This is a low-resolution printable version of the teacher-presentation information. The original PowerPoint slides are clearer and animated to assist the teacher in delivering quality content to the students.

Licensed users of the EST Foundations curriculum have access to:

- the original animated PowerPoint files
- accompanying handouts
- detailed homework assignments
- lesson plans including online reading and research assignments, and
- suggestions on integrating this project-based curriculum.

Topic 3 (ver 1.0) Basic Project Skills-Sketching

Content of this module

- Bell work 3.1
- Role of sketching and drawing in Engineering
- Basic rules of technical sketching
- Bell work 3.2
- Practice orthographic projection
- Bell work 3.3
- Basic rules for isometric views
- Bell work 3.4
- Practice creating isometric views
- Bell work 3.5
- Discuss goals and rules for dimensioning
- Practice interpreting dimensions on engineering drawings

3.1 Orthographic Projection Sketching

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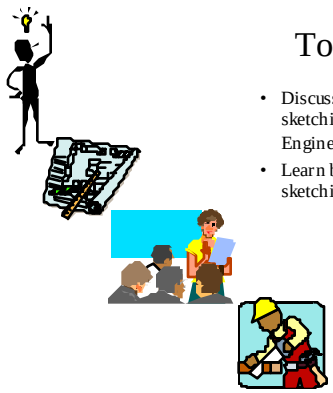
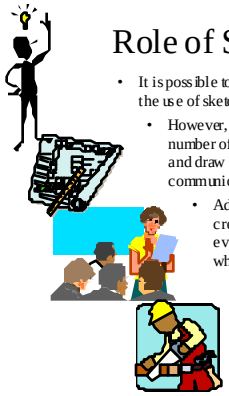
Bell Work 3.1

- As always, begin a new journal page and record the task…
- Draw a picture of the object provided by the teacher. The picture should convey all the detail of the object to someone who has never personally seen the object.



Today's Agenda

- Discuss the role of technical sketching and drawing in Engineering
- Learn basic rules of technical sketching



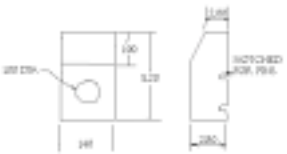
Role of Sketching and Drawing

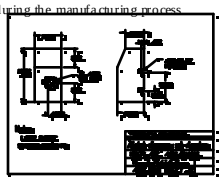
- It is possible to have an idea and bring it to fruition without the use of sketches and drawings.
  - However, as the complexity of the project increases and the number of people involved increases, the ability to sketch and draw quickly becomes an essential tool in communicating the idea to others.
    - Additionally, sketching is as important in the creative process as it is to communicating the eventual solution. Ideas mutate and evolve quickly when the designer is efficient at sketching.
      - It is when a designer begins to sketch that challenges in the details begin to surface. It is much less expensive to address these details on the drawing board than to address them when the part is in the workshop.

Technical Sketch vs. Technical Drawing

- typically drawn "free hand," without the use of instruments or straight edges
- a rapid process that aids thinking
- includes sufficient detail to convey entire concept
- useful for quick documentation of all ideas

- uses drafting instruments or a computer (with **C**omputer **A**ided **D**rafting Software)
- slower process with attention to every detail
- includes sufficient detail to fully describe the final part including: geometric properties, material properties and precautions to take during the manufacturing process



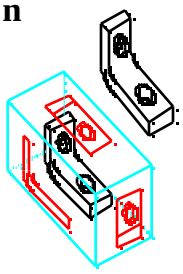


Sketching Guidelines

- Sketching should be a **rapid process** that aids the thinking process.
- If the sketch is not **clear** and **detailed** enough to convey the idea to another person, then the designer probably has not developed the idea enough.
- Representing a 3D world on a 2D sketch is best accomplished by following an established convention. There are many options, but stick with **orthographic,** or **multi-view projection**, as a way to clearly show every side of an object.
- Sketching is a **freehand technique** that does not use instruments or straightedges. You can violate this rule if you want, but it will slow you down. It is better to develop the skills that allow you to sketch without instruments or straightedges.
- Two types of sketches should be mastered: **standard three-view sketching** and **isometric sketching**.

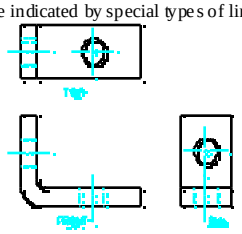
Location of Views in Orthographic Projection

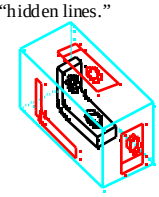
- Imagine placing the object that you want to draw in a glass box. The box has six sides (top, bottom, front, back, right side, left side). These represent the six "principle" views. Think about what each of the six views would look like for the angle bracket that has been placed into such a glass box.



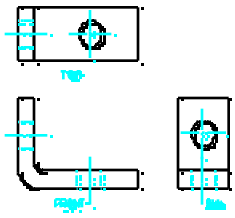
Three primary views

- This is what you would see from each direction…
- Note which view is called "front" and which view is called "side."
- Note that even though the holes cannot be seen from the side, they are indicated by special types of lines called "hidden lines."





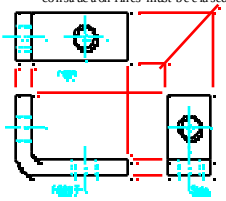
Rules for placement on page

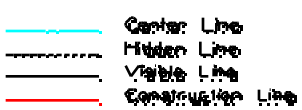


1. Orthographic views should be aligned with each other (temporary lines can be drawn to show how each edge is lined up with edges in other views…but they should be erased when you are finished drawing)
2. Width appears in Top and Front views
3. Height appears in Front and Side views
4. Depth appears in Side and Top
5. Height and width project directly between views
6. Depth must be projected via a 45 degree angle

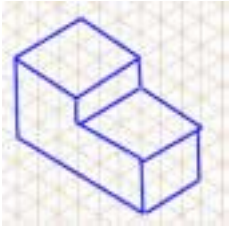
Important Types of Lines

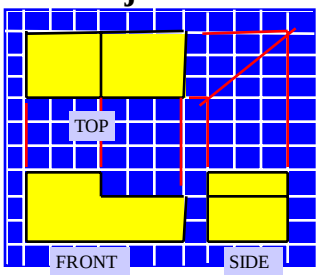
- Ignore the color…all lines are printed black, but they are shown in color to help you see where the different line types are used
- **Center Lines** indicate where the center of a radial element is located.
- **Hidden Lines** indicate surfaces that are not really there but you would need x-ray glasses to see them. The lines are not hidden…the surface is hidden from plain view.
- **Visible Lines** are slightly darker than any other line type. They indicate the geometry that is actually viewable with the naked eye.
- **Construction Lines** are any temporary lines you might use to line things up. ALL construction lines must be erased when the sketch or drawing is completed.





Practice Sketching Orthographic Views of This Object





3.2 Practice Orthographic Projection Sketching

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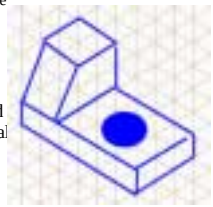
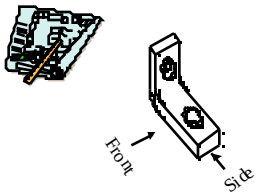
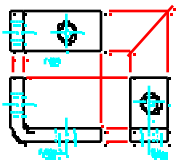
BELL Work 3.2

- As always, begin a new journal page and record the task…
- In your journal, try to draw the 3-view sketch for the object
- Normally you would use orthographic grid paper, but just draw directly in your journal for now.



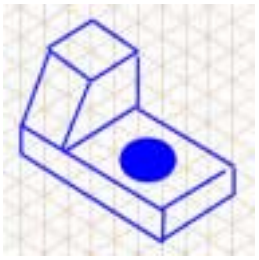


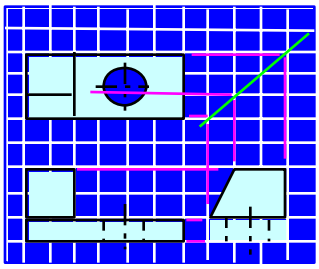


Today's Agenda

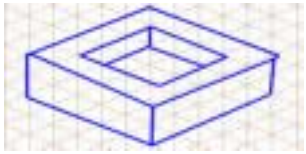
- Work one more example of orthographic projection
- Spend class individually practicing orthographic projection

Let's draw the 3-orthogonal views





One More Practice Orthographic Projection



Lots of Practice

- Individually work through the ortho-sketching practice handout. All sketches should be drawn to the correct scale (one unit on isometric grid equals one unit on orthographic grid).
- You must turn in your work before you leave. It will be graded on correctness, neatness, and completeness.

3.3 Isometric Sketching

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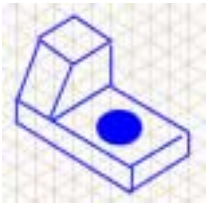
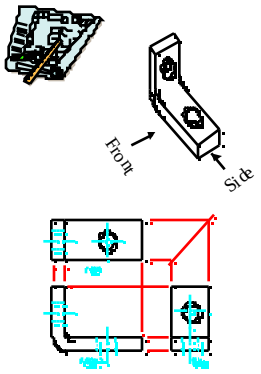
BELL Work 3.3

- As always, begin a new journal page and record the task…
- Copy the isometric object onto isometric grid paper.
- If each triangle on the iso-grid represents one inch, and you wanted to cut the object out of a single block of Styrofoam, what would be the volume of the Styrofoam block?



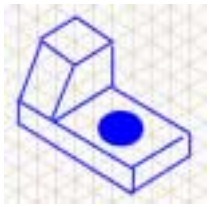


Today's Agenda

- Learn basic technique for creating isometric views of parts
- Work examples as a class

Isometric Sketching

- An Isometric view is a way of showing a 3D representation of the object



- It is easiest to learn if you use special grid paper
- Important notes:
  - Angles cannot be measured with a protractor in isometric pictorials.
  - Circles are not round in isometric pictorials.
  - If two sloping planes intersect each other, then each plane must be drawn separately.

Examples Drawing the Isometric Views

- Teacher: Insert in-class examples here.

3.4 Practice Isometric Sketching

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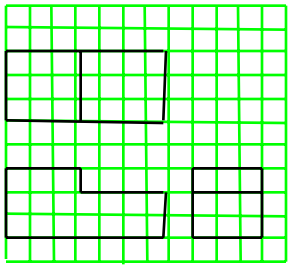
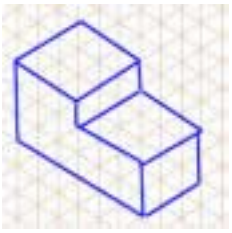
BELL Work 3.4

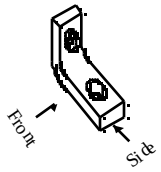
- As always, begin a new journal page and record the task…
- Using iso-grid paper, draw the isometric view of the part represented by the multi-view projection.



Today's Agenda

- Practice creating isometric views of parts.





Lots of Practice

- Individually work through the iso-sketching practice handout. All sketches should be drawn to the correct scale (one unit on isometric grid equals one unit on orthographic grid).
- You must turn in your work before you leave. It will be graded on correctness, neatness, and completeness.

3.5 Dimensioning

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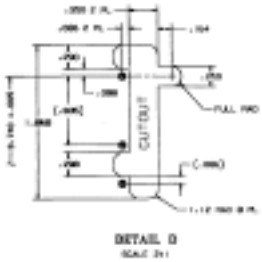
BELL Work 3.5

- As always, begin a new journal page and record the task…
- Begin reading through the handout on dimensioning (handout: example dimensioning).
- Answer these questions:
  - What does an RF cavity protect the electronics from?
  - What does "PL" stand for in the example dimensions?

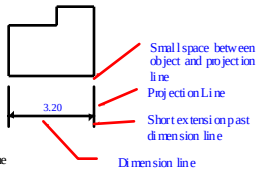
Today's Agenda

- Discuss different types of dimensioning
- Discuss basic rules for dimensioning
- Practice reading dimensions from drawings



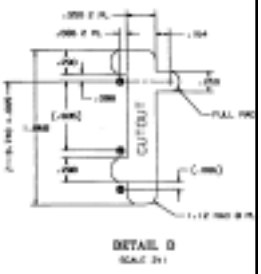
Basic Dimensioning

- There are some very basic rules for dimensioning:
  - Dimensions should be placed on a drawing so that they are easily read. They are always placed **outside** of the boundaries of the object being described.
  - Projection lines (sometimes called extension lines) are projected perpendicular to the object and they do not touch the object. They indicate the start and finish of the feature of interest.
  - The dimension line is a continuous line and no other lines should be allowed to cross it. It can be broken only to insert the text of the dimension if this adds to the clarity of the drawing.
- Units of measure should be consistent on the drawing and indicated somewhere on the drawing. They do not need to be appended to every dimension…that would simply add unnecessary clutter.



Enforcing the Rules

- There is generally not a "dimensioning police force" to make sure you adhere to the rules. However, you will really do your production crew a favor by using proper dimensioning procedures.
- What basic rules seems to be violated in the example to the right? Does it effect the clarity of the drawing?
- Why is it advantageous to use the term "PL?"
- What does the ±.005 mean? Why don't the other dimensions have similar callouts?
- Remember, the goal is to clearly convey the design. Sometimes you need to be creative in how you apply the dimensions in order to achieve clarity.



Practice Reading Dimensions

- In groups of 2-3, read through the handout and answer these questions. Each student must turn in their own paper to receive credit.
  - What is the job of an RF-Cavity?
  - Where is the zero datum of the part? (you'll have to read the handout to know what "datum" means)
  - Why do draftsmen sometime include "Detail" views on the drawing?
  - What does the symbol $\triangle$ mean?
  - What is the maximum dimension of the part (the largest overall dimension)?
  - Looking at the top view, there are three inserts across the upper edge. How far is the middle insert from the right edge of the part? How do you calculate the distance?