John Troutman Southern Durham High School

**TOPIC:** International Cribs

**NCTM STANDARDS:** Algebra, Represent and analyze mathematical situations using, algebraic symbols, Use mathematical models to represent and understand quantitative relationships, Geometry, Problems Solving, Connections, Communication, Representation

**GOALS:**

Students will use the quadratic relationship between a one-dimensional measurement of a traditional housing structure or famous building and its area to construct mathematical statements. The will use these statements to analyze whether the shape they study hold more or less area than a rectangle.

**INTRODUCTION:**

Ever wondered why so many people today spend most of their time in rectangular rooms? Is this the only shape that people can use to build? Throughout human evolution people have slept, worked, learned, worshipped, and lived in many differently shaped buildings. In this project you will explore one of those shapes, using your research skills and knowledge of quadratics to discover some information about the area of these structures.

**ACTIVITIES:**

- Part 1. Research. Using links, students research a traditional housing style or architectural structure. After selecting a shape that they would like to use, they follow another set of links to determine a formula for the area and perimeter of this shape.
- Part 2. Determining Dimensions. Once they have determined an area formula for the shape they will be studying, students will be given a desired area and asked to use the formula to determine the length of one or more of the dimensions of this shape. Using the dimension(s) they solved for they will calculate the perimeter of the shape with a fixed area.
- Part 3. Compare. Students will determine the maximum area for a rectangular building of the same perimeter. They will compare the amount of area this shape encloses to the amount enclosed by the shape they studied and write a proposal to a planning committee about which shape to use for a new room at their school.

**ASSESSMENT:** Students will create a poster that includes all their work along with a picture of the housing structure they studied and the letter they wrote to the planning committee. See grading rubric for more details regarding assessment.

## Part 1. Research.

Using the first page of the companion project hand out (attached) and the following links students will research international architectural structures and the formulas used to calculate the area of those shapes.
Some helpful websites are linked at the page on the top of the students' handout. If the link does not work use the list below to give students a variety of options of structures.

**Africa**
Somalia: **http://www.rit.edu/~africa/somali/somaliAqalPg1.shtml**
Pyramids **http://www.ancientegypt.co.uk/pyramids/home.html**
Maasai **http://maasai-association.org/**
Xhosa **http://www.safari.co.za/africa_xhosa.html**
Kwamsiza **http://www.sahistory.org.za/pages/specialprojects/kwamsiza/menu.html**

**Asia**
Middle East: **http://en.wikipedia.org/wiki/Islamic_architecture**
Saudi Arabia **http://www.arab.net/saudi/sa_tents.htm**
Mongolia **http://www.chaingang.org/yurtquest/FAQ.html**
Mongolia **http://depts.washington.edu/uwch/silkroad/culture/dwellings/dwellings.html**
Japan **http://www.tjf.or.jp/eng/ge/ge02kutsu.htm**
Japan **http://www.sg.emb-japan.go.jp/JapanAccess/kenchiku.htm**
Kazakhstan **http://intangiblenet.freenet.uz/en/kaz/kaz312.htm**
India **http://www.geocities.com/prashant_iitr/INDEX/pprs/trblar.htm**
China**: http://en.wikipedia.org/wiki/Chinese_architecture**

**Americas**
American Indian **http://www.tipis-tepees-teepees.com/**
American Indian **http://www.kstrom.net/isk/maps/houses/housingmap.html**
Native Americans **http://www.kstrom.net/isk/maps/houses/housingmap.html**
Puerto Rico **http://www.elboricua.com/history.html**
Hopi **http://www.hopi.nsn.us/view_article.asp?id=17&cat=1**
Inuit **http://www.canadianencyclopedia.ca/index.cfm?PgNm=TCE&Params=A1SEC822108**

## Europe

Germany **http://www.germanculture.com.ua/library/weekly/german_castles.htm**
England **http://www.royal.gov.uk/output/page563.asp**
France **http://www.chateauversailles.fr/en/**
Rome **http://www.roman-empire.net/society/soc-house.html**
Norway **http://www.olavsrosa.no/en/redaksjonelt.aspx?id=145997**

Math Links (include formulas for most of the shapes):
http://www.math.com/tables/geometry/areas.htm

http://math.about.com/library/blmeasurement.htm

**Part 2. Determining Dimension.**

Once students have chosen and shape and researched its area formula, they can complete page 1 of the student handout, which asks them to determine dimensions and perimeter for their shape that will give them a specified area.

**Part 3. Compare.**

Students will then use the perimeter that they just calculated to make a comparison between their shape and a shape that is more commonly used in our culture-the rectangle. Their work in making this comparison will be guided by the instructions on page 2 of the student handout. They might find it helpful to construct a chart similar to the one below to make the information they now have clear.

| Shape | Student's shape: the one she/he researched | 3 sided rectangle (the other proposal for the arcade) |
|---|---|---|
| Area | 500 (given) | Y (calculated) |
| Perimeter | X (calculated)` | X (from part I) |
| Dimensions | Radius, side length, etc. (calculated) | Length, width (calculated) |

**Part 4. Assessment.**

See attached rubric.

**TEACHER NOTES/SOLUTIONS**

Part 1. The hardest thing for students to understand was that they were looking for the ground area, so all that mattered about the shape was its base. It will be helpful to emphasize this in pre-research instructions. Also, encourage students to use shapes that may not have an easy area function. While students who choose these shapes may need some additional help to find dimensions, it makes the project more interesting and student products more diverse. Instructors may have to fix some dimensions for some students so that they can perform calculations.

Part 2. Each student should plug 500 into their area formula for the A. Solving this equation for each shape will yield different answers. Make sure that students know to write out all their work and clearly label their answers.

Part 3. Finding the area of the 3 sided rectangle is a maximization problem. Students will create a quadratic function $f(x) = x(P - 2x)$ which gives the area of the rectangle as a function of $x$, its the width (the side that there are 2 of). $P$ is the perimeter of the shape (for which they will plug in the value for perimeter that they found in part 1. To find the maximum of area, students will calculate the maximum point of this function (most easily done with a graphing calculator) and take the Y coordinate. This area will almost always be greater, by virtue of the fact that this particular rectangle only requires them to use the fixed perimeter to cover 3 sides. Students' letter to the planning committee should reflect some knowledge of the fact that one shape creates more area given the same amount of building material; however, students should not limit themselves to a purely economic argument. It may be that aesthetics or other factors play a role in their decision leading them to recommend the shape which encloses a smaller area. As long as students explain their reasoning they should be encouraged to make a decision based on whatever factors are most important to them.

Part 4.

## Grading Rubric

After completing this project, all students will present their research, mathematical calculations, and conclusions on a poster. The poster should include **all of the components below**. Grades for the project will be assigned based on **the work students show on their poster only**.

Each poster should include:

- a picture of their architectural structure
- a map highlighting the region where their structure is found
- both pages of student handouts
- all mathematical computations
- the memo they wrote for part 2 of the assignment

**Student Name: _____**

**Research on architectural structure** (20 points total)

- Choose an appropriate structure from the correct continent (4 points)
- Correctly identify the shape of the structure (2 points)
- Find the correct area formula for this structure (2 points)
- Include important information about the structure's unique characteristics (6 points)
- Include a map of the continent highlighting where the structure is most frequently found (4 points)
- Include a picture of the structure (2 points)

**Mathematical computations in part 1** (30 points total)

- Set up an equation to give the dimensions of a model with a 500 $ft^2$ area (12 points)
- Correctly solve the equation and identify dimensions that would give this area (10 points)
- Correctly determine the perimeter of a figure with that area (8 points)

**Mathematical computations in part 2** (30 points total)

- Set up an equation to find the area of the given rectangle with a fixed perimeter (12 points)
- Includes a sketch of the quadratic curve that of this equation with the max point labeled (8 points)
- Correctly identify the maximum area of the rectangular room (10 points)

**Concluding memo** (20 points total)

- Correctly describes the differences in the two shapes (6 points)
- Correctly identifies the shape which encloses the larger area (6 points)
- Thoroughly explains recommendation to the committee (8 points)

Student's total grade: _____

Name: _____

# Algebra 2 Project

## International Cribs

Visit http://www.wfu.edu/~trouj5/quadraticproject.html and follow the directions on the page to conduct research on an architectural structure in your grade level's continent.

**Part 1:** Once you have selected a structure for your project and found a formula for determining its area you are ready to complete this project. Follow these steps to discover more about the structure you've chosen.

**Step 1**: The structure you researched:

_____

Its shape: _____

Area formula for this shape: _____

What are some unique characteristics about this structure? Include information on where it is found, the people who live, work, or worship there, and the types of materials typically used to build it.

_____

_____

**Step 2:** Suppose you were told that you needed to create a model of your structure that could enclose 500 $ft^2$ (approximately the size of a high school classroom). What are some dimensions of your structure that would enclose this area? Show your **all work neatly** on a separate page (hint: use the area formula you wrote in step 1).

Dimensions= _____

**Step 3**: What would the perimeter of your model be if it had these dimensions

P= _____

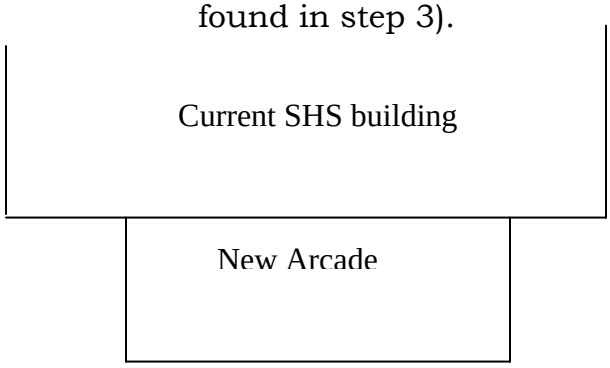
Name: _____

# Algebra 2 Grade Level Project:
# International Cribs

**Part 2:** Once you've chosen a structure and calculated some information about its area, consider the following situation at Southern. Use the numbers you discovered above and your knowledge of quadratic equations to answer the following questions and make a recommendation to the planning committee.

Parkland students have decided to build an arcade on the side of the school. Students have suggested two plans for the design of the new arcade.

- **Plan 1**: Build the arcade in the shape of the model you have described above (with the same area, side length, and perimeter).
- **Plan 2**: Build a rectangular arcade using the existing school building as one side (see picture below). The other three sides would have the same perimeter as your model (the number you found in step 3).




Use a graphing calculator to determine the **maximum area** you could enclose with the rectangle in plan 2. Show your work on a separate page. Include a sketch of the quadratic curve you used to answer the question.

Max Area= _____

**Step 5**: Compare the maximum area you calculated in Step 4 to the area of the shape you analyzed in steps 1-3 (area=500 $ft^2$). Which plan allows for the arcade with the largest area?

On a separate sheet of paper, write a memo to the arcade planning committee about which plan they should use when building the arcade. Include all the following information:

- How the two shapes are different
- Which shape encloses the largest arcade
- A recommendation for which plan to use