TIES 2003

Teachers in Industry for Educational Support

One of a Kind in America

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All handouts are with the ALTs.

One of a Kind in America
Curriculum Unit Summary

Summary

This unit combines several mathematics, science, and business concepts needed for manufacturing and construction. Individual authentic learning tasks for teach students some basic mathematics behind engineering research, determining cost, and maximizing resources, the importance of safety, concept of potential and kinetic energy when dealing with machines, and the teamwork. This unit was designed for high school students of various ability levels. Teachers may wish to modify or extend existing materials to suit the ability level of students. It may take a class 2-3 weeks to complete all lessons.

Business	Science	Mathematics
ALT 1 - Toothpicks and Playdough Give students 6 toothpicks and a lump of playdough. Challenge them to make four triangles using all the toothpicks and playdough. .	**ALT 1 - Safety** The students will perform several lab activities demonstrating the importance of safety when working with chemicals and machinery.	**ALT 1 – Bridge Strength and Levers** Students will explore the mathematics behind bridge strength and levers by collecting data, organizing it in a table, making graphs and equations, and answering questions
ALT 2 – Product Marketing The students will be given building materials. Students will then develop a product and make a flier and commercial to market the product.	**ALT 2 – Creating Energy** Students will perform a lab to demonstrate how energy can be created.	**ALT 2 – Determining Cost** Individually and in groups, students will explore the mathematics of determining how much a product should cost based on labor and material costs.
ALT 3 – Building Bridges Give the students simple building materials and challenge them to make a bridge spanning x feet that will hold as much weight as possible.	**ALT 3 – Potential/Kinetic Energy** The students will simulate a four-stroke engine to demonstrate potential and kinetic energy.	**ALT 3 – Linear Programming** In this lesson students will be challenged to solve a maximization problem using simple trial and error techniques. Students will then be shown how to use linear programming to solve such problems.

Transfer or Culminating Activity

In the transfer activity students will bid on a contract to build a bridge. All concepts taught in ALT's should be incorporated to support the bid. A written and oral bid will be completed by each group.

Business
ALT One: Toothpicks and playdough

Summary

Give students 6 toothpicks and a lump of playdough. Challenge them to make four triangles using all the toothpicks and playdough.

Competencies

1. Individual problem solving

Time

15 – 20 minutes

Materials

toothpicks
playdough

Instructions

1. Pass out 6 toothpicks and a lump of playdough to each student.
2. After all the students have the materials, then challenge them to construct four triangles using all the toothpicks and playdough.
3. Discuss with a few students their process of finding the solution.

Evaluation/Assessment of Student's Competency

1. Participation

Closure

Have a discussion about thinking outside the box to come up with a solution. Discuss general problem solving processes that will help with future lessons.

Business
ALT Two: Product Marketing

Summary

The students will be given building materials. Students will then develop a product and make a flier and commercial to market the product.

Competencies

1. TSWBAT work cooperatively with others.
2. TSWBAT understand basic marketing principles such as visual/auditory stimulation, product name repetition, emphasizing benefits, etc.

Time - one or two 50 minute class periods

Materials

Popsicle sticks	glue	milk Carton
Egg cartons	tape	paper plates/cups
Cereal/tissue box	toothpicks	etc. – use your imagination

Instructions

1. Give students building materials.
2. Develop a product using these materials. (15-20 minutes)
3. Make a flier to advertise your product. (10 minutes)
4. Make a 30 second commercial (television or radio) to market your product. (15-20 minutes)
5. Students will perform their commercial and show their flier to the class.
6. During the presentations, students will evaluate each other's commercials on a scale of 0-5.

Evaluation/Assessment of Student's Competency

Evaluation will be done using rubric scoring.

		Length (4)
Teamwork:	Flier:	Commercial:
Getting along (4)	Originality (4)	Originality (4)
Respect (4)	Attention getter (4)	Attention getter (4)
Participation (4)	Appropriateness (4)	Appropriateness (4)
Total (12)	Total (12)	Total (16)
Project total (40)		

Closure

Discussion: What makes a good product? What makes a commercial effective? Which group marketed their product the best and why?

Business
ALT Three: Building Bridges

Summary

Give the students simple building materials and challenge them to make a bridge spanning x feet that will hold as much weight as possible.

Competencies

1. Teamwork
2. Problem solving skills

Time

Two 50 minute class periods

Suggested materials

Cardboard	string (x feet)	toothpicks	glue
Two 5 lb. weights	tape (x feet)	popsicle sticks	etc.

Be sure that you set a specific amount of tape, glue, and string that are allowed to be used. You don't want these items to be determining factors as to why one group has a stronger bridge than another.

Instructions

1. As an introduction to bridges, discuss and show pictures of the four types of bridges – arch, beam, suspension, and cable-stayed. Use the following website if desired – it is a wonderful site! www.pbs.org/wgbh/nova/bridge/build.html. (15-20 minutes)
2. Pass out building materials to each group.
3. Challenge students to build a bridge – any type they want – spanning x feet that will hold as much weight as possible. (30-45 minutes)
4. Test bridges to see which one holds the most weight. (10-15 minutes)

Evaluation/Assessment of Student's Competency

Evaluation will be done using a rubric.
Bridge design (5)
Teamwork (5)
Amount of weight it held (5)
Group participation (5)
Length of bridge (5)
Total points (25)

Closure

Discussion: Why did you pick the type of bridge you chose? What core idea made the bridges strong? If you had to change something to make a better bridge the next time, what one thing would your group change and why?

Science
ALT One: Safety

Summary
The students will perform several lab activities demonstrating the importance of safety when working with chemicals and machinery.

Competencies
At the conclusion of this activity students will be able to:

1. work as a team
2. understand electrical conduction

Time
Approximately 30 minutes.

Materials

Teacher Demo
1. sulfuric acid
2. sugar
3. 250 ml beaker

Student Lab
1. orange juice
2. conductivity tester
3. 250ml beaker
4. ammonia cleaner

Instructions
Teacher Demo

Add sulfuric acid to sugar in a beaker. Sulfuric acid reacts with the hydrogen and oxygen in sugar, removing them as water and leaving only carbon.

Student Lab

1. ***CAREFULLY*** place the electrodes of a conductivity tester into a glass of orange juice.

QUESTIONS: Did the juice conduct electricity? What acids are present in orange juice?

CAUTION: DO NOT TASTE THE JUICE!!

2. Try the same conductivity procedure with ammonia cleaner.

QUESTIONS: Did this solution conduct electricity? What base is present in the cleaner? What are the most important ions formed in aqueous solutions of acids? of bases?

Evaluation/Assessment of Student's Competency
Student competency will be assessed and evaluated by answering questions pertaining to the lab(s) and by successfully completing the lab activity.

Closure
This activity will show the importance of knowing electrical conductors for safety purposes.

DO ACIDS AND BASES CONDUCT AN ELECTRICAL CURRENT?

Teacher Demonstration Lab

Watch as the teacher adds sulfuric acid to sugar in a beaker. The sulfuric acid will react with the hydrogen and oxygen in the sugar, removing them as water and leaving only carbon (in the form of a "snake" coming out of the beaker.

Student Lab

Materials:

orange juice
conductivity tester
250 ml beaker
ammonia cleaner

PROCEDURE #1:

1. CAREFULLY place the electrodes of a conductivity tester into a beaker with 100ml of orange juice (the amount of orange juice may be varied).

CAUTION: DO NOT TASTE THE ORANGE JUICE!!

QUESTIONS:

1. Did the orange juice conduct electricity?
2. What acids are present in the orange juice?

PROCEDURE # 2:

1. Try the same conductivity procedure with an ammonia cleaner.

QUESTIONS:

1. Did the ammonia solution conduct electricity?
2. What base is present in the ammonia cleaner?
3. What are the most important ions formed in aqueous solutions of acids?
4. What are the most important ions formed in aqueous solutions of bases?

Science
ALT Two: Creating Energy

Summary
Students will perform a lab to demonstrate how energy can be created.

Competencies
At the conclusion of this activity students will be able to:

1. work as a team
2. understand how/why energy can be created

Time
Approximately 15-25 minutes.

Materials
1. sand
2. styrofoam cup
3. cup lid
4. thermometer
5. stop watch

Instructions
1. Pour sand into a Styrofoam cup until the cup is about half full.
2. Measure the temperature of the sand to the nearest tenth of a degree.
3. Remove the thermometer and place a lid on the cup.
4. While holding the lid firmly in place, shake the cup vigorously for several minutes.
5. Stop shaking, remove lid, and measure the temperature of the sand immediately.

Evaluation/Assessment of Student's Competency
Students will be assessed and evaluated by answering questions pertaining to the lab and by successfully completing the lab activity.

Closure

This activity will demonstrate how easy it is to create energy. Another lab measuring power will now be done.

CAN YOU "CREATE" ENERGY?

MATERIALS

1. sand
2. styrofoam cup
3. styrofoam cup lid
4. thermometer
5. stop watch

PROCEDURES

1. Pour sand into a Styrofoam cup until it is about half full.
2. Measure the temperature of the sand to the nearest tenth of a degree.
3. Remove the thermometer and place a lid on the cup.
4. While holding the lid firmly in place, shake the cup vigorously for several minutes.
5. Stop shaking, remove the lid, and measure the temperature of the sand immediately.

QUESTIONS

1. What effect did the shaking have on the temperature of the sand?
2. Was energy "created", yes or no? Explain?

Science

ALT Three: The Four Stroke Engine – When does Potential Energy Change To Kinetic Energy?

Summary
The students will simulate a four-stroke engine to demonstrate potential and kinetic energy.

Competencies
At the conclusion of this activity students will have a better understanding of the concept of potential and kinetic energy.

Time
Approximately 30 minutes

MATERIALS:
1. matches
2. 250ml flask
3. glass or plastic "T"
4. 2-pinch clamps
5. large plastic syringe
6. 3 pieces of rubber tubing
7. small piece of yarn or cloth
8. one-2 hole rubber stopper with glass tubing

INSTRUCTIONS:
1. Set up a model four-stroke engine
2. Prepare a data table showing number of steps, stroke number, and observations. As you complete each step, identify the stroke and record your observations.
3. Ignite a small piece of cloth or yarn and drop it in the flask. **CAUTION: EXERCISE CAUTION WHEN USING OPEN FLAMES!** Allow the flask, representing the carburetor, to fill with smoke.
4. With the piston inside the cylinder, open the intake valve and pull the piston down.
5. Close the intake valve and push the piston up into the cylinder.
6. Release the piston and observe what happens.
7. Open the exhaust valve and push the piston up into the cylinder.
8. Close the exhaust valve and repeat steps 4-7.

Evaluation/Assessment of Student's Competency
Student competency will be assessed and evaluated by answering questions pertaining to the lab and by successfully completing the lab activity.

Closure
After completing this activity students will do another lab pertaining to fuel efficiency.

THE FOUR STROKE ENGINE - WHEN DOES POTENTIAL ENERGY CHANGE TO KINETIC ENERGY?

MATERIALS:

1. matches
2. 250ml flask
3. glass or plastic "T"
4. 2-pinch clamps
5. large plastic syringe
6. 3 pieces of rubber tubing
7. small piece of yarn or cloth
8. one-2 hole rubber stopper with glass tubing

PROCEDURES:

1. Set up a model four-stroke engine
2. Prepare a data table showing number of steps, stroke number, and observations. As you complete each step, identify the stroke and record your observations.
3. Ignite a small piece of cloth or yarn and drop it in the flask. **CAUTION: EXERCISE CAUTION WHEN USING OPEN FLAMES!** Allow the flask, representing the carburetor, to fill with smoke.
4. With the piston inside the cylinder, open the intake valve and pull the piston down.
5. Close the intake valve and push the piston up into the cylinder.
6. Release the piston and observe what happens.
7. Open the exhaust valve and push the piston up into the cylinder.
8. Close the exhaust valve and repeat steps 4-7.

ANALYZE

1. During which stroke are the smoke particles most likely separated?
2. What happens to the smoke particles when the intake valve is closed and the piston moves into the cylinder?
3. What happens when the piston is released?
4. What happens to the smoke particles when the exhaust valve is opened and the piston moves into the cylinder?
5. During what strokes are both valves closed?

CONCLUSION AND APPLICATIONS

1. In this model, what does the smoke represent in steps 4 and 5? In step 7?
2. When would be the best instant to explode a fuel-air mixture?
3. In which stroke is kinetic energy changed to potential energy? Potential to kinetic?

Mathematics

ALT One: Bridge Strength and Lever Mathematics

Summary
Students will explore the mathematics behind bridge strength and levers by collecting data, organizing it in a table, making graphs and equations, and answering questions. *Engineering Disasters*, a History Channel video would make an excellent introduction to this unit.

Competencies
At the end of this lesson the students will be able to:
1. Accurately collect experimental data
2. Identify a linear and nonlinear relationship using tables, graphs, and equations
3. Answer problem solving questions about the data and results

Time
Each of the four sections should take one 50-minute class period.

Materials
Paper bridges (11x4, 10x4, …, 4x4 inches)
Coin weights or washers
Small paper/plastic cups
Meter stick
Triangular prisms (fulcrum)

Instructions
1. Demonstrate the data collection activity
2. Distribute materials and group students to complete the activity

Evaluation/Assessment of Student's Competency
Students should be evaluated on their ability to work together collecting data and completing the questions. Worksheets may be graded for correctness or effort.

Closure
Determining the quality of a product or service is essential to any business. Data may be collected and analyzed to determine the quality of such service or product, particularly in manufacturing or construction where high quality is needed for safety. In the transfer activity students will be asked to show data supporting the quality of their bridge.

Bridge 1: Thickness and Breaking Weight

Make a paper bridge by folding up one inch sides of an 11x4 inch piece of paper. Suspend one paper bridge between two books. Add weights to a small cup in the middle of the bridge until it collapses. Record the number of weights it took to break the bridge in the table below. Repeat this process with bridges 2,3,4, and 5 layers thick.

Layers	0	1	2	3	4	5
Breaking Weight						

1. Use the space below graph the data from the table above.

2. Describe patterns in the table and graph of your data. (Be specific)

3. Use the table and / or graph to estimate an equation relating these two variables.

4. What type of relation / function is this?

5. How is this type of function identified by its:

   a. Table

   b. Graph

   c. Equation

6. What have you learned about bridge thickness from this activity? How does this information impact the type of bridge one may choose to construct?

Bridge 2: Length and Breaking Weight

Make a paper bridge by folding up one inch sides of an 11x4 inch piece of paper. Suspend the bridge between two books. Add weights to a small cup in the middle of the bridge until it collapses. Record the number of weights it took to break the bridge in the table below. Repeat using bridges 10,9,8,7,6,5, and 4 inches long.

Length	4	5	6	7	8	9	10	11
Breaking Weight								

1. Use the space below graph the data from the table above.

2. Describe patterns in the table and graph of your data. (Be specific)

3. Use the table and / or graph to estimate an equation relating these two variables.

4. What type of relation / function is this?

5. How is this type of function identified by its:

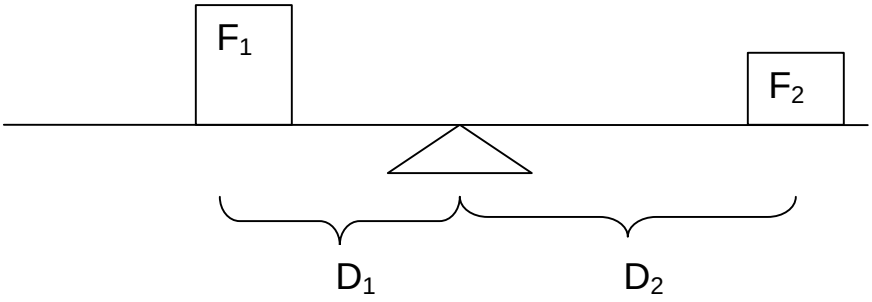
   a. Table

   b. Graph

   c. Equation

6. What have you learned about bridge length from this activity? How does this information impact the type of bridge one may choose to construct?

Lever 1: Hold F_1 and D_1 Constant



Balance a meter stick on a fulcrum. Place 5 weights (F_1) 12 cm (D_1) from the fulcrum. Find the distance (D_2) one weight (F_2) must be to balance the lever. (This distance may be greater than 50cm.) Record the balancing distance for each weight in the table below.

F_2	1	2	3	4	
D_2					

1. Use the space below to graph the data from your table above.

2. Describe the patterns in the table and graph of your data. (Be specific.)

3. Use the table and/or graph to estimate an equation relating these two variables.

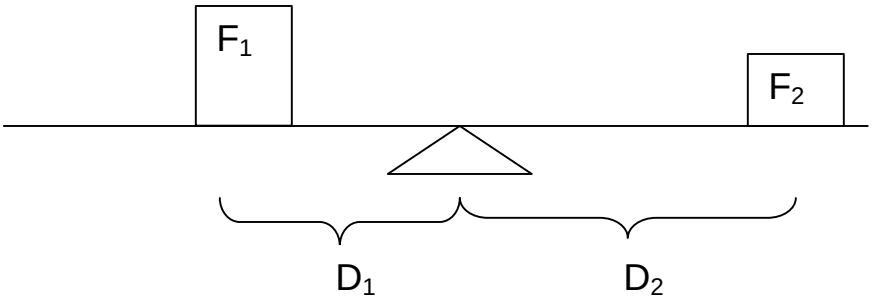
4. Repeat the experiment using $F_1 = 3$ and $D_1 = 20$. Make a table, graph, and an equation of your results. (Predict the results you may observe prior to conducting the experiment.)

5. What equation would approximate the data collected in an experiment for $F_1 = 6$ and $D_1 = 8$? (If you are not sure, repeat the experiment.)

6. What type of relation/function is this? How did you identify it?

7. What have you learned about levers from this activity? What connections do you see between this activity and the bridge activity?

Lever 2: Hold F_1 and F_2 constant



Balance a meter stick on a fulcrum. Place one weight (F_1) 5cm (D_1) from the fulcrum. Find the distance (D_2) 5 weights (F_2) must be from the fulcrum to balance the lever. Repeat this experiment moving the one weight (F_1) out to distances 10, 15, 20, 25, 30, 35, 40, 45, and 50cm from the fulcrum.

D_1	5	10	15	20	25	30	35	40	45	50
D_2										

1. Use the space below to graph the data from your table above.

2. Describe the patterns in the table and graph of your data. (Be specific)

3. Use the table and/or graph to estimate an equation relating these two variables.

4. Repeat the experiment using $F_1 = 1$ and $F_2 = 2$. Make a table, graph, and equation of your results. (Predict the results you may observe prior to conducting the experiment.)

5. What equation would approximate the data collected in an experiment for $F_1 = 2$ and $F_2 = 5$? (If you are not sure, repeat the experiment.)

6. What type of relation/function is this? How did you identify it?

7. What have you learned about levers from this activity? What connections do you see between this activity and the bridge activity?

Mathematics

ALT Two: Determining Cost

Summary
Individually and in groups, students will explore the mathematics of determining how much a product should cost based on labor and material costs.

Competencies
At the end of this lesson the students will be able to:
1. Work cooperatively with others to solve an open-ended problem
2. Graph a table of linear data and determine the equation of the relation
3. Extrapolate data in problem-solving
4. Explain the significance of x- and y-intercepts and points of intersection in the context of an application

Time
Two 50-minute class periods.

Materials
1. Building materials for the product.
2. Three worksheets and assessment rubric for part one

Instructions
1. Make a generic product out of recycled materials: tissue box, straws, toilet paper / paper towel rolls, tape, string, buttons, etc… Name this product
2. Put students in groups of 3 or 4
3. Give each person the first worksheet, "How Much Should You Charge". A name for the product and a list of materials with prices will need to be added.
4. Show them the grade rubric and explain how they will be assessed
5. When students complete the first activity they should begin the second worksheet, "Relating Units and Money", individually
6. Summarize the group activity
7. Explain and answer question on the second "Relating Units and Money" and third "Relating Hours of Operation and Money" worksheets
8. Students complete individually
9. Summarize, sharing student work and emphasizing big ideas

Evaluation/Assessment of Student's Competency
On the first activity students will be assessed using the rubric provided. On the second and third parts, the students' work may be evaluated for correctness or effort.

Closure
When running a business of any kind it is important to determine a fair and profitable price of the product or service. This lesson points out some of the skills needed for this. Students will be asked to do some type of cost analysis on their transfer activity.

How Much Should You Charge?

Product: (insert clever/humorous name)
Labor = Minimum Wage
Manager = Double Minimum Wage
Owner = Set your own wage/salary
Parts: (insert a list of costs per part)

You are going to mass produce this product using as many or as few laborers and managers as you'd like. A manager can supervise at most 10 laborers.

1. Calculate how much you will charge. You will need to account for salaries, materials, rate of production, and amount of desired profit. Keep in mind that overpricing your product will affect sales.
2. What is your % profit on each unit sold?
3. How many units must you sell to break even each week?

Assessment Rubric: How Much Should You Charge?

1. Salaries accounted for (5) _____
2. Materials cost accounted for (5) _____
3. Units per hour (5) _____
4. Total manufacturing cost per unit (5) _____
5. Total manufacturing cost per unit plus profit per unit (5) _____
6. Percent profit (5) _____
7. Number of units sold to break even (5) _____
8. Teamwork (5) _____
9. Organization (10) _____

Total (50) = _____

Relating Units and Money

1. We have 20 laborers, 2 managers and your salary to account for. If you pay yourself $1,000 a week, then our labor cost per week are constant. Our materials cost vary based on how many units can be produced an hour. Using the same materials cost in the previous activity, make a table showing our total manufacturing cost per hour for making 0-10 units per hour.

Units	0	1	2	3	4	5	6	7	8	9	10
Manufacturing Cost/Hr											
Average price/unit											

2. Make a graph and equation of this data. Units are the independent variable and the manufacturing cost per hour is the dependent variable.

3. Using the retail price of M dollars per unit, make a table, graph, and equation relating the number of units sold to the gross profit for 0-10 units.

Units	0	1	2	3	4	5	6	7	8	9	10
Gross Profit											

4. Make a table, graph and equation for 1-10 units showing the net profit.

Units	1	2	3	4	5	6	7	8	9	10
Net Profit										

5. How many units must be sold for us to break even each hour? … to make $100 an hour? Where do we see these numbers in the tables, graphs and equations above?

Relating Hours of Operation and Money

1. Once things begin to run smoothly, our factory is able to produce 7 units per hour. Make a table, graph, and equation giving our cost per hours of operation. Complete the table. When calculating profit, assume that all units produced are sold.

Hours	1	2	3	4	5	6	7	8
Cost/Hr								
Gross Profit/Hr								
Net Profit/Hr								

2. Make a graph of these three relationships in the same plane. Hours will be your independent variable, and Cost/Hr, Gross Profit/Hr and Net Profit/Hr will be your three dependent variables.

3. Find the three equations that show each relationship.

4. How many units must be sold for us to break even each hour? … to make $100 an hour? Where do we see these numbers in the tables, graphs and equations above?

Mathematics

ALT Three: Linear Programming

Summary

In this lesson students will be challenged to solve a maximization problem using simple trial and error techniques. Students will then be shown how to use linear programming to solve such problems.

Competencies

At the end of this lesson the students will be able to:

1. Problem-solve in groups
2. Solve maximization problems using linear programming

Time

One 50-minute class period.

Materials

Linear programming worksheets (The first one may simply be shown on a transparency)

Instructions

1. Put students in groups of 2 or 3
2. Challenge them to solve the first maximization problem (Give them plenty of time!)
3. Once all groups have an answer, share solution strategies
4. Solve the problem using linear programming
5. Have students complete the remaining problems individually

Evaluation/Assessment of Student's Competency

Students should be evaluated on how well the worked as a group to solve the first problem regardless of the accuracy of their solution. The remaining problems should be graded for correctness.

Closure

Summarize this lesson by discussing the applications of linear programming in running a business. Develop an example with many variables to point out the disadvantages of their original solution processes. Their ability to develop an example for their transfer activity will be important for winning the contract.

Linear Programming: Challenge Problem

1. A small company has five 3-ton trucks and four 5-ton trucks for hauling gravel. Only 7 crews are available at any one time to operate the trucks. How many of each kind of truck should be used to haul the maximum amount of gravel per trip?

Linear Programming: Practice

1. A manufacturer makes two models of bicycle. The profit on Model A is $15 per bicycle and the profit on Model B is $18 per bicycle. Because of a labor shortage, the manufacturer can produce no more than 200 bicycles per week. To meet the market demand, at least 50 Model A and 80 Model B bicycles must be available each week.
    a. Let x represent the number of Model A bicycles and let y represent the number of Model B bicycles produced per week. Write an expression to represent the total weekly profit.
    b. Write a system of inequalities that show the constraints on x and y.
    c. Graph the system of inequalities you wrote in part b.
    d. State the coordinates of the vertices of the polygonal region graphed in part c.
    e. What is the maximum possible profit?

2. The manager of a small toy shop decides to make up two types of variety packages in order to sell off 12 whistles and 32 small cars left in the shop. Each type A package contains 2 whistles and 8 small cars and sells for $6.50. Each type of B package contains 3 whistles and 5 small cars sells for $5.75.
    a. Let x represent the number of type A packages and let y represent the number of type B packages. Write an expression to represent the store's income from the sale of these packages.
    b. Write a system of inequalities to show the constraints on x and y.
    c. Graph the system of inequalities from part b.
    d. State the coordinates of the vertices of the region graphed in part c.
    e. What is the store's maximum possible income from the sale of packages?

Transfer Activity

Summary

In the transfer activity students will bid on a contract to build a bridge. All concepts taught in ALT's should be incorporated to support the bid. A written and oral bid will be completed by each group.

Competencies

At the end of this lesson the students will be able to:

1. Problem-solve in groups
2. See competencies of previous lessons

Time

Two or three class periods

Materials

Transfer activity worksheet and rubric

Instructions

1. Put students in groups of 3 or 4
2. Distribute instruction sheet and rubric
3. Explain the activity and method of assessment
4. Students should spend at least one or two classes preparing their bid
5. Collect written bids prior to presentations

Evaluation/Assessment of Student's Competency

Students will be assessed on how well they worked with others as well as the quality of work. A rubric will be used for assessing their written and oral presentations. Each person in a group should receive the same grade.

Closure

Conclude by discussing how each previous activity contributed to them being able to create a quality presentation. The group with the most detail supporting quality work in constructing the bridge should get the contract regardless of cost. Award this group with a special prize.

Transfer Activity: Bridge Bid

I need a bridge built in 45 minutes that is 3.5 feet off the ground, 6 feet long and 4 feet wide that will hold 8 textbooks. Your group will bid for the job. Use any or all of the mathematics, science, and business concepts we have discussed recently to support your bid.

The contract will be given to the group who not only has a good price, but convinces me that they will do a quality job in the given time. You must pay yourself an appropriate salary/wage, and your company must make at least 15% profit on the job.

Your group will turn in a written bid for the job showing all of your calculations. The specific items I will be looking for are included in the rubric. Also, you will give a formal presentation bid for the job that should last between 3 to 5 minutes.

Labor costs: Construction workers = $0.75 a minute
Foremen = $2.25 a minute
Owner's Salary = ?

Material costs: 5x3 ft cardboard = $5.00
Paper towel roles = $1.25
String = $0.82 per foot
Tape = $0.63 per foot
5lb weight = $3.10
Scissors Rental = $0.12 per minute