) and explore the features needed for their chosen component.	4
PLAN	**Core Skill B: Planning and preparation** ▪ Propose and plan key activities, stages, methods, processes, techniques, documentation, resources (including types of tools and equipment) and risk assessments.	Students identify materials that would have the correct properties for their component and plan testing procedures for these materials.	10
PERFORM	**Core Skill C: Developing responses** ▪ Apply engineering and manufacturing processes to achieve specific objectives and to produce quality outcomes, using relevant techniques and technology, within limits of own authority.	Students carry out an inquiry into the properties of suitable materials to manufacture their chosen components. Students explore ways of joining/ connecting their individual parts to make a functioning component – both as a prototype and during manufacture. Students identify and describe the key steps in a manufacturing process and consider kit and materials needed to perform this.	10
REVIEW	**Core Skill D: Evaluating and quality assuring** ▪ Carry out investigations, generate proposals and options, identify standard components and systems at relevant stages to gather and evaluate relevant evidence and data, and to confirm the suitability of plans, processes, actions and outcomes (including quality control and quality assurance activities)	Students review their proposed solution and comment on their work and performance individually and as a team. Students prepare their work output for presentation to client.	4
PRESENT	**Core Skill E: Communication** ▪ Interpreting, using, and producing engineering representations and drawings following graphical language and industry conventions. Interpreting and using technical information and media. Communicating with technical and non-technical audiences using technology.	Students present their plans, data, calculations, and risk analysis to the client.	2