NOTE: This Summer Training Institute (STI) Notebook is not the entire Project Lead The Way® (PLTW) course curriculum. This notebook is a subset of the PLTW curriculum for training purposes only. Please refer to the course curriculum for the complete materials and resources needed to teach the course.
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Teacher Signature________________________________ Date____________

Print Name _______________________________________________________________________

School Name ______________________________________ State ______________

Participant Copy
Please sign and retain this copy for your records.
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Teacher Signature________________________________ Date____________
Print Name __________________________________________________________
School Name ________________________________ State ____________

PLTW, Inc. Copy
Please sign and give to your Core Training Instructors. The Affiliate Director will send all signed copies to PLTW, Inc. at the completion of the STI.
Introduction to Engineering Design™ (IED)
Statement of Understanding
2009 Summer Training Institute™

Name (please print): ________________________________________________

All participants at the Project Lead The Way® Summer Training Institute™ (STI) are required to maintain a portfolio of exercises, activities, and projects as assigned by the instructors during the STI. Your instructors will periodically review and sign-off on completed portions of the portfolio over the duration of the STI.

The course portfolio is collection of the selected coursework that was assigned during the STI and provides evidence that the participant successfully completed the material at the STI. An instructor will initial each activity when it has been determined by the instructor to demonstrate adequate competency with the subject matter.

The STI provides a comprehensive overview of the course content, and is not inclusive of the full scope and breadth of the course. Due to the time constraints inherent in a 2-week professional development session, the STI provides only an introduction to select lessons, activities and projects within the course. In preparation to teach the course, it is the responsibility of the participant to continue to familiarize him or herself with the entire course curriculum upon completing the STI.

I understand it is my responsibility to complete a course portfolio and to continue to become competent in the full scope of the specific Project Lead The Way® curriculum for this course.

Signature: ___________________________     Date: ________________

Note to STI Participants:
It is the intent that all of the activities on the Portfolio Checklist be completed either during the scheduled class time or as a homework exercise.
Introduction to Engineering Design™ (IED)
Statement of Understanding
2009 Summer Training Institute™

Name (please print): __________________________________________

All participants at the Project Lead The Way® Summer Training Institute™ (STI) are required to maintain a portfolio of exercises, activities, and projects as assigned by the instructors during the STI. Your instructors will periodically review and sign-off on completed portions of the portfolio over the duration of the STI.

The course portfolio is a collection of the selected coursework that was assigned during the STI and provides evidence that the participant successfully completed the material at the STI. An instructor will initial each activity when it has been determined by the instructor to demonstrate adequate competency with the subject matter.

The STI provides a comprehensive overview of the course content, and is not inclusive of the full scope and breadth of the course. Due to the time constraints inherent in a 2-week professional development session, the STI provides only an introduction to select lessons, activities, and projects within the course. In preparation to teach the course, it is the responsibility of the participant to continue to familiarize him or herself with the entire course curriculum upon completing the STI.

I understand it is my responsibility to complete a course portfolio and to continue to become competent in the full scope of the specific Project Lead The Way® curriculum for this course.

Signature: ___________________________ Date: ________________

Note to STI Participants:
It is the intent that all of the activities on the Portfolio Checklist be completed either during the scheduled class time or as a homework exercise.
Introduction to Engineering Design™ (IED)
Participant Completion Report
2009 Summer Training Institute™

Participant’s Name: ________________________________
STI Location: ________________________________
STI Dates: ________________________________
School District: ________________________________
School Name: ________________________________
Email Address: ________________________________
Instructors’ Names: ________________________________

My instructor(s) has reviewed the Portfolio Checklist with me and I am aware of the final evaluation.

Signature: ________________________________ Date: ________________

The student ( has / has not ) met the requirements of this course.

Instructor’s Signature: ________________________________ Date: ________________
Instructor’s Signature: ________________________________ Date: ________________

Note to STI Instructors:
When completed, please provide a copy of the Statement of Understanding, Participant Completion Report, and the Portfolio Checklist to the participant and to the STI Affiliate Director.
# Introduction to Engineering Design™ (IED)

## Portfolio Checklist

### 2009 Summer Training Institute™

<table>
<thead>
<tr>
<th>Day</th>
<th>Assignments and Deliverables</th>
<th>Instructor Initials</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAY 2</td>
<td>Students will create 10 sketches of the iso problems found in the base set (sketch style should vary (Iso, Oblique, multi-view, perspective)</td>
<td></td>
</tr>
<tr>
<td>DAY 3</td>
<td>Student will create 1 Sketched solution set of cube designs</td>
<td></td>
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<tr>
<td>DAY 4</td>
<td>Students will create multi-view dimensioned drawing files of their individual and assembled puzzle parts as well as a ballooned, exploded isometric with parts list.</td>
<td></td>
</tr>
<tr>
<td>DAY 4</td>
<td>Activity 2.2.2 Model Dimensioning (place and dimension 6 of the 10 ISO modeled in Activity 2.1.6)</td>
<td></td>
</tr>
<tr>
<td>DAY 6</td>
<td>Project 2.3.1 2.3.1a Miniature Train-Instructors Choice-A Complete set of working Drawings is due.</td>
<td></td>
</tr>
<tr>
<td>DAY 6</td>
<td>2.4.1 Design Challenge - Select from 6 design briefs</td>
<td></td>
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<tr>
<td>DAY 8</td>
<td>Problem 3.4.3 Product Improvement design documents w/Design Brief. Physical Properties displayed on *idw's.</td>
<td></td>
</tr>
<tr>
<td>DAY 10</td>
<td>Project 4.2.1 – Virtual Design Challenge w/ design Documents &amp; proof of collaboration, Gantt chart</td>
<td></td>
</tr>
<tr>
<td>DAY 10</td>
<td>Self Reflection Review Interview</td>
<td></td>
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<tr>
<td>DAY 10</td>
<td>Student Will Present Completed Portfolio to Instructors</td>
<td></td>
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<tr>
<td>DAY 10</td>
<td>End-of-Course Assessment</td>
<td></td>
</tr>
<tr>
<td>Day</td>
<td>Estimated Time</td>
<td>Lesson</td>
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<tr>
<td></td>
<td>8:00 AM - 10:00 AM</td>
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<tr>
<td>1.1</td>
<td>10:00 AM - 12:00 PM</td>
<td></td>
</tr>
<tr>
<td>Design Process</td>
<td>Activity 1.1.1 Beverage container</td>
<td>Engineering Notebook entries/presentation to class</td>
</tr>
<tr>
<td></td>
<td>Activity 1.1.2 Product Evolution</td>
<td>Review Only</td>
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<tr>
<td></td>
<td>Activity 1.1.3 Gossamer Condor Design Brief</td>
<td>Design Brief</td>
</tr>
<tr>
<td>1.2</td>
<td>1:00 PM - 3:00 PM</td>
<td></td>
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<tr>
<td></td>
<td>Technical Sketching and Drawing</td>
<td>Activity 1.2.2 Oblique Sketches, Activity 1.2.3 Perspective Sketches</td>
</tr>
<tr>
<td></td>
<td>Activity 1.2.4 Multi-view Sketches</td>
<td>Work through Activity w/Students</td>
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<tr>
<td></td>
<td><strong>Virtual Teaming</strong></td>
<td>Collection Skype names and email address. STI instructors to skype each other for connectivity check.</td>
</tr>
<tr>
<td>1.3</td>
<td>3:00 PM - 5:00 PM</td>
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<tr>
<td>Measurement and Statistics</td>
<td>Activity 1.3.2 English and Metric Linear Measurement</td>
<td>Review documents and [PPTs]</td>
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<tr>
<td></td>
<td>Activity 1.3.3 fischertechniks Block Measurement</td>
<td>Review only</td>
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<tr>
<td></td>
<td>Activity 1.3.4 Linear Dimensions</td>
<td>Work through Activity w/Students</td>
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<tr>
<td></td>
<td>Activity 1.3.5 Applied Statistics</td>
<td>Work through Activity w/Students</td>
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<tr>
<td>Homework</td>
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<td></td>
<td>Read and review “Opening and Unblocking” link on Virtual Academy Landing Page</td>
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<td>Day</td>
<td>Estimated Time</td>
<td>Lesson</td>
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<td>8:00 AM - 10:00 AM</td>
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<td></td>
<td>10:00 AM - 12:00 PM</td>
<td>Puzzle Cube</td>
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<td>1:00 PM - 3:00 PM</td>
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<td>3:00 PM - 5:00 PM</td>
<td>Software Basics</td>
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<td>Homework</td>
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<tr>
<td>Day</td>
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<td>Lesson</td>
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<td>8:00 AM - 10:00 AM</td>
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<td>Puzzle Cube</td>
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<tr>
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<td>Geometric Shapes and Solids</td>
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<td>1:00 PM - 3:00 PM</td>
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<td>Dimensions and Tolerances</td>
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<td>2.3</td>
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<td>8:00 AM - 12:00 PM</td>
<td>Advanced Modeling Skills</td>
<td>Activity 2.3.2 Parametric Constraints</td>
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<td>Activity 2.3.3 Auxiliary Views</td>
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<td>Activity 2.3.4 Sectional Views</td>
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<td>Activity 2.3.5 Assembly Models</td>
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<td>Activity 2.3.6 Miniature Train Drawings (named Arbor Press Drawings in curriculum)</td>
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<tr>
<td>DAY 4</td>
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<tr>
<td>1:00 PM - 4:00 PM</td>
<td>2.3</td>
<td>Continue work on Project 2.3.1a Miniature Train or 2.3.1 Arbor Press</td>
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<td></td>
<td></td>
<td>Continue work on Activity 2.3.6 Miniature Train Drawings</td>
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<tr>
<td>4:00 PM - 5:00 PM</td>
<td>2.4</td>
<td>Project 2.4.1 Design Challenge - Select from 6 design briefs</td>
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<tr>
<td></td>
<td>Advanced Designs</td>
<td>Consider introducing 3.1.1 Principles and Elements of Design [PPT]</td>
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<tr>
<td>Homework</td>
<td></td>
<td>Finish work on Project 2.3.1a (Instructor Choice)</td>
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<td></td>
<td>Review [PPT], Teamwork[PPT], Decision Making Matrix[PPT], Fluid Power[PPT]</td>
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<td>Day 5</td>
<td>Estimated Time</td>
<td>Lesson</td>
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<tr>
<td>8:00 AM - 12:00 PM</td>
<td>2.4 Work on Project 2.4.1</td>
<td>Advanced Designs</td>
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<tr>
<td>1:00 PM - 4:00 PM</td>
<td>2.4 Continued work on Project 2.4.1a</td>
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<td>4:00 PM - 5:00 PM</td>
<td>4.2 Share Skype names within the class. Verify WebCam connectivity</td>
<td>Design Teams</td>
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<tr>
<td>Day</td>
<td>Lesson</td>
<td>Topics</td>
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<tr>
<td>8:00 AM - 10:00 AM</td>
<td>3 Reverse Engineering</td>
<td>Intro Unit 3 Reverse Engineering</td>
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<td></td>
<td>3.1</td>
<td>Activity 3.1.1 Visual Design Principles and Elements Identification</td>
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<td></td>
<td>Visual Analysis</td>
<td>Activity 3.1.2 Visual Design Principles and Elements Study</td>
</tr>
<tr>
<td></td>
<td>Activity 3.1.3 What’s going on in this graphic design?</td>
<td>Review only</td>
</tr>
<tr>
<td>10:00 AM - 12:00 PM</td>
<td>Functional Analysis</td>
<td>Activity 3.2.1 Product Observation</td>
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<tr>
<td></td>
<td>3.2</td>
<td>Activity 3.2.1 Product Observation</td>
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<tr>
<td></td>
<td>3.3 Project 3.3.4 Product Disassembly Display</td>
<td>Activity to be done at the discretion of the instructors. Review and discuss possible alternatives to display boards</td>
</tr>
<tr>
<td>1:00 PM - 3:00 PM</td>
<td>Structural Analysis</td>
<td>Activity 3.3.1/a-f Optional Activities</td>
</tr>
<tr>
<td></td>
<td>Activity 3.3.2 Product Disassembly</td>
<td>Activity 3.3.2a Product Disassembly Chart Activity 3.3.2b Materials usage charts</td>
</tr>
<tr>
<td>3:00 PM - 5:00 PM</td>
<td>Structural Analysis</td>
<td>Activity 3.3.3 Mass Property Analysis</td>
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<tr>
<td></td>
<td>3.3</td>
<td>Activity 3.3.3 Mass Property Analysis</td>
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<tr>
<td></td>
<td>Review and demonstrate- Motion Translation, Driving Constraints</td>
<td>Students will work on Inventor tutorial on driving constraints</td>
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<td>Homework</td>
<td>Review the Power Points for Unit 3.1 as listed.</td>
</tr>
</tbody>
</table>

Found on the virtual academy - General Resources - Resources for Engineering Courses
<table>
<thead>
<tr>
<th>Day</th>
<th>Estimated Time</th>
<th>Lesson</th>
<th>Topics</th>
<th>Assignments and Deliverables</th>
<th>Due Date</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8:00 AM - 10:00 AM</td>
<td>3.3</td>
<td>Continue Work on Lesson 3.3</td>
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<td></td>
<td>10:00 AM - 12:00 PM</td>
<td>3.4</td>
<td>Activity 3.4.2 The Deep Dive</td>
<td><strong>SHOW DEEP DIVE FILM AT THIS TIME</strong></td>
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<td></td>
<td>Structural Analysis</td>
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<td>3.4</td>
<td>Activity 3.4.3 Product Improvement</td>
<td>Problem 3.4.3 Product Improvement design documents w/Design Brief. Physical Properties displayed on &quot;idw&quot;s.</td>
<td>x</td>
<td>DAY 8 Annotated Sketches, Design Brief decision matrix, and a set of working drawings</td>
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<td></td>
<td>Product Improvement by Design</td>
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<td>4.2</td>
<td>Introduce Project 4.2.1</td>
<td></td>
<td></td>
<td>Organize groups by class, site, nationally as available and review project options, select teams, select project, set common meeting times, maybe 9:00 am and 2:00 pm from now on as needed, with informal communication on the fly.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.4</td>
<td>Activity 3.4.1 Writing a design Brief</td>
<td>Activity 3.4.1a Child Toy Design Brief (review)</td>
<td>Work through with students</td>
<td>DAY 7 Show - Writing a Design Brief[PPT]</td>
</tr>
<tr>
<td></td>
<td>1:00 PM - 3:00 PM</td>
<td>3.4</td>
<td>Continue Work on Problem 3.4.3 Product Improvement</td>
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<td></td>
<td>3:00 PM - 5:00 PM</td>
<td></td>
<td>Finish working drawings for the Reverse Engineering - Product improvement</td>
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<td></td>
<td>Homework</td>
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<tr>
<td>Day</td>
<td>Estimated Time</td>
<td>Lesson</td>
<td>Topics</td>
<td>Assignments and Deliverables</td>
<td>Due Date</td>
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<td>8:00 AM - 10:00 AM</td>
<td>4.1</td>
<td>Activity 4.1.1 Product Lifecycle</td>
<td>Review only</td>
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<td>Discuss - Global, human and ethical Impacts[PPT]</td>
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<td></td>
<td>Engineering Design Ethics</td>
<td>Problem 4.1.2 Engineering Design Ethics Design Brief</td>
<td>Review only</td>
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<td>Work on Project 4.2.1 Virtual Design Challenge</td>
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<td>10:00 AM - 12:00 PM</td>
<td>4.2</td>
<td>Project 4.2.1 Virtual Design Challenge</td>
<td>Project 4.2.1 – Virtual Design Challenge w/ design Documents &amp; proof of collaboration, Gantt chart</td>
<td>x</td>
<td>DAY 10</td>
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<td>Design Teams Activity 4.2.2 Team Norms</td>
<td>Complete via webcam with worksheet found in base set</td>
<td>Review and discuss Teamwork[PPT]</td>
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<td></td>
<td></td>
<td>Design Teams Introduce and demonstrate - Project Geometry, Lofting, Coil, Threads (surface appearance), Face draft, Rib, As Time Permits</td>
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<tr>
<td>DAY 8</td>
<td>1:00 PM - 5:00 PM</td>
<td>4.2</td>
<td>Work on Project 4.2.1 Virtual Design Challenge</td>
<td>Lesson 4.2 – Design Teams Local constraints will determine how virtual this project will actually be.</td>
<td></td>
<td>Review documents that go with Project 4.2.1; Design Project Tally Sheet, Engineer’s Notebook Evaluation, Periodic Self-Evaluation, Periodic Teammate 10-Point Evaluation, Summary Presentation Evaluation, Team Norms, Teammate Performance Summary</td>
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<td></td>
<td></td>
<td>Homework</td>
<td>Self Reflection</td>
<td>Self Reflection</td>
<td></td>
<td>Complete everything covered to this point</td>
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<tr>
<td>Day</td>
<td>Lesson</td>
<td>Topics</td>
<td>Assignments and Deliverables</td>
<td>Due Date</td>
<td>Comments</td>
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<td>DAY 9</td>
<td>4.2</td>
<td>Continue work on Project 4.2.1 Virtual Design Challenge</td>
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<td>8:00 AM - 12:00 PM</td>
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<td>Design Teams</td>
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<tr>
<td>1:00 PM - 3:00 PM</td>
<td>4.2</td>
<td>Continue work on Project 4.2.1 Virtual Design Challenge</td>
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<td>Derived Parts - use the coaching method to teach this concept.</td>
<td><strong>Discuss presentation options &amp; strategies from Unit 4 Virtual Teaming Project for use within high school setting</strong></td>
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<td>4.2</td>
<td>Virtual team Presentations given.</td>
<td>Project Closure from list:</td>
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<td>Design Elements - Discuss and demonstrate, Creating, Using,</td>
<td>Formal Presentation Electronic Presentation Technical Paper</td>
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<td>Using those on websites</td>
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<td></td>
<td>Homework</td>
<td>Complete Virtual Design Challenge</td>
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<td>Get Portfolio Together</td>
<td>Student Will Present Completed PORTFOLIO TO INSTRUCTORS</td>
<td>DAY 10</td>
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<td>Complete parts A, B, and C of the student final exam</td>
<td>END-OF-COURSE ASSESSMENT</td>
<td>DAY 10</td>
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<td>8:00 AM - 10:00 AM</td>
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<td>DAY 10</td>
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<td>Finish all remaining work, and complete Portfolio</td>
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<td>10:00 AM - 11:30 AM</td>
<td>Course Conclusion Checklist</td>
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<td>Graduation</td>
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<td>Attend graduation/closing ceremonies.</td>
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<td>Coordinate with Affiliate Director</td>
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</table>
Introduction to Engineering Design™ – Self Reflection

Name: _____________________________

The self reflection is to be used as an assessment tool that will identify skills you have acquired during training. It will also identify other areas of the curriculum that you will investigate on your own as preparation for teaching the course. Complete the log to evaluate your understanding of the curriculum objectives.

Once you have completed the self evaluation, make arrangements with an instructor for an exit interview that will be guided using this document. This document will only be viewed by you and the instructors.

Instructions to Complete Self Reflection Log:

☐ Upon completion of each unit, evaluate the objectives listed.
☐ Objective clarification can be sought through your instructor.
☐ The Personal Notes section is provided to record questions, items of attention, etc.
☐ Objective(s) receiving a rating of 1 should be reinforced using the resources available.

1 = I need to further investigate the curriculum to prepare for teaching this subject material.
2 = I think I could do an adequate job teaching this subject material right now.
3 = I’m very confident that I could teach this subject material.

1 2 3 Software Installation
☐ ☐ ☐ I know which software to install for this course.
☐ ☐ ☐ I know how to access the Tech Support from the PLTW Virtual Academy website.

Personal Notes:
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1 2 3 Curriculum
☐ ☐ ☐ I know how to effectively use the curriculum as it is designed to be used.
☐ ☐ ☐ I know how to access the Virtual Academy to download curriculum and VA lessons onto my hard drive.
☐ ☐ ☐ I can access the Project Lead The Way® website and can utilize the exam section.
☐ ☐ ☐ I know how to use the Project Lead The Way® Forums.
☐ ☐ ☐ I know how to access and use the True Outcomes website.

Personal Notes:
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Unit 1 Introduction to Design

Lesson 1.1 - Introduction to a Design Process
- I can explain engineering notebook standards and protocols.
- I can identify and apply group brainstorming techniques and the rules associated with brainstorming.
- I can explain how to research a product’s history, develop a PowerPoint presentation, list chronologically the major innovations to a product, and present their findings to a group.
- I can explain how to use online and published works to research aspects of design problems.
- I can describe the design process steps used in given scenarios and list the steps, if any are missing.

Personal Notes:
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Lesson 1.2 - Introduction to Technical Sketching and Drawing
- I can identify, sketch, and explain the function of points, construction lines, object lines, and hidden lines.
- I can demonstrate how to plot points on grid paper to aid in the creation of sketches and drawings.
- I can describe the concepts of technical sketching and drawing.
- I can demonstrate how to sketch an isometric view of simple geometric solids.
- I can explain how an oblique view of simple geometric solids differs from an isometric view.
- I can demonstrate how to sketch one-point, two-point, and three-point perspectives of simple geometric solids.
- I can explain the concept of proportion as it relates to freehand sketching.
- I can sketch multi-view drawings of simple geometric solids.
- I can determine the front view for a given object.

Personal Notes:
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Lesson 1.3 - Measurement and Statistics
- I can explain how to research and design a CD cover or book jacket on the origins of the measurement systems.
- I can demonstrate how to measure and record linear distances using a scale to a precision of 1/16 inch and 1 mm.
- I can demonstrate how to measure and record linear distances using a dial caliper to a precision of 0.001 inch.
- I can explain how to add and subtract U.S. standard and metric linear measurements.
- I can explain how to convert linear distance measurements from inches to millimeters and vice versa.
- I can demonstrate how to apply linear dimensions to a multiview drawing.
- I can explain how to calculate the mean, mode, median, and range of a data set.
- I can demonstrate how to create a histogram of recorded measurements showing data elements or class intervals and frequency.

Personal Notes:
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Lesson 1.4- Puzzle Cube

☐ I can explain how to brainstorm and sketch possible solutions to an existing design problem.
☐ I can describe how to select an approach that meets or satisfies the constraints given in a design brief.
☐ I can demonstrate how to create simple extruded solid Computer Aided Design (CAD) models from dimensioned sketches.
☐ I can demonstrate how to generate dimensioned multiview drawings from simple CAD models.
☐ I can explain how to measure and fabricate parts for a functional prototype from the CAD multiview drawings.
☐ I can demonstrate how to assemble the product using the CAD modeling software.
☐ I can demonstrate how to test and evaluate the prototype and record results.
☐ I can explain how to apply geometric and numeric constraints to CAD sketches.
☐ I can explain the purpose of packaging in the design of consumer products.

Personal Notes:
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Unit 2 Design Solutions

Lesson 2.1- Geometric Shapes and Solids

☐ I can explain how to identify common geometric shapes and forms by name.
☐ I can demonstrate how to calculate the area of simple geometric shapes.
☐ I can demonstrate how to calculate the surface area and volume of simple geometric forms.
☐ I can demonstrate, identify, and explain the various geometric relationships that exist between the elements of two-dimensional shapes and three-dimensional forms.
☐ I can identify and define the axes, planes, and sign conventions associated with the Cartesian coordinate system.
☐ I can explain how to apply geometric and numeric constraints to CAD sketches.
☐ I can explain how to utilize sketch-based, work reference, and placed features to develop solid CAD models from dimensioned drawings.
☐ I can explain how a given object’s geometry is the result of sequential additive and subtractive processes.

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Lesson 2.2- Dimensions and Tolerances

- I can explain the difference between size and location dimensions.
- I can describe how to differentiate between datum dimensioning and chain dimensioning.
- I can demonstrate procedures which will allow students to identify and dimension fillets, rounds, diameters, chamfers, holes, slots, and screw threads in orthographic projection drawings.
- I can explain the rules that are associated with the application of dimensions to multiview drawings.
- I can identify, sketch, and explain the difference between general tolerances, limit dimensions, unilateral, and bilateral tolerances.
- I can demonstrate how to differentiate between clearance and interference fits.

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Lesson 2.3- Advanced Modeling Skills

- I can demonstrate how to sketch and model an auxiliary view of a given object to communicate the true size and the shape of its inclined surface.
- I can describe the purpose and demonstrate the application of section lines and cutting plane lines in a section view drawing.
- I can demonstrate how to sketch a full and half section view of a given object to communicate its interior features.
- I can explain how to identify algebraic relationships between the dimensional values of a given object.
- I can explain how to apply assembly constraints to individual CAD models to create mechanical systems.
- I can demonstrate how to perform part manipulation during the creation of an assembly model.
- I can explain how assembly constraints are used to systematically remove the degrees of freedom for a set of components in a given assembly.
- I can create and explain an exploded model of a given assembly.
- I can explain how to determine ratios and apply algebraic formulas to animate multiple parts within an assembly model.
- I can create and describe the purpose of the following items: exploded isometric assembly view, balloons, and parts list.

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Lesson 2.4 - Advanced Designs

- I can demonstrate how to brainstorm and sketch possible solutions to an existing design problem.
- I can illustrate how to create a decision making matrix.
- I can explain how to select an approach that meets or satisfies the constraints given in a design brief.
- I can demonstrate how to create solid computer-aided design (CAD) models of each part from dimensioned sketches using a variety of methods.
- I can demonstrate how to apply geometric numeric and parametric constraints to form CAD modeled parts.
- I can explain how to generate dimensioned multiview drawings from simple CAD modeled parts.
- I can demonstrate how to assemble the product using the CAD modeling software.
- I can explain what constraints are and why they are included in a design brief.
- I can explain the steps necessary to create a three-fold brochure marketing the designed solution for the chosen problem, such as a consumer product, a dispensing system, a new form of control system, or a product design extension created to meet a new requirement.
- I can explain the concept of fluid power and the difference between hydraulic and pneumatic power systems.

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Unit 3 Reverse Engineering

Lesson 3.1 - Visual Analysis

- I can explain why it is important to identify visual design elements within a given object.
- I can explain how visual design principles are used to manipulate design elements within a given object.
- I can explain what aesthetics is and how it contributes to a design’s commercial success.
- I can describe the purpose of packaging in the design of consumer products.
- I can identify and explain visual design principles and elements that are present within marketing ads.
- I can describe how to identify the intent of a given marketing advertisement and the demographics of the target consumer group for which it was intended.

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Lesson 3.2 - Functional Analysis

- I can explain why engineers perform reverse engineering on products.
- I can demonstrate how to describe the function of a given manufactured object as a sequence of operations through visual analysis and inspection (prior to dissection).

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Lesson 3.3- Structural Analysis
- I can describe the differences between joinery, fasteners, and adhesives.
- I can identify the types of structural connections that exist in a given object.
- I can explain how to use dial calipers to precisely measure outside and inside diameter, hole depth, and object thickness.
- I can explain how to identify a given object’s material type.
- I can describe material processing methods that are used to manufacture the components of a given commercial product.
- I can explain how to assign a density value to a material and apply it to a given solid CAD model.
- I can explain how to perform computer analysis to determine mass, volume, and surface area of a given object.

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Lesson 3.4- Product Improvement by Design
- I can demonstrate how to write design briefs that focus on product innovation.
- I can explain group brainstorming techniques and the rules associated with brainstorming.
- I can demonstrate how to use decision matrices to make design decisions.
- I can explain the difference between invention and innovation.

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Unit 4 Design Problems
Lesson 4.1- Engineering and Design Ethics
- I can illustrate how to create a brainstorming list of different products made from common materials that are used daily.
- I can explain how to research and construct a product impact timeline presentation of a product from the brainstorming list and communicate ways that the product may be recycled and used to make other products after its life cycle is complete.
- I can explain how to identify the five steps of a product’s life cycle and investigate and propose recyclable uses for the material once the life cycle of the product is complete.

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Lesson 4.2 - Design Teams

I can explain why teams of people are used to solve problems.
I can explain how to identify group norms that allow a virtual design team to function efficiently.
I can explain how to establish file management and file revision protocols to ensure the integrity of current information.
I can demonstrate how to use internet resources, such as email, to communicate with a virtual design team member throughout a design challenge.
I can identify strategies for addressing and solving conflicts that occur between team members.
I can demonstrate how to create a Gantt chart to manage the various phases of a design challenge.

Personal Notes:
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End of Course Assessment

The following pages contain the end of course assessment documents. These are to be kept confidential, and not shared with anyone, especially your students.
End-of-Course Assessment Administrative Regulations

General Rules
To ensure the quality, consistency and integrity of the testing process, Project Lead The Way, Inc. has developed the following regulations regarding the PLTW® end-of-course assessments. All school personnel who are involved in the end-of-course assessment process are required to follow these guidelines.

- The end-of-course assessments are published twice during the school year; once in the fall for schools that are on an accelerated semester block and again in the spring for schools that operate on an annual calendar.
- Due to the proprietary nature of these exams, any school not administering the assessments at the time they are published shall not access the exams. Previous exam questions shall never be shared with students as practice exams. Only tests designated as “Practice Exams” on the PLTW® Virtual Academy may be used as such.
- PLTW® exams shall never be returned to or be reviewed by students.

Because all students, teachers, and schools benefit from the national reliability of these tests, any school/teacher who feels the integrity of the end-of-course assessments has somehow been compromised should immediately contact the PLTW Coordinator of Quality Initiatives, Melissa Daigle at mdaigle@pltw.org or (518) 877-6491, Ext. 342.

College Credit Rules
The following regulations regarding the Project Lead The Way® college credit portion of the end-of-course assessment have been mandated by our university partners. Any PLTW® School offering college credit to its students must strictly adhere to all rules as specified below.

- Only PLTW® certified schools may administer the college credit portion of the end-of-course assessments to qualified students.
- Within a PLTW® certified school; only teachers who have successfully completed PLTW® Core Training for a course may administer the college credit exam for that course to their students.
- The college credit portion of the end-of-course assessment must be administered to students as published by Project Lead The Way, Inc. The tests may not be altered in any way. Possible consequences for the improper use, administration, or handling of the exams include denial of college credit to students, loss of school certification, and/or inability of a school to offer the college credit to its students in the future.
- Students are only allowed to take the college credit portion of the exam for a course once. Students who do not pass the college credit exam at the conclusion of their course may not retake any subsequent college credit exams for that course to pass the test or to raise their grade.
- Students are only eligible to apply for college credit during the school year in which they have taken the PLTW® course and successfully completed the college credit exam. Students who have taken a PLTW® course prior to their school being certified are not eligible to apply for credit retroactively.
- All PLTW® National Engineering Affiliates who grant college credit reserve the right to call in and review the exams administered by schools that are seeking college credit for their students.

Please refer to your local PLTW® National Engineering Affiliate for the specific rules regarding eligibility requirements and application procedures for receiving college credit.
Important:
Before administering this Project Lead The Way® (PLTW™) assessment, please read the document “End-of-Course Assessment Administrative Regulations,” which can be found on the Registered Teacher’s page of the PLTW™ website. This document contains important information regarding the rules for administering the end-of-course exams.

Teacher Directions:
This assessment tool has been designed to serve a dual purpose. The exam components are intended to be combined to serve as students’ year-end exam, or as their *college credit examination*. The assessment should be administered as follows:

- **Part A combined with Part B** = High School Credit
- **Part A combined with Part C** = College Credit

Each part of the assessment (A, B or C) is worth 50% of the exam. Part A combined with either Part B or Part C is worth a total of 100 points.

* Only students who are from PLTW certified schools, have a class average of 85% or higher, and have achieved a score of 70% on Parts A & C combined are eligible to apply for transcripted college credit.

All students will take Part A of the assessment. Part A is a timed exam and must be completed in its entirety within a 45-minute continuous time period.

Depending on the type of credit desired, students will take either Part B (high school credit) or Part C (college credit). Parts B and C are also timed exams and must be completed in their entirety within a 45-minute continuous time period.

Based on your school’s calendar and your class schedule, students may take their two-part exam over two 45-minute periods or all at once during one 90-minute period. If the assessments are administered during one continuous block of time, students **may not** start the second part of the assessment (B or C) before the allotted time has expired for Part A.

<table>
<thead>
<tr>
<th>IED - Part A</th>
<th>40 Multiple Choice Questions</th>
<th>50 Points</th>
</tr>
</thead>
</table>

Timing: 45-minutes

Supplies / Tools:
CLOSED NOTES/NOTEBOOK – CLOSED TEXTBOOK. Students are NOT allowed to use any simulation/course software during this exam.

Grading Part A:
An answer key has been provided for Part A. A conversion chart is available in the IED Answer Key to convert a student’s raw score to its 50-point equivalent.
IED - Parts B or C: High School or College Credit Performance Exam  50 Points

Timing: 45-minutes

Supplies / Tools:

CLOSED NOTEBOOK – CLOSED TEXT BOOK. Students ARE allowed to use calculators, but are NOT allowed to use any simulation/course software during this exam.

Students should have a sharpened pencil and an eraser for the technical drawing. A straight edge or other drawing tools may be used if available.

Students may bring a single-sided, 8-1/2" x 11" sheet of HANDWRITTEN notes to the exam. Each student must create his or her own notes sheet and may not use a facsimile of another student’s notes. The teacher must collect each student’s note sheet at the conclusion of the examination period along with the student exam documents.

Guidelines:

Students should be reminded to give their short answer responses in complete sentences form.

Grading Parts B and C:

An answer key has been provided for both Part B and Part C.

The scores for Part A (after conversion) and Part B must be added together to determine a student’s total high school credit exam grade.

The scores for Part A (after conversion) and Part C must be added together to determine a student’s total college credit exam grade.
Introduction to Engineering Design™
Final Examination

Part A

Spring 2007

Student Name: ___________________________________________

Date: ____________________________

Class Period: _____________

Total Points: _____________ /40

Converted Score: _____________ /50
Part A - Multiple Choice

Directions: This is a CLOSED-BOOK/CLOSED-NOTES exam. Select the letter of the response which best completes the item or answers the question. Then, record your answer on the separate answer sheet provided for Part A.

1. Which of the following disciplines involves the complex analysis, design, and development of solutions to technical problems?
   A. Mathematics  C. Science
   B. Engineering   D. Medicine

2. During which step of the design process would a design brief be written?
   A. Problem Identification  C. Development and Implementation
   B. Design Analysis        D. Conceptualization

3. Which of the following is a design element?
   A. Emphasis  C. Rhythm
   B. Balance   D. Color

4. A designer will often keep ________________ of his or her best work to show off to prospective clients.
   A. a VHS tape  C. a design brief
   B. a portfolio  D. an engineer's notebook

5. The shape pictured on the right is called _____________.
   A. a circle.  C. a spline.
   B. an ellipse. D. a parallelogram.

6. Circles and arcs that share the same center point are _________________.
   A. collinear.  C. concentric.
   B. coincident. D. tangent.
7. Of the pictorial sketches pictured below, which one is a two-point perspective?

A. Figure 1  
B. Figure 2  
C. Figure 3  
D. Figure 4

8. The hand-written messages on the fire truck sketch below are examples of ____________.

A. annotations.  
B. tolerances.  
C. thumbnails.  
D. design briefs.

9. Which of the following triangles has two sides of equal length, and two equal interior angles?

A. Equilateral Triangle  
B. Isosceles Triangle  
C. Scalene Triangle  
D. Right Triangle

10. What physical characteristic is needed to determine a part’s weight on earth?

A. Center of gravity  
B. Surface area  
C. Density  
D. Temperature
11. Study the image on the right. Starting at point C, what relative coordinate would result in a line segment to point A?

A. (-4,1)  
B. (1,-4)  
C. (-1,4)  
D. (4,1)

12. _________ is a type of drawing that is done freehand and without the use of drawing tools.

A. Computer-Aided Design  
B. Sketching  
C. Prototyping  
D. Isometric

13. This type of creative thinking is characterized by a person who has the ability to look at a given situation or problem in a nontraditional way.

A. Vertical thinking  
B. Diagonal thinking  
C. Convergent thinking  
D. Lateral thinking

14. The image below is referred to as a ____________.

A. pie chart.  
B. line chart.  
C. column chart.  
D. bar graph.

15. What type of chart is pictured on the right?

A. Column Chart  
B. Pie Chart  
C. Line Graph  
D. Bar graph
16. What type of full-scale physical model would an engineer use to demonstrate how a design functions?

A. Prototype  
B. Inventor Assembly  
C. Conceptual Model  
D. Appearance Model

17. A full-size clay model of a new car body design would be considered a __________.

A. prototype.  
B. mock-up.  
C. conceptual model.  
D. mathematical model.

18. What is the total surface area of a 3" cube?

A. 54 in²  
B. 27 in²  
C. 36 in²  
D. 45 in²

19. The list on the right shows the amount of time that it took for four students to solve a puzzle. What was the average solution time?

• Amy – 5 minutes 0 seconds  
• Bob – 4 minutes 32 seconds  
• Teresa – 3 minutes 21 seconds  
• Jim – 2 minutes 58 seconds

A. 2 minutes 58 seconds  
B. 3 minutes 58 seconds  
C. 5 minutes 0 seconds  
D. 15 minutes 51 seconds

20. What 3D solid modeling feature would be used to establish a two-dimensional drawing surface that is tangent to the outside of a sphere?

A. Sketch Plane  
B. Revolve  
C. Origin  
D. Work plane

21. If the sweep feature was applied to the shape and path pictured below, which figure would most likely result?

A. Figure 1  
B. Figure 2  
C. Figure 3  
D. Figure 4
22. If an entire automobile was modeled as a 3D CAD assembly, which of the following would most likely serve as a subassembly?
   A. A windshield  
   B. A rubber tire  
   C. An engine  
   D. A coil spring

23. Why would a designer want the ability to drive an assembly constraint between two or more parts in a CAD assembly model?
   A. To verify that an assembly is bottom-up  
   B. To verify that an assembly is top-down  
   C. To verify that a part can be edited  
   D. To make sure parts don’t interfere with each other

24. How many degrees of freedom will the pin have once it is joined to the hinge body with an Insert constraint? Assume the hinge body is grounded.
   A. Three degrees of freedom  
   B. Two degrees of freedom  
   C. One degree of freedom  
   D. No degrees of freedom

25. When creating an assembly model of the carabiner, which part would be the most logical choice for serving as the grounded component?
   A. Part 1  
   B. Part 2  
   C. Part 3  
   D. Part 4
26. Following an Insert constraint that is placed between Block B and Block A, what 3D assembly constraint would be used to position Block B as shown in the After image? Assume Block A is grounded.

A. Motion  
B. Translational  
C. Offset  
D. Angle

27. Which of the following is the most time efficient method of incorporating a standard-sized fastener into a 3D CAD assembly?

A. Assembly drawings don’t use standard-sized fasteners.  
B. Copying and pasting a picture of the standard fastener from the Internet.  
C. Modeling the standard fastener as a part file and inserting it into the assembly.  
D. Using a parts library to access the standard fastener.

28. The 1 inch diameter THRU hole dimension shown on the drawing below represents __________ dimension.

A. a datum  
B. a size  
C. a location  
D. an aligned

---

[Diagram of a 3D assembly with dimensions and notes: Material: 6061 Aluminum, General Tolerances: .x = ±.020, .xx = ±.010, .xxx = ±.005]
29. Which figure below could result in the greatest amount of overall width variation if the tolerance for each dimension is ±0.02 inch?

- A. Figure 1
- B. Figure 2
- C. Figure 3
- D. Figure 4

30. Study the image at right. The section lines in regions A and C in the front view of the drawing indicate ______________.

- A. the cutting plane contacts material only in regions A and C.
- B. the cutting plane contacts material only in region B.
- C. that regions A and C are hollow.
- D. that regions A and C are finished surfaces.

31. ____________ often take the form of dimensions, symbols, or notes that are added to a drawing to provide details and give clarity.

- A. Auxiliaries
- B. Annotations
- C. Schematics
- D. Sections
32. Which figure below contains a multiview drawing that is associated with the given isometric pictorial?

A. Figure 1  
B. Figure 2  
C. Figure 3  
D. Figure 4

33. When a professional delivers a formal presentation, he or she should

A. dress informally.  
B. read the contents of each PowerPoint slide to the audience.  
C. maintain eye contact with the audience.  
D. speak in a monotone voice.

34. Which of the following is concerned with the containment and protection of a product during shipping, commercial display, and sale?

A. Packaging  
B. Computer Integrated Manufacturing  
C. Mass Property Analysis  
D. Finite Element Analysis
35. Which figure below contains an auxiliary view?

A. Figure 1  
B. Figure 2  
C. Figure 3  
D. Figure 4

36. Part model will change its size automatically to accommodate the dimensional changes of parts to which it is constrained in an assembly model.

A. An adaptive  
B. A revolved  
C. A grounded  
D. A base

37. Which of the following processes involves gathering and analyzing statistical information on a manufactured product to verify that it conforms to pre-determined standards and specifications?

A. Just In Time Manufacturing  
B. Quality Control  
C. Cost Analysis  
D. Computer Numerical Control
38. Which figure below represents the most complete and appropriately dimensioned multiview drawing?

- **A.** Figure 1
- **B.** Figure 2
- **C.** Figure 3
- **D.** Figure 4

39. Information found in a title block, such as material type and surface finish, that applies to an entire part drawing is referred to as a _____________.

- **A.** revision block.
- **B.** hole note.
- **C.** general tolerance.
- **D.** general note.

40. Graphs, charts, mock-ups, prototypes, and computer graphics represent what type of presentation aid?

- **A.** PowerPoint
- **B.** CAD
- **C.** Written Documentation
- **D.** Visual
DIRECTIONS: Complete each of the following exercises. Record answers to questions 1 through 8 in the spaces provided on the separate answer recording sheet for Part B. Record the solutions to problem 9 directly on the orthographic grid on Page 8 of this document.

1. Match each line type indicated in the illustration below (1.1, 1.2, 1.3, 1.4, 1.5, and 1.6) with its corresponding name from the Answer Bank. Answers may be used only once.

[6 POINTS – 1 point each]

**Answer Bank**

A. Extension Line  
B. Object Line  
C. Section Line  
D. Leader Line  
E. Hidden Line  
F. Dimension Line  
G. Center Line  
H. Construction Line
2. Match the letter of the correct physical property term from the Answer Bank to the corresponding scenario.
[4 POINTS – 1 point each]

2.1 A structural engineer must calculate the cost of shipping all the steel truss members for a bridge based only on their combined weight. The sizes and shapes of the truss members vary.

2.2 The Acme Glue Company is designing a new cartoon style glue bottle that is targeted for elementary school users. Acme needs to make sure that the new bottle design will hold at least 4 ounces of glue.

2.3 A hardwood door manufacturer must order a sufficient amount of wood finish to apply three coats of polyurethane to 250 mass-produced doors.

2.4 A rocking chair designer noticed that her prototype chair is not well balanced, and rests in a position that has too steep an angle for a person to use comfortably.

Answer Bank
A. Mass
B. Center of Gravity
C. Principal Axes
D. Volume
E. Moments of Inertia
F. Surface Area

3. Use the illustration below to answer the following parametric equation questions.
[4 POINTS – 1 point each]

![Diagram](image)

3.1 What is the parametric equation for dimension \( d_6 \), if the vertical distance to the hole’s center must always be \( \frac{1}{4} \) the overall width of the plate?

3.2 What is the parametric equation for dimension \( d_1 \), if its size must always be half the overall width of the plate?
3.3 What is the parametric equation for dimension \( d_3 \), if its value must always be \( \frac{3}{4} \) of the overall height of the plate?

3.4 What is the parametric equation for dimension \( d_8 \), if the hole’s diameter is always equal to the vertical distance from its center to the bottom edge of the plate?

4. List the 6 Degrees of Freedom (DOF) that an ungrounded component has within a CAD assembly as it relates to the coordinate axes shown below.
[6 POINTS – 1 point each]

5. List and describe the assembly constraint(s) needed to completely constrain the parts in the two assemblies (5.1 and 5.2) below. Use the numbered surfaces to describe how the constraints would be applied between corresponding parts. Assume that Part B in each problem is the grounded part. Note: all edges on Part A are rounded.
[4 POINTS – 2 points each]

5.1 Assemble the Key (Part A) to the Shaft (Part B). Reference the numbered surfaces to fully explain your assembly constraints.

Given: Apply a Mate constraint between surface 6 (Key) and surface 2 (Shaft).
5.2 Assemble Hinge Plate 2 to Hinge Plate 1 so that surfaces C and D form an angle of 80°. Reference the numbered surfaces and edges to fully explain your assembly constraints.

6. Read the narrative below. Use the Word Bank to indicate which phase of the design process is being described in items 6.1 through 6.3.

[3 POINTS – 1 point each]

Narrative: TCD Design Incorporated has just signed a contract to create a new keyless entry system that is based on fingerprint verification technology. The design team, led by Ms. Jennifer Taylor, has eight months to design, test, and deliver the system to the client.

6.1 Jennifer schedules a meeting between her design team and several representatives from the client company to discuss the project constraints and to write up a design brief.

6.2 The team creates a decision-making matrix to compare the ideas that the design team has generated and narrows down the list of possible solutions to pursue.

6.3 The team demonstrates the final design prototype to the client and delivers a detailed technical report.

Answer Bank
A. Problem Identification
B. Conceptualization
C. Refinement of Preliminary Ideas
D. Design Analysis
E. Development and Implementation
F. Optimization
G. Presentation
7. Use the word bank below to match each of the following parts with the feature selection that BEST REPRESENTS how the part was created. Each feature may only be used once.

[7 POINTS – 1 point each]

Answer Bank

A. Rib     
B. Shell   
C. Revolve 
D. Hole    
E. Loft    
F. Fillet  
G. Coil    
H. Sweep   
I. Extrude with Taper Angle
8. Use the drawing of the Gear Rack to answer the following questions. 
[6 POINTS – 1 point each]

![Gear Rack Diagram]

**Gear Rack**

8.1 Which of the following overall dimensions has an associated tolerance?  
   A. The overall part width  
   B. The overall part depth  
   C. The overall part height  

8.2 What is the height dimension from the base of the part to the center of the .250 diameter hole?  

8.3 What is the depth of the .250 diameter hole?  

8.4 What is the overall width of the part?  

8.5 What is the smallest acceptable hole diameter according to the dimension tolerance?  

8.6 What is the overall height of the part?
9. Examine the technical drawing below. The top, front and right-side orthographic views are incomplete. Draw the 10 missing lines to complete the three orthographic views. Do not include centerlines or center marks. Note: the hole is drilled through the part.
[10 points – 1 point each]
1. [6 points- 1 point each]
   1.1 ___________
   1.2 ___________
   1.3 ___________
   1.4 ___________
   1.5 ___________
   1.6 ___________

Score ________ (Teacher use only)

2. [4 points- 1 point each]
   2.1 ___________
   2.2 ___________
   2.3 ___________
   2.4 ___________

Score ________ (Teacher use only)

3. [4 points- 1 point each]
   3.1 ___________
   3.2 ___________
   3.3 ___________
   3.4 ___________

Score ________ (Teacher use only)

4. [6 points- 1 point each]
   4.1 ___________
   4.2 ___________
   4.3 ___________
   4.4 ___________
   4.5 ___________
   4.6 ___________

Score ________ (Teacher use only)

5. [4 points- 2 points each]
   5.1 ___________
   5.2 ___________

Score ________ (Teacher use only)

6. [3 points- 1 point each]
   6.1 ___________
   6.2 ___________
   6.3 ___________

Score ________ (Teacher use only)

7. [7 points- 1 point each]
   7.1 ___________
   7.2 ___________
   7.3 ___________
   7.4 ___________
   7.5 ___________
   7.6 ___________
   7.7 ___________

Score ________ (Teacher use only)

8. [6 points- 1 point each]
   8.1 ___________
   8.2 ___________
   8.3 ___________
   8.4 ___________
   8.5 ___________
   8.6 ___________

Score ________ (Teacher use only)

9. [10 points – 1 point each line]
   Record answers directly on the orthographic drawing on Page 8.

Score ________ (Teacher use only)
DIRECTIONS: Complete each of the following exercises. Record answers to items 1 – 7 in the spaces provided on the separate answer recording sheet for Part C.

Record the solutions to problem 8 directly on the orthographic grid on Page 11 of this document.

1. Identify the three line types (1.1, 1.2, 1.3) indicated on the orthographic drawing below. In complete sentences, explain the specific purpose of each line type as it is used in an orthographic drawing. Record your responses on the answer sheet provided.

[6 POINTS: 1 point for correctly identifying each line type, 1 point for explaining the purpose of the each line type]
2. Calculate the volume, mass, and surface area of the part below. Then, determine the number of cans (pints) of stain a manufacturer would have to buy in order to apply one coat to 120 wood blocks. Assume each pint will cover 1000 square inches.
[4 POINTS – 1 point each]

Pine Wood Block (Material Density = .02 lbs/in³)

3. Items 3.1 through 3.4 explain the computer-aided design (CAD) work that a group of aerospace engineers has performed on a recent design project. Using only the terms found in the Answer Bank below, identify the missing sketch or feature operation(s) that BEST completes each sentence.
[9 POINTS – 1 point each]

Answer Bank
(Note: each item in the Answer Bank may only be used once)

axis work planes fillet coil
revolve profile rib sweep
chamfer thread loft path
3.1 The sub-team in charge of wing design used CAD to sketch a series of wing-shaped profiles on separate offset \[3.1a\]. The shapes were then merged into a solid by using the \[3.1b\] feature.

3.2 The sub-team in charge of power control used CAD to design the airplane’s metal hydraulic lines. A tube cross-section was sketched, along with a carefully designed \[3.2a\] that occurred across several adjacent sketch planes. The \[3.2b\] function was then used to change the sketches into a solid model of a hydraulic line.

3.3 The sub-team in charge of the airplane’s suspension systems used CAD to design a hydraulic landing-gear piston. They began by sketching half of the \[3.3a\] of the piston. The \[3.3b\] feature was then used to swing the image around a central \[3.3c\] to form the piston model.

3.4 The suspension sub-team then used the CAD program to place a 45° \[3.4a\] on the smaller end of the piston shaft, thus removing the sharp circular edge. The \[3.4b\] feature tool was then used to create a REPRESENTATION of the surface needed to mechanically fasten the end of the piston rod to the rest of the landing-gear assembly.
4. Directions: Use the detail drawing below to answer the following parametric equation questions.
[5 POINTS – 1 point each]

4.1 What would be the parametric equation for dimension $d_1$ if the height (not including the height of the stem) of the object is always equal to the size of its overall width?

4.2 What would be the parametric equation for dimension $d_4$ if the stem is always to be centered within the width of the object?

4.3 What would be the parametric equation for dimension $d_6$ if the stem diameter must always be 40% of the width of the object?

4.4 What would be the parametric equation for dimension $d_{10}$ if the hole must always have a diameter that is .002 larger than the diameter of the stem?

4.5 What would be the parametric equation for dimension $d_{11}$ if the depth of the hole must always be .010 in greater than the height of the stem?
5. Describe the assembly constraints that are needed to adequately constrain the parts in the two assemblies (5.1 & 5.2) shown below. In your description, reference the numbered surfaces to describe how the constraints would be applied between corresponding parts. List the Degrees of Freedom (DOF), if any, that remain on Part A based on the constraints applied. Assume that Part B in each problem is the grounded part.

5.1 Roller Bearing and Axle assembly
[3 POINTS – 1 point for correctly identifying the constraint, 2 points for identifying the remaining degrees of freedom]

5.2 Plate with Counterbored Hole and Machine Screw
Note: surface C and surface D must be parallel.
[3 POINTS – 2 points for correctly identifying the constraints, 1 point for identifying the remaining degrees of freedom]
6. Use the Answer Bank to fill in the missing steps of the design process by matching the letter that corresponds to the missing step. Record your responses on the answer sheet provided. [6 POINTS – 1 point each]

Phase 1: 6.1 ______
Description: Identify areas of need or want through market research. Compose a formalized design brief stating the problem that needs to be solved. Identify all constraints that affect the design and classify the constraints within the various resources available.

Phase 2: Conceptualization
Description: 6.2 ______

Phase 3: Refinement of Preliminary Ideas
Description: 6.3 ______

Phase 4: 6.4 ______
Description: Compare alternatives and specifications. Create a decision matrix to compare the attributes of the various design solutions and analyze trade-offs. Generate alternative solutions that better satisfy the design criteria. Narrow the available solutions and select a final design.

Phase 5: 6.5 ______
Description: Detailed documentation of final design is created. Prototyping is done. Testing and analysis are completed.

Phase 6: Optimization
Description: 6.6 ______

Phase 7: Presentation
Description: Several forms of reporting may be used to adequately express the design solution to any and all parties involved.

Answer Bank:
A. Reassess the design specifications. Implement any modifications that might be necessary. Update drawings.
B. Development and Implementation
C. Workable solutions are identified. Detailed/annotated sketches are developed.
D. Design Analysis
E. Brainstorming occurs and ideas are collected and/or recorded, often in graph form. Research is completed. Thumbnail sketches of ideas are drawn.
F. Problem Identification
7. Use the drawing of the Table Plate below to answer the following questions. [5 POINTS – 1 point each]

7.1 What is the diameter of the Table Plate?

7.2 If the center hole on the Table Plate was made with a 9/32" diameter drill bit, would the resulting hole be within tolerance?

7.3 How deep is the Table Plate's center hole?

7.4 What is the overall height of the Table Plate?

7.5 What is the angle of the chamfer that occurs on the top edge of the Table Plate?
8. Examine the technical drawing below. The top, front and right side orthographic views are incomplete. Draw the 9 missing lines to complete the three orthographic views. Note: no centerlines or center marks are used in the drawing.
[9 POINTS – 1 point each]
1. [6 points – 1 point correct line type; 1 point for correct purpose] Score #1 ________ (Teacher use only)
   1.1 Line type: ________________________________________________________________
   Use: ________________________________________________________________________
   1.2 Line type: ________________________________________________________________
   Use: ________________________________________________________________________
   1.3 Line type: ________________________________________________________________
   Use: ________________________________________________________________________

2. [4 points – 1 point each] Score #2 ________ (Teacher use only)
   2.1 Volume = _____________
   2.2 Mass = _____________
   2.3 Surface Area = _____________
   2.4 Amount of stain = _____________

3. [9 points – 1 point each] Score #3 ________ (Teacher use only)
   3.1a ___________ 3.1b ___________
   3.2a ___________ 3.2b ___________
   3.3a ___________ 3.3b ___________
   3.3c ___________
   3.4a ___________ 3.4b ___________

4. [5 points – 1 point each] Score #4 ________ (Teacher use only)
   4.1 __________________________ 4.4 __________________________
   4.2 __________________________ 4.5 __________________________
   4.3 __________________________

5. [6 points total] Score #5 ________ (Teacher use only)
   5.1 [3 points total – 1 point for constraint, 2 points for DOF]
      Constraint/s: ________________________________________________________________
      DOF: ________________________________________________________________________
   5.2 [3 points total – 2 points for constraints, 1 point for DOF]
      Constraint/s: ________________________________________________________________
      DOF: ________________________________________________________________________

6. [6 points – 1 point each] Score #6 ________ (Teacher use only)
   6.1 __________________________ 6.4 __________________________
   6.2 __________________________ 6.5 __________________________
   6.3 __________________________ 6.6 __________________________

7. [5 points – 1 point each] Score #7 ________ (Teacher use only)
   7.1 __________________________ 7.4 __________________________
   7.2 __________________________ 7.5 __________________________
   7.3 __________________________

8. [9 points – 1 point each line] Score #8 ________ (Teacher use only)
   Record answers directly on the orthographic drawing on Page 9.
Introduction to Engineering Design
Final Examination

Parts A, B & C
ANSWER KEY

Spring 2007

For Teacher Use ONLY
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<td>26</td>
<td>11</td>
<td>14</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
Part B – High School Credit

1. [6 points – 1 point each]
   1.1 __G____
   1.2 __F____
   1.3 __B____
   1.4 __A____
   1.5 __D____
   1.6 __E____

2. [4 points – 1 point each]
   2.1 __A____
   2.2 __D____
   2.3 __F____
   2.4 __B____

3. [4 points – 1 point each]
   3.1 \( d_6 = d_0 \times 0.25 \) OR \( d_6 = d_0/4 \)
   3.2 \( d_1 = d_0 \times 0.5 \) OR \( d_1 = d_0/2 \)
   3.3 \( d_3 = d_1 \times 0.75 \)
   3.4 \( d_8 = d_6 \)

4. [6 points – 1 point each]
   4.1 Rotation around the X-axis
   4.2 Rotation around the Y-axis
   4.3 Rotation around the Z-axis
   4.4 Translation along the X-axis
   4.5 Translation along the Y-axis
   4.6 Translation along the Z-axis

6. [3 points – 1 point each]
   6.1 ___A____
   6.2 ___D____
   6.3 ___G____

7. [7 points – 1 point each]
   7.1 ___G____
   7.2 ___C____
   7.3 ___H____
   7.4 ___B____
   7.5 ___A____
   7.6 ___I____
   7.7 ___E____

8. [6 points – 1 point each]
   8.1 B or The overall part depth
   8.2 ___0.312____
   8.3 ___0.625____
   8.4 ___4.375____
   8.5 ___0.249____
   8.6 ___0.625____

5. [4 points – 2 points each] Note: Students’ answers may vary from those identified. Credit should be awarded if a student’s answer is feasible.

5.1 Given: Apply a Mate constraint between surface 6 (Key) and surface 2 (Shaft).
   Apply a Mate constraint between surface 4 (Key) and surface 3 (Shaft).
   Apply a Flush constraint between surface 5 (Key) and surface 1 (Shaft).

5.2 Apply an Insert constraint between the pin edge (Hinge Plate 1) and the Hole Edge (Hinge Plate 2).
   Apply an Angle constraint between surface C (Hinge Plate 1) and surface D (Hinge Plate 2), and set the value so that the angle between the two surfaces is 80°.
9. Missing line question [10 points total – 1 point each line]
Answer Key: Missing lines are in red.
Part C – College Credit

1. [6 points – 1 point for identifying the correct line type; 1 point for correctly identifying its purpose]
   1.1 Line type: Cutting plane line
   Use: A cutting plane line illustrates where the cutting plane has passed through the object and the direction in which the section is being viewed.
   1.2 Line type: Hidden line
   Use: A hidden line is used in an orthographic drawing to represent an edge that is concealed behind another surface and that is not visible in the viewing plane.
   1.3 Line type: Section line
   Use: Section lines are used in section views to represent material that has been in contact with the cutting plane.

2. [4 points – 1 point each]
   2.1 Volume = 88 in³
   2.2 Mass = 1.76 lbs
   2.3 Surface Area = 124 in²
   2.4 Amount of stain = [15 cans of stain (14.9 pints)]

3. [9 points – 1 point each]
   3.1a work planes
   3.1b loft
   3.2a path
   3.2b sweep
   3.3a profile
   3.3b revolve
   3.3c axis
   3.4a chamfer
   3.4b thread

4. [5 points – 1 point each]
   4.1 \( d_1 = d_0 \)
   4.2 \( d_4 = d_0/2 \) OR \( d_4 = d_0*.5 \)
   4.3 \( d_6 = d_0*.4 \)
   4.4 \( d_{10} = d_6 + .002 \text{ in} \) OR \( (d_0*.4)+.002 \text{ in} \)
   4.5 \( d_{11} = d_7 + .010 \text{ in} \)

5. [6 points total]
   5.1 [3 points total – 1 point for constraint, 2 points for DOF]
   Constraints: Apply a **Mate** constraint between the center axis associated with surface B and the center axis of surface A.
   DOF: Rotation and translation around and along the X-axis.
   5.2 [3 points total – 2 points for constraints, 1 point for DOF]
   Constraints: Apply an **Insert** constraint between surface B in the Counterbored Hole and surface A on the Machine Screw. Apply a zero degree (0°) **Angle** constraint between surface C on the Machine Screw and surface D on the Plate.
   DOF: There are no degrees of freedom remaining.

6. [6 points – 1 point each]
   6.1 \( F \)
   6.2 \( E \)
   6.3 \( C \)
   6.4 \( D \)
   6.5 \( B \)
   6.6 \( A \)

7. [5 points – 1 point each]
   7.1 \( 2.000 \)
   7.2 yes
   7.3 .500 or THRU
   7.4 .500
   7.5 45°
8. Missing line question [9 points total – 1 point each line]
Answer Key: Missing lines are in red. (The discontinuous hidden line in the top view represents a single hidden edge and is considered to be one line.)
<table>
<thead>
<tr>
<th>Item No.</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Example Design Process.doc</td>
</tr>
<tr>
<td>2</td>
<td>Example Design Process Graphic.doc</td>
</tr>
<tr>
<td>3</td>
<td>Activity 1.2.1 – Isometric Sketches.doc</td>
</tr>
<tr>
<td>4</td>
<td>Isometric Graph Paper.pdf</td>
</tr>
<tr>
<td>5</td>
<td>Isometric Parts Sheet 1.pdf</td>
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<tr>
<td>6</td>
<td>Isometric Parts Sheet 2.pdf</td>
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<tr>
<td>7</td>
<td>Activity 1.2.4 – Multiview Sketches.doc</td>
</tr>
<tr>
<td>8</td>
<td>How do I create a project pathway.doc</td>
</tr>
<tr>
<td>9</td>
<td>Activity 2.2.1 – What Is Wrong With This Picture?.doc</td>
</tr>
<tr>
<td>10</td>
<td>Activity 2.2.2a – General Rules for Dimensioning.doc</td>
</tr>
<tr>
<td>11</td>
<td>Assembly angle constraint solutions.doc</td>
</tr>
<tr>
<td>12</td>
<td>Building a New Title Block.doc</td>
</tr>
<tr>
<td>13</td>
<td>Problem 3.4.3a – Decision Matrix Template.doc</td>
</tr>
</tbody>
</table>
Example Design Process

There are many Design Processes that are used in the field. For purposes of Lesson 1.1 Introduction to Design Process and this course, Project Lead The Way, Inc. has adopted this design process from Standards for Technological Literacy Standard 8, Benchmark H. This design process will be used for all courses. The design process includes:

1. **Define a Problem**
   - Identify a problem that exists.
   - Determine the root cause.
   - Gather information.

2. **Brainstorm**
   - Present ideas in group.
   - Generate and record ideas.
   - Seek quantity not quality.
   - Keep the mind alert through rapidly paced sessions.

3. **Research and Generate Ideas**
   - Analyze the reasons for the need, want, or problem.
   - Investigate who or what it is that is affected, and consider the need, want, or problem from their perspective.
   - Research any existing solutions, and identify why they are not adequate or appropriate.
   - Listen to clients to solve problems that they have discovered.
   - Perform market research to determine if a want or need exists and warrants the development of a design solution.

4. **Identify Criteria and Specify Constraints**
   - Identify the end user if the client is not.
   - Redefine the problem to the agreement of both client and engineer.
   - Identify what the solution must do, and the degree to which it will be pursued.
   - Identify the limitations within which the engineer must perform his/her duties.
   - Compile the information into a design brief.

5. **Explore Possibilities**
- Initiate further development of brainstorming ideas with constraints and tradeoffs considered.
- Explore alternative ideas based on further knowledge and technologies.

6. Select an Approach
- Create a decision-matrix to compare the attributes of the various ideas and analyze the trade-offs associated with each one.
- Verify alignment between the idea selected and the criteria and constraints.

7. Develop a Design Proposal
- Develop detailed and annotated sketches.
- Determine the type(s) of material from which the solution will be constructed.
- Make computer models.
- Create technical drawings from the computer model(s).

8. Make a Model or Prototype
- Make study models (scaled models or mock-ups).
- Fabricate a functional prototype.

9. Test and Evaluate the Design using Specifications
- Test the prototype under controlled conditions.
- Test the prototype under actual conditions.
- Record the results.
- Evaluate results to determine if problems exist and further work is needed.

10. Refine the Design
- Reassess the validity of the design criteria and make adjustments to the design brief, if necessary.
- Work through the design process until the solution satisfies the design criteria.
- Update the documentation of the final solution.

11. Create or Make Solution
- Determine Custom/Mass Production.
- Consider packaging.

12. Communicate Processes and Results
- Present oral presentations with visual aids (computer generated slide show, models, prototype).
- Develop written reports with appropriate graphic documentation (charts, graphs, technical drawings, renderings, etc.).
- Market the Product.
• Distribute.
Design Process

1. Define the Problem
2. Brainstorm
3. Research and Generate Ideas
4. Identify Criteria and Constraints
5. Explore Possibilities
6. Select an Approach
7. Develop a Design Proposal
8. Model or Prototype
9. Test and Evaluate
10. Refine
11. Create or Make
12. Communicate Results
Activity 1.2.1 – Isometric Sketches

Purpose

How do reading the face of a clock and sketching isometric pictorials relate to each other? Picture a cube in your mind. All of the surfaces of the cube form right angles with their adjacent faces. If you were to draw an isometric pictorial of the cube, you would see that the edges point toward 2 and 8 o’clock, 4 and 10 o’clock, and 6 and 12 o’clock. This idea helps when sketching isometric pictorials on writing surfaces that do not have isometric grids.

Isometrics are very common in Computer-Aided Design (CAD) programs and are only slightly more difficult to sketch than oblique pictorials.

Equipment

- Engineer’s notebook
- Number 2 pencil
- Various objects

Procedure

In this activity, you will develop your isometric sketching skills by drawing views of objects that are already given in an isometric orientation. You will then apply your sketching skills throughout the remainder of the course.

Before you begin, you must understand how an isometric view is called out. The image on the left represents a top, front, right side view isometric. The order is first face, second face, then third face. The same object is pictured again on the right, but shown in a top, left side, front view orientation.
Complete the isometric pictorial of the object pictured below. Use points and construction lines to layout the isometric sketches. DO NOT ERASE YOUR POINTS AND CONSTRUCTION LINES.

Make isometric sketches of the three objects pictured below. Sketch the objects in the same orientation that they are pictured in. Use points and construction lines to layout the isometric sketches. Then, delineate the visible edges of each sketch with object lines to make them stand out. DO NOT ERASE YOUR POINTS AND CONSTRUCTION LINES. Add tonal shading to the sketches when finished.
Study the isometric objects below. Using the grid paper provided, recreate the three objects for practice. Use the back side of the grid paper to recreate your drawings. This will make the sketches look cleaner while still having the grid lines as a guide.
Conclusion

1. What is the difference between a two-dimensional sketch and an isometric sketch?

2. Why do designers use tonal shading on their sketches?

3. If you were not given isometric graph paper, what technique could you use to approximate the proper isometric angles in order to complete an isometric sketch?
Directions: Each isometric grid square is equal to \( \frac{1}{4} \)".
Directions: Each isometric grid square is equal to $\frac{1}{4}''$. 
Activity 1.2.4 – Multiview Sketches

Purpose

It’s a very common occurrence to see a product advertisement and think, “I thought of an idea for something like that just a few months ago.” People spend a lot of time in their various interest areas and envision ideas for making things work better. Spend some time with someone who has a permanent disability and see how many product ideas come to mind that would provide a degree of freedom to a person who has lost a physical capability years ago. Coming up with wonderful ideas are only the first step in developing solutions to problems. At some point, ideas must be built.

You’ve practiced different techniques for sketching objects so that they appear to have a three-dimensional quality. These techniques are excellent for quickly communicating ideas to both technical and non-technical people. Those who make their living building ideas require a different type of drawing format. A multiview sketch, also referred to as an orthographic projection sketch, is the standard sketch format used by engineers to communicate ideas to professionals in the building trades.

However, pictorials do not provide accurate information about the true size and shape of an object and all of its features. It is often the case that engineered objects have features and edges that are obscured by the standard surface views of a multiview drawing. These views require hidden lines. When engineers create drawings of cylindrical objects, or objects that have holes, they must represent their axes and axes points with centerlines.

Knowing how to sketch and interpret multiviews is an important skill for any engineer.

Equipment

- Number 2 pencil
- Engineer’s notebook

Procedure

In this activity, you will develop your ability to see and sketch objects as a series of related two-dimensional views. Understanding and using the different line conventions, discussed earlier in this lesson, will help when creating these views.
Study the image below. The various surfaces of the object are identified by letters on the isometric drawing and by numbers on the multiview drawing. In the table, write the number that corresponds with the lettered surface in each of the top, front, and right side views.

<table>
<thead>
<tr>
<th></th>
<th>Top</th>
<th>Front</th>
<th>Side</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>9</td>
<td>3</td>
<td>21</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
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<td>C</td>
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<tr>
<td>H</td>
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</tr>
</tbody>
</table>

Study the images below. Use points, construction lines, hidden lines, center lines and object lines where applicable to sketch the missing view. DO NOT ERASE YOUR POINTS AND CONSTRUCTION LINES.
Extending Your Learning

The following problems have students sketching the missing views, and allowing them to experiment with sketching other types of line conventions.
Study the isometric views in the next four pages. Use points, hidden lines construction lines, and object lines to sketch the three common views used to explain the object. The scale is 1:1 which means each grid line on the isometric view represents a grid line on the orthographic grid. **DO NOT ERASE YOUR POINTS AND CONSTRUCTION LINES.**
Extending Your Learning- Part II

The following problem has students sketching the missing views, and allowing them to experiment with sketching other types of line conventions.
Conclusion

1. Why would building professionals, such as machinists and contractors, prefer multiview drawings over pictorial drawings?

2. How would you describe the geometric relationship that exists between the adjacent views of a multiview drawing?

3. Why is it important to layout a multiview sketch with points and construction lines before drawing object lines?

4. What is the purpose of hidden lines and center lines?
PROJECT PATHWAYS

Keeps all files together

1. Close all files (but have Inventor open)
2. Go to “Projects” under the File pull down menu
   a) Select “new”
   b) Enter project name. This only NAMES the pathway. It will appear as an *.IPJ file.
   c) Select the location where you want to save your project. **IMPORTANT STEP!**
   d) Create a new folder and name it the same as your project.
   e) Double check the location and that here is a folder that the files are going into. Select “finish”.

---

A

B

C

D

E
Activity 2.2.1 – What Is Wrong With This Picture?

Purpose

If you’ve ever taken something apart or looked at the parts of a product closely, you may have been surprised to see how the parts fit together. Some parts don’t always fit together well for a variety of reasons. It’s possible that the parts were made in different locations, possibly even different parts of the world. Perhaps, the drawing provided to the manufacturer of the part did not correctly communicate the information: the accuracy of the part was compromised. To keep this from happening, universal drafting standards, such as the American National Standards Institute (ANSI) by the American Society of Mechanical Engineers (ASME), are used. The language of design or drafting standards provides a means for designers and engineers to communicate information clearly and accurately.

The graphic representation used to create a detailed drawing is a language. Learning this new language takes a certain degree of determination. This language is not unlike any other you may have learned, such as English. It has an extensive vocabulary, style and format conventions, and standards, which must be followed if the message is to be effectively communicated. This activity is designed to provide you with the opportunity to learn the standards by evaluating a variety of drawings and determining whether or not they have been dimensioned according to ANSI or ASME standards.

Equipment

- Engineer’s notebook
- Pencil
- Dimension Guidelines

Procedure

In this activity, you will work in teams of two to evaluate dimensioned computer-aided drawings (CAD) and make recommendations for changes so the drawings will align with dimensioning standards.

Study the following drawings with your partner, and use a pencil to fix the dimensions by marking all incorrect or misplaced dimensions, and adding all missing dimensions.
Place a letter, A through Z, next to each change on the drawing. In the space provided below each drawing, next to the appropriate letter, give the reason for each correction by citing the dimensioning guideline that is misapplied.

**Drawing #1**

A. ________________________  B. ________________________
C. ________________________  D. ________________________

**Drawing #2**
E. ______________________  F. ______________________
G. ______________________  H. ______________________

Drawing #3
I. ____________________
K. ____________________
M. ____________________
O. ____________________

J. ____________________
L. ____________________
N. ____________________
P. ____________________
During a class discussion, you and your partner will identify and defend the changes that you made to each drawing. Your teacher will moderate the discussion.

During the class discussion, correct any errors that you and your partner may have made on the drawings.
Conclusion

1. What could result from incorrectly applying or omitting dimensions on a technical drawing?

2. Based on your experiences in this activity, why is the use of dimension guidelines important?
Activity 2.2.2a – General Rules for Dimensioning

General Rules for Dimensioning

1. Dimensions should NOT be duplicated, or the same information given in two different ways.
2. No unnecessary dimensions should be used – only those needed to produce or inspect the part.
3. Dimensions should be placed at finished surfaces or important center lines.
4. Dimensions should be placed so that it is not necessary for the observer to calculate, scale or assume any measurement.
5. Dimensions should be attached to the view that best shows the shape of the feature to be dimensioned.
6. Dimensioning to hidden lines should be avoided.
7. Dimensions should not be placed on the object, unless that is the only clear option.
8. Overall dimensions should be placed the greatest distance away from the object so that intermediate dimensions can nest closer to the object to avoid crossing extension lines.
9. A dimension should be attached to only one view (i.e., extension lines should not connect two views).
10. Dimension Lines should never be crossed.
11. A center line may be extended and used as an extension line.
12. Leaders should slope at a 30, 45 or 60 degree angle.
13. Dimension numbers should be centered between arrowheads, except when using stacked dimensions where the numbers should be staggered.
14. In general, a circle is dimensioned by its diameter; an arc by its radius.
15. Holes should be located by their center lines.
16. Holes should be located in the view that shows the feature as a circle.
17. Extension lines start approximately 1/16” from the object and extend 1/8” past the last dimension.
18. The first dimension is approximately 3/8” from the object and each associated dimension spaced uniformly approximately 1/4” apart.
19. Dimensions should reflect the actual size of the object, not the scaled size.
Assembly angle constraint solutions

When driving an angle constraint through a range, two possible solutions to the angle may be possible: directed angle and undirected angle. You can now set the preferred solution so that the driven angle constraint represents the expected behavior.

- **Type and Solutions**
  - **Directed Angle** solution always applies the right-hand rule. This is the default solution.
  - **Undirected Angle** allows either orientation, thus resolving situations where component orientation flips during a constraint drive or drag.

- **A Mate** constraint positions components face to face or adjacent to one another with faces flush. Removes one degree of linear translation and two degrees of angular rotation between planar surfaces.
  - **A Mate** constraint positions selected faces normal to one another, with faces coincident.
  - **A Flush** constraint aligns components adjacent to one another with faces flush. Positions selected faces, curves, or points so that they are aligned with surface normals pointing in the same direction.

- **A Tangent** constraint causes faces, planes, cylinders, spheres, and cones to contact at the point of tangency. Tangency may be inside or outside a curve, depending on the direction of the selected surface normal. A tangent constraint removes one degree of linear freedom and one degree of rotational freedom.
  - **Inside** Positions the first selected part inside the second selected part at the tangent point.
  - **Outside** Positions the first selected part outside the second selected part at the tangent point. Outside tangency is the default solution.

- **An Insert** constraint is a combination of a face-to-face mate constraint between planar faces and a mate constraint between the axes of the two components. The Insert constraint is used to position a bolt shank in a hole, for example, with the shank aligned with the hole and the bottom of the bolt head mated with the planar face. A rotational degree of freedom remains open.
  - **Opposed** reverses the mate direction of the first selected component.
  - **Aligned** reverses the mate direction of the second selected component.
Building a New Title Block. aka “The Hula Hoop of Fire”

Note: please save only when it says to save! Look for sample of title blocks and start with a sketch of how you want yours to look in your engineering notebook.

Open a new IDW. Delete the existing TB (ANSI – Large) by right clicking under sheet:1 and deleting it.

You should also change your sheet size. Start with the A size, the size we use most often (the default is size C). Right click on Sheet:1 and choose edit sheet. Change to A.

Save this IDW as a file on your desktop. This is important because you want to be able to locate it easily and be able to move it later. Do not worry about a project pathway.

Placing Lines and Static Text
Go to Format (pull down menu) – Define new title block. This places you in sketch mode. Begin drawing your title block by using the sketch tools from your menu. (Rectangle, line etc) You can draw this in the center of your page because later Inventor will place it in the corner you want automatically. You can constrain the TB with dimensions and placing additional constraints. It will look odd, but the only thing you will end up seeing is the lines you drew and static text.

Now place all of your lines, and static text (on sketch panel, towards the bottom). Remember the static text is what you want to see the same on every title block. All of the text you see above is static!
Placing Text to Pulled From Your Drawing

Now we will place text (on sketch panel, towards the bottom) that can be pulled from your drawing file. To do this go to the TEXT command and decide what you will place.

1. In this case we are pulling the filename from your model.

2. Next, click on “Add text Parameter”

3. Next you will highlight the field, and format it with font you want along with the size, spacing etc.

Placing Text Your Students will be prompted for:

Now we will place Prompted Entries. You can have Inventor ask your students questions and it will show up in your title block. Again, once you have typed in your prompted entry, highlight it and select placement, font, and size.
**Saving – NOW HERE’S THE TRICKY PART - FEEL THE BURN?**

**First:** Right click and save your title block as **SAMPLE**. (We are not saving the IDW yet.) Your title block will disappear. Relax.

**Second:** Insert your new title block on your IDW by expanding the drawing resources folder by right clicking on **SAMPLE** and choosing, insert title block. Save Do **not** fill in the **PROMPTED ENTRIES**, just press **OK**.

![Image of title block folder hierarchy]

Now **save** your IDW. This saves your new IDW with the blank title block, and it should go on your desktop so we can easily locate it!

**Placing Your New Title Block + IDW in the Templates Folder.**

Right click on START, go to Explore and locate the following path:

![Address of Templates Folder]

Here we will put a copy of your new template. If you want you can make a new folder “other” and move the files we do not use often into it. See below.

**Try It Out**

Open a new IDW in Inventor and see how your title block looks. Print it out and check your sizes of text and placement and prompts. You can only tell for sure if you **print**!

**Now I Want to Change It !**

You will! You will want to change this! Open Inventor, and open the IDW file we put on YOUR DESKTOP. Right click on the Title Blocks in the browser and select “edit title block” Make the changes you want but **REMEMBER:**

- Save the title block edits
- Save the template IDW
- Recopy the template into the template directory

Here is what my template folder looks like with my IDW “sample.” Remember every folder is a TAB.
## Problem 3.4.3a – Decision Matrix Template

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Ideas</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Totals</th>
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