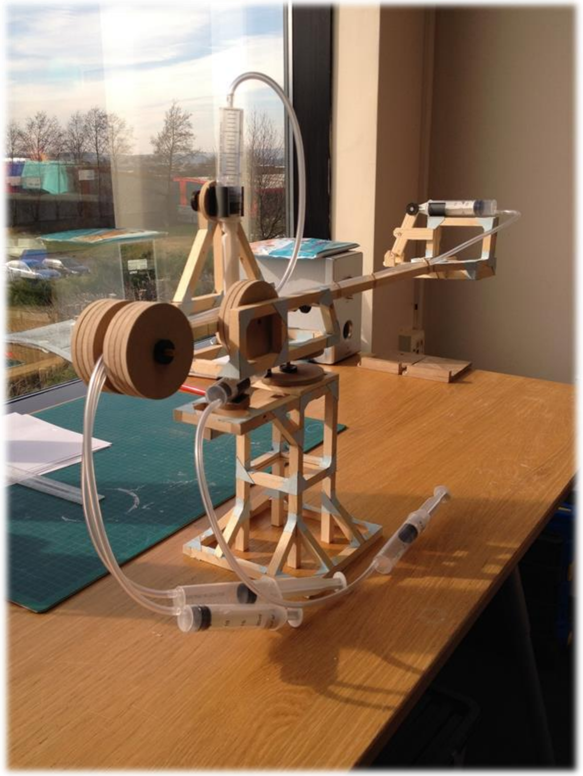
Curriculum Map of Secondary Engineer – Fluid Power Challenge

About the Challenge:



- **IDL:** The Fluid Power course for Secondary teachers has been designed to bring together the practical aspects of Design and Technology, Science and Maths into a coherent practical based project
- The culmination of the training and input to the pupils from S1-3 back in the respective schools will be the coming together of teams of pupils in the 'Fluid Power Challenge'
- Here teams of 4 or 5 pupils will compete against each other in practical and presentation challenges to decide the overall winner. The challenge will take the form of a design and make task undertaken at the school, where a mechanism to move weighted objects from one location to another will take place under a timed situation
- Teams will also produce a portfolio of work showing their design process and thinking and incorporating the relevant maths and science theory that has underpinned their design
- Finally, the teams will give an oral presentation to a panel of judges who will interview them as to how the final design came about and the journey to the challenge day
- The course seeks to highlight the importance hydraulics and pneumatics plays in our everyday life. The built environment in which we live has been highly influenced by the use of fluid power as the construction industry relies so heavily on the technology used in this course
- The course content also indicates the latest technology underpinning hydraulics in the earth moving industry and how GPS technology and earth mapping systems are playing their part in the modern construction environment (see the Virtual Learning Environment VLE for more details and PowerPoints to use with pupils)

- The Fluid Power Challenge Mark Scheme is included at the end of this document for reference

- **Moray Skills Pathway - See Activity Overview Guidesheet for more details on Activities Pre/Post Engineer Visit**

Engineering as a Context for Learning:

- Engineering as a context for learning encourages pupils to develop key transferable skills through development of the Engineering habits of Mind - systems-thinking, adapting, problem finding, creative problem-solving, visualising, and improving. See Learning to be an Engineer - Implications for the education system By Royal Academy of Engineering (Summary Report published March 2017)

EHoM	Sub-habit 1	Sub-habit 2
CREATIVE PROBLEM-SOLVING is … Generating ideas and solutions by applying techniques from different traditions, critiquing, giving and receiving feedback, seeing engineering as a 'team sport'.	**Generating ideas:** comes up with suggestions in a range of situations.	**Working in team:** has good people skills to enable idea and activity sharing; good at giving and receiving critique/feedback.
IMPROVING is … Making things better by experimenting, designing, sketching, guessing, conjecturing, thought-experimenting, prototyping.	**Experimenting:** makes small tests or changes; sketching, drafting, guessing, prototyping.	**Evaluating:** making honest and accurate judgments about 'how it's going'; comfortable with words and numbers as descriptors of progress.
PROBLEM-FINDING is … Deciding what the actual question is, finding out if solutions already exist by clarifying needs, checking existing solutions, investigating contexts, verifying, thinking strategically.	**Checking and clarifying:** questions apparent solutions methodically and reflectively.	**Investigating:** has a questioning, curious and, where appropriate, sceptical attitude.
ADAPTING is … Making something designed for one purpose suitable for another purpose, by converting, modifying, transforming, adjusting, changing, reshaping, re-designing, testing, analysing, reflecting, rethinking.	**Critical thinking:** analyses ideas, activities and products; able to defends their own thoughts and ideas in discussion and also to change their mind in light of evidence.	**Deliberate practising:** disciplined; able to work at the hard parts.
VISUALISING is … Seeing the end product, being able to move from abstract ideas to concrete, manipulating materials, and mentally rehearing practical design solutions.	**Thinking out loud:** puts 3D ideas into words as they become pictures or rehearses possible lines of thought or action.	**Model-making:** moves between abstract and concrete, making models to capture ideas.
SYSTEMS-THINKING is … Seeing connections between things, seeking out patterns, seeing whole systems and their parts and how they connect, recognising interdependencies, synthesising.	**Connecting:** looks for links, connections, relationships; working across boundaries.	**Pattern-making:** uses metaphors, formulae, images etc. to find patterns to illustrate new meaning.

Fluid Power Challenge

Experiences & Outcomes/ Career Education Standards/Career Management Skills covered in this IDL (this list is not exhaustive)

CMS

- Horizons, Strengths, Networks

CES

- I can learn about the world of work from visits, projects and my experiences. Horizons - 4
- I can demonstrate and apply the skills I have learnt across the curriculum in relation to the world of work. Strengths – 2
- I can identify my interests, strengths and skills and use them to make informed choices. Strengths – 2
- I can extend and use my networks to find and apply for opportunities that match my interests, strengths and skills. Networks - 2

E&O

- I am investigating different careers/occupations, ways of working, and learning and training paths. I am gaining experience that helps me recognise the relevance of my learning, skills and interests to my future life. **HWB 3-20a**
- I have collaborated with others to find and present information on how scientists from Scotland and beyond have contributed to innovative research and development. **SCN 3-20a** (specifically relating to use of Science/STEM in careers)
- I understand how scientific and technological developments have contributed to changes in everyday products. **TCH 3-05a**
- I can apply my knowledge and understanding of engineering disciplines and can develop/build solutions to given tasks. **TCH 3-12a**
- By contributing to investigations of energy loss due to friction, I can suggest ways of improving the efficiency of moving systems. **SCN 3-07a**
- I can create solutions in 3D and 2D and can justify the construction/graphic methods and the design features. **TCH 3-09a**
- I can explore the properties and performance of materials before justifying the most appropriate material for a task **TCH 3-10a**
- I can apply a range of graphic techniques and standards when producing images using sketching, drawing and software. **TCH 3-11a**
- I can apply my knowledge and understanding of engineering disciplines and can develop/build solutions to given tasks. **TCH 3-12a**
- I can solve problems through the application of engineering principles and can discuss the impact engineering has on the world around me. **TCH 4-12a**
- I can solve practical problems by applying my knowledge of measure, choosing the appropriate units and degree of accuracy for the task and using a formula to calculate area or volume when required. **MNU 3-11a**

	Suggested Activities – Secondary Engineer Provide materials on their VLE to assist with teaching the Maths/Science. It is not a scheme of work but some sugges5tions.
What is an Engineer?	1. Complete the Pre-activity survey on STEM & Engineering. 2. Draw an Engineer Activity (may be well suited to S1/2 pupils) – pupils draw an engineer and name their character (interesting to note proportion of males/female characters drawn and any safety clothing they might be wearing. This can be used to tease out misconceptions about this job and help you come up with ideas for questions for their engineer. 3. Identify the skills/attributes of an engineer – use labels to annotate their drawing: • Creativity – good at problem solving, imagination • Employability – good at making decisions, taking responsibility • Self-Management – confident and don't give up • Teamwork – good at working with others • Communication – listening and talking • Thinking – creating and applying knowledge • Interpersonal – respect others, resolve group issues • Leadership – encourage others, enthusiastic, contributes ideas 4. Engineering as a process – introduce the idea of Making 'things' that work and making 'things ' work better (Core Engineering Mind). Examine examples of engineered products like bridges, towers, buildings, household objects (phones/TV etc) before moving on to cars as an engineered product. 5. Access My WOW using link below. There are 36 examples of engineering jobs. Pupils can individually or in pairs research one job title and write a brief summary of the job along with noting down the top skills. Share this with peers and see if there are common skills. https://www.myworldofwork.co.uk/my-career-options/engineering Create interview questions for the engineer (include questions related to the skills identified in Activity 2, 3 or 4) – send to the engineer along with pictures of their drawings to prompt discussion.
Investigating Mechanisms & Hydraulics – The maths & science behind the challenge	1. Research into hydraulic systems – what are they commonly used for? How do they work? 2. Application of Pythagoras as design uses many right-angled triangles 3. Application of Trigonometry as design uses many right-angled triangles e.g. calculating angle of robot arm when its down 4. Forces – F=ma. The design requires the use of counterweights 5. Pressure – use of syringes in model 6. Moment (Nm) = Force (N) x distance to Pivot 7. Structures – can use more advanced maths but essentially using your judgment to determine of a mechanism will work 8. Linkages – allows you to study friction

Designing & Making a Prototype Hydraulic Crane	Designing • Designing is a big part of what engineers do. • It means thinking about everything before you build it • Drawing diagrams of what we want. • Using our maths and science to solve problems before we reach them during construction. • It's easiest to correct mistakes during design, so the best robots will be those that have been well designed. How to use it • Work through the construction in your head. Draw what you think you want to do, and then you can see what problems there are with the design. • Think about how things will move: Will they hit anything? Will they break the structure? • Think about the forces (weights and syringes), does your design take these into account? • Think how I can make this better. It's easy to change lines on paper, but much harder to make changes once you start building! Making a prototype • Use cheaper materials e.g. cardboard (old boxes) to make a prototype of your design or parts of your design • Allows you to try things out in 3D and see if they work Some pupils bright their prototype as this allowed them to show judges the changes they had made in their design
Making the Hydraulic Crane	Risk Assessment for task – you would be expected to complete a standard Risk Assessment for your context There is a manufacture booklet for support if needed on the VLE. This has some useful sketches and measurements as well as lists of materials to help pupils.

Testing the Hydraulic Crane/Refining the Design and Re - testing	The teams that did well with their model had demonstrated that they worked well as a team to complete the challenge – as the mechanisms has to be able to lift object, turn and raise object up there were at least three hydraulic systems involved that each had to be operated independently. They key to speed is to work together! Refining the model involves • Using the evaluation to decide on changes that need to be made to your design • Draw out your design highlighting your changes (this gains marks for the project) • Make changes re-testing. Engineers may have to do this a few times until they iron out all the faults/issues with a machine – problem finding, adapting and improving!
Link Engineer Visit	1. Interview the engineer about their job – what do they do? How did they get into this job? What skills does it need? What school subjects did they do that help them in their job? What do they like best about their job? 2. Some schools scheduled their engineer visit at the start of the process and the engineer helped pupils with the design and make activities. Others asked the engineer to come in for the testing days to help them test, evaluate and refine their models. Post Visit – The Post Activity Survey should be completed, then choose activities suitable for your class from the ideas list below. 3. Complete Post Activity Survey 4. Pupils create a news report from the interview – this could be written formally or as a blog or a news round style video. 5. Access My WOW again using link below. This time get pupils to look into the useful subjects for the different engineering jobs. Are there common subjects? Do you think these subjects develop particular skills? 6. Look at the job profiles of some of our Local Engineers – what pathways did they take into their current role?

Project – Completion of Booklet/Paperwork	Some schools got pupils to write up a “How to make a hydraulic crane” as an example of functional writing Examples of Good Practice for gathering evidence: • Some pupils created a poster of their learning covering these key aspects to bring to the celebration event along with photographs, models and evidence of their experiments to create a showcase around their model. Others went for a Project Booklet approach or a PowerPoint of their work which they displayed on a laptop. • Some schools created a video detailing their work – this linked digital literacy into the project as well. • Some schools have used a specific class project book for the Engineering Project to gather pupils ideas/thoughts and pictures from the various activities. This was also brought to the Celebration Event and really helped the judges when talking to the pupils to pick up on various aspects of what they had been doing. Scores from the portfolio (0-5 for each point) • Each team member has defined roles and has contributed to the portfolio. • At least two rough sketches and an isometric sketch of a section of the design. • An orthographic drawing showing dimensions and construction notes (hand or computer generated) • A bill of materials for each element of the design. • Description of the principals of structures and how this has influenced the design. • Explanation of the operation and placement of fluid power systems to include the maths and science. • Overall product evaluation and possible modifications.