Airplane Activity: Lesson 1

Purpose: To create, modify, and analyze a paper airplane design.

Background: The elements of engineering and design are used to create skyscrapers, build space stations, write computer programs, and even create art. Having an understanding of the elements and procedures of engineering and design makes us better scientists, consumers, managers, musicians, or anyone else creating something new.

Materials:
Paper, pencils, paper clips, glue-sticks or tape, scissors.

SciVis: Lesson 1 Student Worksheet

Names____ Date__________

Essential question:

How well and how far did the paper airplane fly?

Brainstorming notes/sketches.

Design change or changes

1. ____
2. ____
3. ____

How did the second design change affect performance compared to the first design change. Did it improve? Why or why not?

What further changes might you make?

How could the process you just went through apply to building a space station?

SciVis: Lesson 2 – Elements of the Design Process

Provide a definition or explanation for each of the terms or phrases listed below.

Define the problem—

Brainstorming—

Generating ideas—

Identify criteria—

Specify constraints—

Explore possibilities—

Select an approach—

Develop a design principle—

Make a model or prototype—

Evaluate the design—

Refine—

Communicate process and results—

SciVis: Lesson 2 Student Worksheet 1

Names____ Date_________

Purpose: To become familiar with the steps of the design process and the importance of research.

Background: When any creative process is undertaken, there is a list of steps the creator must go through. With a little thought, you are probably able to identify all or most of them.

Procedure: In the space provided below, try to list the elements of the design process. Think about the airplane activity that you already completed as you try to complete this list.

List below your best guesses for the elements of the design process.

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.

SciVis: Lesson 2 Student Worksheet 2

Names____ Date_________

Purpose: To become familiar with simple machines.

Materials:

Books, magazines, encyclopedias, Internet, etc.

Procedure: Research and develop a basic understanding of what simple machines are and how they are used.

Write a short paragraph that describes what you know about simple machines. For example, since you cannot lift a car with your bare hands, how are you able to do so with a jack? Be specific.

Write two or three sentences outlining what you think you need to know about simple machines.

Record resources used here. For books and encyclopedias include authors, publishers, and copyright dates. Also be sure to write down any Internet addresses used as resources.

SciVis: Lesson 3 Student Worksheet

Names____ Date_________

Purpose: Practice and become familiar with how to identify variables and solve problems regarding simple machines.

Background: At this point you have already collected information on simple machines. Most of this information may be conceptual in nature, types of simple machines, the three different classes of levers, etc. What you may still lack is the knowledge to solve mathematical problems regarding simple machines. The ability to solve these problems is very important. You will not be able to explain how simple machines multiply force if you do not know the mathematical concepts. Remember, the grade you get on your presentation can only be as good as your understanding of the concept or system being presented. If you know how simple machines work, you can share the knowledge in your SciVis presentation. If you can explain how they work, your presentation will be a success.

Materials:

paper, pencil, calculator.

Procedure: Use your research and notes to solve the word problems below.

1. The effort force on a lever being used to move a rock is 800 N. This force is applied through a distance of 0.6 m. What is the work input?

2. What is the work output?

3. If the resistance distance (how far the rock moved) is 0.1 m, what is the resistance force?

4. What is the object's mass? (Clue: a = g = 9.8 m/s2)

5. The amount of output work required to lift a crate with a pulley system is 1200 J. The effort force on the pulley is 60 N. What is the effort distance? (How far must the rope be pulled?)

6. If the resistance distance is 10m, what is the mechanical advantage of the pulley?

7. The effort arm of a lever is 2m. The resistance arm is 0.25m. What is the mechanical advantage of the lever?

8. Make up your own word problem. It should include effort force, effort distance, resistance distance, and resistance force. Make sure you include the solution.

SciVis: Lesson 3 Work Equations

W = Work [unit of measure is Joules (J)]
F = Force [unit of measure is Newtons (N)]
d = distance [unit of measure is meter (m)]
m = mass [unit of measure is grams (g)]
a = acceleration [unit of measure is meters/second2 (m/ s2)]
e = effort (input)
r = resistance (output)

Win = Wout

Fe ? de = Fr ? dr

Win = Fr ? dr

Fe ? de = Wout

F = ma

de ÷ dr = Fr ÷ Fe = Mechanical Advantage

Efficiency = Wout ÷ Win ? 100%

SciVis: Lesson 3 Student Worksheet Answer Key:

1. Win = Wout
   Fe x de = Fr x dr
   Win = Fr x dr
   Win = (800N) (0.6m) = 480J

2. Win = Wout   480J = Wout

3. Win = Fr x dr   480J = Fr x 0.1m   Fr = 480J/0.1m = 4,800N

4. F = ma   4,800N = m x 9.8m/s2   m = 4,800N/9.8m/s2

5. Win = Wout   Fe x de = 1,200J   60N x de = 1,200J
   de = 1,200J/60N = 20m

6. Win = Wout   Fe x de = Fr x dr   MA = de/ dr = Fr/ Fe
   de/ dr = 20m/10m = 2

7. MA = effort arm / resistance arm = 2/0.25 = 8

SciVis: Lesson 4 Student Worksheet

Names____ Date_________

Purpose: To distinguish between criteria and constraints and to see how they are related.

Procedure: Complete the following activities.

1. Define Criteria.

2. Define Constraints

3. Give 2 examples of how design criteria and constraints might compete or conflict with each other.

A.

B.

SciVis: Lesson 5 Student Worksheet

Names______________________________________ Date_________

Purpose: The purpose of this lesson is for students to recognize the need for prototypes, and to create a computer generated prototype.

Procedure: Complete the following activities.

1. Define "prototype"

2. Why is it important to create a prototype?

3. What Simple Machine are you going to model?

4. Give one example of how each of the following actions relate to engineering design.
a) Creativity

b) Resourcefulness

c) Ability to Visualize

SciVis: Lesson 6 Student Worksheet

Names____ Date_________

Purpose: Identify specific criteria and constraints of your machine.

Procedure: Complete the following activities.

1. Identify the specific criteria of your machine.

2. Identify the specific constraints of your machine.

SciVis: Lesson 7 – How To Collect Data From A Simple Machine

If your machine is a lever, move the lever a short distance and measure how far the resistance arm moved. This is your resistance distance. Record this value on a chart. (Independent variable) Now measure how far the end of the effort arm moved. This is the effort distance. (Dependent variable) Record this value.

Now move the lever some more. Again, measure how far it moved from the original starting point and record resistance and effort distance. Record values. Repeat this 5 or 6 more times and record values. See Figure 1.

Resistance distance (cm)	Effort distance (cm)
1	3
3	9
5	15
7	21
9	27
11	33

Fig 1.

The information from the chart (fig 1) is entered into a spreadsheet program and graphed. The graph is labeled and the program was asked to display the equation of the resulting line. We remember the equation of a straight line is $y = mx + b$. In this case $b = 0$.
We see that m (slope) = 3. This is the mechanical advantage of the machine.

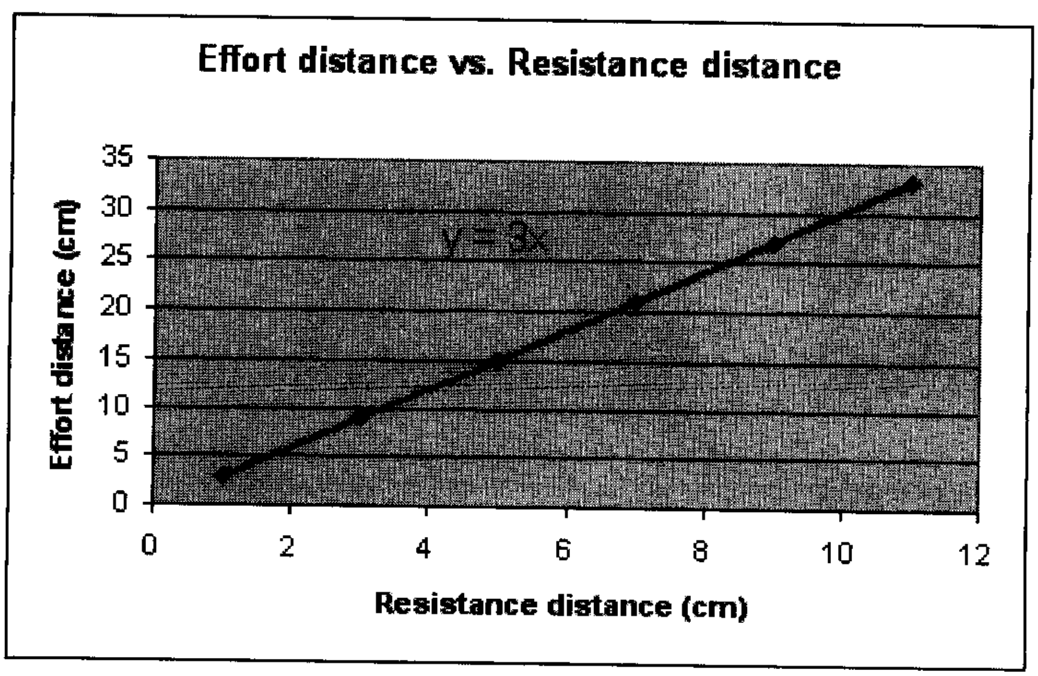


Fig 2.

Since Work in = Work out and W = Fxd, we can say
Fe x de = Fr x dr. A little algebra yields...
de/dr = Fr/Fe = MA

It is clear to see now that if we need to move an object that weighs say, 10,000 N, but only 3,300 N of force are available (for whatever reason) we can easily calculate the MA a machine would need to move that object.

10,000 N / 3,300 = 3 = MA

Similarly, if that object needed to be moved 10 m, we can calculate the distance through which the effort force must be applied; ie; how much rope will be needed, how long a ramp must be etc.

de/dr = MA

de = MA x dr

de = 3 x 10m = 30 m

Finally, if we know the MA of a machine, and how much something weighs, we can determine how much input force will be needed.

Fr/Fe = MA

Fe = MA/Fr

If the machine is an incline plane, measure how far an object is moved up a ramp (de) and how high the object is off the ground (dr). See figures 3 and 4.

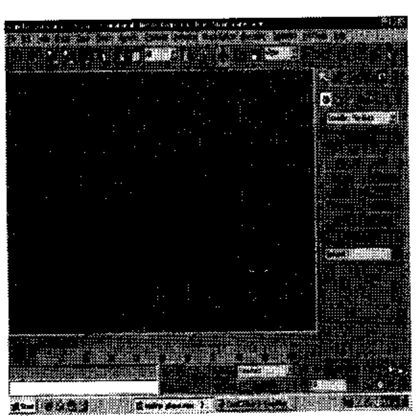


Fig 3.

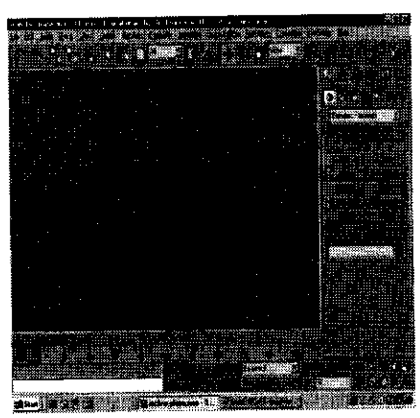


Fig 4.

For pulleys the MA of a pulley system can be determined by measuring how far the string is moved (de) and how high the object is off the ground (dr). Determine if there is a relationship between the MA and the number of strings that support the load. See figures 5 and 6.

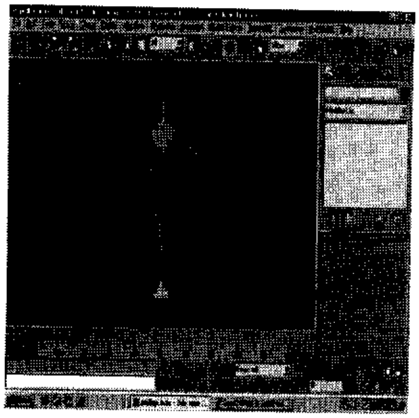


Fig 5.

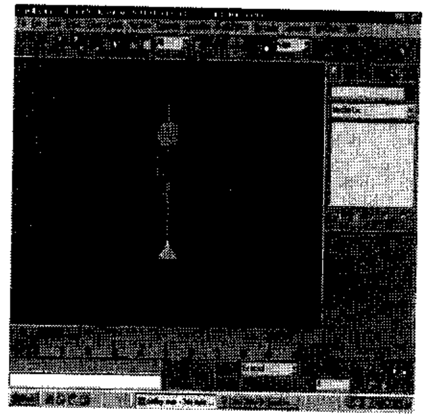


Fig 6.

Determining the efficiency of a machine is a similar process to the one above.

Using the chart below, under mass, enter 5 masses such as .5 kg, 1.0 kg, 1.5 kg, etc. Next, fill in the de and dr from your previous chart. The resistance force of each "object" is the weight or Fr.

F = ma.
a = g = 9.8 m/s2
Fr = mass (kg) x 9.8 m/s2
Enter the Fr for each "object".
Now you need the effort force (Fe) for each "object" that would have been applied to your simple machine.
Fe = (Fr x dr)/de
Now fill in Fe for each of the 5 "objects".
The work in (Win) for each "object" is (Fe x de).
The work out (Wout) for each "object" is (Fr x dr).
Now fill these in for each of the 5 "objects".

Finally, create a graph that plots (W in) on the "x" axis and (W out) on the "y" axis.

Add a trend line with its equation as you did for MA. What is the slope of this line, and what does it represent?

Mass (kg)	De (m)	Dr (m)	Fr (N)	Fe (N)	Win (J)	Wout (J)

SciVis: Lesson 7 Student Worksheet

Names______________________________________ Date__________

Procedure: Complete the following activities.

1. What does "multidisciplinary" mean?

2. What type of simple machine did you construct?

3. What is its Mechanical Advantage (MA)?
   Show your data collected and your calculations.

SciVis: Lesson 8 Student Worksheet

Names____ Date_________

Procedure: Complete the following activities.

1. Should a design engineer be concerned with the elements of art? Why?

2. List as many professions, at least four, as you can that might involve the need to illustrate concepts, thoughts, ideas, or designs.

SciVis: Lesson 9 Student Worksheet

Names____Date_________

Procedure: Complete the following activities.

1. Do pictures communicate information? Why use pictures instead of words?

2. List as many, at least six, everyday examples that you can think of that shows how pictures can communicate important ideas.

SciVis: Lesson 10 Student Worksheet

Names____ Date__________

Procedure:

1. Are design problems normally presented in a clearly defined form? Explain.

2. What is the purpose of analyzing both theoretical and actual experimental data?

3. You are going to attach a load mass to the work end of your machine. Before you do this you must determine its mass in kg. Then use the equation, F = ma to determine the resistance force of the object. (acceleration due to gravity is 9.8m/s2). Enter this value on a chart. m = F/9.8m/s2

4. Attach a load to the work end of your machine.

5. On the work input end of your machine, provide some force a certain distance and measure that distance. (de) Record that effort distance in the chart below. How far did the load mass move? (dr).

6. Exchange the first mass for another one and repeat. Use 5 different masses and fill in the chart.

7. You will now have to measure the effort force (Fe) for 5 different masses. Make sure to note the resistance force (Fr) for each mass as well. Record Fe and Fr for each of the 5 masses.

8. Next show the work input (Win) and work output (Wout) for all 5 masses.

object	mass	de	dr	Fe	Fr	Win	Wout

SciVis: Lesson 11 Student Worksheet

Names____ Date_________

Purpose: The purpose of this lesson is to allow you to create graphs of your experimental data from the day before. These graphs will be compared to the graphs made of the theoretical data.

Background: No matter how much thought goes into a design, the finished product will almost always have room for improvement. Was your machine conducive to data collection? Was it easy to handle? Was it stable?

Procedure: Before you start making graphs, answer the following questions.

1. What does "Ergonomics" mean?

2. How might your machine be redesigned to make it easier and more convenient to use?

SciVis: Lesson 12 Student Worksheet

Names______________________________________ Date__________

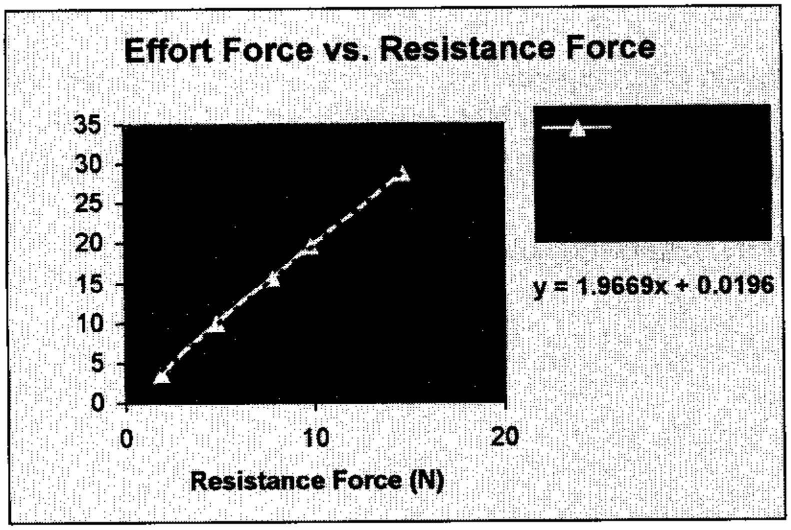
Purpose: The purpose of this section is to help you to see how powerful computers are in experiment, prototyping, designing, analyzing, and communicating information.

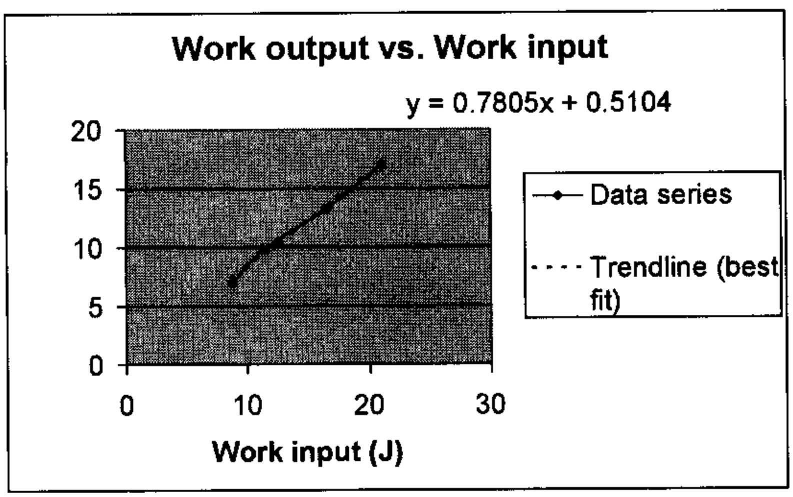
Procedure: Complete the following activities.

1. What role do computers play in engineering and technical design?

2. What role might computers play in fashion design?

3. List as many ways, at least four, you can of how computers can be used in the design process.


Effort Force vs. Resistance Force
35
30
25
20
15
10
5
0
0
10
20
Resistance Force (N)
y = 1.9669x + 0.0196


Work output vs. Work input
y = 0.7805x + 0.5104
20
15
10
5
0
0
10
20
30
Work input (J)
Data series
Trendline (best fit)

SciVis: Lesson 14 Student Worksheet

Names____ Date_________

Purpose: The purpose of these questions is to provide you with important additional information for your presentation.

Background: The final step in the design process is to communicate results. You must remember, the design process is a cycle. Therefore, these final thought questions are not just the end of this cycle, but the beginning of the next. If you were designing autos, space shuttles, clothing, toys, or just about anything else, you would be striving to improve upon existing designs.

Procedure: Complete the following activities.

1. How did your actual machine compare to your computer model? (In terms of mechanical advantage and efficiency) Compare your graphs.

2. List some possible causes for these differences.

3. How could you make your machine more efficient?

SciVis: Lesson 15 Student Worksheet

Names____ Date________

Procedure: Complete the following activities.

1. The design process for this or any project includes many things. Look at the steps in the design process from day 2 and list each step your group performed.

2. Write two or three sentences that address how your research affected the final product.

3. For each of the items listed below give one example of how information systems are used to:

   Inform

   Persuade

   Entertain

   Control

   Manage

   Educate

4. Write a self-reflection. Include what was learned, what went well and why, and what would have made the project better and why.