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ABSTRACT

This training module on the Roaring River bridge design project was developed for a problem-solving unit in a ninth-grade research and development course. This project requires six to seven class periods and requires students to work in teams of two. The project contains the following information: level; time required; description; objectives; content--problem solving, structural stress, types of bridges, and budget/materials specifications/limitations; methodology; student worksheets; resources; and evaluation (125 total points)--bill of materials (20 points), bridge design paper (20 points), craftsmanship (20 points), general design (15 points), and bridge testing (50 points). The following materials are included: a diagram of acceptable and unacceptable construction joints; materials ledger; Roaring River bridge design evaluation; optional problems to be presented to student groups; an outline on the problem-solving process; and a radioactivity problem. (NLA)

# High-Technology Training Module

Module Title: THE ROARING RIVER BRIDGE DESIGN PROJECT

Unit: PROBLEM SOLVING

Course: RESEARCH & DEVELOPMENT

Grade Level (s): 9TH GRADE

Developed by: JOSEPH HUFTEL & WILLIAM RADEMAKER

Date: JUNE 6, 1990

School: RICE LAKE HIGH SCHOOL

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Developed as a part of the High-Technology Training Model for Rural Based Business and Industry, Technical Colleges and Local and State Educational Agencies under Grant No. V199A90151.

Title: **The Roaring River Bridge Design Project**

Level: Grade 9 Time Required: 6 - 7 Class Periods

Description:

Careful planning is essential in any building project. This is especially true when a person is about to construct a large and complicated project such as a bridge. Being awarded a contract to build a large bridge, will often times either make, or break a construction company. Construction engineers must be able to design a bridge that will meet all specifications insisted on by the people wanting the bridge built, and yet be low cost and easy to build.

For this project, you and your partner's company will build a model bridge out of 1/8" x 1/8" balsa wood "beams", 2 x 4 inch sections of paper, glue, and string. All of the materials will cost your company "megabucks", so you'll want to carefully plan your bridge design in order to reduce costs, and yet hold as much weight as possible. The people that you are building the bridge for have budgeted only $500,000.00 for construction of the bridge, so you may not spend any more than that. The following is a list of materials you may use, their size or quantity, and the cost for each unit.

(note: some items subject to limited availability)

| | | |
|---|---|---|
| one unit of paper | 2 x 4 inches | $30,000.00 |
| one unit of beam | 6 inches | $20,000.00 |
| one unit of beam | 12 inches | $45,000.00 |
| one unit of string | 8 inches | $ 5,000.00 |
| one unit of glue | 5 mg | $ 5,000.00 |

When purchasing any of these materials, you must purchase an entire unit. However, you may trade materials, via a barter system, with other companies in order to get the materials you need.

Keep in mind the dynamics of the materials you are working with. Balsa wood should have the same dynamics as the steel used in vertical columns and, hopefully, will take a lot of compression before it fails. String on the other hand has very poor compression

strength, but can take a lot of tension like wire cables. The paper acts like sheet steel, and has good omni-directional strength if used to its best advantage. The glue acts like cement in bonding and reinforcing.

You and your partner must build a bridge that will span a distance of ten inches, and hold a minimum of ten pounds. The walls of the "canyon" that you will be spanning over are very unstable, and the canyon is very deep, so your bridge must not touch the inner walls, nor the bottom of the canyon. The bridge deck must be a minimum of two inches wide. The bridge height must be a minimum of two inches high. No laminating will be allowed (see the last page of this packet, which outlines acceptable and unacceptable construction joints). The weights will be hung from the center of the bridge to determine load capacity.

After you have designed your bridge on paper, you may begin obtaining the materials you will need to build your bridge from the instructor, who will keep a running total of material costs for your company. Your company must also keep track of material used, as you will need to turn in a detailed bill of materials for grading. After you have built your bridge, you and your partner will determine the cost per ounce that your bridge held by dividing the total cost by the weight held. The weight must be on the bridge for a period of ten seconds in order to count as weight actually held.

Objectives:

1. Given the materials and construction specifications, the student will design and construct a bridge that will hold a minimum of ten pounds.

2. Given detailed information, the student will design a bridge to within a tolerance of ± 10% of the specifications.

3. Given a typical problem faced in the construction industry, the student will identify three possible solutions.

4. Given a detailed drawing of a bridge, the student will identify the three different types of simple stress.

Content:

1. The problem solving process.

2. Types of structural stress.

3. Different types of bridges.

4. Working with budget/material specifications/limitations.

Methodology:

Day one of the activity would consist of a brief lecture on the problem solving process followed by a short spontaneous problem solving activity. The instructor will discuss a hand out on the different types of bridges and issue the Roaring River Bridge Design Activity packet as an assignment to be read for day two.

On day two the instructor would briefly explain the activity packet and the procedures to design and build the bridge structure, and how it will be evaluated. An overhead presentation covering the types of stuctural stress will lead into the initial design phase of the activity. The students will work in groups of two for the remainder of the period at which time they will submit a rough sketch of their bridge design to the instructor for evaluation and approval.

On day three and four the students will redesign and construct the bridge project. Day five will be used as lab time to finalize construction. The last day (day 6) of the activity will be used for evaluation and testing.

Student Worksheets:

1. The Roaring River Bridge Design Project Activity Packet.

2. Bridge Construction Handout - Delmar Activity Guide.

3. Materials Record Handout.

Resources:

1. DelMar Publishing Technology Activity Guide.

2. Department of Public Instruction Research and Development handbook.

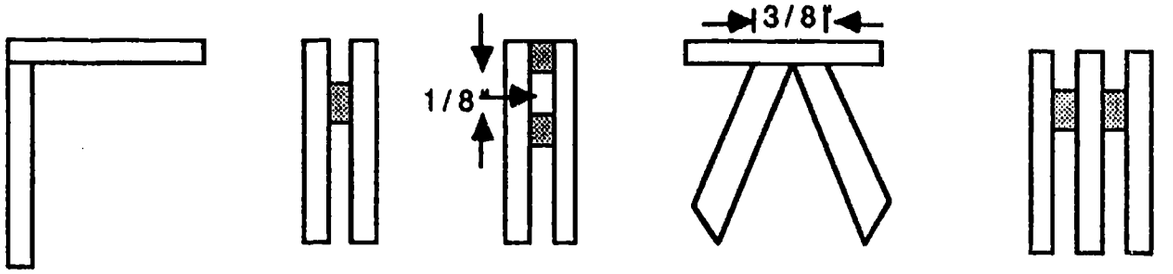
3. Department of Public Instruction Curriculum and Activity Guides.

4. Problems, Problems, Problems. The OM Association.

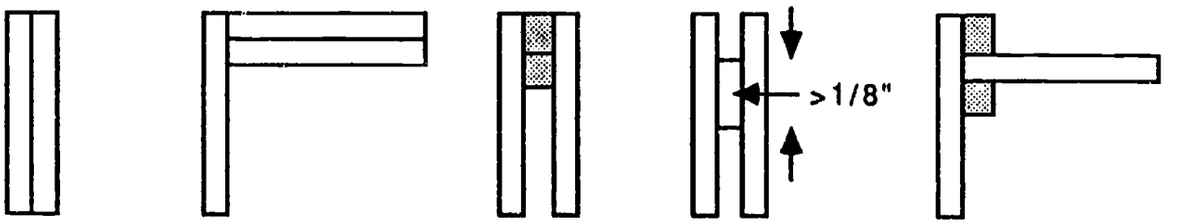
Evaluation:

| Item | Criteria | Points |
|---|---|---|
| Bill of Materials | Complete, accurate, neat | 20 |
| Bridge Design-Paper | Neat(!), dimensioned, parts labeled, type of design noted, forces identified, $ per ounce noted on drawing. | 20 |
| Craftsmanship | Accurate cuts, neatness, wise and economic use of materials. | 20 |
| General Design | Design patterned after one of the major types of bridge designs. | 15 |
| Bridge Testing | Design supporting at least 160 ounces* for the fewest dollars per ounce receives 50 points. 2 point reduction for second best, 4 points for third, etc. (*5 point penalty if structure fails to hold 160 ounces) | 50 |
| | Total possible points: | 125 |

## Acceptable Construction Joints




## Unacceptable Construction Joints



# MATERIALS LEDGER

COMPANY NAME/OWNERS_ :_____

| MATERIAL | QTY. | COST / UNIT | TOTAL COST | MAT'L COSTS TO DATE |
|---|---|---|---|---|
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# Roaring River Bridge Design Evaluation

**Construction Company Employees:** _____

_____

**Evaluation:**

| Item | Criteria | Points |
|---|---|---|
| **Bill of Materials:** | Complete, accurate, and neat | _____out of 20 |
| **Craftsmanship:** | Accurate cuts, neatness, wise and economic use of materials | _____out of 20 |
| **General Design:** | Design patterned after one of the major types of bridge designs | _____out of 15 |
| **Bridge Design-Paper:** | Neat(!), dimensioned, parts labled, type of design noted, forces identified | _____out of 20 |
| **Bridge Testing:** | Design supporting at least 160 ounces* for the fewest dollars per ounce receives 50 points. 2 point reduction for second best, 4 points for third, etc. (*5 point penalty if structure fails to hold 160 ounces) | _____out of 50 |
| **Total Points:** | | _____out of 125 |

**********

**Weight Held:** _____ ounces **Dollars spent:** _____

**Dollars Per Ounce Held:** _____

# Optional problems to be presented to student groups---

These mini problems can be presented to students to make the activity even more of a challenge. Each group could be presented with one of the following problem sheets sometime during the course of the activity.

## WEATHER DELAY!

BRING ALL MATERIALS TO INSTRUCTOR UNTIL RAIN STOPS, WHICH WEATHER FORECASTERS PREDICT WILL LAST FOR 10 TO 15 MINUTES. WORK ON "INSIDE" WORK (PAPER WORK).

## FIRE !!!

YOU LOSE A PART OF YOUR AS OF YET UNUSED MATERIAL.

** IMPORTANT **

TURN IN INSURANCE CLAIM ON LOST MATERIALS.

## ACCIDENT !!

YOU LOSE ONE LABORER! DOCTOR ESTIMATES FULL RECOVERY WITHIN ONE CLASS PERIOD.

## SHUT DOWN NOTICE !!!

FOR VIOLATIONS OF OSHA (OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION) SAFETY REGUALTIONS. NOTICE IS EFFECTIVE FOR THE NEXT 15 MINUTES.

## MATERIAL SHORTAGE !!

WAREHOUSE WILL CALL WHEN ORDER IS IN. YOU MUST MAKE A MEMO TO THE WAREHOUSE, DEMANDING DELIVERY ASAP (AS SOON AS POSSIBLE).

## STRIKE !!!!

____ONE LABORER GOES ON STRIKE TO DEMAND BETTER WORKING CONDITIONS. OTHER PEOPLE IN CONSTRUCTION COMPANY CROSS PICKET LINE, AND KEEP ON WORKING. STRIKER WILL HOLD OUT UNTIL HIS/HER PERSONAL SAVINGS IS DEPLETED (ABOUT 20 MINUTES).

## CORPORATE SCANDAL !!

___ COMPANY MUST HIRE LAWYER TO FIGHT GOVERMENT PROSECUTOR. RETAINING FEE FOR LAW FIRM IS $5000.00 !!

# Problem Solving Process

A. Understand the Problem
   1. Statement of problem.
   2. Analysis and research of problem.

B Devise a plan
   1. Brainstorm possible ideas
      a. no right or wrong answers
      b. everything is a possibility
   2. Develop goals
   3. Think verbally, visually, quantitatively, or through sensory languages.

C. Experimentation (pick a plan and begin to develop it out)
   1. Sketch it.
   2. Make model.
   3. Make mockup.
   4. Make prototype.

D. Implement Idea
   1. Begin solving the problem.

E. Final Solution.
   1. Examine solution to meet first step.
   2. Modify to meet limitations.

F. Test Solution
   1. Implement solution.
   2. Redesign to improve.

# RADIOACTIVITY PROBLEM

You are a member of a radioactive-waste disposal team that is responsible for cleaning up and storing spent radioactive fuel bundles.

**The Problem:** There are twelve bundles (balls) to be stored today, and you only have three minutes in which to work with the balls before they begin to become a *very serious health risk.* The balls need to be transferred from their current holding facility (the plate), to the green "safe tank."

**The Limitations:** You may not come in direct contact with a ball at any time, or the ball will be confiscated. The only tools you may use to transfer the balls with are listed below:

1 - baggie
1 - straw
1 - pen
1 - pencil
1 - rubber band
1 - popsicle stick
1 - envelope
1 - paperclip
1 - piece of string
1 - pliers

These tools can only be used once, and then must be discarded. Before you begin trying to solve the problem, your team will be given one minute to discuss, as a group, how you might go about solving the problem.

If a ball falls out of the plate while you are trying to pick it up, the ball(s) that fall out will be confiscated. Each person on the team must take a turn placing a ball in storage. If the person placing the ball in storage is stuck and can't get the ball in the storage tank, the entire team is stuck! Team members will take turns placing a single ball in storage until all twelve balls are stored, or until the three minute time limit is up.

Each **red** ball is worth 20 points, each **blue** ball worth 10 points, and each **white** ball is worth 5 points, for a total of 100 possible points.

*Good Luck!*