Teaching Style – Inquiry based

An old adage states: "Tell me and I forget, show me and I remember, involve me and I understand." Inquiry implies involvement that leads to understanding. Furthermore, involvement in learning implies possessing skills and attitudes that permit you to seek resolutions to questions and issues while you construct new knowledge.

Unit Overview

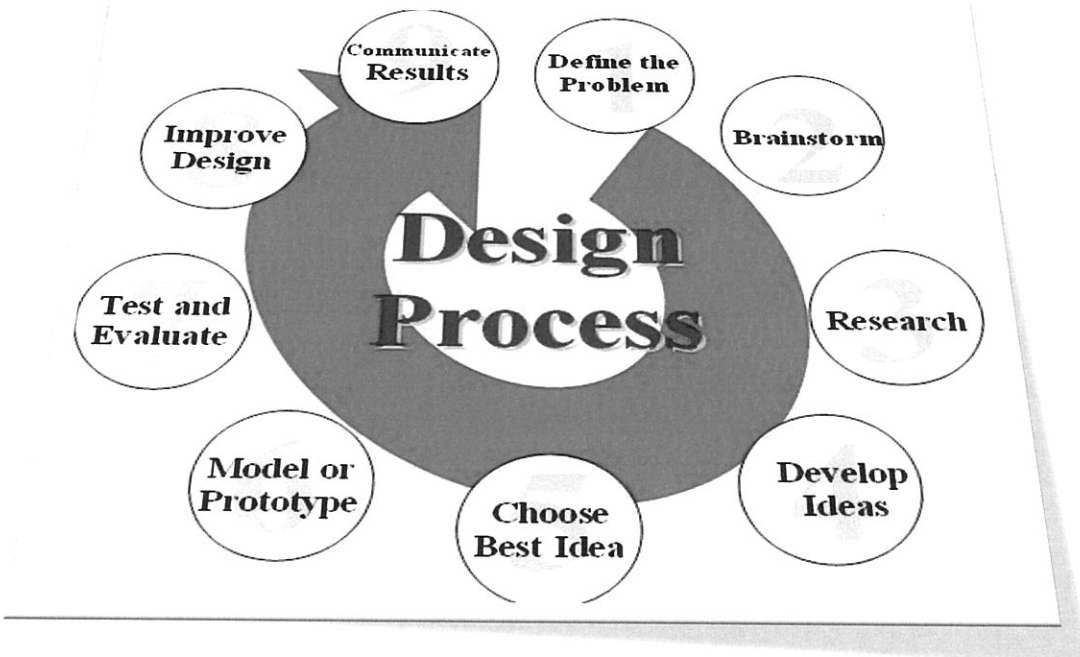
This unit is 30 days of instruction over a 60 day period. Its emphasis is:

- What is engineering
- What is design
    - Use sketching and drawing to convey design concepts
    - Learn the basics of Google Sketch Up
- What is modeling
    - Build and discuss multiple models to learn:
        - Class 1 Lever
        - Class 2 Lever
        - Class 3 Lever
        - Clamp & Rotating Bases
        - Composites designs
    - Tools – Begin tool competencies
        - Ruler (standard and metric)
        - Scissors
        - Wood glue
        - Handsaw and miter box
        - Hand drill or drill press
        - Razor blade

What is Engineering?

Concepts

1. Science is the study of the natural world, while technology is the study of how humans develop new products to meet needs and wants.
2. Teams of people can accomplish more than one individual working alone.
3. Technological change is seen through inventions, innovations, and the evolution of technological artifacts, processes, and systems.
4. Technology can have positive and negative social, cultural, economic, political, and environmental consequences.
5. Engineers, designers, and engineering technologists are needed in high demand for the development of future technology to meet societal needs and wants.
6. An engineering notebook is used to record original ideas or designs.
7. A portfolio is an organized collection of best works.



Performance Objectives

It is expected that students will:

- Assemble an engineering notebook and a portfolio.
- Explain the relationship between science, technology, engineering and math.
- Distinguish between invention and innovation.
- Describe engineering and explain how engineers participate in or contribute to the invention and innovation of products.
- Describe impacts that technology has had on society.

Essential Questions

1. What is the purpose of a portfolio for a student?
2. What is the purpose of a portfolio for an engineer?
3. Why is it important for engineers to document their work in their engineering notebook?
4. How are our lives impacted by engineers?
5. What is the difference between an invention and innovation?
6. How does the use of technology affect the way that you live?

Day	Lesson Focus	
1	Class Type - Teacher led **<u>Safety, Scissors skills, Measuring (in two systems) and introduce Engineering Notebook</u>** **Concepts** • In the United States, we use both Standard and Metric systems of measurement. • Being able to measure accurately is important at school and at home, at work and when pursuing hobbies. • Precision measuring tools are needed for accuracy, but tools must be used correctly to ensure accurate measurements are taken. • Quality workmanship and accurate measurements with precise instruments are necessary to successfully solve problems. • Engineer's notebook is used to record: - Record ideas - Things that work and don't work - Information like formulas, conversion factors, and data - Could be used for future patents **Performance Objectives** *It is expected that students will:* • Demonstrate the ability to measure accurately with different devices and scales. • Explain how to measure in different contexts. • Measure using both the Standard and Metric systems. **Essential Questions** 1. Do you think the U.S. should convert to all metric measuring, or should the U.S. stay with using both the Standard and Metric systems? Why? 2. Why don't we use such measurement forms as the hand span, cubit, and pace very often today? 3. Give two reasons why precision measuring tools are not always accurate. 4. Begin discussion of what is an engineer? 5. **An Engineer** applies the principles of science and mathematics to develop economical solutions to technical problems. They are problem solvers. Any one can be an engineer but college trained engineers are trained to solve problems faster and better. Also two other elements have been added in recent years:	

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The engineer should make his design ecologically friendly and
The engineer should be ethical in his design.

It has been said, "ask an engineer what time it is and he/she will tell you how to build a clock."
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Class Type – Pairs Lab
<u>Build 1 mini-hydraulics kit</u>
Concepts

Hydraulics is used in everyday life everywhere
Hydraulics uses a closed system whereas pneumatics uses an open system
Fluids can be air, water, oil

Performance Objectives
It is expected the students will:

Identify and compare examples of hydraulic equipment
Assemble the levered devices
Identify the forces acting on the lever
Sketch the design of a device
Describe potential improvements to the devices

Essential Questions

What is the difference between pneumatics and hydraulics?
Is pneumatics or hydraulics more environmentally friendly?
What do we know about force?
What are the forces on the levers?

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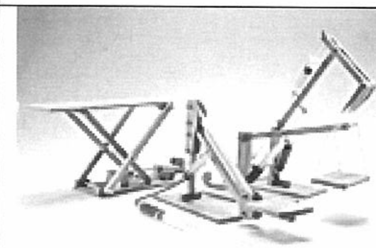



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Class Type – Pairs Lab
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Class Type - Teacher led
<u>Class 1 Levers</u>
Concepts
Class 1 Levers - Fulcrum in the middle: the effort is applied on one side of the fulcrum and the resistance on the other side, for example, a crowbar or a pair of scissors or a seesaw.
Force - In physics, a force is any influence that causes an object to undergo a certain change, either concerning its movement, direction, or geometrical construction. In other words, a force is that which can cause an object with mass to change its velocity (which includes to begin moving from a state of rest), i.e., to accelerate, or which can cause a flexible object to deform.
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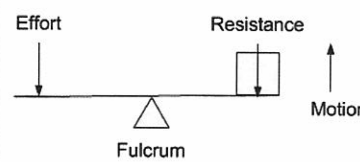
Class 1 Lever


Man lifting a stone with a lever
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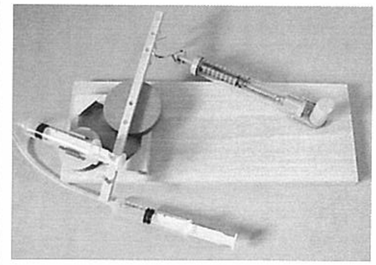
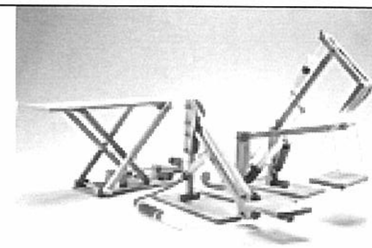
	Performance Objectives Students will be able to define what force is and standard and metric units of measurement Students will be able to draw forces acting on levers using arrows. **Essential Questions** 1. What is force and how does it affect design? 2. How does a lever make things easier and provide an advantage to the user? 3. What is pressure and where is it used in everyday life? 4. What happens when we put water in the system? 5. Can anyone design this device? What is designing, what is construction? Who can be an engineer?	
5	Class Type - Teacher led **<u>Class 1 Levers</u>** (Continued)	
6	Class Type – Pairs Lab **<u>Build 1 mini-hydraulics kit</u>** **Concepts** 1. A feedback system is required to control fluidic devices 2. Hydraulic systems are easier to control than pneumatic ones 3. The position of the actuating cylinder changes the performance of the levered device **Performance Objectives** It is expected the students will: • Identify and compare examples of hydraulic equipment • Assemble the levered devices and operate them pneumatically and hydraulically • Identify the forces acting on different classes of lever • Describe potential improvements to the devices • Draw an isometric representation of one of the devices **Essential Questions** 1. What is the difference between a class 1 lever and a class 3 lever? What are the advantages and disadvantages of each? 2. How does the particle theory of matter explain the how the devices operate using air and water? 3. What do we know about forces inside the actuating cylinders?	
7	Class Type – Pairs Lab (continued)	

8

Class Type - Teacher led

Class 2 Lever

Concepts

Class 2 Level - Resistance in the middle: the effort is applied on one side of the resistance and the fulcrum is located on the other side, for example, a wheelbarrow or a nutcracker or a bottle opener.

Class 3 Levers – Effort in the middle: the resistance is on one side of the effort and the fulcrum is located on the other side, for example, a pair of tweezers or the human_mandible.

Performance Objectives

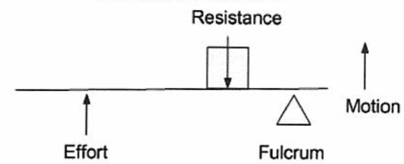
It is expected the students will:

- Identify examples of levered devices throughout history in agriculture, industry and the home
- Understand by practical means the difference between class 2 and class 3 levers
- Calculate the effort force required to overcome a given resistance using a class 2 lever using standard and metric systems of measurement
- Calculate the effort force required to overcome a given resistance using a class 3 lever using standard and metric systems of measurement
- Represent class 2 and 3 levered systems using two-dimensional measured diagrams

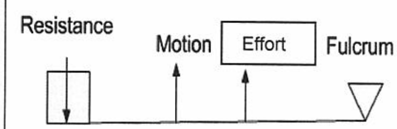
Essential Questions

1. What is the difference between class 2 and class 3 levers?
2. How has the design of a baby stroller changed over the last 50 years and why?
3. What are the levered systems in a bicycle designed to do?

Class 2 Lever



Class 3 Lever



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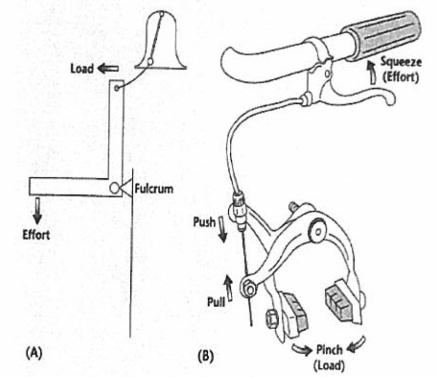

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Class Type - Teacher led
Review - Linkages; Pivots

Concepts

1. Linkages are levers that change the direction of force and motion in mechanical systems
2. Fixed pivots are fulcrum points in a mechanical system
3. Moving pivots are joints in a mechanical system
4. Linkages and pivots combine to change the direction and size of an input force into a manageable and appropriate output

Performance Objectives

It is expected the students will:

- Identify different linkages: reverse motion linkage; push-pull linkage; treadle linkage (crank-slider); toggle linkage
- Identify how a change in the position of a fixed pivot alters the output force
- Distinguish between mechanical systems that change the direction of linear motion and those that change linear motion to rotary motion
- Construct a linkage system that has an output force greater than its input force
- Construct a linkage system that has output motion greater than its input motion

Essential Questions

1. Where, in the home, are examples of linkage systems?
2. Why might linkage systems be important in hydraulic and pneumatic systems?

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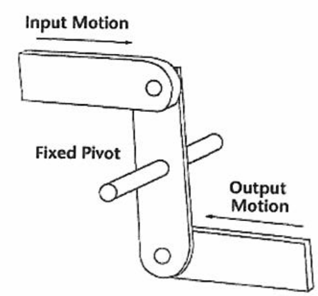

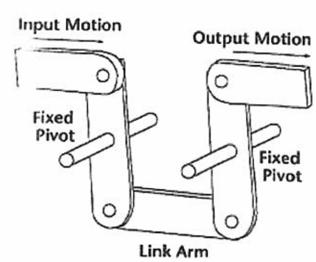

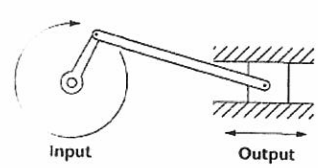

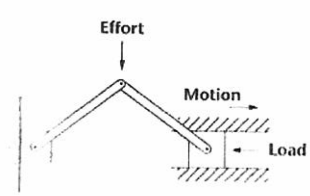

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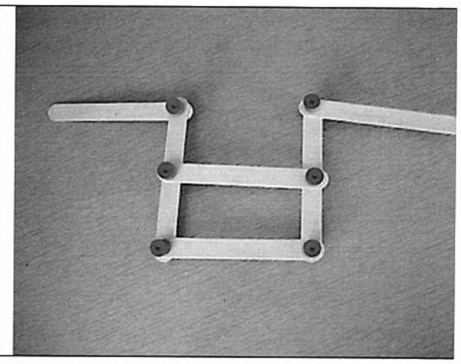
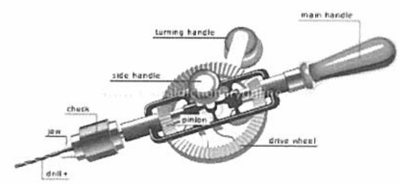
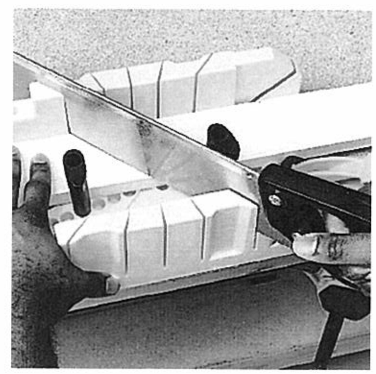
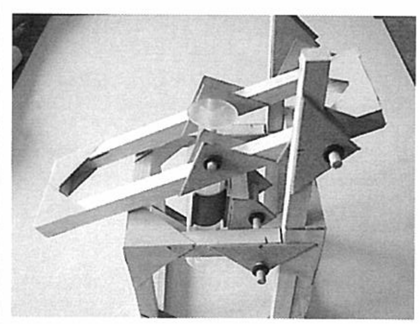
		
11	Class Type - Teacher led Cutting and drilling using hand tools **Concepts** 1. Safety is our number one priority 2. Your eyes are you most important resource! 3. Safety glasses must be worn when cutting, drilling or hammering! 4. Care will be taken when carrying tools from one location to another 5. Tools will be safety stored in a manner ready for future use **Performance Objectives** It is expected the students will: • Understand how and use a handsaw and miter box to cut wood to length • Use corner gussets and a small amount of wood glue to join pieces of wood • Construct a square that has external measurement of 4" **Essential Questions** 1. How many ways are there of cutting the pieces to form a square? 2. How long does it take for the wood glue to dry? 3. What addition pieces are required to build a cube with external dimensions of 4"?	 
12	Class Type – Pairs Lab Build Lifter **Concepts** 1. A cylinder strategically placed can cause a device to move 2. The linear motion of an actuating plunger, when connected to a levered arm, can cause a rotary motion 3. A strong and stable structure is required to house a fluidic system 4. The output cylinder of the pneumatic system does not respond immediately to the input cylinder as air is a "spongy" fluid	

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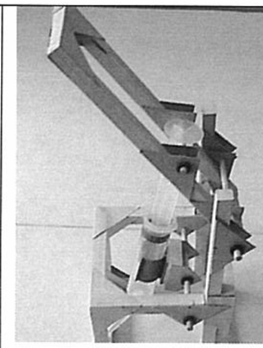
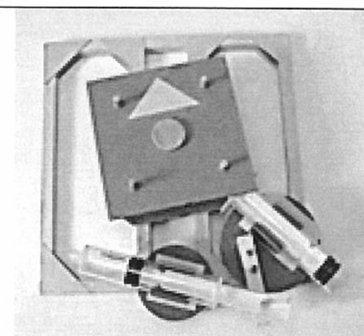
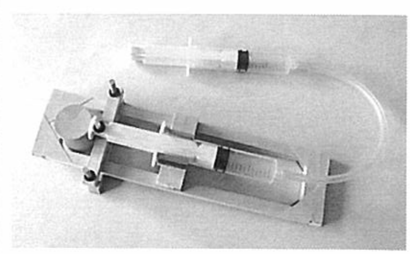
	Performance Objectives It is expected the students will: • Follow PowerPoint instructions to construct a pneumatic lifter • Identify that the lifter is an example of a class 3 lever • Identify the position of fixed and moving pivots **Essential Questions** 1. Why does the small platform that the actuating cylinder is mounted on have to rotate? 2. How might the lifter be re-designed so that it can lift a heavier load? 3. How might the lifter be re-designed so that it can rotate through a greater angle?	 
13	Class Type – Pairs Lab (Continued)	
14	Review - Clamp & Rotating Base **Concepts** 1. The three essential movements of a robotic arm are rotation, up and down, and, "grabbing" 2. The clamping device is an example of linear input and linear output 3. The rotating base is an example of linear input achieving rotational output 4. A levered arm can be used to increase the degrees of rotation in a linear to rotary system 5. A robot arm system combines different sub-systems **Performance Objectives** It is expected the students will: • Appraise the clamping device and suggest ways to improve it • Appraise the rotating base device and suggest ways to improve it **Essential Questions** 1. What other ways can an object be clamped or "grabbed"? 2. Way is it useful to incorporate a platform into the design of the rotating base sub-system?	 

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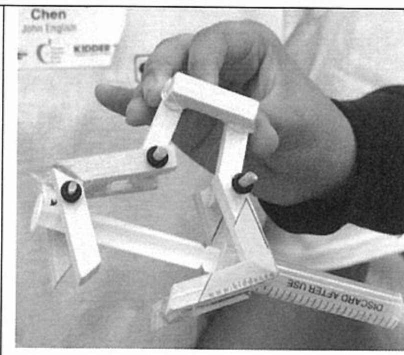
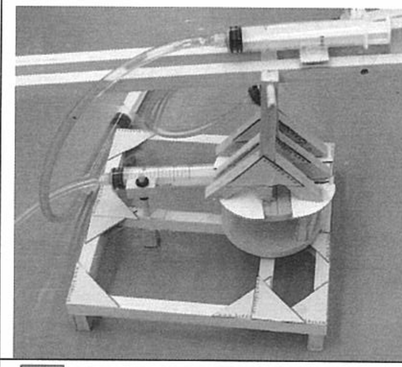
<td>3. Why is a strong and stable structure required to house a fluidic system such as a robot arm?</td>
<td>

</td>
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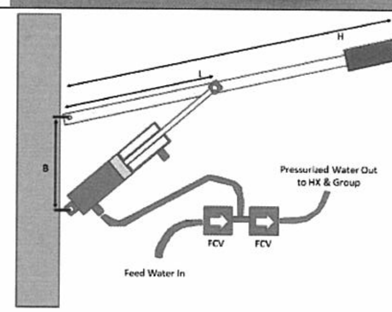
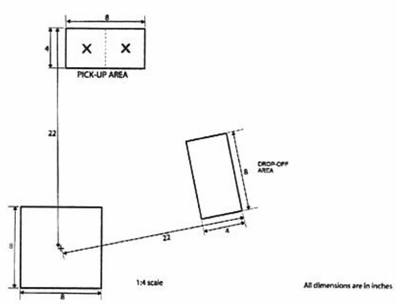
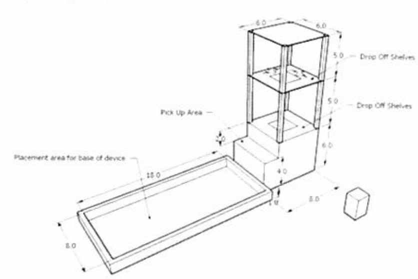
<td>Class Type – Individual Lab
Introducing Sketch-Up
Concepts
1. The ability to create a rapid, accurate sketch is an important skill to communicate ideas.
2. Orthographic drawings of an object are used to provide information that a perspective drawing may not be able to show.
3. Engineers apply dimensions to drawings to communicate size information.
Performance Objectives
It is expected that students will:
• Summarize the reasoning for using sketching as a communication tool.
• Use visualization, spatial reasoning, and geometric shapes to sketch two and three dimensional shapes.
• Recognize and create thumbnail, perspective, isometric, and orthographic sketches.
• Recognize and accurately interpret one and two point perspective drawings.
• Communicate ideas for a design using various sketching methods, notes, and drafting views.
• Dimension an orthographic sketch following the guidelines of dimensioning.
Essential Questions
1. What are pictorial drawings and how are they used by engineers?
2. What is an orthographic drawing and how is it used by engineers?</td>
<td>

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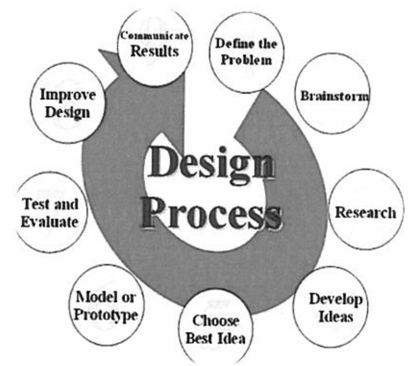
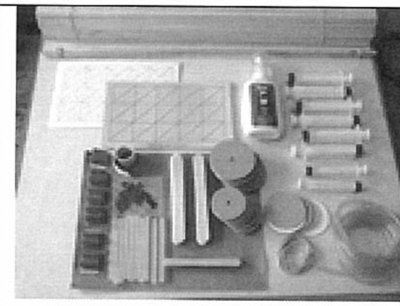
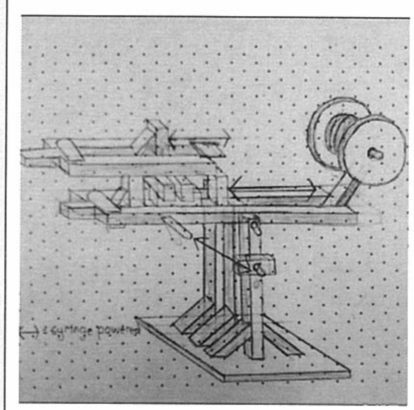
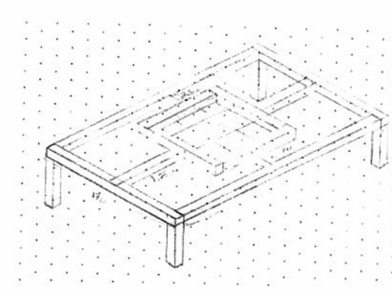
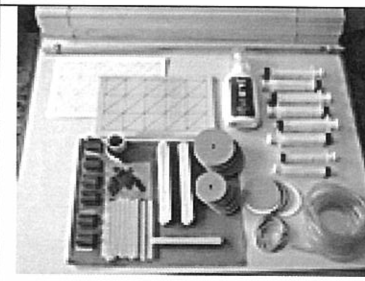
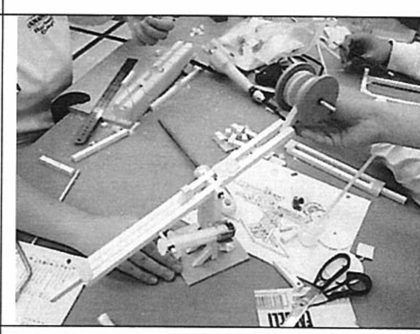
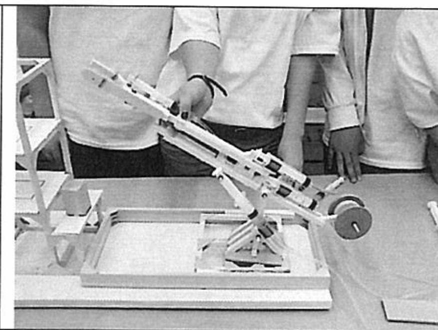
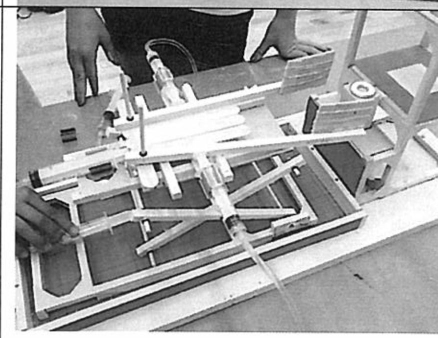
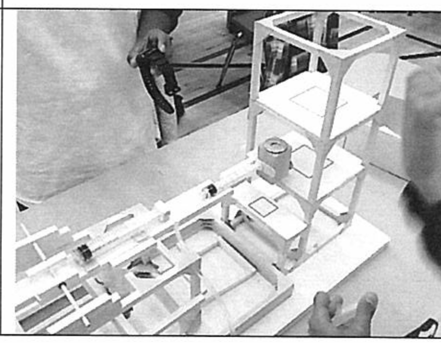
	3. Why is it important to follow the "rules" of sketching and dimensioning?	
16	Class Type – Individual Lab Introducing Sketch-Up Continue from 15	
17	Class Type – Individual Lab Continue from 16	
18	Class Type – Teacher led Elements of Design **Concepts** 1. The essential elements of design are Understanding the context of the problem; establishing of objectives and criteria; researching ideas and theories, developing possible solutions; testing the elements of the possible solutions; selecting the different elements and building a prototype; testing and evaluating the prototype; improving the design using the feedback (iterative process); communicating the solution 2. There are different models of a design process **Performance Objectives** It is expected the students will: • Understand and use a design process to design a solution to an everyday problem • Keep a record of their process in the form of a log containing illustrations and text **Essential Questions** 1. Can a design process be used for purposes other than engineering design? 2. Why are Apple products like IPhones and I Pads so popular? 3. When designing a product how many times will the design process be repeated, or a part of it?	  

19	Class Type – Teacher led Elements of Design (Continued)	
20	Class Type – Teacher led Introduction to Challenge and Portfolio **Concepts** 1. A design task will meet certain criteria 2. A design portfolio will contain a complete record of the process of designing an optimal solution to problem 3. A rubric contains information about how the solution and the process of achieving it are measured **Performance Objectives** It is expected the students will: • Understand the Challenge task • Understand what is required of them prior to the Challenge event • Understand how their performance and the performance of their solution will be measured **Essential Questions** 1. What tools and materials are available for use? 2. What are the criteria for success? 3. What are the limitations on how the solution will perform?	 NFPA NFPA EDUCATION AND TECHNOLOGY FOUNDATION Fluid Power Challenge **Judging Rubric**
21	Class Type – Teams of 4 Portfolio work **Concepts** 1. A portfolio contains a record of the processes by which the team of students decides a solution to the Challenge 2. A portfolio is a record of possible solutions, testing criteria and the results of testing sub-systems of the possible final solution **Performance Objectives** It is expected the students will: • Undertake an engineering design process • Produce a portfolio from which a final solution may be constructed • Include in the portfolio Sketch-Up representations, hand-drawn illustrations and text and all other required elements including scientific and technological explanations **Essential Questions** 1. Are all the portfolio's required elements addressed in depth?	 

22	Class Type – Teams of 4 Portfolio work (Continued)	
23 24?	Class Type – Teams of 4 Portfolio work (Continued)	
25	Class Type – Teams of 4 Building Solution to Challenge **Concepts** 1. A portfolio communicates the process of design to the team members and to others 2. Engineering problems are solved using limited materials and tools and within a limited timeline **Performance Objectives** It is expected the students will: • Use their portfolio as a guide to building their solution • Safely use the tools available and the materials provided in the Challenge Kit to build a solution to the Challenge • Build a device that has all parts securely built and attached **Essential Questions** 1. Are the tools and materials being used safely? 2. Is the team being efficient in dividing its workforce? 3. Is the available time being allocated effectively to allow for testing the final solution? 4. Are you going to meet the deadline? Will the customer be happy?	 
26	Class Type – Teams of 4 Building Solution to Challenge (Continued)	
27	Class Type – Teams of 4 (Continued)	

28	Class Type – Teams of 4 Building Solution to Challenge (Continued)	
29	Class Type – Teams of 4 Challenge Event **Concepts** 1. Working with other team members requires high quality communication skills **Performance Objectives** It is expected the students will: • Operate as a team to meet the Challenge • Perform a specific task under the pressure of time **Essential Questions** 1. How will the team operate their device efficiently? 2. Will the device remain intact during the pressure of the competition?	
30	Class Type – Teams of 4 Challenge Event (Continued)	

Reference Sources

Additional Resources for teaching hydraulics

National Fluid Power Association, May 17, 2012
Fluid Power Training Manual, PDF, pp1-172
www.nfpa.com
Sangari, 5th Grade Machines and Motion Unit, pp.192-203
www.sangariglobaled.com
Sangari 6th Grade Chem Unit Science. "How can we model the things gases do?". Pp. 1-15

Additional references suggested by GTT to help teachers teaching engineering

Baine, C. & Cox, C. (2006). *Teaching engineering made easy.* Springfield, OR: Bonamy Publishing.

Gomez, A., Oakes, W., & Leone, L., (2004). *Engineering your future.* Okemos, MI: Great Lakes Press, Inc.

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Appendix I – The NFPA Judges Rubric

	Part A: PORTFOLIO				
Success criteria	***5***	***4***	***3***	***2***	***1***
Co-operation of	All team members	All team members	Most team	Portfolio was	Portfolio was done

team members in production of portfolio & planned production of their device	participated in a material way and were familiar with portfolio contents and all offered answers to questions	participated in a material way and were familiar with portfolio contents, however only one or two offered answers to questions	members participated but one or two were not very familiar with portfolio contents	done mostly by one student who answered questions with some answers from others	completely by one student; other team members not at all familiar with portfolio contents
At least two sketches and an isometric drawing of a small portion of a device properly dimensioned	Two detailed sketches and an isometric drawing properly dimensioned and of high quality	Two detailed sketches and an isometric drawing of fair quality with some correct dimensioning	Two sketches and an isometric drawing of fair quality with some correct dimensioning	Two sketches of fair quality and a poor isometric drawing	One or two low-quality sketches and no isometric drawing
An orthographic drawing showing dimensions and construction notes	The orthographic drawing shows front, side and plan views and is set out so the scaled dimensions relate to the views	Three orthographic drawings are presented showing front, side and plans views using a consistent scale	Three orthographic drawings are presented showing front, side and plans views using an inconsistent scale	Only two of three orthographic drawings are available	Only one of three orthographic drawings are available
A list of materials including consideration of alternatives	A comprehensive list of materials is provided, including dimensions and alternative materials are discussed that are "outside the box"	A comprehensive list of materials is provided, including dimensions and alternative materials are discussed that are much the same as provided	An incomplete list of materials is provided without dimensions and alternative materials are discussed that are much the same as provided	An incomplete list of materials is provided without dimensions and no alternative materials are discussed	No list of materials or alternatives are provided
Description of the use of the principles of structural strength and stability	Uses 5 terms from the following sets: force or load or compression or tension; symmetry or triangulation; center of gravity or balance and counterbalance; support beams or struts; gusset or	Uses 4 terms from the following sets: force or load or compression or tension; symmetry or triangulation; center of gravity or balance and counterbalance; support beams or struts; gusset or	Uses 3 terms from the following sets: force or load or compression or tension; symmetry or triangulation; center of gravity or balance and counterbalance; support beams or struts; gusset or	Uses 2 terms from the following sets: force or load or compression or tension; symmetry or triangulation; center of gravity or balance and counterbalance; support beams or struts; gusset or	Uses 1 term from the following sets: force or load or compression or tension; symmetry or triangulation; center of gravity or balance and counterbalance; support beams or struts; gusset or

	joining methods; aesthetics	joining methods; aesthetics	joining methods; aesthetics	joining methods; aesthetics	joining methods; aesthetics
Explanation of the placement of fluid systems	Uses 5 terms from the following sets: pneumatic and hydraulic; system or input and output; density or particle theory; pressure or Pascal's principle; lever or pivot; friction; work done or mechanical advantage	Uses 4 terms from the following sets: pneumatic and hydraulic; system or input and output; density or particle theory; pressure or Pascal's principle; lever or pivot; friction; work done or mechanical advantage	Uses 3 terms from the following sets: pneumatic and hydraulic; system or input and output; density or particle theory; pressure or Pascal's principle; lever or pivot; friction; work done or mechanical advantage	Uses 2 terms from the following sets: pneumatic and hydraulic; system or input and output; density or particle theory; pressure or Pascal's principle; lever or pivot; friction; work done or mechanical advantage	Uses 1 term from the following sets: pneumatic and hydraulic; system or input and output; density or particle theory; pressure or Pascal's principle; lever or pivot; friction; work done or mechanical advantage
Success criteria	***5***	***4***	***3***	***2***	***1***
Evaluation of a prototype including conclusions from making it	A good description of two prototypes and thorough documentation of lessons learned including reasons for choosing one of the prototypes	A good description of a prototype and documentation of lessons learned with conclusions	A fair description of a prototype and poor documentation of lessons learned	A poor description of prototype and no documentation of conclusions	No mention of prototype or conclusions
	Part B: TEAMWORK SKILLS				
Success criteria	***5***	***4***	***3***	***2***	***1***
Members of the group work independently and co-operatively	All team members work co-operatively sharing the workload in a planned way by working in pairs and individually	All team members work co-operatively sharing the workload by working in pairs and individually without an organized plan	3 team members work co-operatively sharing the workload by working in pairs and individually. One team member participates minimally	2 team members work co-operatively sharing most of the workload. The remaining members participates minimally	1 team member does most of the work on their own with the remaining members participating minimally
Safe working practices	Team members wear safety glasses while cutting and drilling using the	Team members wear safety glasses while cutting and drilling using the	Team members wear safety glasses while cutting or drilling using the	Some team members do not wear safety glasses while cutting or drilling	No team members wears safety glasses while cutting or drilling

	appropriate tools safely with material held in a secure way	appropriate tools safely with material held in an insecure way	inappropriate tools with material held in an insecure way		
	Part C: DEVICE DESIGN AND OPERATION				
Success criteria	***5***	***4***	***3***	***2***	***1***
The system is well constructed	The system has all parts securely built and attached. The materials involved are used efficiently	The system has all parts securely built and attached. However there are redundant materials that perform no useful function	The system has most parts securely built and attached. Breakage occurs when force is applied to the fluid subsystem	The system has all parts securely built and attached however it does not function	The system has few parts securely built and attached and it does not function
A number of actions of the device are controlled by hydraulics	Four intact	Three intact	Two intact	One intact	None
A number of students operate the device without "breakage"	Four (one may give directions to the other 3)	Three	Two	One	None
TOTAL TEAM SCORE:	**SUMMATION OF SCORES**				
	Portfolio (35)	Work Habits (10)	Interview Questions (20)	Device Design and Operation (15)	Points accumulated in designated time period

Appendix III – Individual Learning Plan

Appendix IV – Copyrights

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Class Type - Teacher led
Review - Linkages; Pivots

Concepts

1. Linkages are levers that change the direction of force and motion in mechanical systems
2. Fixed pivots are fulcrum points in a mechanical system
3. Moving pivots are joints in a mechanical system
4. Linkages and pivots combine to change the direction and size of an input force into a manageable and appropriate output

Performance Objectives

It is expected the students will:

- Identify different linkages: reverse motion linkage; push-pull linkage; treadle linkage (crank-slider); toggle linkage
- Identify how a change in the position of a fixed pivot alters the output force
- Distinguish between mechanical systems that change the direction of linear motion and those that change linear motion to rotary motion
- Construct a linkage system that has an output force greater than its input force
- Construct a linkage system that has output motion greater than its input motion

Essential Questions

1. Where, in the home, are examples of linkage systems?
2. Why might linkage systems be important in hydraulic and pneumatic systems?

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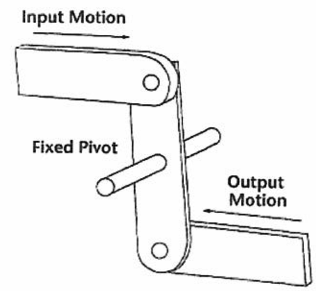

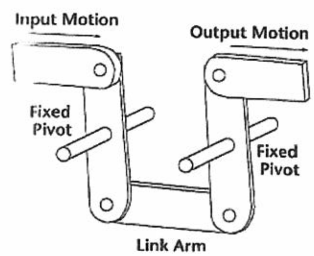

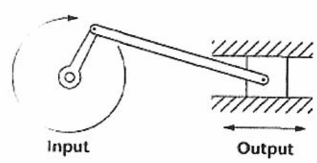

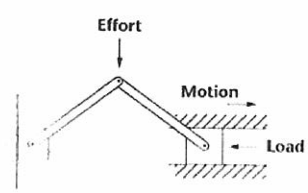

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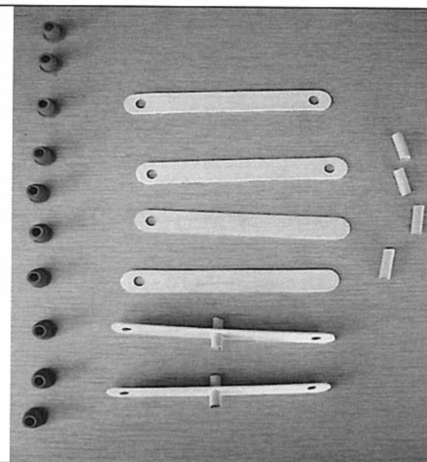
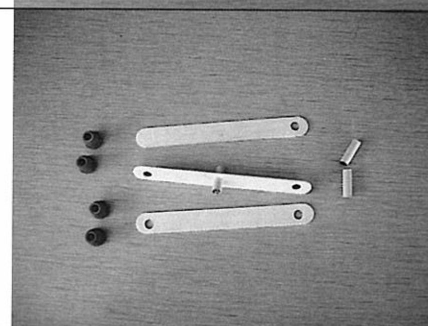
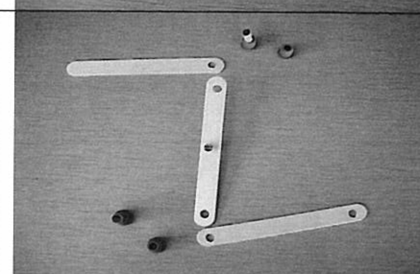
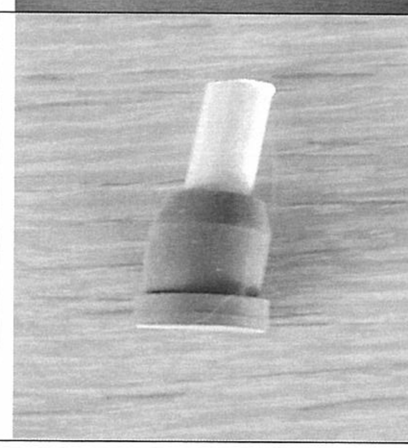
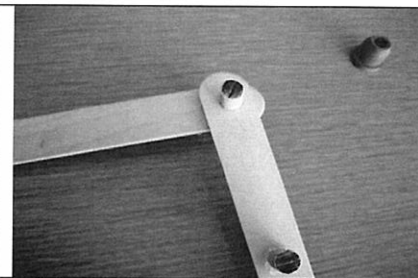
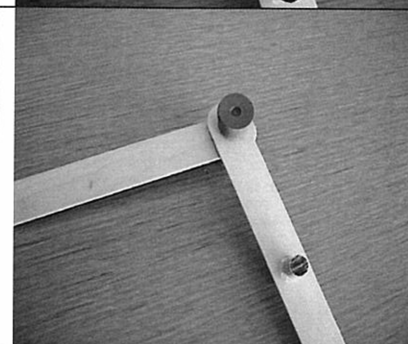
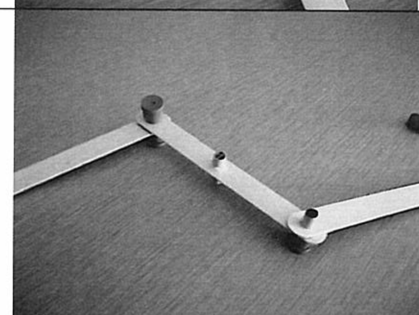
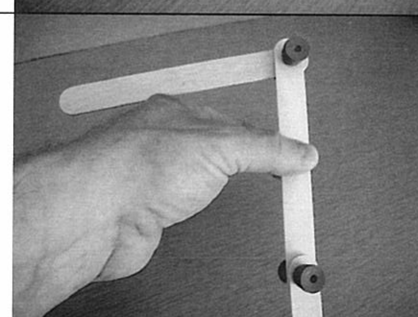
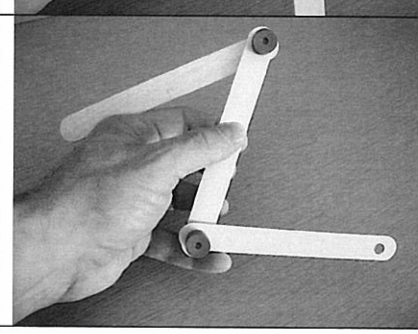
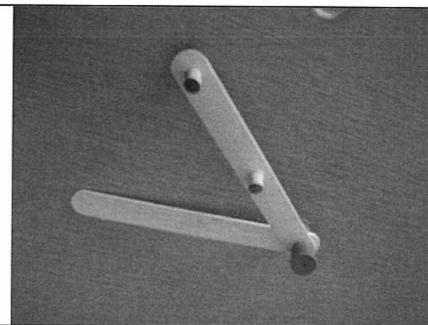
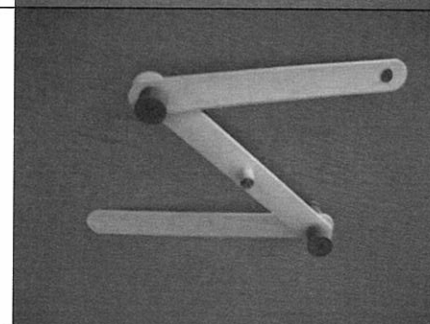
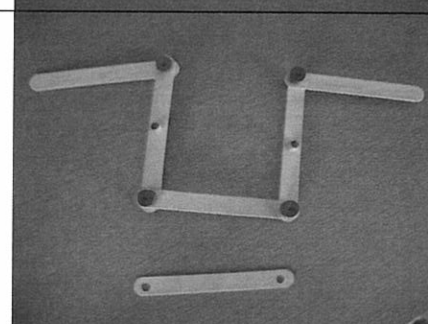
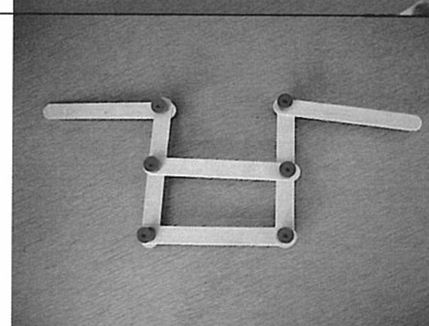
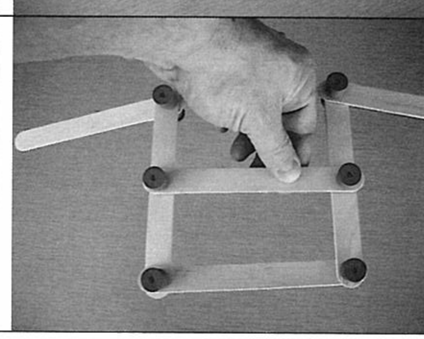
1		
2		
3		
4		

5		
6		
7		
8		
9		

10		
11		
12		
13		
14		

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