FY-16 August 10, 1995
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The Top Heavy Ship

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Type:	Design Problem
Student Time:	Two Weeks
Location:	Classroom/Home

Summary

In the late 1500's, the King of Sweden, King Gustav Adolph II, while off in Germany fighting the Catholics, ordered his ship builders to build him four new ships. The Swedish ships of those days were built by Dutch ship builders who built rather flat bottom ships with rock ballast. One of the ships was to be the King's new flag ship, called the Vassa. Just before the Vassa was completed, the King heard the English were adding a second row of cannons. So he sent messengers back and ordered his shipbuilders to put another row of 50 cannons on the top deck. Each cannon weighed about 2 tons.

On a day of great celebration, a small sailing crew along with family members sailed the ship out of the harbor, but before it made it out to sea, a gust of wind came up and the ship heeled over. It began to take in water at the lower level of cannons. It righted itself, but just then another gust of wind came, and it toppled over, sinking to the bottom of the harbor channel, to a depth of about 30 meters.

Suppose you were an ship builder. Write a report on the importance of the location of the center of buoyancy and the center of gravity. Design a device that would stabilize the ship, solving the problem the Admiral had.

ABET Descriptors

Engr Sci Content:	First Year Engineering
Type:	Component
Elements:	Analysis, synthesis, construction, testing
Features:	Design methodology, creativity
Constraints:	Safety, economic factors
Effort:	Individual

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The Top Heavy Ship

In the late 1500's, the King of Sweden, King Gustav Adolph II, while off in Germany fighting the Catholics, ordered his ship builders to build him four new ships. These ships were to replace ships that were lost in battle or at sea so the King could continue to make Sweden a major power. The Swedish ships of those days were built by Dutch ship builders who built rather flat bottom ships with rock ballast. One of the ships was to be the King's new flag ship, called the Vassa. Just before the Vassa was completed, the King heard the English were adding a second row of cannons. So he sent messengers back and ordered his shipbuilders to put another row of 50 cannons on the top deck. Each cannon weighed about 2 tons.

It was custom to test the ships for stability while tied to the dock. The Admiral would take 30 men and order them to run from side to side. If the swaying was moderate, the ship was judged to be sailable. For the Vassa, the Admiral had to stop the test after three runs across the deck for fear of it capsizing at the dock. But what could he do? He could not send a message to the King , who was soon to come home to take the helm of his command ship, that it was unsailable. And he could not rebuild the ship, as each oak plank had been cut just to fit and the bottom was filled with as much rock as possible. So he did nothing.

In the meantime, the ship's designer had died and his assistant completed the work. On a day of great celebration, a small sailing crew along with family members sailed the ship out of the harbor, but before it made it out to sea, a gust of wind came up and the ship heeled over. It began to take in water at the lower level of cannons. It righted itself, but just then another gust of wind came, and it toppled over, sinking to the bottom of the harbor channel, to a depth of about 30 meters. The ship from stern to tip of mast was about 50 meters, so the top of the sail and the Swedish flag was all the King saw when he arrived home. After several days, he ordered the top cut off to avoid more embarrassment.

A hearing was held to lay the blame, but since the designer had died, and the King could not be blamed, no one was punished. Some say it was an act of God. Others said it was bad luck to sail with family members on board a warship. The ship was refloated in 1957 and now sits in a museum for you to visit some day.

Suppose you were an ship builder. Write a report on the importance of the location of the center of buoyancy and the center of gravity. (Note that airplanes and rockets have the same problem of stability depending on the location of the center of pressure and the center of gravity). Design a device that would stabilize the ship, solving the problem the Admiral had.

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The Top Heavy Ship

Build a model from balsa wood that would demonstrate the stability problem of ships. This is not an uncommon problem, especially on flat bottom ferries. Use the model to demonstrate the stability phenomena by putting a mast on the model, and stacking small washers on the mast. Show that the slightest tipping causes the model to tip over.

Design a device to improve the stability of your model ship. Demonstrate the improved stability with your device by repeating the experiment with the washers.

Find some reported instances of ships capsizing. Write a report on your results including drawings or sketches of the solution. For extra credit, get the dimensions of the VASA from your instructor and estimate the center of buoyancy and the center of gravity.

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The Top Heavy Ship

Engineering Notes:

Objectives/Comments: This is a good opportunity to talk about what is meant by a stable and unstable system. Be prepared to show how to calculate center of gravity and center of buoyancy. You should also be prepared to talk about center of pressure for flying vehicles.

Expected Outcomes: This should be a fun exercise for the students. You might have a few water fights if not careful. Bring a dish pan half full of water so the students can test their ship before and after.

Discussion/Follow Up: You can use this as a discussion of more recent instances of need rushing engineering design with disastrous results. Of course the Challenger accident comes to mind. Ask the students if they can come up with other situations.

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Date: 3 August, 1995

Food in Space

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Type:	Design Problem
Student Time:	One semester
Location:	Classroom/Home

Summary

Recent biological experiments have shown that fertilized tadpole eggs do not incubate very well in weightless conditions. On earth, as the embryo grows, the waste products fall to the bottom of the egg, away from the embryo. In space, the waste products surround the egg, killing the embryo. If the Astronauts want frog legs for dinner as they fly to Mars, design a system that will solve this problem, i.e., design a frog farm in space.

ABET Descriptors

Engr Sci Content:	First Year Engineering
Type:	System
Elements:	Analysis, synthesis, construction, testing
Features:	Design methodology, creativity
Realistic Constraints:	Reliability, limited resources, economic factors
Effort:	Team

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Food in Space

Go to the library and research what experiments NASA has conducted to provide food for astronauts on long trips. Propose a method for generating an artificial gravity for a frog farm. Also research what type of environment frogs need to grow. What type of environment must you provide? How would you accomplish this task. Can you think of other ways to grow food in space? Write a report on your findings and a proposed solution.

Construct a hardware solution to this problem. Include in your report engineering drawings, the method of achieving the artificial gravity, and show how the necessary ecological environment will be provided.

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Food in Space

Engineering Notes:

Objectives/Comments: This is a good opportunity to discuss some basic physics principles while encouraging the students to develop a very useful system.

Expected Outcomes: The most probable solution here is some type of spinning wheel. You should be prepared to discuss the types of acceleration a body experiences while rotating about a point Be prepared to answer questions about what NASA has done. This information can be obtained from one of the many teacher resource centers around the country. See what kind of solutions the students come up with to provide the necessary ecological environment.

Expect some lively discussion to develop. These types of discussions generate a lot of interest.

Discussion/Follow Up: Encourage the students to consider other methods of food generation. Could catfish farms be developed? Is the requirement for water for these proposed food sources a major drawback?

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A Bicycle Light

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Type:	Design Problem
Student Time:	Four Weeks
Location:	Classroom/Home

Summary

The most common design for a bicycle light is either a large battery or a small dc generator, that is powered by friction contact with the front wheel. These devices either add extra weight to the bike, or put some additional drag on the bicycle. The generator does not work if any mud gets on the wheel. Some work has been done with electric trains with the track being the stator and the train being the rotor of an induction motor. Design a contactless generator to power a bicycle light. No external power source is allowed.

ABET Descriptors

Engr Sci Content:	First Year Engineering, Electricity
Type:	Component
Elements:	Analysis, synthesis, manufacture, spec, evaluation
Features:	Design methodology, creativity, open-ended
Realistic Constraints:	Reliability, Economic Factors, Space
Effort:	Team

A Bicycle Light

The idea is to replace the wheel generator or battery with a device as efficient but lighter and more robust. Consider the devices on heels of running shoes that provide light. Could small magnets be placed on the rim of the wheel? This is only one suggestion. Build your device and test it. Provide engineering drawings, test results, and a filled out patent application form with your report. Present a marketing plan and packaging plan to sell this device through bicycle stores.

A Bicycle Light

Engineering Notes:

Objectives/Comments:

Be prepared to discuss some basic electromagnetic field theory.

Expected Outcomes:

Look for solutions that could be sold as a kit in a bicycle store.

Discussion/Follow Up:

Let the students critique each others designs.

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Small Rocket Altitude Estimator

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Type:	Design Problem
Student Time:	Two Weeks
Location:	Classroom/Home

Summary

Build a simple device to measure the maximum vertical height (altitude of from 500-1000 feet) of a small model (for example Estes rocket kit - found in many hobby shops) rocket. The device is not attached to the rocket. This measurement will be used to estimate the coefficient of drag of the rocket from a spread sheet.

ABET Descriptors

Engr Sci Content:	Dynamics
Type:	Component
Elements:	Analysis, synthesis
Features:	Design methodology, creativity
Constraints:	Safety, economic factors
Effort:	Individual

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Small Rocket Altitude Estimator

Safety concerns require you to be at least 50 feet from the launch. The maximum altitude device can not be on the rocket itself. If you use a pointing device, be sure not to look into the sun and hurt your eyes. Once you launch the rocket and get the altitude, use the spreadsheet program and manually change the coefficient of drag until you match the altitude achieved during flight.

You can get the altitude by using the equation tan (elevation angle) = height/distance to launch. Be careful about using degrees or radians in your calculator.

Write a report describing your device and the results. Comment on the sources of error. Use your spread sheet program to determine the sensitivity of measurement errors on the error in coefficient of drag.

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Small Rocket Altitude Estimator

Engineering Notes:

Objectives/Comments:

Discuss the acceleration equation for a rocket. Show the components that add up to the total acceleration on the rocket. Show that the thrust provides positive acceleration of the rocket, while the gravity and atmospheric drag provide negative acceleration.

Expected Outcomes:

Even though all the students will use the same rocket, they will come up with different answers. This is due to measurement errors and how well the rocket flies. Some students may have cocked fins or rough surfaces which effect drag.

Discussion/Follow Up:

This is a good opportunity to show how physics helps in understanding a problem. It also show how drag is an important factor to minimize when trying to achieve high speeds or altitude.

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Toaster Fire Prevention System

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Type:	Design Problem
Student Time:	Six Weeks
Location:	Classroom/Home

Summary

Toaster ovens have been known to start a fire in a home. While many heating devices such as hand held hair dryers have a temperature sensitive switch to prevent overheating, sometimes foods placed in a toaster oven will catch fire before the temperature switch either pops open the oven door. The task will be to design a device to include in a new toaster oven to prevent the occurrence of fires. The device should be non-destructive. That is it should detect the fire or the conditions of the fire before it starts and turn off the heating element.

ABET Descriptors

Engr Sci Content:	Electrical
Type:	Component
Elements:	Analysis, synthesis, manufacture, testing, evaluation.
Features:	Design methodology, creativity
Constraints:	Safety, space, economics
Effort:	Team

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Toaster Fire Prevention System

You will be working with a team of two other product engineers. You are given a toaster oven and a slice of bread. Set the scale to the darkest level and toast the bread. Once the toaster cycle is complete, repeat with the same bread. Watch closely for the fire to start. Observe any particular conditions that you could use to predict the occurrence of a fire. Quickly turn the toaster off and extinguish the fire. Fanning or blowing will usually do the trick.

Wait for the toaster to cool. Disassemble the toaster to the point you need to investigate the construction. You will need to design a system to prevent the disastrous results of the experiment you just conducted.

Research the number of house fires caused by a faulty toaster oven. Find any information available on legal liability or product recall.

Write a report on your design effort. The report should include the following:

1. A description of the problem and the results of your investigation.
2. The design of the device that could be added to this toaster oven to prevent fires.
3. Engineering drawings of the device and how it interfaces with the toaster.
4. Manufacturing costs.
5. Marketing plan for this device.
6. A patent pending disclosure.

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Toaster Fire Prevention System

Engineering Notes:

Objectives/Comments:

This is a study in product design. You might have a fire extinguisher handy but if the students are observant, the fire will go out very quickly.

Expected Outcomes:

Try to watch the teams and be sure that all students participate. Since some library work is required, obtaining a balance of work between the team members may not be possible. Since this is an appliance that all students have probably used without problems, you might see some surprised students at the results of the experiment.

Discussion/Follow Up:

Have the groups give a presentation on their product investigation. Once all the presentations have been made, let the students decide which one is probably the best design. Discuss how this design flaw could have got through the product engineers at the manufacturing company. Shouldn't they have tested this fire possibility?

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Low Temperature/High Altitude Test Chamber

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Type:	Design Problem
Student Time:	One Semester
Location:	Classroom/Home

Summary

The space studies program here at University of Colorado at Colorado Springs (UCCS) flies a high altitude balloon (to about 30KM) once each semester. A device is needed to allow tests of experiments that will fly on this balloon before the actual flight takes place. A low temperature test chamber is desired. This project will allowing testing of the proposed experiments in the low temperature environment of high altitude flight. The chamber must enclose the payload which fits inside a box of approximately .3m on a side.

ABET Descriptors

Engr Sci Content:	Thermal
Type:	System
Elements:	Establish objectives/requirements, analysis, synthesis, construction, testing, evaluation
Features:	Design methodology, creativity
Constraints:	Economic factors, reliability, safety
Effort:	Team

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Low Temperature/High Altitude Test Chamber

You will work with three other students on this project. Your first task will be to determine what the atmospheric environment is like at about 30 KM altitude. Your design needs to try to come as close as possible to the nominal temperature conditions at this altitude.

Since the payload is about .3 m on a side, you must design a test chamber that will allow easy access for the payload. Flow of air around the payload is necessary. Electrical connections to the outside are also necessary. Here are the constraints:

1. Payload is .3m on a side.

2. Must have easy access to the payload

3. Wires from the payload must be able to exit chamber

4. Chamber should be portable and not too heavy.

5. Temperature must be measured and displayed outside the chamber. A fan may be necessary.

Write a report showing your design and test results. Show any calculations that you used in your design.

Low Temperature/High Altitude Test Chamber

Engineering Notes:

Objectives/Comments:

This is not an easy project. You need to get the students to quickly determine the ambient conditions at 30KM. Probably a basic physics book would have some discussion of the upper atmosphere. Although this chamber just simulates low temperature, the students should realize that at the higher altitudes, temperature does not come from the heat transfer through the air medium but through the kinetic energy of molecules. This phenomena of the stratosphere is discussed in many physics textbooks.

Expected Outcomes:

Make sure the students show reasonable care on sealing the chamber especially where the sensor leads come out. They should propose a tray of dry ice underneath the payload. Cooling is actually increased by heating the dry ice with small resistive wires. See if any of the students come up with this idea.

Discussion/Follow Up:

Discuss the engineering constraints with this type of problem. Are there any safety concerns?