

# Rhinoceros<sup>®</sup>

NURBS modeling for Windows

Curriculum and Instructor's Guide

Rhino Curriculum Guide v4.doc

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**Note: This document (Rhino Curriculum Guide v4.doc) is on the CD that was included with this curriculum guide. Edit the document to meet your specific course requirements.**

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## Table of contents

<b>Curriculum Guide .....</b>	<b>1</b>
<b>Design Activities Process .....</b>	<b>4</b>
Ideas for Design Assignments .....	5
<b>Sample Design Activities .....</b>	<b>6</b>
<b>Sample Fifteen-Week Syllabus .....</b>	<b>22</b>
<b>Sample Week-by-Week Lesson Plans .....</b>	<b>25</b>
Worksheets .....	27
<b>Tests .....</b>	<b>34</b>
<b>Sample 10 Week Syllabus for Industrial Design CAD Skills Course .....</b>	<b>45</b>
<b>Teacher Contributions .....</b>	<b>47</b>
Problem Solving .....	48
"Fun with Blocks" activity .....	49
Reverse Engineer a mechanical device .....	50
Building a Pi Tape .....	51
Building a Protractor using the laser cutter .....	52
Room Design Project: .....	53
Containers and Textures .....	55
Trim or Split a Surface .....	56
The Design Process .....	57
3D Printer Assignment .....	60
Business Logo Design .....	61
Car Rack Accessories .....	62
Design Engineering Advanced .....	63
Program Offering for Concept Development and Design .....	64
CONTAINER DESIGN (2 WEEKS) .....	65
Mechanical Mechanism Project .....	66
Educational Toy Design .....	67
Game Design .....	68
Tool Design (2 WEEKS) .....	69
Key Chain .....	70
Kitchen Tool Design (2 WEEKS) .....	71
Lego Project .....	72
Multiple Function Assignment .....	73
Replication brief: Model an Existing Product or Mechanical Device .....	74
Mechanical Device Replication Ideas .....	75
Materials Science Project - Metallic Unit .....	76
Poster Design Project .....	77
Strategy Game Design .....	78
Finished Student Project Presentations .....	79
Wayland Marine Boat Seat Prototype .....	86
Reverse Engineer A Steam Engine .....	87
Unique Flashlight Design .....	88
Spy Specs Example .....	89
The High Tech Flashlight Example .....	90
The Gemini Flashlight Example .....	91
Dinnerware Project .....	93
Dinnerware Project .....	94

## Curriculum Guide

This guide provides curriculum ideas and other helpful suggestions for computer graphics, drafting, design, engineering, manufacturing, and art instructors who want to incorporate Rhinoceros® NURBS modeling for Windows into their program. The guide includes curriculum ideas as well as a complete sample 15 week and 10 week syllabus. Use as much or as little from this guide as you need, or modify it to fit your particular needs. This guide gives you a starting point for teaching 3-D modeling. If you choose to customize the guide, the original document in Microsoft Word format, is included on the enclosed CD.

Rhino can be used in almost any curriculum that teaches 2-D layout or 3-D modeling. This guide uses design/problem solving activities as well as step-by-step instruction to teach NURBS modeling.

Rhino is a powerful design and visualization tool you can use with most computers running Windows. Use it to create designs and 3-D images that would be difficult to make or take a very long time with other CAD or drawing programs. Rhino lets students create models quickly without having to go through weeks of instruction before they can make something that is precise and looks realistic. Many students can create simple models in less than ten minutes after some demonstration and instruction.

Students can continue beyond modeling. Once a model is completed in Rhino, it can then be used with other applications to further enhance a project. For example, students can create a model and export the file to a CNC machine for prototyping or manufacturing or render the model and use it on Web pages, newsletters, and presentations. Using Rhino plug-ins, like Flamingo, Penguin, and Bongo, the student can render, illustrate, and animate the model. In addition, models can be exported to most other design, rendering and animation software applications.

The biggest decision to make is your approach to teaching Rhino. We will discuss two approaches in this document: *technical proficiency* and *technical adequacy*.

### Technical Proficiency

Technical proficiency is learning NURBS modeling as a subject using Rhino. It requires a structured approach to learning. Each command and technique is presented and practiced on a daily basis. The following sample schedule is based on using the *Rhino Level 1 Training Manual* as a textbook. Students will become familiar with most of the commands available in Rhino before they begin their design projects. The sample schedule can be modified to take from four to six weeks to cover the basics of Rhino.

This approach allows for mastery of the program with fewer projects. While this approach requires more structured class time to learn the software, they will have a broad range of skills in which to complete any project.

Customizing Rhino workspaces and toolbars is not recommended for classes with multiple sections using the same lab. Skip Part Four of the *Level 1 Training Manual*.

### Sample Schedule

Week	Subject	Training Guide Section
1	Rhino basics, create two-dimensional objects, simple editing commands	Chapter 2 & 3
2	Precision modeling	Chapter 4
3	Editing	Chapter 5 & 6
4	Solids modeling, surface modeling	Chapter 7, 8, & 9
5	Importing and exporting, dimensioning, printing, rendering	Chapter 10, 11, 12 & 13
6–18	Projects (See Sample Activities)	

## Technical Adequacy

Technical adequacy is using Rhino as a tool. It requires students to learn only those commands that will help them finish a project. Only the most frequently used commands and techniques will be presented. Other commands will be learned as needed ("just-in-time" learning).

With this approach, students will be involved in more projects and will learn how to model in Rhino through problem solving activities.

The following sample schedule represents the most common commands used to make most of the objects students will want to model. There are advanced tools that will let them get greater precision and accuracy with their design, but these can be left for later.

Demonstrating a command can take as little as five minutes. The total time used to teach Rhino can be as little as two and a half weeks or as long as a quarter. Once students see how it works, they can practice and create designs with each new tool. It is important that students not only create designs that are assigned to them, but also be allowed to make their own.

## Sample Schedule

This guide breaks down the basic Rhino commands into several main areas. Each area contains step-by-step instruction and design activities that help reinforce previously learned commands. The purpose is to get students to draw real-world objects quickly. Notice that this approach lets you introduce students to a wide variety of commands in the first two weeks and gets them started with modeling very quickly. With this method, you should use the *Rhino Level 1 Training Manual* as a reference.

The **Rhino User Guide** is complete with tutorial models that build on the introductory tutorials below.

For example, you might want your students to create the surface model flashlight, from the User Guide, right after they create the flashlight model with solids in week 2.

Week	Operation	Commands	Activity/Project
1	The instructions are in Help>Learn Rhino>Getting Started. Start with the Introduction.		
	Basic interface	Command line, changing viewports, Zoom, and Pan Selecting objects	Use the <b>Start.3dm</b> in the tutorials folder.  <b>Select Objects.3dm</b> (tutorials folder)
	Basic editing	Moving by dragging Copying objects, undoing a mistake Move objects vertically Rotate and Scale objects Mirror objects	<b>Drag Objects.3dm</b> (tutorials folder) <b>Copy Objects.3dm</b> (tutorials folder) <b>Elevator Mode.3dm</b> (tutorials folder) <b>Rotate-Scale.3dm</b> (tutorials folder) <b>Mirror.3dm</b> and <b>Change.3dm</b> (tutorials folder)
	Solid primitives	Sphere, Cone, Box,	Start a new model. Use the <b>SmallObjects - centimeters.3dm</b> in the tutorials folder.
	Creating curves and surfaces.	Line, Curve, Arc, Trim, Join, and Revolve	Then use the following models to learn about surfacing.  <b>EdgeSrf.3dm</b> , <b>Extrude.3dm</b> , <b>Revolve.3dm</b> , <b>BlendSrf.3dm</b> , <b>Loft.3dm</b> , <b>Sweep1.3dm</b> , <b>Sweep2.3dm</b> , <b>RailRevolve.3dm</b> , <b>OffsetSrf.3dm</b>
2	Next, in Help>Learn Rhino>Getting Started, begin the Build a model with solids tutorial.		
	Solid modeling and Boolean operations	Cylinder, Sphere, Union, Difference, Intersection	Make a flashlight.
	Rendering	Properties, Spotlight, Render	Create light and shadows on previous design activity and all future design activity.
2	Making extruded surfaces	Circle, Ellipse, ExtrudeCrv  Rectangle, Rounded Rectangle	2-D text of personal name, a product, a slogan, or slang.  Create various 2-D surfaces (cookie cutter shape). Extrude them both straight and along a curve. Extrude 2-D text from previous activity.
3	Practice	Commands from week 1 and 2	Desk lamp, Christmas bell, ink pen, pool table,

Week	Operation	Commands	Activity/Project
			screwdriver, flowerpot, coffee mug.
	Advanced editing tools	Fillet, Cap Planar Holes, Array	Floppy disk, Zip disk, computer monitor, calculator.
4	Sweeping surfaces	Sweep 1 Rail, Sweep 2 Rail Sweep to a point option	Pipes and tubes with various diameters along a path. Animal tail, octopus, banana, headphones, stapler.
	Lofted surfaces	Loft, Dir, and Flip commands	Boat hull, canoe, airplane wing, game pad/joystick, skateboard, telephone.
5	Next, in Help>Learn Rhino>Getting Started, begin the Create a Rubber Duck tutorial.		
	Making squishy surfaces	Control point editing	Rubber ducky, food, other organic shapes.
6	Design activities	All of the previous commands and new commands as needed	Projects. (See Sample Activities section)

## Sample Course Outline

### Course Overview

This course introduces students to the features and functionality of Rhinoceros, a NURBS modeler.

Prerequisite: Students should have a general knowledge of operating standard applications under Windows. This includes logging in (for networks), launching applications, finding drives, managing files and navigating menus and dialogs.

### Objectives

Upon completion of this course, the student will be able to:

- Understand 3-D modeling concepts
- Use commands and capabilities of Rhino
- Set up a 3-D scene and view 3-D space
- Create 2-D dimensioned drawings of 3-D models.
- Create basic geometry including curves, solids and surfaces
- Define properties
- Place lights and render scenes

### Resources

The *Rhinoceros User's Guide*, the *Rhinoceros Level 1 and Level 2 Training Manuals*, and Web resources on 3-D modeling (<http://www.rhino3d.com/tutorials.htm> and <http://www.rhino3d.tv>).

### Evaluation

Students will be evaluated on the timely completion of projects planned and outlined according to class handouts and assignments.

### Examinations

### Peer Review

Peer review is an expected source of feedback for all students. There will be a form and methods established that would encourage each student to be a part of the evaluation process. Modelers should save or archive their model files. Files of the rendered image should also be saved. Make sure that wherever your model is saved, you include your name and the date on the label. These files will be used as examples for other students and may be posted on an Internet gallery.

## Design Activities Process

All of the sample activities are based on the following design problem format:

- **Problem statement**—Give a scenario and the task students must solve.
- **Limitation/parameters**—these are the things like materials used, time, cost, boundaries of the design solution and other information affecting the final design.
- **Brainstorm** solutions—Sketchy, hand drawn ideas. Set a minimum number expected.
- **Select best one**—should provide rationale of their selection.
- **Develop idea/prototype/finalize** idea—this is the “just do it” phase.
- **Test/evaluate** solution—should provide an analysis on the design and any conclusions.
- **Redesign/retest** if possible—Time consuming, but valuable experience.
- **Presentation**—Finished assignment presented to the class.

## Instructions

### Organizing the Activity

Instructor	Student
Arrange students into groups (details to follow).	Students get into groups and go to assigned areas.
Instruct students on the design challenge (give them the problem handout). Make sure they understand the parameters of the designs (See Sample Activities section).	Read the handout.
Instruct them to begin drawing ideas on paper. Instruct them to model in Rhino.	Students begin drawing their designs on paper and modeling their products on the computer.
Review objects with students to determine if they meet the design parameters. If not, have them fix. Peer review (details to follow).	Students analyze their material against the parameters to insure it meets the criteria.

### Instructional Materials

- Display examples of similar products.
- Try to include items of different shapes, materials, and sizes.
- Have magazines and newspapers that contain advertisements of various products available as idea starters.

### Multi-Level Class

When your class includes students with computer drawing experience varying from basic to advanced, you will have to do some grouping.

Students with similar experience form groups and work together as a team. Students can be separated into levels—basic, intermediate, and advanced. The example below is based on the bottle design activity (see sample activities).

Minimum objectives for each group are shown in the following table:

Levels	Rhino Capabilities Used (Basic Navigation and following:)	Type of Bottle (Required)	Other Projects (Or other objects chosen)
Basic	Line/Curve, Solid primitives, Boolean operations, Revolve, Rendering	Any bottle	Glasses filled with a liquid
Intermediate	All above and the following: Extrude, Sweep, Transparent materials rendering	Bottle with wall thickness	All above and following: Table Chairs
Advanced	All above and the following: Lofts, Control points editing, Surface tools, Text tools and Rendering	Irregularly shaped bottle with label	All above and following: Interior walls Floor and windows

## Ideas for Design Assignments

One of the best ways to get students to learn how to use Rhino is to have them make real-world objects. Encourage them to figure out how to break down an object into various modeling operations and then do it with precision. Here are some examples to give to students so they can practice their skills:

Entry-Level	Intermediate	Sophisticated
Kleenex box	Tube of toothpaste, toothbrush	Car, truck, train
Pen/pencil	Computer, monitor, printer	Roller blades
Pop can/bottle	Headphones	Ship/boat
Dice (4, 6, 8 sided)	School desk, office chairs	Bicycle
Flower vase	Watch, alarm clock	Animals
Stool	VCR, CD player, stereo	Sunglasses, safety glasses
Table with objects on top of it	Dishes/pots & pans	Tennis shoe
Drinking cups	Stove/dishwasher	Airplane, helicopter
Christmas ornaments	Lipstick, mascara, perfume bottle	Computer mouse
Squirt bottle	Overhead projector	Piano, musical instruments
Screwdriver, nails, clamps	Hammer, wrench, pliers	Skull/bones
Jewelry box	MP3 Player	Child's pull toy
CD case	Calculator	Hat, helmet
Radio, speakers	Electric wheel chair	Humanoid
Table or desk lamp	Telephone	Cell phone, remote control



## Sample Design Activities

Two of the activities included are modifications of the examples from previous activities. They have been included to show how small modifications can alter a project and to show how the finished product can vary from program to program.

### Example Problem Statements

- Design a new soda drink holder for movie theaters.
- Design a new screwdriver that allows for both a Phillips head and flat head.
- Design a wooden toy that is adequate and safe for kids ages 8 to 12. It should be based on a theme.
- Design your dream vehicle (plane, car, train, boat, space craft)
- Design two blocks that will fit into each other using holes and posts that line up. Two teams design each block and communicate the design specifications.

### Evaluation

A grading rubric is also included as a possible guide to what can be expected from students. It reflects one instructor's bias toward achievable excellence. The grading scale can be interpreted as 4.0=A, 3.0=B, 2.0=C, 1.0=D, 0.0=F. In this scale, half points could be interpreted as pluses or minuses.

### Grading Rubric

Unique/innovative design AND All of the elements presented with excellence	4.0 points
All of the elements well presented	3.5 points
Most of the elements adequately presented	3.0 points
Some of the elements adequately presented	2.0 points
Some of the elements shown	1.0 points
None of the elements adequately presented	0.0 points

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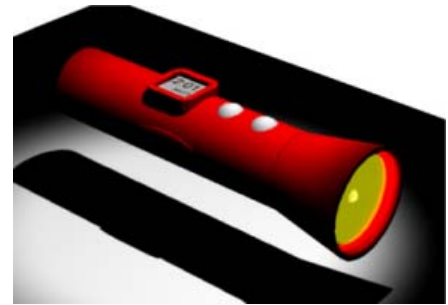
**Note: This document (Rhino Curriculum Guide v4.doc) is on the CD that was included with this curriculum guide. Edit the following design briefs to meet your classroom needs.**

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## Example 1 — Flashlight I

### ***Problem statement***

You are working for an industrial design company that creates new product ideas for a major outdoor/camp gear manufacturer. You have been given the task of designing a new rugged flashlight that incorporates a digital clock and alarm for campers. It should also include a battery life indicator.



### ***Parameters***

You have been given the following limitations from the manufacturer

- Should be lightweight for easy hiking.
- Clock should be incorporated seamlessly into the flashlight design.
- Controls for the clock should be simple and easy to use.
- Should be able to see clock in the dark.
- Need a design in five days.

### ***Brainstorm***

Brainstorm at least three different flashlight designs—hand drawn sketches.

### ***Select best one***

Select the best flashlight—give your reasons for that selection.

### ***Develop the idea***

Develop your flashlight design further by producing several model files and renderings in Rhino.

### ***Test/evaluate***

Evaluate your flashlight against the parameters; change anything if necessary.

### ***Presentation***

Present your flashlight design to the class or “client.”

## Example 2 — Flashlight II

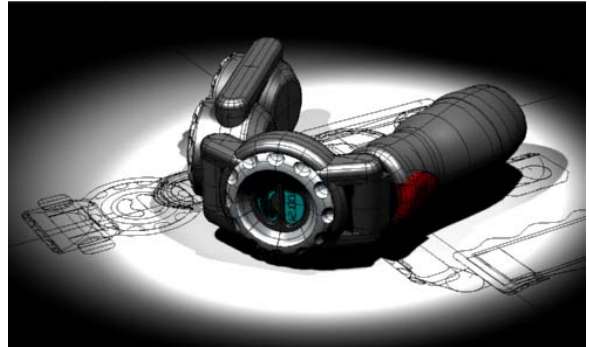
### ***Problem statement***

You are working for an industrial design company that creates new product ideas for a major outdoor/camping gear manufacturer. You have been given the task of designing a new rugged flashlight that incorporates a digital clock and alarm for campers. It should also include a battery life indicator.

### ***Parameters***

You have been given the following limitations from the manufacturer:

- It should be lightweight for easy hiking.
- Clock & GPS incorporated seamlessly into design.
- Controls for clock should be easy to use.
- It should be simple and easy to use.
- Should be able to see the clock in the dark.
- It will use C-cell, D-cell, or 9-Volt batteries.
- Need a design in 5 days.



### ***Brainstorm***

Brainstorm at least three different flashlight designs—hand-drawn sketches and simple Rhino drawings.

### ***Select best one***

Select the best flashlight—give your reasons for the selection.

### ***Presentation***

Present your flashlight design to the “client” in the form of a specification sheet(s) and working drawing(s) (dimensioned 3-view drawing). Tell what materials were used and give overall dimensions in specification sheet. Include rationale for selection of final design. Include sketches and notes.

## Example 3 — Jack O'Lantern Design Project

### Problem statement

You are an intermediate or advanced engineering design student looking for some extra credit. The instructor has said that you can participate in a Jack O'Lantern design contest. You have until the first day of the last week of October to finish a Jack O'Lantern.

### Parameters

You have been given the following limitations from the instructor:

- The pumpkin can be modeled from a sphere.
- The pumpkin model should be 20" diameter.
- It must be done by Monday of the last week of October.
- The design must be flattened and printed so that it can be mounted on a pumpkin.
- A rendered picture of the design on a pumpkin must be made and printed.
- Any special instructions for making the Jack O'Lantern must be given in the instruction document.



Created by: Blake Hellman, Cedarcrest HS

### Presentation

A two-page document giving instructions on the design, rendering of the design, and a flat layout of the design will be given to the instructor.

### Grading (extra credit in drawings category)

Best design as determined by a panel of unbiased judges

5 points

Second place

3 points

Third place

1 point

In addition, each person creating a design may receive 2 points (and leadership points) for actually carving a pumpkin and donating it to a community event. Documentation of this donation may be accomplished with a photo or a note from the event coordinator.

## Example 4 — Cosmetic Packaging

### **Problem statement**

You have been hired by a new company in the high-end beauty industry to create packaging for their line of "Elixir" cosmetics. These products are expensive, so the packaging should promote a luxurious image. Your team will create a container for renewing/anti-wrinkle lotion ("Eden").

### **Parameters**

Your design must adhere to the following limitations:

- Should be very aesthetically appealing
- Must have a screw-top lid

Base of container must be glass (somewhat transparent)



*Ed Hawkins, La Crescenta,  
California, USA*

### **Brainstorm**

Brainstorm at least three different container designs—hand drawn sketches.

### **Select best one**

Select the best container—give your reasons for that selection.

### **Develop the idea**

Develop your container design further on Rhino.

### **Test/evaluate**

Evaluate your container against the parameters; change anything if necessary.

### **Presentation**

Present your container design to the class or "client."

## **Example 5 — Key Chain I**

### ***Problem statement***

Your school wants to sell a set of key chains for this school year. The ASB has found a company that will make it for them. ASB officers have heard that you know how to design things using Rhino. They want you to come up with a mock-up design for the key chain. They will then take that design to the manufacturer, who will use the drawing to make the key chain. The key chains have to be designed within specific requirements. These requirements must be met and approved by the ASB before the production.

### ***Parameters***

- The material must be made from plastic.
- The over all size should be no more than 1/8" thick. The width and height of this key chain should be 1" by 1".
- One side of the key chain should display the school logo and the other side should display the current school year. They would like you to come up with a logo and neat design for the year that will fit in the limited space.
- It must be low in cost, probably selling retail for less than \$2.00.
- Need a design in five days.

### ***Brainstorm***

Brainstorm at least three different key chain designs—hand drawn sketches.

### ***Select best one***

Select the best key chain—give your reasons for that selection.

### ***Develop the idea***

Develop your key chain design further on Rhino.

### ***Test/evaluate***

Evaluate your key chain against the parameters; change anything if necessary.

### ***Presentation***

Present your idea to the ASB officers.

## Example 6 — Key Chain II

### **Problem statement**

Your school wants to sell a set of key chains for this school year. The ASB has found a company that will make it for them. ASB officers have heard that you know how to design things using Rhino. They want you to come up with a mock-up design for the key chain. They will then take the design to the manufacturer who will take your drawing and make the key chain. The key chain must be designed within specific requirements. These requirements must be met and approved by the ASB before the production.

### **Parameters**

You have been given the following limitations from the ASB:

- The key chain will be made of plastic.
- The maximum overall size is 1" x 1" x 1".
- One side of the key chain should display the school logo and the other side should display the current school year. The ASB would like you to come up with a logo and design for the year that will fit in the limited space.
- It must be low cost, probably selling retail for less than \$2.00.
- Need a design in five days.



### **Brainstorm**

Brainstorm at least three different key chain designs—hand-drawn sketches and simple Rhino drawings.

### **Select best one**

Select the best key chain—give your reasons for the selection.

### **Develop the idea**

Develop your key chain design further by producing several models and renderings in Rhino.

### **Presentation**

Present your key chain design to the “client” in the form of a specification sheet(s) and working drawing(s) (dimensioned three-view drawing). Tell what materials were used and give overall dimensions in specification sheet. Include rationale for selection of final design. Include sketches and notes.

## **Example 7 — Room Identification Project**

### ***Problem statement***

The administration is tired of trying to figure out who is in what classroom and what classes are being taught in that room. They want to install a system of identification for who is in a classroom and what is being taught there each period during the day. It should be simple to read and easy to modify during the school year. Your project is to come up with a system or method to solve this problem and then model and render examples in Rhino.

### ***Parameters***

You have been given the following limitations regarding the design of the project.

- The system must contain a picture of the instructor who is in the classroom.
- The system must show what class is being taught during each period.
- You must show the room name or identification number.
- If more than one instructor uses the room, develop a method for identifying all of the people using the room.
- It should be easy to modify the information during the school year.

### ***Brainstorm/select best one***

Using your freehand sketching techniques, draw at least three concepts with notes identifying your ideas and then select the design you would like to pursue and show the choice to your instructor. You should be prepared to justify your selection to your instructor.

### ***Develop the idea/test and evaluate***

Using Rhino, develop a model and render your selection. Discuss solution with your team members and make any changes that might be necessary.

### ***Presentation***

Present your idea to the school administration.



## Example 8 —Whirl Bottle

### **Problem statement**

A beverage company has contracted with your design firm to create a distinctive new bottle and identity for their newest beverage, *Whirl*. The beverage taste will be revolutionary and they need an image that will distinguish *Whirl* from the crowd.

### **Parameters**

The bottle is to be light gray glass with a wrap-around plastic label. You are allowed complete freedom to create the bottle shape, label, and packaging. The company needs promotional materials that will be used for initial marketing. Before making molds, printing, or anything, they want to look at design ideas.

The project places you in the designer's chair on a critical schedule to complete a rendering of the finished product. You must consider your capabilities, the time you have available and outline a project plan within a week. Your firm fortunately has 3-D modeling capabilities, which allows you to make the bottle with a computer. The marketers can then unleash their *Whirl in the World* campaign.



### **Brainstorm**

Using your freehand sketching techniques, complete three sketches of potential designs with notes identifying your ideas.

### **Select best one**

Select the design you would like to pursue and show the choice to your instructor. You should be prepared to justify your selection to your instructor.

### **Develop the idea**

Using Rhino, develop a model and render your selection.

### **Test and evaluate**

Discuss solution with your team members and make any changes that might be necessary.

### **Presentation**

Present your idea to the class or "client." The scene that you create should show the bottle in a realistic setting that would make you want to stop and have a drink. You can show the bottle alone on a table or create a scene with glasses filled with *Whirl* or whatever scene you can imagine.

## Example 9 — Cellular Phone

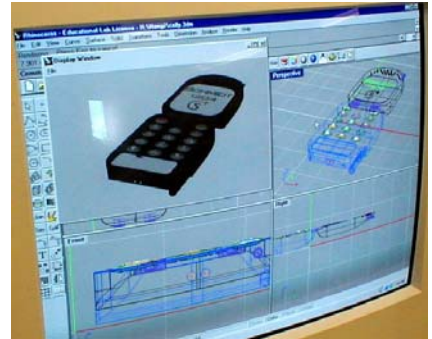
### **Problem statement**

Personal technology will undergo dramatic changes in the near future. The size of the electronics will be reduced to approximately 60% of the current size. Design a personal electronic device that incorporates cellular phone, pager, pocket PC/organizer, and takes advantage of the electronics size breakthrough. Make sure that your design takes into consideration ergonomic and other practical considerations. Also, come up with a name for the new technology.

### **Parameters**

You have been given the following limitations from the manufacturer:

- It should be aesthetically appealing.
- Must be practical for people with large fingers or small.
- Should be ergonomically sound.
- Should fit into the front shirt pocket without much bulge.
- Need a design in 10 days.



### **Brainstorm and research**

Brainstorm at least two different cellular phone designs—hand-drawn sketches and simple Rhino models. Research the size of current technology (electronic parts most important).

### **Select best one**

Select the best device—give your reasons for the selection.

### **Develop the idea**

Develop your device design further by producing several models and renderings in Rhino.

### **Presentation**

Present your device design to the “client” in the form of a specification sheet(s) and working drawing(s) (dimensioned three-view drawing). Tell what materials were used and give overall dimensions in specification sheet. Include rationale for selection of final design. Include sketches, notes, and relevant research. The research should be synthesized into a readable document not just the print out of a web page.

## Example 10 — Video Game Concept

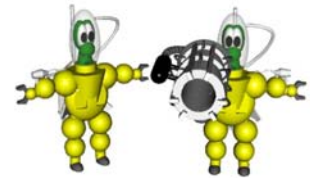
### Problem statement

You and 1 to 4 of your classmates (groups from 2 to 5 people) have decided to start up a new computer game company. Investors are willing to back up your project if you can develop a theme, design some characters, and make some scenes. It will be a role-playing or action adventure game with at least 5 to 10 “base” characters. Come up with a theme for the game, develop the characters, and make some scenes.

### Parameters

You have been given the following tasks from your investors:

- Determine a segment of society that will be your target market.
- Come up with a theme for the game.
- Develop a main character and at least four other characters.
- Back up your decisions with research as to what games are big sellers.
- Need a business plan in ten days.



*Isaac Sprague, Duvall,  
Washington*

### Game theme

Determine what the time setting, object, and other themes of the game.

### Make a main character

Come up with a main character that will progress through the game.

### Develop other characters and scenes

Develop your characters and scenes by producing several models and renderings in Rhino.

### Game plan

Present your game plan including character designs to your “investors” (3 page single-spaced minimum).

Present the elements above in a clear and concise manner and in such a way that the “investors” are willing to fund your project.

Describe characters in as much detail as is necessary to show the themes of the game.

### Grading (80 points)

Description	Points	Grade
Unique/innovative design AND All of the elements presented excellently	80	A
All of the elements presented well	70	B+
Most of the elements adequately presented	60	B
Some of the elements adequately presented	40	C
Some of the elements shown	20	D
None of the elements adequately presented	0	F

## Example 11 — Automotive Accessories

### ***Problem statement***

You have decided to start up a new automotive accessory manufacturing company. Investors will only look at your company seriously if you have between 10 and 15 types of accessories designed and if you have a specific target market selected. The investors will make a decision on whether to back your company in 15 days.

### ***Parameters/research***

You have been given the following tasks from your investors:

- Determine a segment of society that will be your target market.
- Come up with a simple yet recognizable logo.
- Make a mission statement.
- Back up your decisions with research.
- Need a business plan including 10-15 accessory designs in 15 days.



*Geofrey Oestreich, Duvall,  
Washington*

### ***Mission statement***

Determine what your company will do. The mission statement should tell who you are and what you intend to do. It should be short and sweet. It should use active verbs. (You might need to research what a mission statement is.)

### ***Make a logo***

Come up with a recognizable company logo. Make sure that it does not violate anybody else's copyrighted material.

### ***Develop accessory designs***

Develop your accessory designs by producing several models and renderings in Rhino.

### ***Business plan***

Present your business plan including accessory designs to your "investors" (three-page, single-spaced minimum). Include a page (not included with the page count) with the company name, mission statement, and logo. Create a one-page specification sheet for each accessory that includes what materials will be used, what vehicles it will be accessorize, and other pertinent information (not included in page count). Include rationale for target market chosen.

## Example 12 — Toy Company

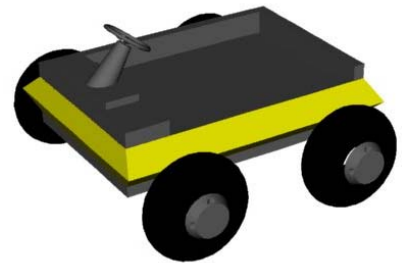
### **Problem statement**

You have decided to start up a new toy manufacturing company. Investors will only look at your company seriously if you have between 10 and 15 toy designs and if you have a specific target market selected. You must also decide what niche of the target market you will seek to enter (children's playground equipment). The investors will make a decision on whether to back your company in ten days.

### **Parameters/research**

You have been given the following tasks from your investors:

- Determine a segment of society that will be your target market.
- Determine your niche in that market.
- Come up with a simple yet recognizable logo.
- Make a mission statement.
- Back up your decisions with research.
- Need a business plan including 10-15 designs in ten days.



*Shad Saindon, Duvall, Washington*

### **Mission statement**

Determine what your company will do. The mission statement should tell who you are and what you intend to do. It should be short and sweet. It should use active verbs. (You might need to research what a mission statement is.)

### **Make a logo**

Come up with a recognizable company logo. Make sure that it does not violate anybody else's copyrighted material.

### **Develop toy designs**

Develop your toy designs by producing several models and renderings in Rhino.

### **Business plan**

Present your business plan including shoe designs to your "investors" (three-page, single-spaced minimum). Include a page (not included with the page count) with the company name, mission statement, and logo. Create a one-page specification sheet for each toy design, which includes the materials that will be used, the assembly that will be required, and other pertinent information (not included in page count). Include rationale for target market chosen.

## **Example 13 — Shoe Company**

### ***Problem statement***

You have decided to start up a new athletic shoe manufacturing company. Investors will only look at your company seriously if you have between five and nine shoe designs and if you have a specific target market selected. Currently, there is a great need for shoes that are relatively inexpensive, have simple lines, but have distinctive trademarks (like the Nike swoosh). The investors will make a decision on whether to back your company in ten days.

### ***Parameters/research***

You have been given the following tasks from your investors:

- Determine a segment of society that will be your target market.
- Come up with a simple yet recognizable logo.
- Make a mission statement.
- Back up your decisions with research.
- Need a business plan including 5–9 designs in 10 days.

### ***Mission statement***

Determine what your company will do. The mission statement should tell who you are and what you intend to do. It should be short and sweet. It should use active verbs. (You might need to research what a mission statement is.)

### ***Make a logo***

Come up with a recognizable company logo. Make sure that it does not violate anybody else's copyrighted material.

### ***Develop shoe designs***

Develop your shoe designs by producing several models and renderings in Rhino.

### ***Business plan***

Present your business plan including shoe designs to your "investors" (three-page, single-spaced minimum). Include a page (not included with the page count) with the company name, mission statement, and logo. Create a one-page specification sheet for each shoe design, which includes what materials will be used, what shoe sizes will be available, and other pertinent information (not included in page count). Include rationale for target market chosen.

## Example 14 —Final Design Assignment

### **Problem statement**

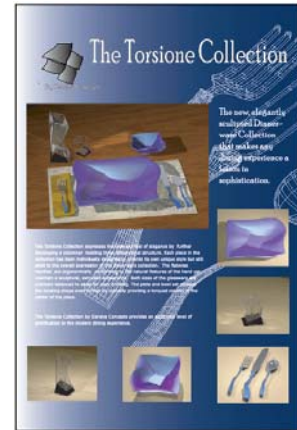
You have been contracted to design an integrated set of dinnerware that could be used for formal or informal settings. The client is interested in a set of pieces that has a sculptured or free-form look. They also need a logo that fits the design.

They would like to see concepts for a complete place setting to include dinnerware, glassware, cutlery, and accessories.

### **Parameters**

You have been given the following tasks from the client:

- Create a set of thumbnail sketches of potential designs for review.
- Design a simple yet recognizable logo.
- Create 3D models that could be used for rapid prototyping.
- Create rendered images and drawings for presentation.



Composite by Jeff Ladwig

### **Make a logo**

Come up with a recognizable product logo. Make sure that it does not violate anybody else's copyrighted material.

### **Develop designs**

Develop your designs by producing several models and renderings in Rhino.

### **Presentation**

Make a presentation board to present to the client.

Boards must be a composite plotted image at least 20"x30" mounted on foam core. Composite should include enough text to describe your concept, a logo, renderings, drawings.

### **Evaluation**

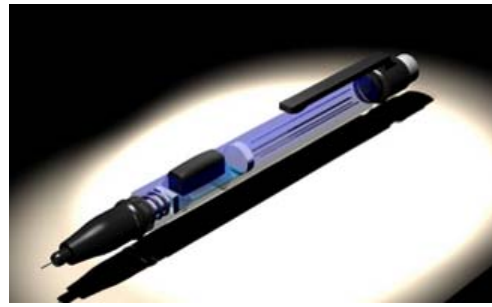
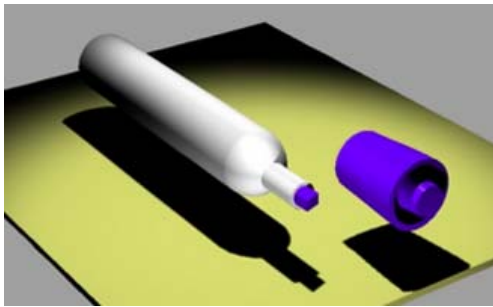
In addition to the presentation board, all sketches, Rhino models, rendered images, and the digital composite are required.

## Rendering Tips

One of the most time-consuming skills students will have to learn is rendering. The process to render a model is actually quite easy. However, students will spend hours trying to get just the right color, lighting, and shadows on their models. One way to teach rendering skills is to use the following lighting technique. It is quick and easy and allows them to understand the basics of how Rhino renders a scene.

1. Draw a large rectangular surface in the top viewport.
2. Move the model just above the flat surface so it appears to float over it.
3. Draw a spotlight so it shines from above, down to the object and onto the flat surface
4. Make the background color black, the ambient color gray (default), and the spotlight white. Give the flat surface a color other than black or dark gray.
5. Render in the Perspective viewport rotating the scene so you see it slightly from the top.

### *Examples of the Basic Lighting Technique*



### *Additional Rendering Tips and Hints*

1. Have students play around with the placement of the spotlight, using the Rotate command. Also, have them use different color schemes for the spotlight and the flat surface. Eventually, they will get the hang of it and know what the appropriate colors should be and the placement of the spotlight.
2. You cannot shine a spotlight through a transparent object. The object goes black. For example, if you have a flashlight and you shine a spotlight from behind the lens outward, the lens will go dark. The only way around it is to shine the spotlight on the lens from the outside so it looks like that light is coming out from the lens.
3. Most of the objects in Rhino will have a flat, plastic look. The Texture option can give objects a different look and feel. Have students create a texture file in a paint program. Start them off with making a picture that has three colored stripes. Save it as a BMP or JPG file. Insert that texture file name in the Texture dialog box when they use the Render command. Students can create metal, wood, fabric, or stone surfaces by importing a picture file that has an image of that surface.



## Sample Fifteen-Week Syllabus

In this section we will combine both technical proficiency and technical adequacy to produce a well-rounded 3-D instructional program covering 15 weeks of instruction. At the end of this 15-week program, students will be proficient in using the Rhino software and will be able to break down images into three-dimensional designs.

The following sample course curriculum is based on using the *Rhinoceros Level 1 Training Manual* as a textbook. The instructor lecture information is based on the *Rhinoceros User's Guide* and information from the Rhino Help file.

### ***In this section you will find:***

- Week by week break down for instructors
- Topics covered
- Worksheets
- Quizzes
- Midterm exam
- Final exam
- Additional project ideas
- Suggested Grading information; of course alter as needed

### **Course Description**

This course is concerned with the visualization and creation of 3-D computer-generated models and their applications in today's manufacturing, communication, and publishing industries.

Students will be instructed in the principles of 3-D modeling using Rhinoceros NURBS modeling software. In a laboratory setting, students will have an opportunity to practice the strategies and methods commonly used in creating and solving 2-D and 3-D geometric problems. Information given in lectures and demonstrations will address aspects of modeling free-form curves, surfaces, and solids. Students will be introduced to a variety of 3-D model applications as they are used in illustration, engineering, design, documentation drawing, entertainment, and animation.

In addition to developing a working knowledge of 3-D terminology and concepts, each student will learn how to create a variety of 3-D geometric models from technical drawings, sketches, real models, and written descriptions.

### **Course Objectives**

This course will:

- Provide a working foundation in sketching, interpreting, and creating computer-generated models.
- Provide students with the ability to describe the organization, terminology, function, capabilities, and limitations of 3-D computer graphic software in regards to modeling.
- Use Rhino 3-D modeling software to create surface and solid models.
- Set up a 3-D scene and view 3-D space.
- Develop sketches of models and practice viewpoint identification and selection.
- Place lights and render scenes.
- Create 2-D dimensioned drawings of 3-D models.

**Textbooks and Materials**

- Rhinoceros Level 1 Training Manual.
- Sketch pad (this does not have to be new)
- Pencils
- Ruler
- 3-ring binder with plastic pages to keep projects in.
- Graph paper .2 or .25 grid

**Grading****Design assignments 50%**

Completing assigned activities on time is essential to learning computer software. Students must be encouraged to keep up with the daily computer work so future projects can be completed. Students who fall behind in assignments in the first few weeks of class find it difficult to produce more complicated designs near the end of the semester.

**Worksheets and Quizzes 20%**

Worksheets are used to teach the basic vocabulary of the software program. Learning the terminology of a software program lets a student use the correct term when asking a question or contributing to a class discussion. Filling out worksheets gives students a written guide for studying quiz, midterm, and final test material. Quizzes require students to commit to memory the vocabulary used in the software program and the general commands for navigating around the software.

**Midterm and Final Tests 5%**

The midterm is the halfway point in the semester. The midterm gives both the instructor and the student the opportunity to look at the progress the student has made so far. This is a good time for the instructor to evaluate the pace of the class and make any necessary changes in the curriculum. The final is a cumulative collection of information given over the course of the semester. The final covers vocabulary and a computer modeling section. By the end of the semester, students should be able to re-create simple computer models without detailed instruction.

**Student Notebook 10%**

A required student notebook is one way for instructors to teach students the importance of keeping all of their work together. Students should keep a notebook containing their projects for the entire semester. For the instructor this is a good way to see the improvement in the progress of the student over a period of time. For the student, the notebook is a valuable reference source for future design projects. It also becomes the basis for the required portfolio of work that will be done at the end of the class.

Students are required to keep all handouts, sketches, photographs, computer printouts, projects, and any other information that pertains to the class in the notebook.

**Final Project Portfolio 15%**

The final project is the students' chance to show off the work they have put into learning the software and design elements over the semester. Although students are given final project guidelines to follow, encourage them to be inventive and creative. The final project should be a major portfolio piece when completed.

## Portfolio Requirements and Rhino Competencies

Design students need to know the importance of the competencies they are learning. At the highest level of competence, they also need to know how to teach others the skills they are learning. Each student will create a portfolio of work to show the level of competence achieved in each competency as well as to showcase his or her work.

The portfolio will consist of models that showcase the student's work. Each of the drawings should show the skill(s) listed in the competencies. For a student to receive the highest competency level, he or she must be able to teach others how to do the skill. To this end, the portfolio will also have written documentation to accompany the drawings.

The documentation will:

- Describe what competencies are shown by the models (with short word descriptions and competency numbers).
- Tell how the competencies are accomplished.
- If a competency level of 4.0 is to be shown, describe how the competency would be taught to another student.

Portfolio should be neat and clean. The portfolio should be bound in a binder with the documentation at the beginning, end, or interspersed throughout. If the documentation is at the beginning or end of the portfolio, the models should be numbered in a logical fashion such that the documentation references make sense.

### Rhino Competencies

The student:

30001	Understands general modeling terms & techniques
30002	Models on other than world plane
30003	Manipulates drawing environment
30004	Uses CAD tools
30005	Creates models at full scale
30006	Creates simple surfaces & solids
30007	Creates surfaces from polylines
30008	Creates solids from surfaces
30009	Creates surfaces from solids
30010	Performs point editing
30011	Performs Boolean operations
30012	Performs rail sweeps
30013	Performs splits and trims
30014	Creates scenes with lighting
30015	Applies planar curves to surface
30016	Creates complex "terrain"
30017	Arrays elements along curves and surfaces
30018	Imports and exports drawings or parts
30019	Uses object properties including textures
30020	Uses layers to organize model
30021	Changes rendering options
30022	Plots drawings

## Sample Week-by-Week Lesson Plans

Assignments are based on using the Rhino Level 1 Training manual as a reference and the Sample Design Activities for projects.

Week	Lesson Topic	Know	Exercise	Worksheet
1	Rhino basics and display options	Chap. 2	1-2	1
	Introduction to Rhino: Lines & curves, modeling aids, model setup, saving, layers, selecting and deleting objects	Chap. 3	3-9	
	On Your Own:			
	Using shapes from exercise 1, build a three-dimensional model of your own Print four viewpoints and hand in the exercise. (See Chapter 13 – Printing for help if needed)			
Week	Lesson Topic	Know	Exercise	Worksheet
2	Coordinates, x, y, and z	Chap. 4	10-27	2
	Absolute coordinates vs. relative coordinates			
	Distance constraints and angle constraints including ortho, elevator, and planar mode.			
	On Your Own: On graph paper redraw the arrow shape and write in the x,y coordinates Design Project: Flashlight I (see Sample Design Activities - Example 1)			
Week	Lesson Topic	Know	Exercise	Worksheet
3	The art of rendering	Chap. 11	63	
	Bringing in outside textures			
	Building a shadow room			
	Spotlights. Rendering Tips	Curriculum Guide Handout		
Week 4	Design Project: Flashlight II (see Sample Design Activities - Example 2)			
	Editing objects	Chap. 5	28-42	3
	Quiz 1			
	On Your Own: Complete exercises 43-46. Design Project: Complete Flashlight II (see Sample Design Activities - Example 2)			
Week	Lesson Topic	Know	Exercise	Worksheet
5	The five fundamental geometric objects in Rhino	Chap. 6	47-48	4
	Points, curves, surfaces, polysurfaces and solids			
	Point editing.			
	Creating Deformable Shapes	Chap. 7	49	
Week 6	On Your Own: Model an organic shape (apple, pear, potato)			
	Design Project: Jack O'Lantern (see Sample Design Activities - Example 3)			
	Rhino Solids	Chap. 8	50	5
	Text in Rhino How to make a screen capture Design Project: Key Chain I or II (see Sample Design Activities - Example 5 or 6)			

Week	Lesson Topic			
7	Midterm Exam			
	Review for midterm exam			
	Exam at end of week			
	Design Project:			
	Complete Key Chain I or II (see Sample Design Activities - Example 5 or 6)			
Week	Lesson Topic	Know	Exercise	Worksheet
8	Surfaces	Chap. 9	51-59	6
	On Your Own:			
	Complete exercises 60-61.			
	Design Project:			
	Cellular Phone (see Sample Design Activities - Example 9)			
Week	Lesson Topic	Know	Exercise	
9	Importing and Exporting Models	Chap. 10	62-63	
	Downstream Use of a Model			
	Importing and Exporting Mesh Objects			
	Quiz 2			
	Dimensioning	Chap. 12	64-65	
	Making 2-D Drawings			
	Printing	Chap. 13	66	
	On Your Own:			
	Export one of your projects to another application (CAM, rapid prototyping, rendering, publishing)			
	Design Project:			
	Complete Cellular Phone (see Sample Design Activities - Example 9)			
Week	Lesson Topic	Know	Exercise	
10	Rhino Settings and Options	Chap. 14	67-68	
	Group Design Project:			
	Video Game Concept (see Sample Design Activities - Example 10)			
Week	Lesson Topic	Know	Exercise	
11	Rhino Customization	Chap. 15	69	
	Group Design Project:			
	Complete Video Game Concept (see Sample Design Activities - Example 10)			
Week	Lesson Topic			
12-14	On Your Own:			
	Finish all Model Work			
	Develop Presentation methods for your work; both hard copy and digital			
	Utilize your class notebook to begin portfolio.			
	Portfolio Production:			
	8 ½ x 11			
	Bound			
	Table of Contents			
	Chronology of Work			
	Tabs Section Dividers			
	Headers for content sections			
	Problem statements must accompany design solutions			
	Two Copies; 1 for student, 1 for teacher			
Week	Lesson Topic			
15	Final Exam			
	Review for final exam			
	Exam at end of week			
	On Your Own:			
	Project Presentations			
	Portfolio Presentations			

## Worksheets

The worksheets and answer sheets provided are examples *only*. Open the document and edit the worksheets, exams and answer sheets to meet your course needs.

Initially, you could assign one or more students to create answer sheets for the following worksheets.

### Worksheet 1

#### ***Define the following Rhino terms:***

- 1 Viewports:
- 2 Command line:
- 3 Status bar:
- 4 Flyout toolbar:
- 5 Grid:

#### ***Answer the following questions:***

- 6 How do you pan and rotate in viewports?
- 7 How do you zoom in and out in viewports?
- 8 What are two other options to using the 'enter key' in Rhino?
- 9 How do you cancel a command?
- 10 What is the command line history, what is it used for, how do you access it?
- 11 What is the difference between a line and a polyline?
- 12 If you click on the Curve: interpolated points button, what kind of object is drawn?
- 13 While in the interpolated curve command, what happens when you type the C option? When you type the U option?
- 14 What is ortho? What is the default angle? What would you draw with ortho on?
- 15 Why would a grid come in handy, and what is its function key?
- 16 What is snap? What is the command key? Where else can you turn snap on and off?

## Sample Answer Sheet 1

### ***Define the following Rhino terms:***

- 1 Viewports: Displays different views of the model within the graphics area.
- 2 Command line: Lists commands you enter and information produced.
- 3 Status bar: Displays the coordinates of the pointer, the status of the model, options, and toggles.
- 4 Flyout toolbars: Sub-toolbar that includes options. Buttons that have flyout toolbars are marked with a small white triangle in the lower corner.
- 5 Grid: Reference on construction plane used for building precise models.

### ***Answer the following questions:***

- 6 How do you pan and rotate in viewports? Drag with the right mouse button. Pans in parallel projection viewports; rotates in perspective projection viewports.
- 7 How do you zoom in and out in viewports? Hold the CTRL key and drag with the right mouse button or use the mouse wheel.
- 8 What are the two substitutes for pressing the Enter key in Rhino? Spacebar or right mouse button.
- 9 How do you cancel a command? Press the Esc key or select a new command from a button or menu.
- 10 What is the command line history, what is it used for, how do you access it? It lists the 500 command lines from the current Rhino session. It is used so you can view the last actions you made in the program. Access it by pressing F2.
- 11 What is the difference between a line and a polyline? Line draws a single line segment end to end. A polyline draws a line with multiple vertices, multiple segments.
- 12 If you click on the Curve: interpolated points button, what kind of object is drawn? An interpolated point draws a curve through the points you pick.
- 13 While in the interpolated curve command, what happens when you type the option C? When you type the option U? C closes the shape. U undoes the last command.
- 14 What is ortho? What is the default angle? What would you draw with ortho on? Ortho restricts cursor movement to a specified angle from the last point created. The default angle is 90 degrees. You would draw something like a box.
- 15 Why would a grid come in handy, and what is its function key? It would help you line up objects. Function key F7.
- 16 What is snap, what is the command key, where else can you turn snap on and off? Snap forces the pointer to snap on grid intersections. The command key is S. It is also found in the status bar on the bottom of the page.

## Worksheet 2

### ***Define the following Rhino terms:***

- 1 Elevator mode:
- 2 Object snaps:
- 3 Analysis commands:
- 4 Circumscribed:
- 5 Perpendicular:

### ***Answer the following questions:***

- 6 What are absolute coordinates?
- 7 What are relative coordinates?
- 8 What are polar coordinates?
- 9 Where do you find object snaps (osnap)? Describe the function of some of the osnaps.
- 10 Where you would go to find the angle between two lines?
- 11 How do you measure the radius of a circle?
- 12 Discuss the various circle creation commands? What would be a good situation for using each?
- 13 What is one way you can make a drawing 3-D?
- 14 Discuss the various arc creation commands? What would be a good situation for using each?
- 15 While using the Ellipse command, what happens when you use the V option?
- 16 What do you type to undo your last move or point?
- 17 How do you close a curve to its start point?
- 18 What is angle constraint and what is it used for?
- 19 What is distance constraint, and what is it used for?



### Worksheet 3

***Define the following Rhino terms:***

- 1 Fillet:
- 2 Chamfer:
- 3 Mirror:
- 4 Join:
- 5 Scale:
- 6 Array:
- 7 Offset:
- 8 Split:
- 9 Extend:
- 10 Helix:

***Answer the following questions:***

- 11 What does the Radius option do in the Fillet command?
- 12 What does the Join option do in the Fillet command?
- 13 What is the difference between a rectangular array and a polar array?
- 14 When you are using the Rotate command, in what direction do positive numbers rotate?  
Negative numbers rotate?
- 15 In Array Rectangular, what is the meaning of the following: Number in x-direction, number in y-direction, number in z-direction, unit cell or x-spacing, y-spacing (show examples)?

## Worksheet 4

### ***Define the following Rhino terms:***

- 1 NURBS:
- 2 Control points:
- 3 Degree:
- 4 Knots:
- 5 Edit points:

### ***Answer the following questions:***

- 6 Why it is important to have the option to be able to edit the control points when working on an object in Rhino?
- 7 What are two ways to turn on and off the control points?
- 8 How do you change polylines into curves without kinks?
- 9 Can a degree-3 curve have kinks?
- 10 What happens when you loft a surface over curves?
- 11 What are the two basic ways to model in Rhino?
- 12 Explain why or when you would use the two different ways in question 6.
- 13 In the Properties dialog box, what effect does highlight have on your finished model?
- 14 In the object properties box, what effect will sliding the transparency bar to transparent have on your finished model?
- 15 What are the five geometric objects in Rhino, and which of these can you use control points to edit?

## Worksheet 5

### Define the following Rhino terms:

- 1 Extrude Curve:
- 2 Cap Planar Holes:
- 3 Boolean Union:
- 4 Boolean Difference:
- 5 Boolean Intersect:

### Answer the following questions:

- 6 True or False: You would use Cap Planar Holes to close simple holes in a surface or a partial solid.
- 7 True or False: Extrude Curve creates a solid by extruding a surface horizontally.
- 8 What is Boolean Difference used for?
- 9 What is Boolean Union used for?
- 10 What is Boolean Intersect used for?
- 11 True or False: An Ellipsoid would be a good choice if you were designing an Easter egg. This is a trick question. Are ellipsoids really "egg-shaped"? What would be a good method of creating a real egg-shape?
- 12 When applying a Boolean Difference to a model, which do you select first: the main item or the item you want to subtract?
- 13 Why is it a good idea to render an object before you copy and place it in other areas of the design? (Give two reasons)
- 14 What is the fastest and easiest way to arrange the same object multiple times in a circle?
- 15 What are the five geometric objects in Rhino, and which of these can you use control points to edit?

## Worksheet 6

### ***Define the following Rhino Commands:***

- 1 Patch:
- 2 Sweep1:
- 3 Sweep2:
- 4 FilletEdge:
- 5 RailRevolve:
- 6 Plane:
- 7 Extrude:
- 8 Loft:
- 9 Revolve:
- 10 BlendSrf:

### ***Answer the following questions:***

- 11 If you wanted to put a smooth end cap on an irregularly shaped surface what command would you use?
- 12 True or False? Surfaces have area, but their shape cannot be changed by moving control points, and they cannot be meshed.
- 13 True or False? Loft creates a surface from shape curves. The normal option makes a surface with creases as it passes over the shape curves.
- 14 To visualize surface shape, Rhino displays a grid of isocurves on the surface. What are isocurves?
- 15 True or False: A Rhino surface is similar to a piece of cloth, but it cannot be stretched.

## Tests

### Quiz 1

***Define the following Rhino terms and describe what each action is used for.***

- 1** Fillet:
- 2** Chamfer:
- 3** Mirror:
- 4** Split:
- 5** Extend:
- 6** Elevator mode:
- 7** Object snaps:
- 8** Analysis commands:
- 9** Circumscribed:
- 10** Join:
- 11** Scale:
- 12** Array:
- 13** Offset:
- 14** Perpendicular:
- 15** Viewports:
- 16** Command line:
- 17** Status bar:
- 18** Flyout toolbar:
- 19** Ortho:

## Quiz 1 — Instructor's Copy

Define the following Rhino terms and describe what each action is used for.

- 1 Fillet: Connects two lines, arcs, or curves extending or trimming them to intersect or to join with a circular arc.
- 2 Chamfer: Connects two curves by extending or trimming them to intersect or to join with a beveled line. Chamfer works on convergent or intersecting lines.
- 3 Mirror: Creates a copy of the objects flipped over a specified axis on the construction plane.
- 4 Split: Splits one object with another, or a curve at a point. Split breaks the object where it intersects of the cutting object, but does not delete anything.
- 5 Extend: Extend lengthens an object to make it end precisely at its intersection with another object or you can lengthen an object when there is no intersection.
- 6 Elevator mode: Lets you pick points that are off the construction plane. Elevator mode requires two points to completely define the point.
- 7 Object snaps: Tools for selecting specific points on existing objects.
- 8 Analysis commands: Are used to find lengths, angles, areas, distances, volumes and centroid of solids.
- 9 Circumscribed: To draw a line around.
- 10 Join: Join unites curves that meet at a common end, making a single curve. Join can unite curves that do not touch, if you select them after the command has started.
- 11 Scale: Changes the size of existing objects without changing their shape.
- 12 Array: Use Array commands to make multiple copies of selected objects.
- 13 Offset: Offset creates an object parallel or concentric to another object.
- 14 Perpendicular: Standing at right angles to the plane of the horizon, meeting another line at a right angle.
- 15 Viewports: Displays different views of the model within the graphics area.
- 16 Command line: Lists commands you enter and information produced.
- 17 Status bar: Displays the coordinates of the pointer, the status of the model, options, and toggles.
- 18 Flyout toolbar: Sub-toolbar that includes options. Buttons that have flyout toolbars are marked with a small white triangle in the lower corner.
- 19 Ortho: Restricts the movement of the cursor to specific angles. Normal angle is 90 degrees.

## Quiz 2

### ***Define the following Rhino commands:***

- 1 Patch:
- 2 Sweep1:
- 3 Sweep2:
- 4 FilletEdge:
- 5 RailRevolve:
- 6 Plane:
- 7 ExtrudeCrv:
- 8 Loft:
- 9 Revolve:
- 10 BlendSrf:

### ***Answer the following questions:***

- 11 To put a smooth end cap on an irregularly shaped surface what command would you use?
- 12 What is BooleanUnion used for?
- 13 What is BooleanDifference used for?
- 14 What is BooleanIntersection used for?

Circle **T** if the answer is true and **F** if the answer is false.

- 15 T F You would use cap planar holes to close simple planar holes in a surface or partial solid.
- 16 T F Extrude Curve creates a solid by extruding a surface horizontally.
- 17 T F An Ellipsoid would be a good choice if you were drawing a perfect circle.
- 18 T F Surfaces have area, but their shape cannot be changed by moving control point, and they cannot be meshed.
- 19 T F Loft creates a surface from shape curves. The normal option makes a surface with creases as it passes over the shape curves.
- 20 T F A Rhino surface is like a piece of stretchy fabric. It can take on many different shapes.

## Quiz 2 — Instructor Copy

### Define the following Rhino commands:

- 1 Patch: Creates a surface that goes through a set of curves and or point objects.
- 2 Sweep1: Creates a surface from shape curves that follows along a rail curve. This command controls one edge of the surface.
- 3 Sweep2: Creates a surface from shape curves that follows along two rail curves. The two-rail sweep allows you to control the surface's edges.
- 4 FilletEdge: Creates a fillet or round on the edge of a polysurface or solid.
- 5 RailRevolve: Revolves a shape curve holding one end along a rail curve. This command is very useful for putting a smooth end cap on an irregularly shaped surface.
- 6 Plane: Creates a rectangular planar surface parallel to the construction plane from two diagonal points.
- 7 ExtrudeCrv: Extrudes a curve perpendicular to the construction plane with the option to taper the surface with a draft angle.
- 8 Loft: Creates a surface from shape curves; the normal option makes a surface with no creases as it passes over the shape curves.
- 9 Revolve: Revolve a curve around an axis to create a surface.
- 10 BlendSrf: Makes a smooth surface between two existing surfaces.

### Answer the following questions:

- 11 To put a smooth end cap on an irregularly shaped surface what command would you use?  
RailRevolve
  - 12 What is BooleanUnion used for? To combine solids.
  - 13 What is BooleanDifference used for? To subtract surfaces and solids from one another.
  - 14 What is BooleanIntersection used for? To create an intersection between surfaces or solids.
- Circle **T** if the answer is true and **F** if the answer is false.
- 15 ☒ **T** **F** You would use cap planar holes to close simple planar holes in a surface or partial solid.
  - 16 **T** ☐ **F** Extrude curve creates a solid by extruding a surface horizontally.
  - 17 **T** ☐ **F** An Ellipsoid would be a good choice if you were drawing a perfect circle.
  - 18 **T** ☒ **F** Surfaces have area, but their shape cannot be changed by moving control point, and they cannot be meshed.
  - 19 **T** ☒ **F** Loft creates a surface from shape curves. The normal option makes a surface with creases as it passes over the shape curves.
  - 20 ☒ **T** **F** A Rhino surface is like a piece of stretchy fabric. It can take on many different shapes.



## Midterm Exam

### Matching: (1 pt. ea.)

- 1 \_\_\_\_\_ Are used to find lengths, angles, areas, distances, volumes, and centroid of solids.
- 2 \_\_\_\_\_ Lets you pick points that are off the construction plane. Requires two points to completely define the point.
- 3 \_\_\_\_\_ Creates a copy of the objects flipped over a specified axis on the construction plane.
- 4 \_\_\_\_\_ Unites curves that meet at a common end, making a single curve. It can unite curves that do not touch, if you select them after the command has started.
- 5 \_\_\_\_\_ Lengthens an object to make it end precisely at its intersection with another object or you can lengthen an object when there is no intersection.
- 6 \_\_\_\_\_ Connects two curves by extending or trimming them to intersect or to join with a beveled line. Works on convergent or intersecting lines.
- 7 \_\_\_\_\_ Tools for selecting specific points on existing objects.
- 8 \_\_\_\_\_ Connects two lines, arcs, circles, or curves extending or trimming them to intersect or to join with a circular arc.
- 9 \_\_\_\_\_ To draw a line around.
- 10 \_\_\_\_\_ Divides one object with another, or a curve at a point. Divides the object where it intersects of the cutting object, but does not delete anything.
- 11 \_\_\_\_\_ Changes the size of existing objects without changing their shape.
- 12 \_\_\_\_\_ Makes multiple copies of selected objects.
- 13 \_\_\_\_\_ Displays the coordinates of the pointer, the status of the model, options, and toggles.
- 14 \_\_\_\_\_ Sub-toolbars that include different options. Buttons are marked with a small white triangle in the lower corner.
- 15 \_\_\_\_\_ Standing at right angles to the plane of the horizon, meeting another line at a right angle.
- 16 \_\_\_\_\_ Displays different views of the model within the graphics area.
- 17 \_\_\_\_\_ Restricts the movement of the cursor to specific angles. Normal angle is 90 degrees.
- 18 \_\_\_\_\_ Lists commands you enter and information produced.
- 19 \_\_\_\_\_ Creates an object parallel or concentric to another object.
- 20 \_\_\_\_\_ Making contact at a single point or along a line, touching but not intersecting.

### Match these terms

A	Split	H	Scale	O	Command history
B	Perpendicular	I	Status bar	P	Viewports
C	Mirror	J	Fillet	Q	Flyout toolbar
D	Object snaps	K	Join	R	Copy
E	Ortho mode	L	Elevator mode	S	Circumscribe
F	Tangent	M	Analysis tools	T	Chamfer
G	Extend	N	Offset		

### True / False (1 pt. ea.)



























- 21 \_\_\_\_\_ All NURBS surfaces contain curves.
- 22 \_\_\_\_\_ All surfaces can be edited by moving their control points.
- 23 \_\_\_\_\_ Surfaces can only be untrimmed.
- 24 \_\_\_\_\_ Parameter lines on a surface can also be referred to as isocurves.

**True / False (1 pt. ea.)**

- 25 \_\_\_\_\_ If two or more surfaces are joined together, but do not enclose a volume, the resulting object is a solid.
- 26 \_\_\_\_\_ The arrow keys in Rhino nudge your page view up, down, left, and right.
- 27 \_\_\_\_\_ In Rhino, all surfaces are not 3D NURBS.
- 28 \_\_\_\_\_ You cannot turn on the control points on single surface solids.
- 29 \_\_\_\_\_ You can use point editing on meshes, curves, and surfaces.
- 30 \_\_\_\_\_ Polysurfaces can be edited by using control points.
- 31 What are the five fundamental geometric objects in Rhino: (5pts)
- a.
- b.
- c.
- d.
- e.

**Match each of the buttons on the main toolbar with its command. (10 pts.)**

**Button**

	_____		_____		_____
	_____		_____		_____
	_____		_____		_____
	_____		_____		_____
	_____		_____		_____
	_____		_____		_____
	_____		_____		_____
	_____		_____		_____
	_____		_____		

**Command**

- |                   |            |                   |
|-------------------|------------|-------------------|
| Copy              | Open file  | Set CPlane origin |
| Create spotlight  | Options    | Shade             |
| Cut               | Pan        | Undo              |
| Edit layers       | Paste      | Undo view change  |
| Help              | Render     | Zoom              |
| Hide objects      | Right view | Zoom extents      |
| New file          | Rotate     | Zoom selected     |
| Object properties | Save       | Zoom window       |
| Object snap       | Select all |                   |

**EXTRA CREDIT: What does NURBS stand for?**

## Midterm Exam — Instructors Copy

### Matching: (1 pt. ea.)

- |    |   |  |
|----|---|--|
| 1  | M | Are used to find lengths, angles, areas, distances, volumes, and centroid of solids.   |
| 2  | L | Lets you pick points that are off the construction plane. Requires two points to completely define the point.  |
| 3  | C | Creates a copy of the objects flipped over a specified axis on the construction plane.   |
| 4  | K | Unites curves that meet at a common end, making a single curve. It can unite curves that do not touch, if you select them after the command has started. |
| 5  | G | Lengthens an object to make it end precisely at its intersection with another object or you can lengthen an object when there is no intersection.        |
| 6  | T | Connects two curves by extending or trimming them to intersect or to join with a beveled line. Works on convergent or intersecting lines.                |
| 7  | D | Tools for selecting specific points on existing objects.   |
| 8  | J | Connects two lines, arcs, circles, or curves extending or trimming them to intersect or to join with a circular arc.                                     |
| 9  | S | To draw a line around.   |
| 10 | A | Divides one object with another, or a curve at a point. Divides the object where it intersects of the cutting object, but does not delete anything.      |
| 11 | H | Changes the size of existing objects without changing their shape.   |
| 12 | R | Makes multiple copies of selected objects.   |
| 13 | I | Displays the coordinates of the pointer, the status of the model, options, and toggles.  |
| 14 | Q | Sub-toolbars that include different options. Buttons are marked with a small white triangle in the lower corner.   |
| 15 | B | Standing at right angles to the plane of the horizon, meeting another line at a right angle.   |
| 16 | P | Displays different views of the model within the graphics area.  |
| 17 | E | Restricts the movement of the cursor to specific angles. Normal angle is 90 degrees.   |
| 18 | O | Lists commands you enter and information produced.   |
| 19 | N | Creates an object parallel or concentric to another object.  |
| 20 | F | Making contact at a single point or along a line, touching but not intersecting.   |

### True / False (1 pt. ea.)



























- |    |   |  |
|----|---|--|
| 21 | T | All NURBS surfaces contain curves.   |
| 22 | T | All surfaces can be edited by moving their control points.   |
| 23 | F | Surfaces can only be untrimmed.  |
| 24 | T | Parameter lines on a surface can also be referred to as isocurves.   |
| 25 | F | If two or more surfaces are joined together, but do not enclose a volume, the resulting object is a solid. |
| 26 | F | The arrow keys in Rhino nudge your page view up, down, left, and right.                                    |
| 27 | F | In Rhino, all surfaces are not 3D NURBS.   |
| 28 | F | You cannot turn on the control points on single surface solids.  |
| 29 | T | You can use point editing on meshes, curves, and surfaces.   |
| 30 | F | Polysurfaces can be edited by using control points.  |

**31** What are the five fundamental geometric objects in Rhino: (5pts)

- a. points
- b. curves
- c. surfaces
- d. solids
- e. polygon meshes, polysurfaces

**Match each of the buttons on the main toolbar with its command. (10 pts.)**

**Button**

	New file		Rotate		Hide objects
	Open file		Zoom		Edit layers
	Save		Zoom window		Object properties
	Cut		Zoom extents		Shade
	Copy to Clipboard		Zoom selected		Render
	Paste		Right view		Create spotlight
	Undo		Set CPlane origin		Options
	Undo view change		End Object snap		Help
	Pan		Select all		

**EXTRA CREDIT: What does NURBS stand for?**

Non-uniform rational B-splines

## Final Exam

### Match the following Rhino commands:

- |    |       |  |
|----|-------|--|
| 1  | _____ | Are used to find lengths, angles, areas, distances, volumes, and centroid of solids.   |
| 2  | _____ | Creates a surface from shape curves that follows along a rail curve. This command controls one edge of the surface.                                      |
| 3  | _____ | Standing at right angles to the plane of the horizon, meeting another line at a right angle.   |
| 4  | _____ | Creates a round on the edge of a polysurface or solid.   |
| 5  | _____ | Unites curves that meet at a common end, making a single curve. It can unite curves that do not touch, if you select them after the command has started. |
| 6  | _____ | Revolves a shape curve holding one end along a rail curve.   |
| 7  | _____ | Extrudes a curve perpendicular to the construction plane with the option to taper the surface with a draft angle.  |
| 8  | _____ | Creates a surface from shape curves; the normal option makes a surface with no creases as it passes over the shape curves.                               |
| 9  | _____ | Makes a curve around an axis to create a surface.  |
| 10 | _____ | Makes a smooth surface between two existing surfaces.  |
| 11 | _____ | Creates a copy of the objects flipped over a specified axis on the construction plane.   |
| 12 | _____ | Creates a surface from shape curves that follows along two rail curves. The two-rail sweep allows you to control the surface's edges.                    |
| 13 | _____ | Creates a rectangular flat surface parallel to the construction plane from two diagonal points.  |
| 14 | _____ | Lists commands you enter and information produced.   |
| 15 | _____ | Creates a surface that goes through a set of curves and or point objects.  |

### Match these terms

- |   |                   |   |               |    |                |
|---|-------------------|---|---------------|----|----------------|
| A | Blend Surface     | K | Chamfer       | U  | Patch          |
| B | Sweep 1           | L | Object Snaps  | V  | Array          |
| C | Extrude           | M | Fillet        | W  | Status bar     |
| D | Sweep 2           | N | Fillet Edge   | X  | Flyout toolbar |
| E | Loft              | O | Circumscribed | Y  | Join           |
| F | Mirror            | P | Elevator Mode | Z  | RailRevolve    |
| G | Scale             | Q | Revolve       | AB | Viewports      |
| H | Command line      | R | Perpendicular | BC | Ortho          |
| I | Analysis commands | S | Split         | CD | Offset         |
| J | Extend            | T | Plane         | DE | Tangent        |

### For 5 points

16 What are the five fundamental geometric objects, NOT SHAPES in Rhino:

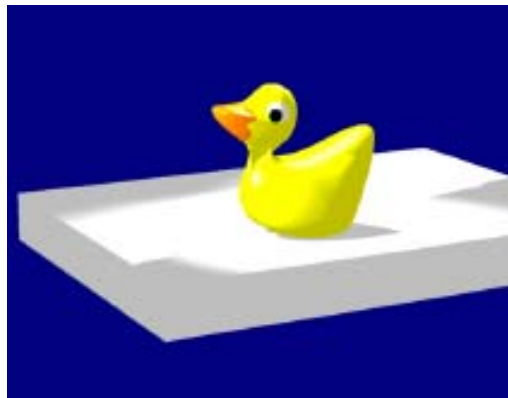
- a.
- b.
- c.
- d.
- e.

**Computer Section Timed: 30 minutes****17 Re-create the duck model.**

Now that you are Rhino experts, you should be able to re-create the duck that we worked on in class.

You will do the following:

- Create a simple surface.
- Rebuild the surface (so it will have control points).
- Edit surface control points.
- Draw a project curve.
- Split a surface.
- Blend between two surfaces.
- Light and render the model.
- Print out in wire frame and in a rendered view.



It is more important that you complete the above steps than to create a great-looking duck.

**Final Exam — Instructors Copy****Match the following Rhino commands:**

- |    |   |  |
|----|---|--|
| 1  | I | Are used to find lengths, angles, areas, distances, volumes, and centroid of solids.   |
| 2  | B | Creates a surface from shape curves that follows along a rail curve. This command controls one edge of the surface.                                      |
| 3  | R | Standing at right angles to the plane of the horizon, meeting another line at a right angle.   |
| 4  | M | Creates a round on the edge of a polysurface or solid.   |
| 5  | Y | Unites curves that meet at a common end, making a single curve. It can unite curves that do not touch, if you select them after the command has started. |
| 6  | Z | Revolves a shape curve holding one end along a rail curve.   |
| 7  | C | Extrudes a curve perpendicular to the construction plane with the option to taper the surface with a draft angle.  |
| 8  | E | Creates a surface from shape curves; the normal option makes a surface with no creases as it passes over the shape curves.                               |
| 9  | Q | Makes a curve around an axis to create a surface.  |
| 10 | A | Makes a smooth surface between two existing surfaces.  |
| 11 | F | Creates a copy of the objects flipped over a specified axis on the construction plane.   |
| 12 | D | Creates a surface from shape curves that follows along two rail curves. The two-rail sweep allows you to control the surface's edges.                    |

- 13 T Creates a rectangular flat surface parallel to the construction plane from two diagonal points.
- 14 H Lists commands you enter and information produced.
- 15 U Creates a surface that goes through a set of curves and or point objects.

**For 5 points**

**16** What are the five fundamental geometric objects, NOT SHAPES in Rhino:

- a. Surfaces
- b. Polysurfaces
- c. Curves
- d. Points
- e. Solids

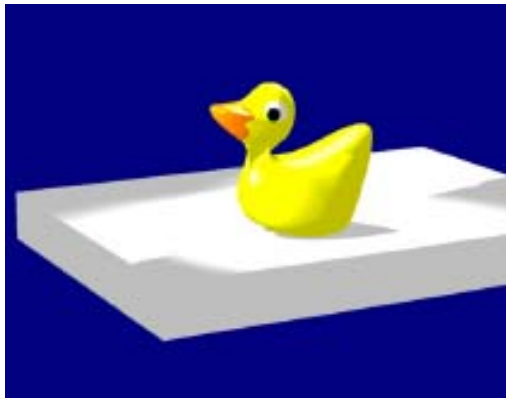
**Computer Section Timed: 30 minutes**

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- Edit surface control points.
- Draw a project curve.
- Split a surface.
- Blend between two surfaces.
- Light and render the model.
- Print out in wire frame and in a rendered view.



It is more important that you complete the above steps than to create a great-looking duck.

## Sample 10 Week Syllabus for Industrial Design CAD Skills Course

**Fall Quarter -Monday and Wednesday 5:00 – 8:00 PM**

Instructor: Jerry Hambly  
Office: ETEC 337, office hours by appointment  
Phone: 360-630-4500  
Email: [xx@wwu.edu](mailto:xx@wwu.edu)

Computer skills covered in the course include: Rhinoceros (surface & solid modeling), Flamingo (rendering), Adobe Photoshop (raster based), and Adobe Illustrator (vector based).

Required for Industrial Design majors.

### ***Using Rhinoceros students will learn to:***

- Create 3D models
- Edit 3D models
- Render 3D models for visualization
- Render 3D models for presentation
- Export 3D models for manufacturing

### ***Using Illustrator students will learn to:***

- Create logos
- Import and export drawings

### ***Using Photoshop students will learn to:***

- Make composites
- Print presentation graphics

Instruction will consist of lectures, group demonstrations, small group activities, and projects.

### ***Course outline:***

- Wed., Sept. 25 Introduction, Rhino basics, drawing with coordinates, simple surfacing
- Mon., Sept. 30 2D geometry creation and editing
- Wed., Oct. 2 Free-form curves and editing, control point editing
- Mon., Oct. 7 Surfacing and surface editing, 3D text creation
- Wed. Oct. 9 Surfacing and surface editing and project development
- Mon. Oct. 14 Project development
- Wed. Oct. 16 Exporting 3D models (STL, IGES, AI)
- Mon. Oct. 21 Project development
- Wed. Oct. 23 Basic rendering
- Mon. Oct. 28 Flamingo rendering
- Wed. Oct. 30 Flamingo rendering (custom materials, settings, decals)
- Mon., Nov. 4 Advanced surfacing
- Wed., Nov. 6 Illustrator basics
- Wed., Nov. 13 Illustrator (Logo design)
- Mon., Nov. 18 Illustrator (Page layouts and printing)
- Wed., Nov. 20 Introduction to Photoshop
- Mon., Nov. 25 Photoshop (Rendering)
- Mon., Dec. 2 Photoshop (Making Composite Images)
- Wed., Dec. 4 Project completion
- Mon., Dec. 9 Final presentations



**Grading**

- Weekly Design assignments 50%
- Student Notebook 10%
- Final Project 40%

**Weekly Design assignments**

- All assignments must be completed on time to receive credit.
- Students must be able to demonstrate knowledge of modeling and drawing techniques.
- Assignments must be turned in on Wednesday or received by email on Friday of each week.

**Student Notebook**

- Students must keep a notebook containing their projects for the entire semester.
- Students are required to keep all handouts, sketches, photographs, computer printouts, projects, and any other information that pertains to the class in the notebook.

**Final Project**

- A composite display board that consists of rendered model images, photos, logo design, and at least one merged image. The displays should include enough text and graphics to describe the final design assignment.
- A written report to accompany the display board that describes the processes used.

**Grading Rubric**

A	4.0 points	Unique/innovative design and all of the elements presented with excellence
B+	3.5 points	All of the elements well presented
B	3.0 points	Most of the elements adequately presented
C	2.0 points	Some of the elements adequately presented
D	1.0 points	Some of the elements shown
F	0.0 points	None of the elements adequately presented

## Teacher Contributions

The following examples of handouts, design briefs, and finished student project presentations have been submitted by teachers that are using Rhino in their classrooms.

If you would like to share your ideas with other teachers, submit your project ideas, handouts, design briefs, and student examples to:

Jerry Hambly  
Director of Education & Training  
Robert McNeel & Associates  
3670 Woodland Park Ave. N.  
Seattle, WA 98103  
[jerry@mcneel.com](mailto:jerry@mcneel.com).

Submit the material in MS Word document or Rich Text format with embedded graphics.

Updated information will be available to download from our web site: <http://www.rhino3d.com>

*Student handout on Problem Solving Process by Skip Carlson  
Technology Teacher, Mountlake Terrace High School, Mountlake Terrace, Washington, USA*

## **Problem Solving**

# A Process For Solving Problems

**T**hink through the problem.

**H**arness information.

**I**dentify the best solution.

**N**ow do it.

**K**eeP evaluating.

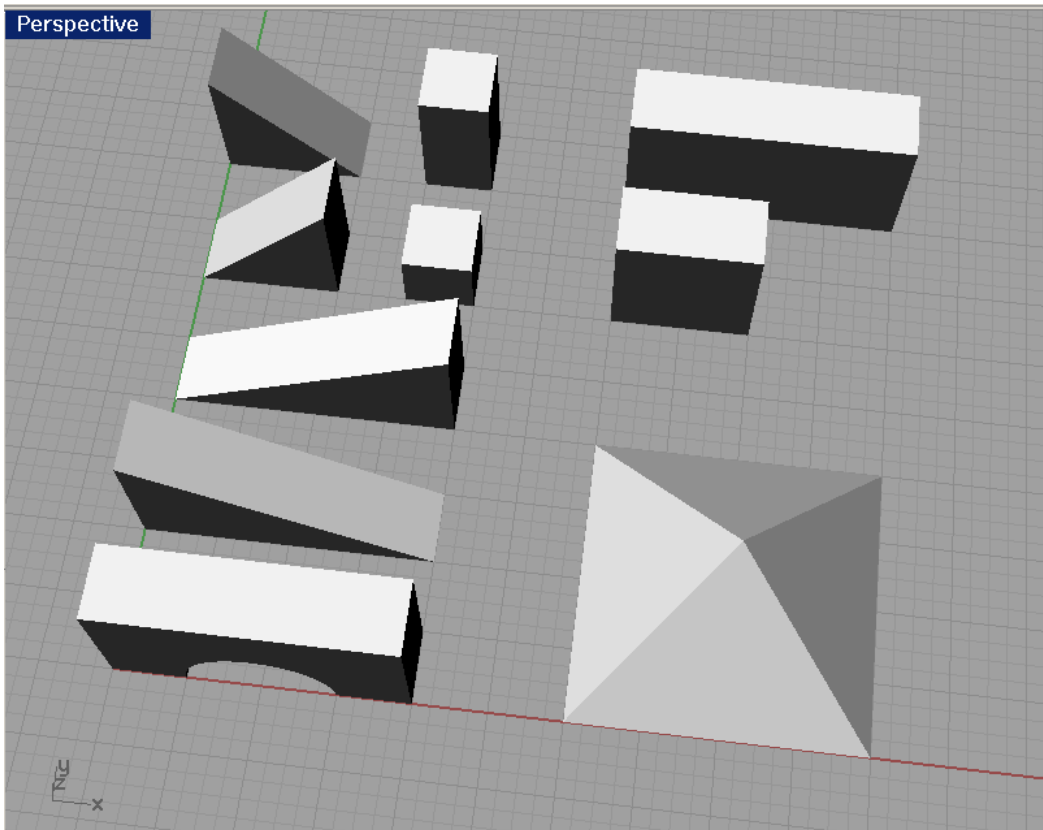
This process is incorporated into all of the curricula in this document. This process was designed by Skip Carlson, Mountlake Terrace High School.

*Student handout for an Introductory 3D Design Assignment by Doug Stuivenga  
McNary High School, Keizer, Oregon, USA  
Stuivenga\_Doug@salkez.k12.or.us*

### "Fun with Blocks" activity

I give the students a template that has some pre-drawn blocks, and show them how to copy and move in 3D. Also how to scale in 2D and 3D. This is to help them learn to navigate the viewports and get comfortable with switching between shading and the various views. I have them stack the blocks up, doesn't matter whether they choose to make a castle or building of their design. The students who move quickest also get a lesson from me on light, color, and render.

**Note:** The blocks are "Blocks objects," also. Students can use the **Insert** command to add additional blocks to their model.



*Design brief submitted by Pete Sorenson, Technology Teacher  
Lake Washington Schools, Kirkland, Washington, USA  
PSorenson@lwsd.org*

## Reverse Engineer a mechanical device

**The Task:** You are going to create a Rhino model of an existing mechanical device. Please select a device that is 'mechanical' in its existing form. For example: An Ipod or Mp3 players, which have no moving parts are not the best choices. CD players, sink faucets, door hinges, clock mechanisms, and ski bindings are better because they contain moving parts that interact with each other.

### Design Restrictions

- 1 Device must be dissectible. You have to be able to take it apart.
- 2 Both external and internal parts must be measured with appropriate measuring tools.
- 3 After disassembly, the device must be reassembled to its original condition.
- 4 Measurements must be accurate to .001 inches wherever possible.



*Select a device that is easy to handle and appropriate for our classroom environment.*

**Estimated time: 14 class periods**

### Math Issues

- Proper Units for Model
- Accurate measurement
- Fit, Scale, and Tolerance
- Angular measurements
- Radial & Linear measurements

### Presentation:

A completed Rhino model.... On screen for review and saved as a Rhino.3dm file

A completed Rhino Page Layout, 24 x 18, printed on the big printer with Border lines and a Title block with a detail containing:

- overall dimensions of the assembled device
- a Rendered 3d perspective of the assembled device
- a Ghosted 3d image of the assembled device
- at least one internal part of the device

A completed 8.5x11 Document with a brief explanation of the project and at least three colored images of the model as part of the document. Include a photograph of the original device as part of this document too.

*Design brief submitted by Pete Sorenson, Technology Teacher  
Lake Washington Schools, Kirkland, Washington, USA  
PSorenson@lwsd.org*

## Building a Pi Tape

- 1 Use a template or set units to inches.
- 2 Construct a standard *6 inch* ruler with divisions to  $\frac{1}{16}$  inch precision.
- 3 Label the ruler down to the  $\frac{1}{4}$  inch increments.
- 4 Make sure to put your full name on the ruler.
- 5 Total height of the ruler should be *no more than* .375 inches, *including* text
- 6 Copy the ruler and scale one copy by the value of **Pi**. (*If using a letter size printer you will need to split your Pi scaled ruler into several parts to fit the paper*)
- 7 Make sure you have an accurate “reading line” as well as a means of holding the tape when measuring.
- 8 Using the materials provided, test your Pi tape. Use your standard ruler to measure the diameter and the Pi tape to measure the circumference. If your work is accurate the rule and the tape will agree. Check the accuracy of your ruler with a “factory” ruler.

**Estimated time:** 3 class periods

**Materials:** Paper, Scissors, clear tape, cylindrical container.

**Questions to answer:**

- 1 Which method of measuring diameter is more accurate?
- 2 If your scale for the ruler was incorrect, what would the result be?
- 3 What scale factor would you use to build a ruler that would yield the circumference if you measured the diameter?



## Teacher Notes for Pi Tape

### CAD skills

- Line
- Trim
- Copy
- Rectangular Array
- Relative Position
- Copy
- Move
- Scale
- OSNAP
- ORTHO

### Math skills

- Use of calculator
- Ratio/Scale
- Percent of error
- Reading a ruler
- Diameter/Radius/Circumference

### Answers for the questions

- 1 The Pi tape should be more accurate as it will measure an object that is somewhat “out of round”. While directly measuring the “diameter” could be either across the “short” or the “long” dimension of the cylinder.
- 2 The error would be magnified by 3.14.
- 3 1 divided by 3.14



### A challenge

- 1 Repeat the exercise with a “Decimal” tape including a Vernier scale measuring to .001 inch.
- 2 Repeat the exercise with a “Pipe and Tube” tape that directly reads the pipe size when wrapped around the pipe or tube.



*Design brief submitted by Pete Sorenson, Technology Teacher  
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## Building a Protractor using the laser cutter

### Design Restrictions

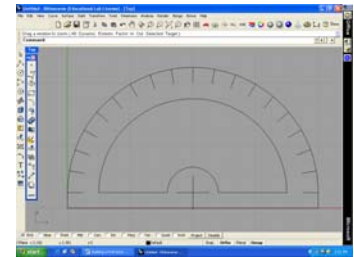
- 1 Must fit on a 4 inch by 3 inch piece of .125 inch transparent Acrylic.
- 2 Must include a 3-1/2 inch ruler with .0625 divisions.
- 3 All lettering must be on the side of the protractor that touches the material being measured.
- 4 Must measure in 1 degree increments.
- 5 Must include an alignment feature as well as a "center target".
- 6 Include your name and the school year as lettering on the protractor.

**Estimated time:** 2 class periods

**Materials:** 4 inch by 3 inch by .125 inch transparent Acrylic.

### Questions to answer:

- 1 Should the protractor read clockwise, counter clockwise or both?
- 2 Why is the lettering on the back side of the protractor?
- 3 What method is used to enable quick and accurate measurement?



### Teacher Notes for Building a Protractor

#### CAD skills

- Polar Array
- Trim/Split
- OSNAP  
Quad, Cen, End
- 
- Relative and  
absolute positioning
- Solid Text

- Arc
- Rotate
- Offset
- Layer
- Move
- Copy
- Mirror

#### Math skills

- Degrees
- Radius
- Diameter
- Inches

### Answers for the questions

- 1 It can read either direction or both. *Our CAD system would read counter clockwise if using it to describe a relative move.*
- 2 To compensate for *parallax*
- 3 The varied length of the tick lines make it easy to quickly compare the values in degrees.

### Terms

- 1 **Center target:** Cross hairs for the *vertex* of the angle being measured.
- 2 **Alignment feature:** A means to ensure the protractor is aligned with the base line of the angle.

### Materials

- Clear Acrylic is satisfactory. Either "green edge" or fluorescent green are easier to use.

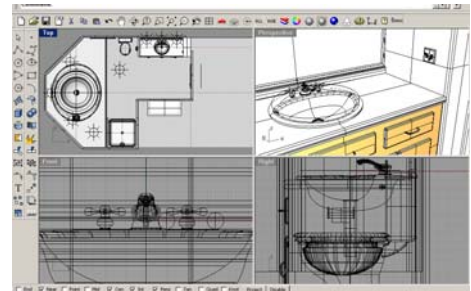
*Student handout for Room Design Project by Mark Schneider  
Technology Teacher, Ferndale High School, Ferndale, Washington, USA  
mschneider@ferndale.wednet.edu*

## **Advanced CAD Design**

### **Room Design Project:**

#### **Problem statement:**

Often times in design, the final presentation is all that matters. A project that took several people months to complete may not be appreciated because of poor rendering, scene selection or description of the project. If projects are to be worthwhile, they must be presented in the best manner and in as natural a setting as possible. With this in mind, we are going to design a room to serve both as a project and a realistic setting in which to insert future projects.



#### **Design Parameters:**

- The room must be recognizable as a certain type of room (game room, media room, kitchen etc.)
- The room must contain several elements to be considered complete:
  - A floor and two walls minimum
  - Fixtures, lights, switches etc. must be realistic and present
  - Two pieces of furniture minimum
  - A focus piece for the room
  - Realistic lighting and textures

#### **Learning Goals and Assessment:**

Through this project you will demonstrate the ability to accurately create, texture and render a scene in 3 dimensional space using Rhinoceros.

You will be assessed on your ability to meet the design parameters and complete the project on time. Creativity and attention to detail are also considered in assessment of design parameters. For more detail see assignment rubric.



*Student handout for Room Design Project by Mark Schneider  
Technology Teacher, Ferndale High School, Ferndale, Washington, USA  
mschneider@ferndale.wednet.edu*

### **Advanced Cad Design, Ferndale High School Engineering and Design**

#### **Room Design Rubric**

<b>Criteria</b>	<b>Levels of Mastery</b>			
	Poor (1pt)	Fair (2pt)	Good (3pt)	Excellent (4pt)
<b>Final Rendered View</b>	Few elements of the design are visible in rendered view. Does not contain a clear focal point of the room, two pieces of furniture, nor a floor and walls.	Some elements of the design are visible in rendered view. Contains one of the following: clear focal point of the room, two pieces of furniture, a floor and walls.	Most elements of the design are visible in rendered view. Contains two of the following: clear focal point of the room, two pieces of furniture, a floor and walls.	All elements of the design are clearly visible in rendered view. Contains all of the following: clear focal point of the room, two pieces of furniture, a floor and walls.
<b>Lighting</b>	Render is not realistically lit. Lighting fixtures do not affect direction of light nor shadows.	Render contains one of the following lighting elements: Realistic brightness for lighting fixtures, shadows are cast in correct direction and shadow intensity is appropriate for fixtures and natural light in room.	Render contains two of the following lighting elements: Realistic brightness for lighting fixtures, shadows are cast in correct direction and shadow intensity is appropriate for fixtures and natural light in room.	Render contains the following lighting elements: Realistic brightness for lighting fixtures, shadows are cast in correct direction and shadow intensity is appropriate for fixtures and natural light in room.
<b>Textures</b>	Render contains textures that are not realistic and are not sized correctly for the items they are on.	Render contains one of the following texture elements: material textures are realistic for the type of room, textures are sized correctly for each item, background textures (through window) are realistic	Render contains two of the following texture elements: material textures are realistic for the type of room, textures are sized correctly for each item, background textures (through window) are realistic	Render contains all the following texture elements: material textures are realistic for the type of room, textures are sized correctly for each item, background textures (through window) are realistic
<b>Details</b>	Finished render contains none of the following elements: Fixtures are appropriate in finish and placement. Details, plants, accent items are not the focus of the room. Details add to natural, realistic look of the room.	Finished render contains one of the following elements: Fixtures are appropriate in finish and placement. Details, plants, accent items are not the focus of the room. Details add to natural, realistic look of the room.	Finished render contains two of the following elements: Fixtures are appropriate in finish and placement. Details, plants, accent items are not the focus of the room. Details add to natural, realistic look of the room.	Finished render contains all of the following elements: Fixtures are appropriate in finish and placement. Details, plants, accent items are not the focus of the room. Details add to natural, realistic look of the room.

Please take a few moments and reflect upon the project you have just completed. Please rank yourself according to the rubric in each of the categories. In a separate Word document, please explain how and where you ranked yourself according to the rubric. Also, please evaluate:

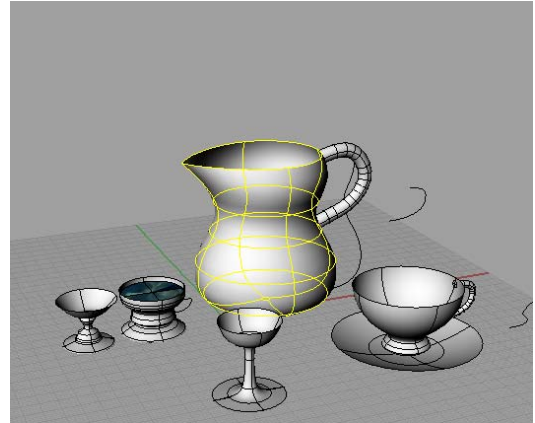
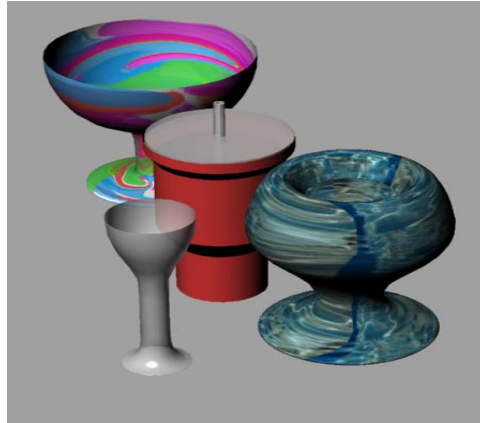
- 1 The finished project
- 2 Your work
- 3 Your learning during this project.

*Tutorial submitted by Janis Brown  
Eanes High School, Austin, Texas  
Janis.Brown@eanes.k12.tx.us*

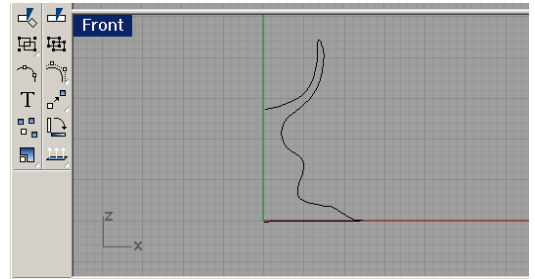
## Containers and Textures

(One period project)

**Make glasses, mugs, bowls, cups, and something of your choice:**



- 1 Make a profile line in the front view.
- 2 Use revolve to revolve your glass (**Menu: > Surface > Revolve**)
- 3 Make sure you do not have a top on your container or it will be solid.
- 4 Make a marble texture 7 tall x 5 wide in PH at 72 dpi (resolution).
- 5 Save a jpeg in your folder with your other textures you have used for Rhino.
- 6 Apply texture to one container



### **Making texture larger in Photoshop:**

- 1 Get a texture from Brown's Multimedia, textures and open in PH
- 2 Make canvas about 3x larger
- 3 Duplicate the texture to fill canvas (if there are large seams apply a Gaussian blur)
- 4 Apply this new texture to second glass
- 5 Make third glass your choice of colors but transparent like glass
- 6 Put a **transparent liquid** in one. Handle and pouring side on one.
- 7 Fourth glass, your choice, but be creative like the sample above. Put a top and a straw for better grade.

This is a screen grade (graded on your computer screen—no printed copy necessary).

**I would like the render file only**, but you must save it in your home folder for future use.

Render file must have your name on it.

*Tutorial submitted by Janis Brown  
Eanes High School, Austin, Texas  
Janis.Brown@eanes.k12.tx.us*

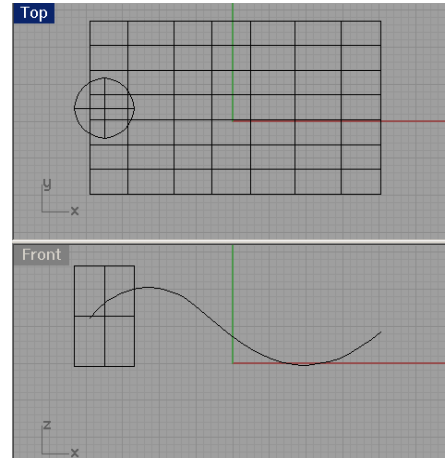
## Trim or Split a Surface

### ***With a Solid, Line and Surface***

Surfaces can be trimmed and split with curves or other surfaces. When you trim a curve the, trimmed parts are deleted. When you split a curve, both parts are left.

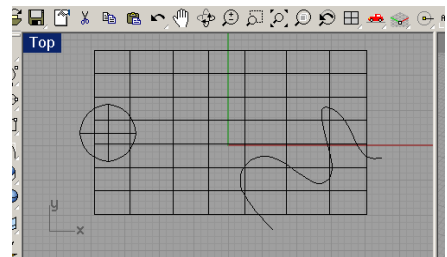
#### ***Trim a shape with a solid cylinder***

In the front view, make a curve. Extrude the line to make a surface. Rebuild surface. See sample. Make a cylinder in front view. Place cylinder to overlap the surface in **top** view and through surface in the **front** view. Using the trim tool and following the commands, click on the cylinder first and on the inside of the cylinder getting the surface second. Move the cylinder out of way. There should be a cut in your surface the shape of your cylinder



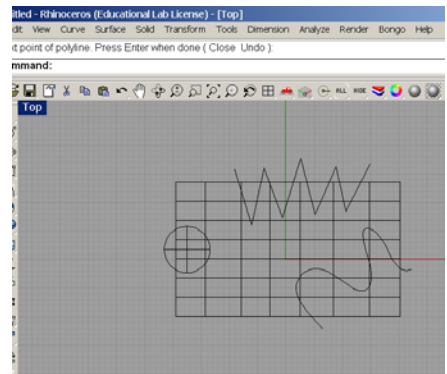
#### ***Trim a shape with a line.***

In **top view** draw a curve line through the surface. Make sure they are line up on top of each other in front view. Using the trim tool follow the commands.

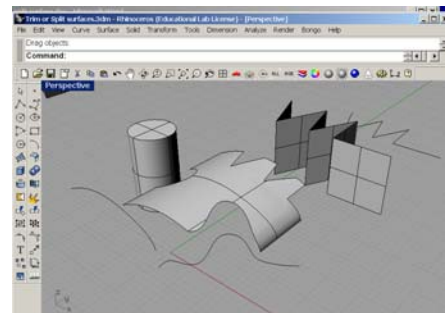


#### ***Trim a shape with another surface.***

In **top view** make a zigzag line with line tool. Extrude the line to make a surface. Using the trim tool follow the commands.



#### ***Finished sample***



*Student handout on Design Process by Karll Rusch  
Technology Teacher, Bellingham High School, Bellingham, Washington, USA,  
krusch@bham.wednet.edu*

## **The Design Process**

The design process is a way of organizing all of the issues and information that must be considered to allow a design team to work together professionally.

### ***Determine the Need***

Determining the need may be hard. Inevitably, there will be more than one need to be satisfied. This could be a problem someone brings you or one that you identify yourself.

### ***Problem Definition***

"Determine the need then convert the need to a problem. Define the problem. Next, make sure you understand the Problem.

### ***State the Problem***

Enter the creative problem-solving cycle with a statement of a problem that pertains to a specific topic. This is a statement describing what the solution to the problem should do and what constraints are being imposed.

- An open-ended question
- An existing condition in need of change
- A kit of materials provided to design and build something

### ***After you define the Problem...***

#### ***Find a place to imagine***

The design process is whatever you make it. You may make the mistake of researching how others solved similar problems (this is the cookbook solution), or you can find a place and let go. Using only the knowledge you already have, ask yourself, "How would I do this?" Use only the information that is between your ears to solve the problem.

#### ***Let go***

The more innovative designers in the world have a secret—they don't worry about looking foolish! They ask *what if* and follow that with free flowing ideas, without bothering to try to make sense or logic of it.

If you are working within a group, it is rare to find the *group* coming up with new ideas. At best, groups help define the problem, stimulate and get innovative people thinking. At there worst, groups strong-arm thinking and the chosen approach is a compromise. Compromise is not a bad word. It is, in fact, what engineering is; but it has no place in the ***innovative process***.

#### ***Try several approaches***

It is important to think of several ways of doing the same thing. Beware of falling-in-love with any single approach too early; this is the kiss-of-death. It's like a tune you can't get out of your head. You cannot think of another way of doing it.

#### ***Do a paper design on each approach***

A paper design can be anything from gestures (quick 15-second sketches) to a CAD layout to formal flowcharts. Whatever way you do it: Do It! The quicker you can get several different views spread out in front of you, the better.

**Remember:** Form does not replace function.

### ***Gather Information***

Before attempting to develop solutions, the designer must become familiar with the influencing factors associated with the problem. Now that you have some handle on what you are doing, you can start to use cookbook. The way others have attacked the same kind of problems will be less apt to prejudice you.

Things you should consider at this time:

- What attempts have others made to solve this problem?
- What are the size, stresses, loads, and power requirements?
- What appearance and ergonomic factors are involved?
- Brainstorm a list of possible solutions to the problem.
- What must the product do (function)?
- What materials will be used to make the product?
- How will the product be put together?
- How much will it cost to make?
- How much will the consumer pay for the product?
- What are the safety issues?

### ***Evaluate your Designs***

Evaluating your approach against others is a check on your powers of observation, analysis, and synthesis. In other words, design. This is a great way to compare and do a reality check.

### ***Modify Design***

When comparing the various ways of doing something, several things happen. The problem may become clearer to you. Now you are ready to fine-tune your design, or to go back to square one and do it again.

NOBODY is PERFECT! Making mistakes is part of sharpening your skills.

### ***Rank Each Design***

You might use a matrix or chart to quantitatively compare each idea. Example (Scoring 5 = high, 1 = low)

Specification	Weight	Concept 1		Concept 2		Concept 3	
		Score	Wt. Score	Score	Wt. Score	Score	Wt. Score
Cost to produce	4	5	20	5	20	3	12
Size	5	2	10	3	15	3	15
Durability	4	4	16	4	16	4	16
Assembly Time	3	5	15	4	12	3	12
Aesthetics	3	3	9	2	6	4	12
Total			70		69		67

### ***Pick the Best Design***

Based on the rankings, choose the design that appears to have the most going for it.

***Keep Remaining Designs Active***

Do not throw away the remaining designs! Often, after pursuing the chosen approach, flaws are revealed, and the designer must go back to square one.

Good designers have other approaches waiting in the wings. They can carry on with little lost time.

Periodically revisit and rethink all of your initial designs using your recently gained insights on the problem at hand.

A word or two of caution: If you do decide to abandon an approach, don't do it until you have tried everything and are convinced on the evidence that this way will not fly. Do not abandon it because you *feel* it won't work, know!

***Keep an Engineering Notebook***

Write everything down. Document! Document! Document!

Keep the notebook up to date, and have it witnessed often by those you trust and who understand your work. This can mean the difference between owning the patent rights to your work or not! It can jog the memory and reduce the number of times you do the same tests.

***Build Prototypes***

This is the construction step of the process. Appearance is more important here, but only insofar as the need to sell the idea or product. Debug and test prototype.

***Test and Evaluate***

The solution should always be evaluated against the requirements established in the design brief and against the original problem statement. Testing the solution to see if it handles the load, operates correctly, meets appearance requirements, is reliable, and solves the problem is an important part of the design process. Evaluating the result should address the need for improvements, changes, etc.

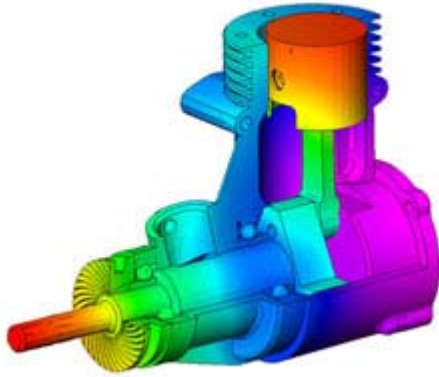
***Redesign and Improve***

This is where the evaluated and tested solution may be re-worked and re-tested. At this stage, the appearance of the product takes on more importance.

*Student handout on 3D Printing by Karll Rusch  
Technology Teacher, Bellingham High School, Bellingham, Washington, USA  
krusch@bham.wednet.edu*

## **Design Engineering Advanced**

### **3D Printer Assignment**



#### **Problem statement**

You are working for an industrial design company that models new product ideas for a variety of companies. You are given freedom to redesign a product that is already in industry.

#### **Parameters**

The 3D Printer has a modeling bed that measures 10"x8"x8" it takes about 1 hour per inch in the z-axis to develop. Your model needs to be much smaller as the cost for material is high and you are just designing a prototype for viewing by your client.

In order to model your design you have the following parameters that you must adhere to:

- Must be a closed solid polysurface (solid). It can contain hollow parts but no part can be a surface without thickness.
- Must be thick enough that the walls do not collapse. This will vary depending on the span.
- Create a mesh model from the NURBS model. Adjust the quality of the mesh to get the results desired when it is printed. Use the 'flat shade' command so you can see the mesh. Check Properties to insure that the model is made of 'closed polysurfaces'.
- Export the mesh as an .stl file. Do not export Open objects.

#### **Presentation**

Present your product in two forms:

- A 3D model from the Rapid Prototyping machine.
- A rendered model with materials, lights, and 'background' printed in color.

*Student handout on Logo Design by Karll Rusch  
Technology Teacher, Bellingham High School, Bellingham, Washington, USA  
krusch@bham.wednet.edu*

## Business Logo Design

Just one look at a logo can tell who you are and what you do thus a logo is one of the most important parts of your business. Since it is so important, you need to design a logo that gives the best representation of your company.

### **Project Assignment:**



To design a business logo for a small company you own. You will create a logo that can be cut on the vinyl cutter and fits in a maximum space of 3" x 3".

### **Task:**

Invent a company name that deals with Industrial Design then create a company name and Logo that represents your company. Research different logo designs and come up with your own design. You will cut out the design in vinyl and apply it to a surface. Make sure you understand the constraints with vinyl signs.

Learning Expectations:

- Develop a design concept and follow it through
- Understand the different logo categories, and be able to design a successful logo
- Create a business logo



*Grading rubric for Car Accessories Assignment by Karll Rusch  
Technology Teacher, Bellingham High School, Bellingham, Washington, USA  
[krusch@bham.wednet.edu](mailto:krusch@bham.wednet.edu)*

## Car Rack Accessories

### Grading Rubric

#### Mission Statement:

Contains action verbs	0	1	2	3
Tells who they are	0	1	2	3
Length of mission statement (should be short)	0	1	2	3

#### Logo:

Originality	0	1	2	3	4
Recognizable	0	1	2	3	4

#### Design:

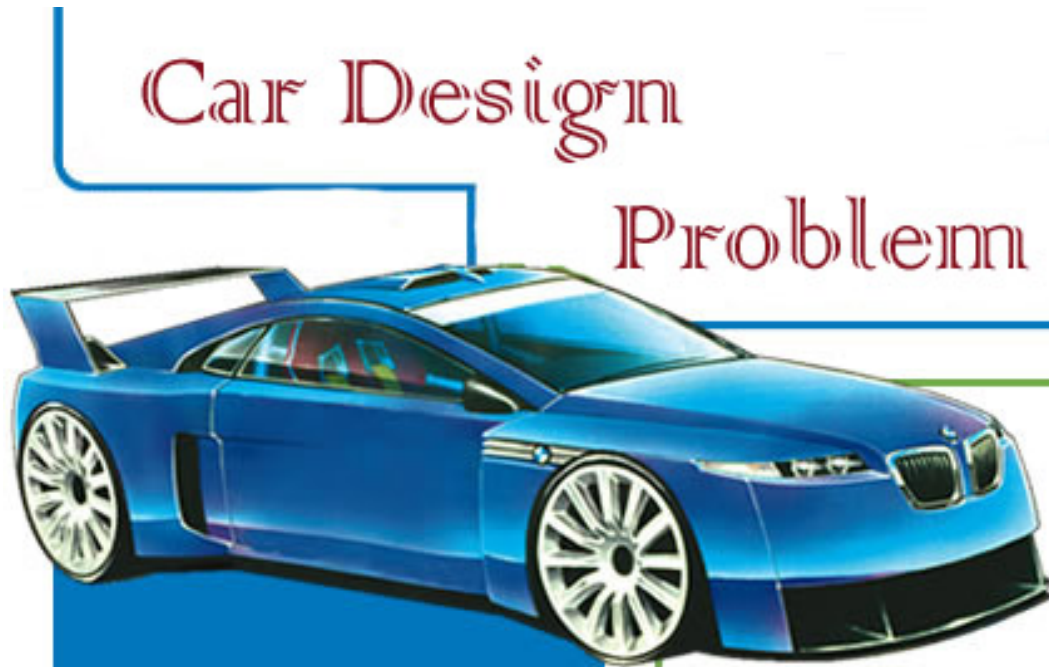
Ergonomic	0	2	4	6	8	10
Original	0	2	4	6	8	10
Meets Criteria	0	2	4	6	8	10
Appropriate design for function	0	2	4	6	8	10

#### Presentation:

Well organized	0	2	4	6	8	10
Rendering & lighting	0	2	4	6	8	10
Student appearance	0	2	4	6	8	10

*Student handout on Car Design by Karl Rusch  
Technology Teacher, Bellingham High School, Bellingham, Washington, USA  
krusch@bham.wednet.edu*

## Design Engineering Advanced



Motor Trend has launched their annual International Design Contest, challenging hundreds of amateur, student and professional designers from around the world to redesign a car of the future.

This year theme is, "Turn the Car of Today into the Car of Tomorrow," challenging contestants to redesign a current model for the year 2025

The vehicle can be of any category and have any number of wheels. It can be a commuter, sports car, rescue vehicle, taxicab, or even a vehicle with a new concept... anything that takes advantage of small size.

### **Your task:**

- To use Rhino and design a 3D car complete with rendering.
- Bring the design into a specification sheet that will give important detail about the car.
- Specification sheet should include over all render
- Zoomed in detail of car
- Add any written detail about the car you deem important as a selling point.

*Student handout on Concept Development and Design by Karl Rusch  
Technology Teacher, Bellingham High School, Bellingham, Washington, USA  
krusch@bham.wednet.edu*

## **Red Raider Enterprises**

### **Program Offering for Concept Development and Design**

Effective October 9, 2000, Red Raider Enterprises is offering a remuneration program for the acceptance of new product concepts and designs meeting published guidelines which may vary, without notice, from time to time.

#### **Concept Development and Design**

##### ***The submission of a new design must include the following:***

- 1 A mini-model to scale carved out from foam or in some other material deemed acceptable by Red Raider Enterprises Director of Operations.
- 2 The mini-model must be uniform and include all features.
- 3 A concept document must be submitted with the mini-model, which details all specifications and defines the basic concept of the product. Plans, details, or ideas for targeted markets, methods of marketing or presentation, included or adaptable features, and how to accessorize should also be included in this document. The more factual or realistic data provided which supports the basic concepts, the likelier the design will be accepted.
- 4 The mini-model design must not copy or appear to duplicate the existing designs from other companies.
- 5 Red Raider Enterprises Product Development Team may limit the number of new mini-model designs it will accept for review within certain time periods or may limit the type of mini-model designs to certain styles or designs for targeted markets.
- 6 The inventor of the mini-model design must agree to assign any and all rights to the particular design submitted to Red Raider Enterprises.
- 7 The inventor of the mini-model design may be requested by Red Raider Enterprises Product Development Team to make modifications to the basic mini-model before agreeing to accept the design.
- 8 To receive remuneration for the new design, Red Raider Enterprises Development Team must agree to accept the mini-model design, along with the required documentation, as a viable/marketable design, which it wishes to pursue development of to take to market.
- 9 All dispute resolutions in regards to any matter associated with this program will be made at Red Raider Enterprises Product Development Team's sole discretion.

#### **Remuneration**

*Upon meeting all requirements and being accepted by Red Raider Enterprises Product Development Team, remuneration for a mini-model design will be paid as follows (No other remuneration will be granted):*

- 1 Red Raider Enterprises will pay the inventor 5 extra credit points at time of acceptance.
- 2 Additional 5 extra credit points will be paid the inventor when sales of the developed invention exceed 10 units or at the end of the semester which ever comes earlier.
- 3 If unit sales of the invention exceed 25 units another 10 points will be given to the inventor.
- 4 And finally, if the unit sales exceed 50 units another 10 points will be given to the inventor.
- 5 In summary, the minimum the inventor will receive for the accepted design is 5 points and the maximum is 40 points.

*Student handout on Container Design by Karll Rusch  
Technology Teacher, Bellingham High School, Bellingham, Washington, USA  
krusch@bham.wednet.edu*

## **CONTAINER DESIGN (2 WEEKS)**

You are a packaging company which designs, manufactures, and markets' containers for specific products. Your company has been approached by a foreign exporter who needs to package a product that will withstand 75 pounds of pressure and will have an airspace of 1000 cubic centimeters. Since this company is overseas it would not be cost effective to send these containers assembled and empty. You must send them over flat and have the foreign company assemble them in their own country. This is a Third World country and they have limited resources so assembly must **not** require additional material such as glue, tape, staples, etc.

### **Action**

- 1 Form a company with another student
- 2 Pick a Third World Country
- 3 Design a container in one or two pieces
- 4 Make a prototype and assemble container
- 5 Test for strength
- 6 Disassemble and refine design
- 7 Make final copy
- 8 Design a company or product logo
- 9 Assemble container
- 10 Display finished product
- 11 Test

### **Grading:**

- 10 points for logo and design
- 10 points for accurate measurements (1000 cc airspace)
- 10 points if it holds required load

*Student handout on Mechanical Mechanism Project by Karll Rusch  
Technology Teacher, Bellingham High School, Bellingham, Washington, USA  
krusch@bham.wednet.edu*

## **Mechanical Mechanism Project**

### ***Build a Mechanical part.***

This part should fit other parts and enhance either the structural or the mechanical system

### ***Competencies:***

As a result of this project the student should be able to demonstrate:

- Measurement skills with calipers and micrometers.
- An ability to convert between measurement systems.
- An ability to scale parts.
- Some understanding of designing with nominal parts
- The ability to control the effects of tolerance build-up when either machining or designing parts.
- The ability to use multiple tool paths to create a part or interrelated parts.
- Ability to model design in 3 Dimensional software.

### ***Equipment Needed:***

- CAD/CAM system
- Resource materials

### ***Steps to complete project:***

- Draw part geometry
- Develop ordered sequence of tool paths
- Cut part out of material selected for prototyping
- Assemble part and test for fit and operation
- Make modifications as needed & retest
- Make final Product

Final Project should be done with various light & dark woods. Apply a finish to the wood. See examples in book.

*Student handout on Toy Design and CNC by Karl Rusch  
Technology Teacher, Bellingham High School, Bellingham, Washington, USA  
krusch@bham.wednet.edu*

## Educational Toy Design

### Project Summary



*Toys are a great way to learn about science, engineering, and the design process*

### Design a child's educational toy

#### Project Assignment

Explore a series of products, targeting education, to enhance learning. Consider the possibility of designing children's toys that are educational and at the same time fun. Depending on their function, they can be designed using multiple materials.

#### Task:

Research what toys are currently available. Using Rhino and possibly CNC machines design a toy that can be constructed in class that targets children 3-8 years of age.

#### Parameters:

You have been given the following limitations from the manufacturer:

- Lightweight
- Should be simple and easy to use
- Safe for children 3-8
- Should be easy to store if toy requires multiple pieces
- Need a design in 2 weeks
- The aim is to make learning a playful process, increase interaction between children and take into consideration the physical and mental development of the children

#### Presentation:

Present your game design to the "client" in the form of a specification sheet(s). Tell what materials were used and give overall dimensions in specification sheet.

*Student handout on Game Design by Karll Rusch  
Technology Teacher, Bellingham High School, Bellingham, Washington, USA  
krusch@bham.wednet.edu*

## **Game Design**

### **Problem:**

Design a strategy game that can be built at school. The game must be your own design or an improvement on an existing game.

### **Design Brief:**

Game must be designed and manufactured in class. Must be intended for 8 year olds through adult with rules easy to follow and fun to play.

### **Steps:**

#### **Information Gathering:**

Before attempting to develop solutions, the designer(s) must become familiar with the influencing factors associated with the problem.

- 1 What strategy games are already on the market, which ones have patents?
- 2 Things to consider: Function, shape, size, materials, cost, production, and appearance.

#### **Generate Alternative Solutions:**

- 1 Brainstorm ideas.
- 2 Alter or improve on an existing game that does not have a patent.
- 3 Sketch your ideas (minimum of 3)

#### **Choosing the Solution:**

- 1 From your list choose the one which best satisfies the problem
- 2 statement.
- 3 Defend your solution in writing.

#### **Prototyping:**

This is the actual construction step of the process. Appearance is more important here, but only so far as the need to "sell" the idea or product. The device or product should be operational and quality work in evidence.

#### **Testing and Evaluation:**

At this stage you should evaluate your product against the requirements established in the design brief. Test your product and ask the questions; what improvements can be made on the design and how can I better manufacture the product to make it more efficient and cost effective to build?

#### **Redesign**

At this stage you should be creating a finished product.

#### **Final Product should include:**

- Prototype or mold
- Final Product
- Rendered Drawing
- Orthographic Projection drawing with dimensions
- Rules to the game (this should be in presentation form)

*Student handout on Tool Design by Karll Rusch  
Technology Teacher, Bellingham High School, Bellingham, Washington, USA  
krusch@bham.wednet.edu*

## **Tool Design (2 WEEKS)**

You are given a box of different Plexiglas circles. All of the different sizes have multiple matching circles. As a Cub Scout leader you are planning to have a car race competition using the circles as wheels. The problem is none of the circles have the center point located for the axle. Your task is to design and make a tool that will accurately locate the center of all the various size circles.

### **Action**

- 1** Brainstorm (write, sketch possible design ideas)
- 2** Gather information (similar tools on the market, mathematical solutions, etc.)
- 3** Evaluate your design against what is out there
- 4** Modify as needed
- 5** Rank each design
- 6** Pick the best design
- 7** Redesign if necessary
- 8** Create finished product as a rendered drawing
- 9** Present your design in the form of a specification sheet.
- 10** Include working drawings showing overall dimensions.
- 11** Describe what materials were used.



*Student handout on Key Chain Design for 3D Printing by Karll Rusch  
Technology Teacher, Bellingham High School, Bellingham, Washington, USA  
krusch@bham.wednet.edu*

### **Design Problem**

## **Key Chain**

### **Problem statement:**

Your high school wants to sell a set of key chains for this school year. The ASB has found a company that will make it for them. ASB officers have heard that you know how to design things using 3D modeling software. They want you to come up with a mock-up design and a prototype for the key chain. They will then take that design to the manufacturer to have the key chain made. The ASB has set the following parameters for the key chain.

### **Parameters:**

- 1 The over all size should be no more than 1/8" thick. The width and height of this key chain should be no larger than 1.5" by 2".
- 2 One side of the key chain should display some representation of the school such as the school logo (you may want to redesign or design something that would represent BHS) and the other side should display the school name and possibly the year you graduate.
- 3 When saving file as an STL you must make sure that it is a closed solid with all surface edges joined.

### **Note:**

You will turn in 2 parts to the assignment.

- 1 Two rendered views showing both sides of your key chain.
- 2 An STL file that will be printed on the 3D printer.

### **Suggestions:**

- 1 You can add material to the object but remember when making a 3D part this will not be recognized.
- 2 This means all designs must be surfaces or solids.
- 3 When adding text to the backside you must use the solid command in the text dialogue box. Your text can either be indented (subtracted from the key chain or embossed (added)).
- 4 All surfaces must be joined with no naked edges or it will not print 3D.

*Student handout on Kitchen Tool Design for 3D Printing by Karl Rusch  
Technology Teacher, Bellingham High School, Bellingham, Washington, USA  
krusch@bham.wednet.edu*

## Kitchen Tool Design (2 WEEKS)



Add spice to any kitchen by redesigning a common tool found in the kitchen. Your task is to survey the kitchen for common household tools. Find one or two tools and ask/check about its function and ergonomic design. Your task is to follow the action plan below and redesign and improve a tool from the kitchen.

### **Action**

See Instructor for Design Loop we will work through to a prototype.

- 1 State the Problem as a Design Brief (problem statement)
- 2 Brainstorm (write, sketch possible design ideas)
- 3 Gather information (similar tools on the market, mathematical solutions, etc.)
- 4 Evaluate your design against what is out there
- 5 Modify as needed
- 6 Rank each design
- 7 Pick the best design
- 8 Build a prototype

*Student handout on Lego Part Design by Karll Rusch  
Technology Teacher, Bellingham High School, Bellingham, Washington, USA  
krusch@bham.wednet.edu*

## **Lego Project**

### ***Build a LEGO part you can't buy***

This part should fit existing LEGO parts and enhance either the structural or the mechanical systems offered by the manufacturer.

### ***Competencies:***

As a result of this project the student should be able to demonstrate:

- 1 Measurement skills with calipers and micrometers.
- 2 An ability to convert between measurement systems.
- 3 An ability to scale parts to allow for shrinkage of cast parts.
- 4 Some understanding of designing with nominal parts
- 5 The ability to control the effects of tolerance build-up when either machining or designing parts.
- 6 The ability to use multiple tool paths to create a part or interrelated parts.
- 7 Ability to model design in 3 D software.

### ***Equipment Needed:***

- 1 CAD/CAM system
- 2 Plastic molding station
- 3 LEGO parts
- 4 Resource materials

### ***Steps to complete project:***

- 1 Draw part geometry
- 2 Develop ordered sequence of tool paths
- 3 Cut wax pattern
- 4 Prepare chase for silicone
- 5 Mix, vacuum and pour silicone
- 6 Pour Urethane
- 7 Remove part and test for fit and operation

*Student handout on Multiple Function Design by Karll Rusch  
Technology Teacher, Bellingham High School, Bellingham, Washington, USA  
krusch@bham.wednet.edu*

## Multiple Function Assignment

### **Problem statement:**

A manufacturing company that wants to create a product that serves multiple purposes has approached you and you have been given the task to design two products into one that can be marketed.

### **Ideas for getting started:**

Observe what people are doing with their leisure time and what things they are wearing, using etc. Come up with a theme or idea to focus on.

Example: camping, hiking, hanging out with friends, tools, etc.

Below is an example with a short description about a product and the inspiration for the design.



*Inspired in both form and function by the dragonfly, this product combines the functions of an MP3 player, headphones, and sunglasses. The link is most evident in the prominent emphasis on the eyes and the flexible temples and earphones that mimic the dragonfly's abdomen as they wrap around the ear. The MP3 controls are integrated into the sides of the glasses and are designed to allow easy hands-only use.*

### **Presentation:**

Design your product in Rhino, Render using Flamingo, Penguin, or Rhino and bring it into Publisher with a short explanation similar to the example above. Your explanation should include a little bit about the product and what inspired the design.

Design brief for replication of a product by Bob Koll ([bkoll@mcneel.com](mailto:bkoll@mcneel.com))  
and Pete Sorenson ([PSorenson@lwsd.org](mailto:PSorenson@lwsd.org))  
Technology Teachers, Lake Washington Schools, Kirkland, Washington, USA

## Replication brief: Model an Existing Product or Mechanical Device

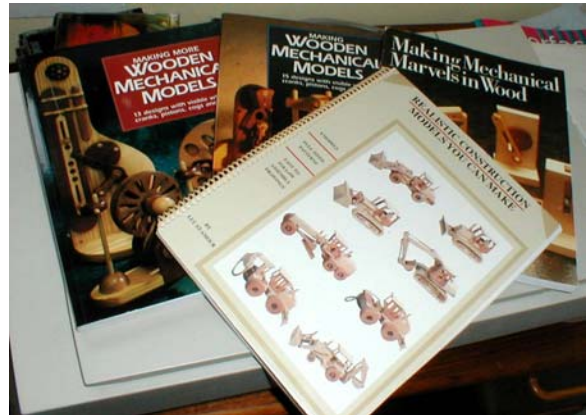
### The Project

Original design is often overrated. Further, it is important to dissect, analyze, take apart, use tools, measure, play, and figure out how it works.

Duplicate or redesign an existing product. Sports equipment, tools, automobiles, bikes, toys, clocks, or mechanical devices are great sources for inspiration.



Miniature Toy Mountain Bicycle

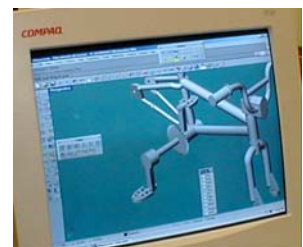


Resources for projects

This sample is a toy picked up at a local department store. From the photo, you will be able to determine the process used to move from the actual object to the Rhino 3d model. Most of these devices are very complicated. It is appropriate the break up the device into its component parts and give a component or two to a team of students.

### The Process

1. Determine downstream requirements for the 3-D Rhino model.
  - 8 Rendered part in a scene for presentation, paper, or web page
  - 9 Rapid prototyping
  - 10 CAM/CNC  
Wax/silicone/urethane parts
  - 11 Other output
2. Disassemble the device.
3. Decide which components you'll model.
4. Takeoff: Use dial caliper or other appropriate measuring tools.
5. Create model of the parts using Rhino.
6. Manipulate the model for the downstream process.



*Examples submitted by Karl Rusch, Technology Teacher  
Bellingham High School, Bellingham, Washington, USA  
[krusch@bham.wednet.edu](mailto:krusch@bham.wednet.edu).*

## Mechanical Device Replication Ideas

One of the nice features of mechanical devices is that each part has to fit other parts so, that when assembled, they create a mechanical system that works. Building to standards is also a nice feature of mechanical devices. Using Lego as a design base is a nice way to move students into parts that must fit with existing parts.

Here are some sample projects:



*Geneva Mechanism*



*Fast Return Actuator*



*Sun and Planet Mechanism*



*The Scotch Yoke*

These parts were modeled in Rhino, exported to CAM software for tool path and NC translation. They were then cut in wax on a CNC machine. Then silicone molds were created. Urethane castings were made using the silicone molds.



*Design brief submitted by Pete Sorenson, Technology Teacher  
Lake Washington High School, Kirkland, Washington, USA  
[PSorenson@lwsd.org](mailto:PSorenson@lwsd.org)*

## Materials Science Project - Metallic Unit

### **Problem statement**

You are working as a designer for a manufacturing company that fabricates metal furniture. You have been given the task of researching and designing a patio chair.

### **Parameters**

You have been given the following limitations from the manufacturer:

- 12** Frame must be welded mild steel tubing.
- 13** Fabric will be used for the seat and back.
- 14** Need a design in five days.

### **Brainstorm**

Brainstorm at least three different designs—hand drawn sketches.

### **Select best one**

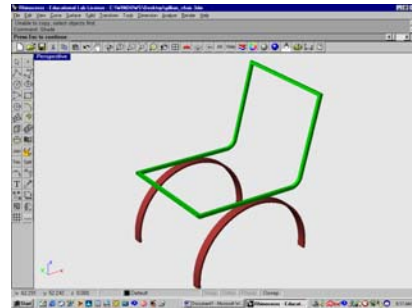
Select the best chair—give your reasons for that selection.

### **Develop the idea**

Develop your chair design further by producing several model files and renderings in Rhino.

### **Test/evaluate**

Evaluate your chair against the parameters, change anything if necessary.



### **Fabrication**

Lay out materials according to plans.

Cut and bend materials.

Weld materials together.

After chair is painted, install webbed seat and back.



*Design brief submitted by Michael T. Miyoshi, Engineering Technology Teacher  
Cedarcrest High School, Duvall, Washington, USA*

## Poster Design Project

### **Problem statement**

Your engineering design teacher wants to increase his enrollment for subsequent school years. In order to do so, he has enlisted you to create a poster that promotes his class to those students in the high school and the students who will be enrolled from the middle school.

Need to consider and/or investigate aesthetics, graphic design, text/font use, wording/grammar/etc.

### **Parameters (30%)**

- 15 The poster will be a C- (24x17) or D-sized (36x24) poster.
- 16 Graphics of projects that you have done (engineering/architecture) must be included.
- 17 Description of why students should take the class must be included.
- 18 Description of benefits of taking the class must be included.
- 19 A listing of who teaches the class must be included.
- 20 Specifics to generate interest for specific groups of students should be included.
- 21 Classroom teachers in the building(s) should be contacted as to the best way to promote the class in their particular classes.
- 22 How the subject material can help with subject matter of the classroom where the ad will be placed should be included.

### **Brainstorm (10%):**

Brainstorm at least three different poster designs—hand-drawn sketches.

### **Develop the idea (30%)**

Develop your poster design further by producing several layouts on small media (11 x 8.5).

### **Test/evaluate (10%)**

Show your small layouts to the instructor who will be displaying the ad, and have the instructor give suggestions and/or critiques.

### **Presentation (20%)**

Print out full-size layout, and have the instructor/staff member display the poster in an appropriate location.

### **Grading (40 points)**

All of the elements presented excellently and poster displayed	40 points
All of the elements presented adequately	35 points
Most of the elements adequately presented	30 points
Some of the elements adequately presented	20 points
Some of the elements shown	10 points
None of the elements adequately presented	0 points



*Design brief submitted by Michael T. Miyoshi, Engineering Technology Teacher  
Cedarcrest High School, Duvall, Washington, USA*

## Strategy Game Design

### Problem statement

You and 1 to 4 of your classmates (groups from 2 to 5 people) have decided that there are no good strategy games, so you decide to design a board game. Companies are always looking for new or redesigned games for children and adults to play. The game should be for people 8 years and older.

### Parameters:

Design a new (or improve an existing) board game.

- 23 Your target market is children 8 and up.
- 24 Determine what competition there will be for your game. (Specify game titles.)
- 25 Determine how many people can play the game.
- 26 Back up your decisions with research of competition.
- 27 Design the board layout, pieces, etc.
- 28 Create rules for the game.



*Knight and P(r)awn  
by Isaac Sprague*

Design the container (including graphics) for the game and all its pieces.

### Presentation

Create everything for the game. The board, needs to be printed full scale. A rendering of all pieces must be included. A rendering of the container or a prototype of the container must also be included. Dimensioned orthographic drawings of all the pieces (including the container) and drawings that show how the pieces fit in the container must be included. The rules must be created and written in a format that is understandable to the youngest players who will be able to play the game (8-year olds). A one-page description of the game to be used for retailers and a one-page magazine advertisement must also be included in the presentation package. An appendix to the submission will include sketches and brainstorming ideas including rationale for decisions.

### Alternative

Create new pieces for the game of chess. The presentation will be different in that a description of each piece, why its form was designed, and how it is distinguished will be included instead of the rules.

### Grading (80 points)

Unique/innovative design and all elements presented excellently	80 points	(A)
All of the elements presented well	70 points	(B+)
Most of the elements adequately presented	60 points	(B)
Some of the elements adequately presented	40 points	(C)
Some of the elements shown	20 points	(D)
None of the elements adequately presented	0 points	

*Student project submitted by Michael T. Miyoshi, Engineering Technology Teacher  
Cedarcrest High School, Duvall, Washington, USA*

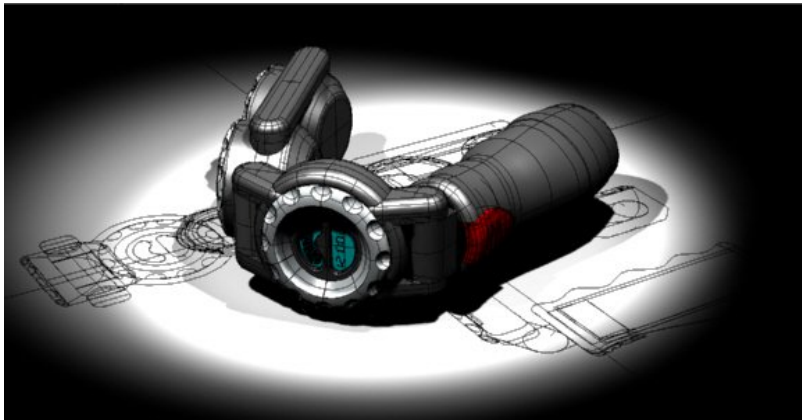
## **Finished Student Project Presentations**

The following example of a finished flashlight project is included to show what quality can be expected from students. The format of the written portion of the project is given as an example specification sheet that students can produce.

### **The Ultimate Flashlight**

*by Shane Winter, Cedarcrest High School (1999)*

# THE ULTIMATE FLASHLIGHT



**Unique Design:**

- 29 Dual shock-mounted xenon bulbs
- 30 Multi-hinged body
- 31 Red light night-vision filters

**Features List:**

- 32 Rubber coated, form-fitting handle
- 33 O-ring sealed, water impervious design
- 34 Retractable tripod
- 35 Battery meter
- 36 12 and 24 hour time
- 37 Alarm
- 38 Timer
- 39 Stopwatch
- 40 Large red on/off button
- 41 Operates on 2 C-sized batteries

**Overall Dimensions:**

- 42 6.5" x 5.0" x 3.0"

**Materials:**

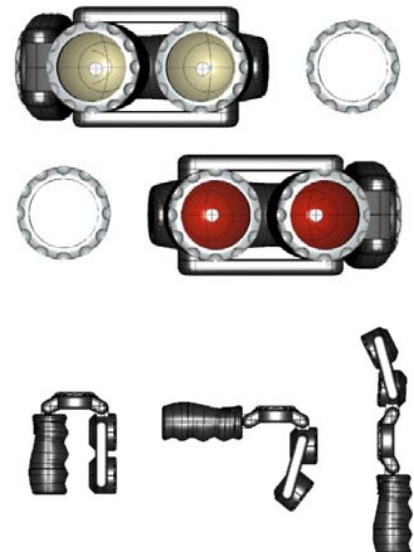
- 43 Machined aluminum
- 44 High-impact ABS plastic

**How tough is T.U.F.?**

Constructed of machined aluminum and high-impact ABS plastic, this flashlight will surely take a beating. The dual rubber-mounted xenon bulbs will provide ultra-bright light, hit after hit. The O-ring sealed compartments will keep the water where it belongs—outside.

**Unique Features—Deluxe Dual Bulb System and Hinged Body:**

The most obvious feature of The Ultimate Flashlight (T.U.F.) is the unique use of two complete light systems. This, along with providing more overall light, provides for a number of useful features that other flashlights simply cannot provide. Two complete lighting systems provide twice as much light as normal flashlights. The second light can also serve as a backup bulb in case one fails. The hinged body also makes it possible to light two different areas at the same time. Trail walkers can light the path and the trail ahead. Opposable hinges allow for a multitude of configurations. The formed and rubberized handle can be used held horizontally, like standard flashlights, vertically like a pistol grip, or anywhere in between so that the hand can be in a comfortable and natural position. With any handle position, T.U.F. retains the ability to point both its lights in any direction(s). By using the retractable tripod, it possible to use both hands while lighting desired areas.

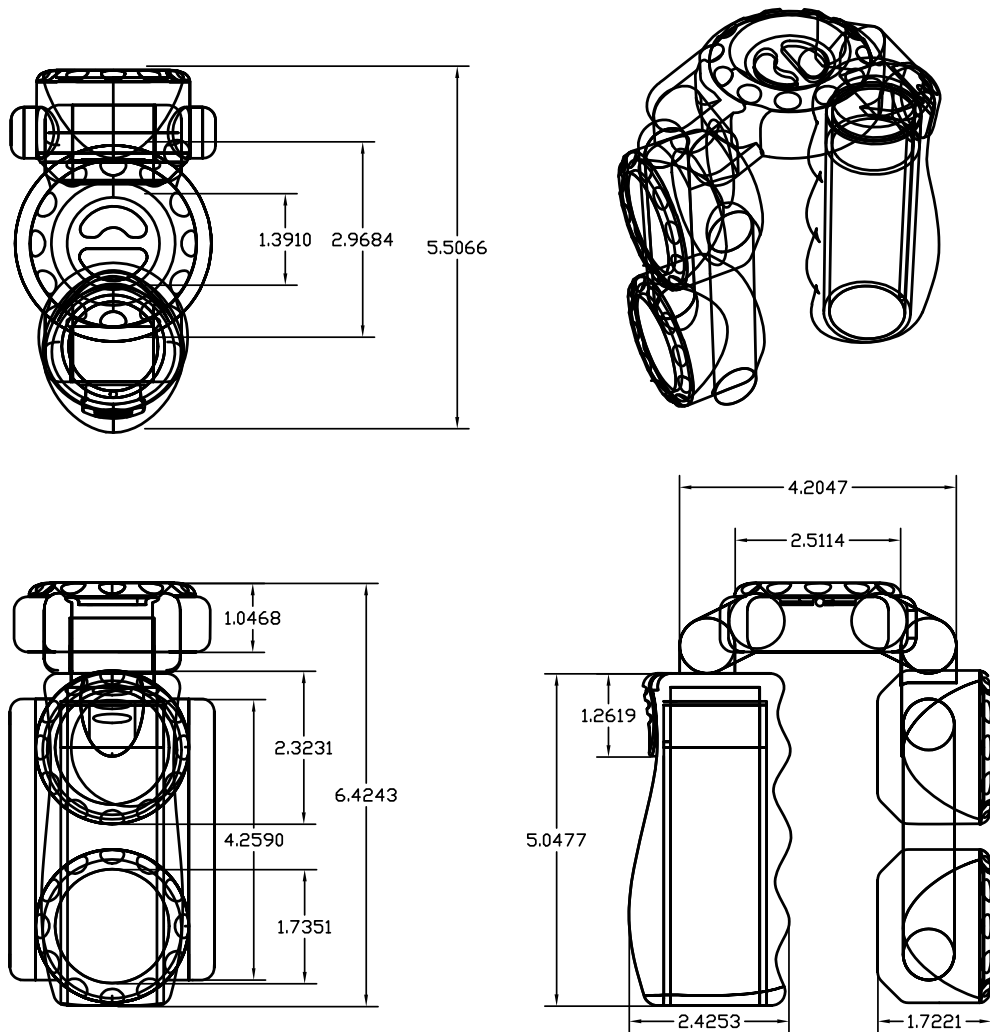


***Instant Red Light:***

For those jobs that require the retention of night vision, such as map reading, each bulb has an integrated red light filter. To switch between full white and night red, the user needs only to twist the ring on the front of each bulb case; no messing with colored filters that inevitably get lost.

***T.U.F. Convenience:***

As convenient as it is versatile, the T.U.F. light also has a built-in battery meter and full function timepiece, including 12- and 24-hour time, alarm, timer, and stopwatch. In the dark, the electro-luminescent backlight makes reading these displays easy.



*Dimensioned drawings*

*Student project submitted by Michael T. Miyoshi, Engineering Technology Teacher  
Cedarcrest High School, Duvall, Washington, USA*

### **Plane Model**

*by Isaac Sprague.*



*Isaac Sprague, Cedarcrest High School, June 5, 2000*

#### 1.1. Introduction

1.2. Isaac Sprague set out with a goal to increase his modeling expertise by accomplishing three challenges: a car, a plane and a boat. This is the completed plane model. A plane was to present many difficulties in modeling, especially if Isaac was to model to the accuracy he desired. The main goal Isaac presented himself with was to greatly increase his expertise.

1.3. Isaac Sprague has one year of Rhino experience. His skill is still only limited to simple designs, although he has improved greatly after conquering the first challenge, the car.

#### 2. Design Features

2.1. The model was that of a plane. Other planes inspired many of the parts. Its main fuselage design was based on the home build kit the Legacy 2000. The cowling was to be from the Legacy 2000 also, but modeling that proved to be too challenging. The empennage was based on the style Piper uses in their airplanes. The wings, horizontal stabilizer and vertical stabilizer are of a basic design. Overall, the plane is a lightweight, high performance and affordable plane. It could possibly be a home build kit.

#### 3. Design Process

3.1. At first, Isaac looked at Cessna, specifically the 152. He chose not to use the 152 mainly because the first attempt to model a plane failed. Next, he looked at several Pipers. Piper's simple plane is rather ugly and the other planes are fairly complicated. The Legacy 2000 was in a magazine of experimental and kit planes. It was simple and sleek. The same magazine was also used as a reference for the final rendering.

3.2. Plane modeling is rather difficult. The technique used for modeling a car could not be applied here. A car has a flat bottom where as a plane has contours on all sides. The NetworkSrf command can't handle closed input curves which would be required to make a basic plane model that is clean enough to edit further. Another difficult task was adding the faring on the wing root and the cap on the wing tip. The airfoil is an odd shape and isn't conducive to surface blends.

#### 4. Description of Parts

4.1. The plane logically organized itself into several layers. The method chosen to create the layers was simple; it was based on materials for the objects. There was a layer for the prop, spinner, cockpit glass, and stripe along the fuselage and the fuselage. The wings and stabilizers were with the fuselage because they were joined for neatness. There was also a layer for the curves used to create the various surfaces that would otherwise be in the way.



4.2. Layer: Glass. This layer contains the cockpit glass. It was textured with a shiny reflective glass material.

4.3. Layer: Body. This layer contains The Fuselage, wings, horizontal and vertical stabilizers. These were textured with a shiny reflective white. The texture was to resemble the lacquered skin of real planes.

4.4. Layer: Blades. This layer has the prop blades on it. They were textured with a matte gray with a subtle hatching. Motion blur was added for realism.

4.5. Layer: Spinner. This layer was for the nose cone. Originally, it was to have a colored swirl on it, but it ended up with the same texture as the body layer.

4.6. Layer: Stripe. This layer contained a section of the fuselage that was split apart. It was to simply create a colored stripe along the fuselage. It was the same texture as the body layer except it was colored a blue.

#### 5. Modeling

5.1. NetworkSrf: First the oval, where the spinner and intakes would be, was created. Then the lengthwise profile curves were created. These were open curves ending at a small rounded rectangle in the back. After these curves were created, the width profile curves were created. These were closed curves. Making the first set of curves open and the second set closed overcame NetworkSrf difficulties with closed curves. Using the curves, I used NetworkSrf to create a clean editable surface.

5.2. Surface Blends: The intakes were created by copying the surface and moving it back 6 inches. It was then scaled down and a surface blend was used on the surface edges; this created the smooth contours. The wings were attached to the main fuselage by blending them to a hole trimmed out of the fuselage with an enlarged version of the profile curve that was used to create them.

5.3. Extruding: An airfoil profile curve was created and then extruded for the wings and stabilizers. Using point editing and scaling the edit points added the tapers to wings.

5.4. Other Surface Creation: The wing tips were created by lofting the surface edge curve with a second curve and a point. The spinner was created by revolving a profile curve. The prop blades were created by two rail sweeps with several profile curves.

5.5. Splits: The cockpit glass was created in the original fuselage surface, which was then split by a curve that had been extruded. The stripe was created the same way.

5.6. Completing the Model: The wings and horizontal stabilizers were then mirrored over to the other side. All the surfaces were then joined.

## 6. Lessons Learned

- 6.1. Isaac gained valuable insight on ways creating the basic surface of a model. In addition, he learned the limitations and ways to get around them for the command NetworkSrf. He learned that modeling the plane to scale helped create correct proportions. The whole project improved Isaac's workflow efficiency and basic skills tremendously.

## 7. Time Spent

- 7.1. The first try took about 2 hours. Then Isaac spent 4 hours trying to figure out a way to avoid problems NetworkSrf has creating a surface such as a plane fuselage. The final plane took 5 hours. The renderings took an hour to set up and an hour to render all the images.
- 7.2. To accomplish the plane model again it would only take 4 hours to model and 2 hours to set up and render the images.

## 8. Competencies

- 8.1. 30001 - understands general modeling terms & techniques. This is demonstrated by creating any 3D model like a plane.
- 8.2. 30002 - models on other than world plane. By modeling a 3D model of a plane, I had to model off the world plane.
- 8.3. 30003 - manipulates drawing environment. The units, snap spacing, gridline spacing, and grid extents were all altered in the plane file.
- 8.4. 30004 - uses CAD tools. Rhino and Max were used for the plane.
- 8.5. 30005 - creates models at full scale. The plane was created to full scale.
- 8.6. 30007 - creates surfaces from polylines. NetworkSrf creates a surface from several polylines.
- 8.7. 30010 - performs point editing. The wings were edited in point editing.
- 8.8. 30012 - performs rail sweeps. The propeller blades were two rail sweeps.
- 8.9. 30013 - performs splits and trims. All surface blends involved trims before hand. The cockpit glass was split from the fuselage surface.
- 8.10. 30014 - creates scenes with lighting. The final rendering used several lights.
- 8.11. 30018 - imports and exports drawings or parts. The plane model had to be exported from Rhino to Max.
- 8.12. 30019 - uses object properties including textures. The object properties were used to switch layers. Textures were applied to the model in max.
- 8.13. 30020 - uses layers to organize model. The plane model was separated into several layers.
- 8.14. 30021 - changes rendering options. The rendering options were changed in Rhino for shading and in Max for the final render.
- 8.15. 30022 - plots drawings. The cover page has a plotted rendering.

## Glossary of Terms

BlendSrf:	Blends two surfaces. Creates a third surface between the surface edges that is tangent to both surfaces.
Cowling:	The piece on the front of a plane that holds the engine, includes the intakes.
Empennage:	French. This is the tail section of the plane, includes stabilizers.
Extrude:	Extrude a curve into a surface or solid. Make a surface with the same profile as the curve.
Fuselage:	The main body of the plane.

NetworkSrf:	Creates a surface from a network of curves.
Horizontal Stabilizer:	Stabilizes the pitch of an airplane.
Join:	Makes several surfaces into a polysurface or solid.
Loft:	Lofts a surface. Creates a surface from several profile curves.
Revolve:	Creates a surface by rotating it around an axis.
Split:	Splits a surface into several.
Sweep2:	Creates a surface with two sweep curves and multiple profile curves.
Vertical Stabilizer:	Stabilizes the yaw of an airplane.

### Renderings

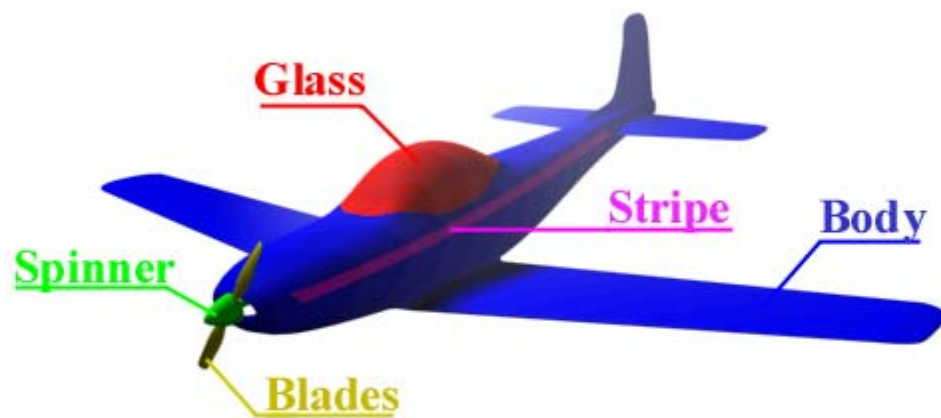


Fig.1 Layer Construction

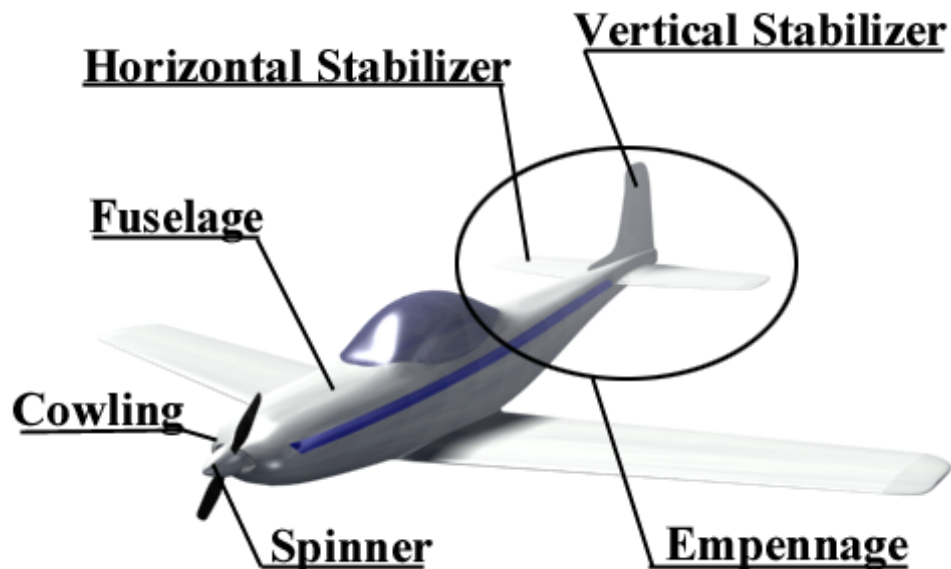


Fig.2 Terms



*Reverse Engineering Project submitted by Karl Rusch  
Technology Teacher, Bellingham High School, Bellingham, Washington, USA  
krusch@bham.wednet.edu*

## Wayland Marine Boat Seat Prototype

by Chris Howard

### Step 1 - Digitizing

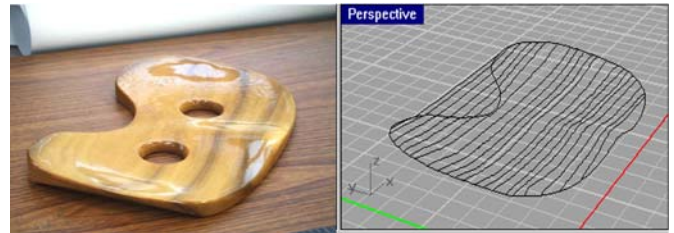
The first step in making this prototype is to digitize the original seat using the MicroScribe.

The MicroScribe is a 3-D digitizer used to digitally plot points on physical objects. It interfaces directly with Rhino, allowing you to create points or curves.



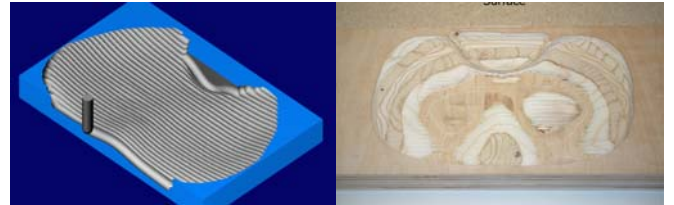
### Step 2 - Modeling

Rhino surface tools are used to create the surfaces from the digitized geometry.



### Step 3 - Import/Export

Export the Rhino surfaces to IGES and then import the IGES file to a CAM program.



### Step 4 - CAM

Generate a tool path in the CAM program.

### Step 5 – Contour an holes

Cut the holes and the outside contour for the seat. Note: The holes are not drilled through. The holes are drilled just deep enough so that when the top of the seat is cut, it meets up exactly with the holes, to prevent a blow out through the surface.



### Step 6 – Jig building

Make a jig to fasten the seat to the router table that uses the partially drilled holes for alignment.



### Step 7 - Machining

Cut the part on a CNC Router or milling machine to produce an exact copy of the boat seat.



*Class learning activity submitted by Pete Sorenson  
Lake Washington High School, Kirkland, Washington, USA*

## Reverse Engineer A Steam Engine

### ***The Project***

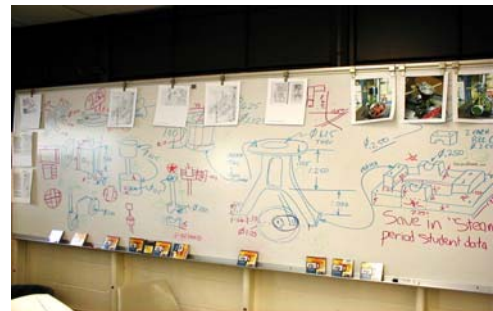
The high school engineering drafting class decided to build a 'working' steam engine using Rhino and a 3-D printer.



*Photo of Steam Engine*

### ***The Process:***

From whiteboard sketches, with added sizes, locations and tolerances, and a photo of an engine, we were able to reverse engineer a single cylinder steam engine.

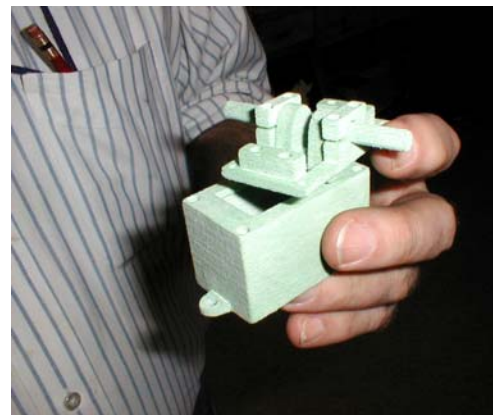


*Classroom Whiteboard with sketches, details, size*

### ***The Result***

By modeling in Rhino, saving in .STL format, we were able to create the actual parts, in full size using the ZCorp 3D printer. This allowed us to check our work and assemble the engine.

This process lead to a greater understanding of the requirements of interchangeable parts, as well as the relationship of the parts in a machine.



*Photo of RP Parts*

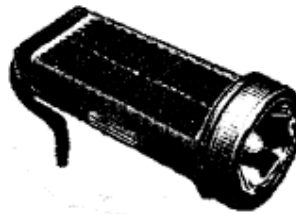
Design brief and finished student projects submitted by *Karll Rusch*  
Technology Teacher, Bellingham High School, Bellingham, Washington, USA  
[krusch@bham.wednet.edu](mailto:krusch@bham.wednet.edu)

## Unique Flashlight Design

Karll Rusch Bellingham H.S.

# Design Engineering Advanced

## Unique Flashlight Design



### Problem Statement

You are working for an industrial design company that creates new product ideas for a major outdoor/camping gear manufacturer. You have been given the task of designing a new rugged flashlight that incorporates a digital clock and alarm for campers. It should also include a battery life indicator.

### Parameters

You have been given the following limitations from the manufacturer:

- Should be lightweight for easy hiking.
- Clock incorporated seamlessly into design.
- Controls for clock should be easy to use.
- It should be simple and easy to use.
- Should be able to see the clock in the dark.
- It will use batteries of your choice.
- Need a design in 2 weeks.

### Brainstorm

Brainstorm at least three different flashlight designs—hand-drawn sketches and simple Rhino drawings.

### Select Best One

Follow the steps in the design loop and select your best flashlight—give reasons for the selection

### Presentation

Present your flash light design to the “client” in the form of a specification sheet(s) and working drawing(s) (dimensioned 3-view drawing). Tell what materials were used and give overall dimensions in specification sheet. Include rationale for selection of final design. Include sketches and notes.

## Spy Specs Example



### Features:

- Face Forming Design
- Heads Up Display
- Maximum UV Protection
- Flexible Fiber Optic Light
- Global Satellite Antenna
- Built in Headphones
- Adjustable Mic
- Full Visual Capabilities



### Materials:

- Titanium Frames
- Scratch/Shatter Proof Lenses
- Fiber Flex Aluminum
- Maximum Grip Material for both Ear and Nose Pieces



### What we offer...

The spy specs offer the ultimate in spy operations, everything from full audio briefings to a heads up display built into the lens. 9 out of 10 Covert-Ops specialist prefer the Spy Specs to any other leading competitor.

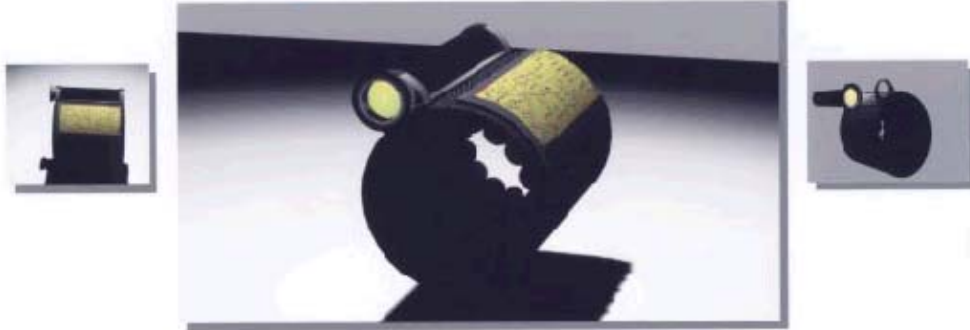
**World Class**  
Bellingham High School

**Designed  
By  
Chris Howard**



## The High Tech Flashlight Example

# The High Tech Flashlight



### GPS:

The GPS system is state of the art. It will locate you within a distance of two inches and comes with a digital clock.



A Detachable flashlight makes it easy to use for those times that you might not need the light at the wrist. The flashlight is light-weight and durable. The carbon body has a state of the art grip design,



### Wrist Band:

The soft rubber arm band comes in three sizes, S, M, & L. Each size has air inflated cushioning for added comfort.



The bulb in the flashlight is the new LED guaranteed to be brighter than a halogen, and last longer



By Craig McGarrity  
Bellingham High School

## The Gemini Flashlight Example

# The Gemini

Teacher: Karl Rusch  
Bellingham High School  
Bellingham, WA, 98225

### Description:

The Gemini is the headlamp for the outdoor enthusiast that demands exceptional quality and functionality. It's rugged design and extensive features list lends it to be the most advanced headlamp on the market. With the Gemini you can switch on the fly between lamps that can hold any type of 2 prong (Mag Light style) bulb, standard, halogen, xenon, and LED. Using the Gemini Triple Cluster LED bulb set it can reach a burn time of over one hundred hours. It's multifunction, projectable watch is also great for anyone who wants to know what time it is. The LCD display also has built in messaging symbols that can be projected, they include: HELP, SOS, OK, and many more.



### Advanced Features List:

- ✓ Dual lamp design for maximum longevity and illumination. One long range lamp and one wide view lamp, each uses any 6V 2 pronged bulb.
- ✓ Integrated LCD watch display over one lamp, can be projected on objects or used as a standard watch with alarm, lap timer, altimeter, chrono, and many other features when lamp is off, automatically mirrors display for projecting and normal viewing.

Designed by: Zach Turner

## The Gemini Flashlight Example (Page 2)

### Basic Features List:

- ✓ Fully rubber coated ABS body
- ✓ Runs on four AA Batteries that also charge the lithium ion battery in the watch so you never have to replace its battery
- ✓ Elastic straps are comfortable to the point of invisibility and provide exceptional support for the Gemini
- ✓ LCD display has a built in red Indiglo style illumination system to read display in the dark or to make the lamp light red to retain night vision
- ✓ O-Ring sealed design offers extreme waterproofness
- ✓ Lexan lens is unbreakable and resists scratching



Battery Pack

### Control Module:

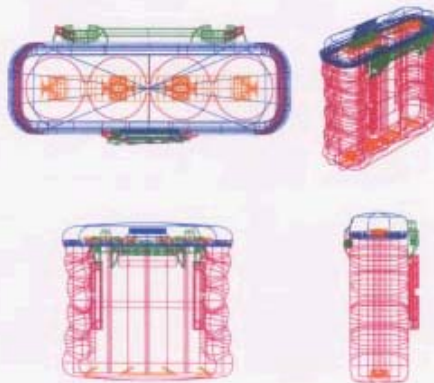
Lamp control, middle off, up=left light, down=right light, pull out to engage indiglo



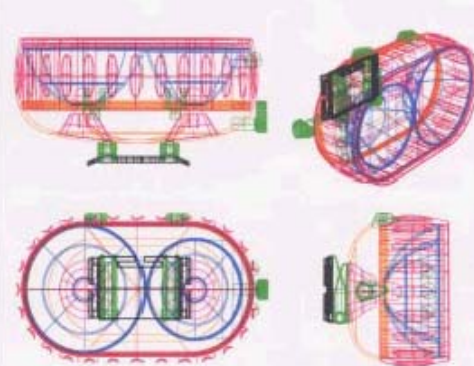
Function buttons, usage varies depending on mode

Main On/Off button, hold to turn on/off, then becomes mode button

### Battery Pack Detail



### Lamp Module Detail





*Final Project Example*  
*Etech 397D, Cad Skills for Industrial Designers, Western Washington University*  
*Student: Sean Matuschak*  
*Instructor: Jerry Hambly*

## Dinnerware Project





Final Project Example  
 Etech 397D, Cad Skills for Industrial Designers, Western Washington University  
 Student: Jonah Griffith  
 Instructor: Jerry Hambly

## Dinnerware Project

