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Table of Contents

Curriculum Guide ............................................................................................................. 1
  Technical Proficiency ........................................................................................................ 1
  Technical Adequacy ........................................................................................................... 2
  Sample Course Outline ................................................................................................... 4

Design Activities Process .......................................................................................... 4
  Instructions ....................................................................................................................... 5
  Ideas for Design Assignments ......................................................................................... 6

Sample Design Activities ........................................................................................ 7
  Example Problem Statements ....................................................................................... 7
  Evaluation ......................................................................................................................... 7
  Example 1 — Flashlight I ............................................................................................... 8
  Example 2 — Flashlight II .............................................................................................. 9
  Example 3 — Jack O’Lantern Design Project ................................................................. 10
  Example 5 — Key Chain I .............................................................................................. 12
  Example 6 — Key Chain II ............................................................................................ 13
  Example 7 — Room Identification Project ..................................................................... 14
  Example 8 — Whirl Bottle ............................................................................................... 15
  Example 9 — Cellular Phone ......................................................................................... 16
  Example 10 — Video Game Concept ............................................................................. 17
  Example 11 — Automotive Accessories ....................................................................... 18
  Example 12 — Toy Company ......................................................................................... 19
  Example 13 — Shoe Company ....................................................................................... 20
  Example 14 — Final Design Assignment ....................................................................... 21
  Rendering Tips ................................................................................................................ 22
  Examples of the Basic Lighting Technique ................................................................... 22
  Additional Rendering Tips and Hints ............................................................................. 22

Sample Fifteen-Week Syllabus .................................................................................. 23
  Course Description ......................................................................................................... 23
  Course Objectives .......................................................................................................... 23
  Textbooks and Materials ............................................................................................... 24
  Grading ............................................................................................................................ 24
  Portfolio Requirements and Rhino Competencies ......................................................... 25

Sample Week-by-Week Lesson Plans ....................................................................... 26

Worksheets ................................................................................................................... 29
  Worksheet 1 .................................................................................................................... 29
Sample Answer Sheet 1 30
Worksheet 2 31
Worksheet 3 32
Worksheet 4 33
Worksheet 5 34
Worksheet 6 35

Tests .......................................................... 36
Quiz 1 36
Quiz 1 — Instructor's Copy 37
Quiz 2 38
Quiz 2 — Instructor Copy 39
Midterm Exam 40
Midterm Exam — Instructors Copy 43
Final Exam 45
Final Exam — Instructors Copy 47

Sample 10 Week Syllabus for Industrial Design CAD Skills Course ....... 49
Grading 50

Teacher Contributions .................................................. 51
The Design Process 53
Replication brief: Model an Existing Product or Mechanical Device 56
Mechanical Device Replication Ideas 57
Materials Science Project - Metallic Unit 58
Poster Design Project 59
Strategy Game Design 60
Finished Student Project Presentations 61
The Ultimate Flashlight 61
Wayland Marine Boat Seat Prototype 69
Reverse Engineer A Steam Engine 70
Unique Flashlight Design 71
Spy Specs Example 72
The High Tech Flashlight Example 73
The Gemini Flashlight Example 74
Final Project Example 76
Final Project Example 77
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.

Rhinoceros 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.

Rhinoceros 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. Rhinoceros 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 Rhinoceros, 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. Models can be exported to other software programs for animation.

The biggest decision to make is your approach to teaching Rhinoceros. 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 Rhinoceros. 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 Rhinoceros Level 1 Training Manual as a textbook. Students will become familiar with most of the commands available in Rhinoceros before they begin their design projects. The sample schedule can be modified to take from four to six weeks to cover the basics of Rhinoceros.

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 Rhinoceros 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

<table>
<thead>
<tr>
<th>Week</th>
<th>Subject</th>
<th>Training Guide Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rhino basics</td>
<td>Chapter 2</td>
</tr>
<tr>
<td></td>
<td>Create two-dimensional objects</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Simple editing commands</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Precision modeling</td>
<td>Chapter 3 &amp; 4</td>
</tr>
<tr>
<td>3</td>
<td>Editing</td>
<td>Chapter 5 &amp; 6</td>
</tr>
<tr>
<td>4</td>
<td>Solids modeling</td>
<td>Chapter 7, 8, &amp; 9</td>
</tr>
<tr>
<td></td>
<td>Surface modeling</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Importing and exporting</td>
<td>Chapter 10, 11, 12 &amp; 13</td>
</tr>
<tr>
<td></td>
<td>Dimensioning</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Printing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rendering</td>
<td></td>
</tr>
<tr>
<td>6–18</td>
<td>Projects (See Sample Activities)</td>
<td></td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Week</th>
<th>Operation</th>
<th>Commands</th>
<th>Activity/Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Basic interface</td>
<td>Command line, changing viewports, Zoom, Pan, Undo/Redo</td>
<td>First model.</td>
</tr>
<tr>
<td></td>
<td>Solid primitives</td>
<td>Cone, Sphere, Box, Cylinder, Torus, Ortho mode, and Shade</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Basic editing</td>
<td>Move, Copy, Rotate, Delete, Mirror, Scale, and Object Snaps as needed</td>
<td>Chocolate bar, flashlight, alarm clock, camera, table, or stool.</td>
</tr>
<tr>
<td></td>
<td>Boolean operations</td>
<td>Union, Difference, Intersection</td>
<td>Create light and shadows on previous design activity and all future design activity.</td>
</tr>
<tr>
<td></td>
<td>Rendering</td>
<td>Properties, Spotlight, Render</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Creating curves and surfaces.</td>
<td>Line, Curve, Arc, Trim, Join, and Revolve</td>
<td>Drinking/wine glass, soda can, water bottle, Frisbee, baseball bat, vase.</td>
</tr>
<tr>
<td></td>
<td>Extruding surfaces</td>
<td>Circle, Ellipse, Extrude</td>
<td>2-D text of personal name, a product, a slogan, or slang.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rectangle, Rounded Rectangle</td>
<td>Create various 2-D surfaces (cookie cutter shape). Extrude them both straight and along a curve. Extrude 2-D text from previous activity.</td>
</tr>
<tr>
<td>3</td>
<td>Practice</td>
<td>Commands from week 1</td>
<td>Desk lamp, Christmas bell, ink pen, pool table, screwdriver, flowerpot, coffee mug.</td>
</tr>
<tr>
<td></td>
<td>Advanced editing tools</td>
<td>Fillet, Cap Planar Holes, Array</td>
<td>Floppy disk, Zip disk, computer monitor, calculator.</td>
</tr>
<tr>
<td>4</td>
<td>Sweeping surfaces</td>
<td>Sweep 1 Rail, Sweep 2 Rail</td>
<td>Pipes and tubes with various diameters along a path.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sweep to a point option</td>
<td>Animal tail, octopus, banana, headphones, stapler.</td>
</tr>
<tr>
<td></td>
<td>Lofted surfaces</td>
<td>Loft, Dir, and Flip commands</td>
<td>Boat hull, canoe, airplane wing, game pad/Joystick, skateboard, telephone.</td>
</tr>
<tr>
<td>5</td>
<td>Making squishy surfaces</td>
<td>Control point editing</td>
<td>Rubber ducky, food, other organic shapes.</td>
</tr>
<tr>
<td>6</td>
<td>Design activities</td>
<td>All of the previous commands and new commands as needed</td>
<td>Projects. (See Sample Activities section)</td>
</tr>
</tbody>
</table>
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)

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

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

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:

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

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:

<table>
<thead>
<tr>
<th>Entry-Level</th>
<th>Intermediate</th>
<th>Sophisticated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kleenex box</td>
<td>Tube of toothpaste, toothbrush</td>
<td>Car, truck, train</td>
</tr>
<tr>
<td>Pen/pencil</td>
<td>Computer, monitor, printer</td>
<td>Roller blades</td>
</tr>
<tr>
<td>Pop can/bottle</td>
<td>Headphones</td>
<td>Ship/boat</td>
</tr>
<tr>
<td>Dice (4, 6, 8 sided)</td>
<td>School desk, office chairs</td>
<td>Bicycle</td>
</tr>
<tr>
<td>Flower vase</td>
<td>Watch, alarm clock</td>
<td>Animals</td>
</tr>
<tr>
<td>Stool</td>
<td>VCR, CD player, stereo</td>
<td>Sunglasses, safety glasses</td>
</tr>
<tr>
<td>Table with objects on top of it</td>
<td>Dishes/pots &amp; pans</td>
<td>Tennis shoe</td>
</tr>
<tr>
<td>Drinking cups</td>
<td>Stove/dishwasher</td>
<td>Airplane, helicopter</td>
</tr>
<tr>
<td>Christmas ornaments</td>
<td>Lipstick, mascara, perfume bottle</td>
<td>Computer mouse</td>
</tr>
<tr>
<td>Squirt bottle</td>
<td>Overhead projector</td>
<td>Piano, musical instruments</td>
</tr>
<tr>
<td>Screwdriver, nails, clamps</td>
<td>Hammer, wrench, pliers</td>
<td>Skull/bones</td>
</tr>
<tr>
<td>Jewelry box</td>
<td>Floppy disk</td>
<td>Child’s pull toy</td>
</tr>
<tr>
<td>CD case</td>
<td>Calculator</td>
<td>Hat, helmet</td>
</tr>
<tr>
<td>Radio, speakers</td>
<td>Electric wheel chair</td>
<td>Humanoid</td>
</tr>
<tr>
<td>Table or desk lamp</td>
<td>Telephone</td>
<td>Cell phone, remote control</td>
</tr>
</tbody>
</table>
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
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 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 template design that can be printed and pasted onto a pumpkin then carved.

Parameters
You have been given the following limitations from the instructor:

- The pumpkin can be modeled as 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.

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)

<table>
<thead>
<tr>
<th>Description</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best design as determined by a panel of unbiased judges</td>
<td>5 points</td>
</tr>
<tr>
<td>Second place</td>
<td>3 points</td>
</tr>
<tr>
<td>Third place</td>
<td>1 point</td>
</tr>
</tbody>
</table>

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)

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 overall 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. They 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 of solving 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.

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

Make a Main Character
Come up with a main character who 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)

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<thead>
<tr>
<th>Description</th>
<th>Points</th>
<th>Grade</th>
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<tr>
<td>All of the elements presented well</td>
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<td>B+</td>
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<td>Most of the elements adequately presented</td>
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<td>B</td>
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<tr>
<td>Some of the elements adequately presented</td>
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<td>C</td>
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<tr>
<td>Some of the elements shown</td>
<td>20</td>
<td>D</td>
</tr>
<tr>
<td>None of the elements adequately presented</td>
<td>0</td>
<td>F</td>
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</tbody>
</table>
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.

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.

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.

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.

<table>
<thead>
<tr>
<th>Week</th>
<th>Lesson Topic</th>
<th>Read</th>
<th>Exercise</th>
<th>Worksheet</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rhino basics and display options</td>
<td>Chap. 2</td>
<td>1-2</td>
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<tr>
<td></td>
<td>Introduction to Rhino: Lines &amp; curves, modeling aids, model setup, saving, layers, selecting and deleting objects</td>
<td>Chap. 3</td>
<td>3-9</td>
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<tr>
<td></td>
<td><strong>On Your Own:</strong></td>
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<td></td>
<td>Using shapes from exercise 1, build a three-dimensional model of your own</td>
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<td></td>
<td>Print four viewports and hand in the exercise. (See Chapter 13 – Printing for help if needed)</td>
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<tr>
<td>2</td>
<td>Coordinates, x, y, and z</td>
<td>Chap. 4</td>
<td>10-27</td>
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<tr>
<td></td>
<td>Absolute coordinates vs. relative coordinates</td>
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<td></td>
<td>Distance constraints and angle constraints including ortho, elevator, and planar mode.</td>
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<td><strong>On Your Own:</strong></td>
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<td>On graph paper redraw the arrow shape and write in the x,y coordinates</td>
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<td><strong>Design Project:</strong></td>
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<tr>
<td></td>
<td>Flashlight I (see Sample Design Activities - Example 1)</td>
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<tr>
<td>3</td>
<td>The art of rendering</td>
<td>Chap. 11</td>
<td>63</td>
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<tr>
<td></td>
<td>Bringing in outside textures</td>
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<td>Building a shadow room</td>
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<td>Spotlights</td>
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<td>Rendering Tips</td>
<td>Curriculum Guide</td>
<td>Handout</td>
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<td><strong>Design Project:</strong></td>
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<td>Flashlight II (see Sample Design Activities - Example 2)</td>
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<td>4</td>
<td>Editing objects</td>
<td>Chap. 5</td>
<td>28-42</td>
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<td><strong>Quiz 1</strong></td>
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<td><strong>On Your Own:</strong></td>
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<td>Complete exercises 43-46.</td>
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<td>Complete Flashlight II (see Sample Design Activities - Example 2)</td>
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<td>Week</td>
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<td>5</td>
<td>The five fundamental geometric objects in Rhino</td>
<td>Chap. 6</td>
<td>47-48</td>
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<td>Points, curves, surfaces, polysurfaces and solids</td>
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<td>Point editing.</td>
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<td>Creating Deformable Shapes</td>
<td>Chap. 7</td>
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<td><strong>On Your Own:</strong></td>
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<td></td>
<td>Model an organic shape (apple, pear, potato)</td>
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<td><strong>Design Project:</strong></td>
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<td>Jack O’Lantern (see Sample Design Activities - Example 3)</td>
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<td>How to make a screen capture</td>
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<td><strong>Design Project:</strong></td>
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<td>Key Chain I or II (see Sample Design Activities - Example 5 or 6)</td>
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<td><strong>Midterm Exam</strong></td>
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<td>Review for midterm exam</td>
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<td></td>
<td>Exam at end of week</td>
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<td><strong>Design Project:</strong></td>
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<td></td>
<td>Complete Key Chain I or II (see Sample Design Activities - Example 5 or 6)</td>
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<td>8</td>
<td>Surfaces</td>
<td>Chap. 9</td>
<td>51-59</td>
<td>6</td>
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<td><strong>On Your Own:</strong></td>
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<td>Complete exercises 60-61.</td>
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<td><strong>Design Project:</strong></td>
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<td>Cellular Phone (see Sample Design Activities - Example 9)</td>
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<td>9</td>
<td>Importing and Exporting Models</td>
<td>Chap. 10</td>
<td>62-63</td>
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<td><strong>Quiz 2</strong></td>
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<td>Making 2-D Drawings</td>
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<td><strong>On Your Own:</strong></td>
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<td>Export one of your projects to another application (CAM, rapid prototyping, rendering, publishing)</td>
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<td><strong>Design Project:</strong></td>
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<td>Complete Cellular Phone (see Sample Design Activities - Example 9)</td>
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<td>Rhino Customization</td>
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<td>Complete Video Game Concept (see Sample Design Activities - Example 10)</td>
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<td><strong>On Your Own:</strong></td>
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<td>Finish all Model Work</td>
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<td>Develop Presentation methods for your work; both hard copy and digital</td>
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<td>Utilize your class notebook to begin portfolio.</td>
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<td>Chronology of Work</td>
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<td>Headers for content sections</td>
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<td>Problem Statements must accompany design solutions</td>
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<td>Two Copies; 1 for student, 1 for teacher</td>
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<td>15</td>
<td><strong>Final Exam</strong></td>
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<td>Review for final exam</td>
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<td>Portfolio Presentations</td>
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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 the three options for entering 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:

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 would you 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 Surface:

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 Surface 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 isoparms on the surface. What are isoparms?

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. Extrude:
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 surface 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. Extrude: 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.

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 surface 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.
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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 isoparms.
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.)**

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<tr>
<th>Button</th>
<th>Command</th>
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<td>![Button Image]</td>
<td>Create spotlight Options Shade</td>
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<td>![Button Image]</td>
<td>Cut Pan Undo</td>
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<td>![Button Image]</td>
<td>Edit layers Paste Undo view change</td>
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<td>![Button Image]</td>
<td>Help Render Zoom</td>
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<td>![Button Image]</td>
<td>Hide objects Right view Zoom extents</td>
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<td>![Button Image]</td>
<td>New file Rotate Zoom selected</td>
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<tr>
<td>![Button Image]</td>
<td>Object properties Save Zoom window</td>
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<tr>
<td>![Button Image]</td>
<td>Object snap Select all</td>
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**EXTRA CREDIT: What does NURBS stand for?**
**Midterm Exam — Instructors Copy**

*Matching: (1 pt. ea.)*

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<td><strong>1</strong></td>
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<tr>
<td><strong>9</strong></td>
<td><strong>S</strong></td>
<td>To draw a line around.</td>
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<tr>
<td><strong>20</strong></td>
<td><strong>F</strong></td>
<td>Making contact at a single point or along a line, touching but not intersecting.</td>
</tr>
</tbody>
</table>
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 isoparms.
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  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  Object snap  Help
   Pan  All  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**

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Blend Surface</td>
<td>K</td>
<td>Chamfer</td>
<td>U</td>
</tr>
<tr>
<td>B</td>
<td>Sweep 1</td>
<td>L</td>
<td>Object Snaps</td>
<td>V</td>
</tr>
<tr>
<td>C</td>
<td>Extrude</td>
<td>M</td>
<td>Fillet</td>
<td>W</td>
</tr>
<tr>
<td>D</td>
<td>Sweep 2</td>
<td>N</td>
<td>Fillet Edge</td>
<td>X</td>
</tr>
<tr>
<td>E</td>
<td>Loft</td>
<td>O</td>
<td>Circumscribed</td>
<td>Y</td>
</tr>
<tr>
<td>F</td>
<td>Mirror</td>
<td>P</td>
<td>Elevator Mode</td>
<td>Z</td>
</tr>
<tr>
<td>G</td>
<td>Scale</td>
<td>Q</td>
<td>Revolve</td>
<td>AB</td>
</tr>
<tr>
<td>H</td>
<td>Command line</td>
<td>R</td>
<td>Perpendicular</td>
<td>BC</td>
</tr>
<tr>
<td>I</td>
<td>Analysis commands</td>
<td>S</td>
<td>Split</td>
<td>CD</td>
</tr>
<tr>
<td>J</td>
<td>Extend</td>
<td>T</td>
<td>Plane</td>
<td>DE</td>
</tr>
</tbody>
</table>
**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

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.
Sample 10 Week Syllabus for Industrial Design CAD Skills Course

Fall 2002      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

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**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Points</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4.0</td>
<td>Unique/innovative design and all of the elements presented with excellence</td>
</tr>
<tr>
<td>B+</td>
<td>3.5</td>
<td>All of the elements well presented</td>
</tr>
<tr>
<td>B</td>
<td>3.0</td>
<td>Most of the elements adequately presented</td>
</tr>
<tr>
<td>C</td>
<td>2.0</td>
<td>Some of the elements adequately presented</td>
</tr>
<tr>
<td>D</td>
<td>1.0</td>
<td>Some of the elements shown</td>
</tr>
<tr>
<td>F</td>
<td>0.0</td>
<td>None of the elements adequately presented</td>
</tr>
</tbody>
</table>
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.

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
A Process For Solving Problems

Think through the problem.
Harness information.
Identify the best solution.
Now do it.
Keep evaluating.

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

<table>
<thead>
<tr>
<th>Specification</th>
<th>Weight</th>
<th>Concept 1</th>
<th>Concept 2</th>
<th>Concept 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Score</td>
<td>Score</td>
<td>Score</td>
<td>Wt. Score</td>
</tr>
<tr>
<td>Cost to produce</td>
<td>4</td>
<td>5</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>Size</td>
<td>5</td>
<td>2</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Durability</td>
<td>4</td>
<td>4</td>
<td>16</td>
<td>4</td>
</tr>
<tr>
<td>Assembly Time</td>
<td>3</td>
<td>5</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td>Aesthetics</td>
<td>3</td>
<td>3</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>70</td>
<td>69</td>
<td>67</td>
<td></td>
</tr>
</tbody>
</table>

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


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.
Design brief for replication of a product by Bob Koll (bobkoll@home.com) and Pete Sorenson (PSorenson@lkwash.wednet.edu), Technology Teachers, Lake Washington Schools, Kirkland, WA.

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](image1)

![Resources for projects](image2)

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.
   - Rendered part in a scene for presentation, paper, or web page
   - Rapid prototyping
   - CAM/CNC
     - Wax/silicone/urethane parts
   - 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.
Mechanical Device Replication Ideas

Examples submitted by Karll Rusch, Technology Teacher, Bellingham High School, Bellingham, WA, krusch@bham.wednet.edu.

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 toolpath 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.
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:
- Frame must be welded mild steel tubing.
- Fabric will be used for the seat and back.
- 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.
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%)
- The poster will be a C- (24x17) or D-sized (36x24) poster.
- Graphics of projects that you have done (engineering/architecture) must be included.
- Description of why students should take the class must be included.
- Description of benefits of taking the class must be included.
- A listing of who teaches the class must be included.
- Specifics to generate interest for specific groups of students should be included.
- Classroom teachers in the building(s) should be contacted as to the best way to promote the class in their particular classes.
- 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
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.

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

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
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)

Unique Design:
- Dual shock-mounted xenon bulbs
- Multi-hinged body
- Red light night-vision filters

Features List:
- Rubber coated, form-fitting handle
- O-ring sealed, water impervious design
- Retractable tripod
- Battery meter
- 12 and 24 hour time
- Alarm
- Timer
- Stopwatch
- Large red on/off button
- Operates on 2 C-sized batteries

Overall Dimensions:
- 6.5” x 5.0” x 3.0”

Materials:
- Machined aluminum
- 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 Mike Miyoshi, Engineering Technology Teacher, Cedarcrest High School, Duvall, WA.

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 Cessnas, 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 fairing 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

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tbody>
<tr>
<td>BlendSrf</td>
<td>Blends two surfaces. Creates a third surface between the surface edges that is tangent to both surfaces.</td>
</tr>
<tr>
<td>Cowling</td>
<td>The piece on the front of a plane that holds the engine, includes the intakes.</td>
</tr>
<tr>
<td>Empennage</td>
<td>French. This is the tail section of the plane, includes stabilizers.</td>
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<tr>
<td>Extrude</td>
<td>Extrude a curve into a surface or solid. Make a surface with the same profile as the curve.</td>
</tr>
<tr>
<td>Fuselage</td>
<td>The main body of the plane.</td>
</tr>
<tr>
<td>NetworkSrf:</td>
<td>Creates a surface from a network of curves.</td>
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<td>---------------------</td>
<td>--------------------------------------------</td>
</tr>
<tr>
<td>Horizontal Stabilizer:</td>
<td>Stabilizes the pitch of an airplane.</td>
</tr>
<tr>
<td>Join:</td>
<td>Makes several surfaces into a polysurface or solid.</td>
</tr>
<tr>
<td>Loft:</td>
<td>Lofts a surface. Creates a surface from several profile curves.</td>
</tr>
<tr>
<td>Revolve:</td>
<td>Creates a surface by rotating it around an axis.</td>
</tr>
<tr>
<td>Split:</td>
<td>Splits a surface into several.</td>
</tr>
<tr>
<td>Sweep2:</td>
<td>Creates a surface with two sweep curves and multiple profile curves.</td>
</tr>
<tr>
<td>Vertical Stabilizer:</td>
<td>Stabilizes the yaw of an airplane.</td>
</tr>
</tbody>
</table>

**Renderings**

*Fig. 1 Layer Construction*
Fig. 2 Terms
Reverse engineering project submitted by Karli Rusch, Technology Teacher, Bellingham High School, Bellingham, WA, 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.
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.

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.

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.
Design brief and finished student projects submitted by Karll Rusch, Technology Teacher, Bellingham High School, Bellingham, WA, krusch@bham.wednet.edu.

Unique Flashlight Design

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 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.
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.

Designed By
Chris Howard

World Class
Bellingham High School
The High Tech Flashlight Example

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

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

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, Fall 2002.
Student: Sean Matuschak
Instructor: Jerry Hambly
Final Project Example
Etech 397D, Cad Skills for Industrial Designers, Western Washington University, Fall 2002.
Student: Jonah Griffith
Instructor: Jerry Hambly