**Intermediate Engineering Graphics**
**2nd Week 1st and 3rd Meeting Lecture Notes**
**Instructor: Edward N. Locke**

# Topic: The Coordinate System and Types of Drawings

## 1st Subject: The Cartesian Coordinate System

**The Cartesian Coordinate System** is the foundation of both manual and digital engineering drafting. To remember the way the Cartesian Coordinate System works, remember "The Right-Hand Rule" (Hold your right hand with thumb pointing towards right direction as X-axis, index finger pointing upwards as Y-axis, and middle finger pointing at yourself as Z-axis, all in positive values).

## 2nd Subject: Categories of Engineering Drawings

Engineering drafting is The Language of Industry, and uses lines and shapes to graphically express ideas about object to by made by small quantity custom construction or large quantity mass production. Categories of engineering drawings include: **(1) Mechanical** (dealing with a variety of products; **(2) Electrical** (dealing with electronic or electrical stuff such as electronic circuit board; **(3) Architectural** (dealing with building construction); **(4) Civil** (dealing with maps and civil works projects, etc.). Traditionally, engineering drawings are produced by hand with tools such as drawing boards, regular or mechanical pencils, rules, protractor, triangles, compass, brush, T-square, divider, grid paper, etc.. nowadays, most of the drawings used in industry are produced by CAD programs using computer workstations, and plotters or printers.

## 3rd Subject: Types of Drawings

**(1) Orthographic drawings:** they show several distinct and separate views of the object; they are used for engineers and production people, and are known as "the language of industry".

**The orthographic drawings are based on multi-view projection where the observer is considered to be at infinity, and the visual rays are parallel to each other and perpendicular to the plane of projection**. They usually include the following types:

**a. One-view drawing:** used for spheres, etc.

**b. Two-view drawing:** used for cylindrical shapes.

**c. Three-view drawing:** used for most rectangular blocks, including top, front, and one side (usually the right side). The left, back and bottom views are rarely used. Sometimes auxiliary views
are needed to show slanted surfaces at true size; and to completely describe the objects. Sometimes sectional views are needed to clearly describe the details of the object's interior.

**d. Sectional Views: the sectional view, also called a cross section, or simply "section", is a cutaway view of the object, which shows the complicated interiors of the object that can not be shown clearly by means of hidden lines. The sectional view is drawn by assuming that an imaginary cutting plane has passed halfway or all the way through the object, and then removed a part of the object to expose its interior construction.**

Sectional views shows the shape of the inside of some object not normally seen; sectional views are especially needed when the inside has some complicated shape which is difficult to show by hidden lines. An imaginary cutting plane is passed through the object to make a sectional view. One part of the object is “removed” in the drafter’s mind so that the inside detail can be seen. A full section is one with the cutting plane passing through the entire object. The imaginary cutting plane is shown on the regular view by a thick broken line with long dashes between two short dashes and arrows indicating the viewing direction, plus coded letter above the arrows. The inside surface exposed by the cutting plane is indicated by thin, solid section line drawn at an angle (usually 45 degrees) and spaces between lines may vary from 1/32” for small sections to 1/8” or more for large sections; for average drawing, a spacing of 3/32” is about right. The spacing must be uniform throughout the same section. There are **full section** (the cutting plane is passed all the way through the object), **half section** (the cutting plane is passed only halfway through the object; used for objects with symmetrical shapes, combining both sectional and regular views on one single view), **offset section** (the cutting plane turns in order to cover several details located at different planes), **broken-out section** (part of the object is broken off to show the interior details; thick break line is used instead of regular cutting plane line), **aligned section** (used for circular objects; cutting plane turns to align itself with certain features so as to avoid foreshortening in the sectional view; read p234 for details). Three important things to remember:

1. Sectional lines should NOT be parallel to any edge line of the object;
2. If two or more parts are included within the same sectional view, then the angles of the sectional lines should be visually different;
3. Sectional views of castings with ribs should follow special conventions so as to avoid misleading (read p239 for details).

**e. Auxiliary Views: a view obtained by a projection on any plane other than the horizontal, frontal, and profile projection planes is called an auxiliary view. It gives the true-size view of an inclined face obtained by viewing the object at right angles to that face, through a special inclined auxiliary plane parallel to it.**

This view shows clearly and at true size and shape the slanting surface with an irregular shape, which would be difficult to show with the regular views (which “foreshortens” it and distorts it). An auxiliary view is the view that would be seen by looking straight at the slanting surface.

**To draw an auxiliary view:** construct projection lines at right angle to the slanting surface line to get the true size of the side that is foreshortened in the regular view, then copy the other true sizes from other regular views.

**(2) Pictorial drawings:** shows a realistic view of the object. Used for presentation to people with little knowledge on engineering drafting. They include:

**a. Isometric (the most used of axonometric drawing):** One corner of the object appears closest. The lines slanting away from this corner are 120 degrees apart, and are drawn true length. The word “isometric” literally means “equal measure”. Other axonometric drawings include diametric and trimetric, they are difficult to draw and are not used as often as isometrics. **In axonometric projection, the observer is considered to be at infinity, and the visual rays are parallel to each other and perpendicular to the plane of projection**.

Isometric drawings can be used for client presentation and product literature, in the forms of explosion and assembly drawings.

**b. Oblique drawings:** in this type of drawings, one side of the object appears closest. The top and one side slant away. They are useful for circular objects. Oblique sketches are based on one perpendicular set of lines and one receding line, at any angle but with 30º or 45º as the most common. All receding lines are parallel. **The oblique drawing is based on oblique projection where the observer is considered to be at infinity, and the visual rays are parallel to each other but oblique to the plane of projection**.

**c. Perspective drawings:** are the most realistic and natural type of pictorial drawing, but do not show the real dimensions of the object, therefore, can NOT be used as working drawings. All measurement in perspective drawings are "estimated", NOT measured with a rule as in isometrics or oblique drawings. Perspective drawings are good for showing large objects such as buildings, and highway in a realistic way, before things are actually built. The perspective drawings are sometimes beautifully rendered, look like photographs and show the object the way it actually appears; and are used in architecture, aircraft and automotive industries. **In perspective projections, the observer is considered to be at a finite distance from the object, and the visual rays extend from the observer's eye, or the Station Point (SP), to all points of the object to form a "cone of rays"**.

# 4th Subject: Basic Principles of Orthographic Projection

**1. Relation of views:** to understand the three-view projection, imagine a block placed inside a glass box with hinges between top and front glass panels, and hinges between front and right side glass panels, trace the views on the three glass panels, and open the glass panels to see the three-view drawings. (p38 "Blue Book")

**2. Selection of the best views with the most favorable position of the object:** that position must

- show the most complete outline in the picture drawing;
- show the desired views, normally top, front and right side, with as few hidden lines as possible in the three-view projection;
- be in a natural position according to common sense (do not turn a chair upside down to reduce hidden lines of the legs);
- Fits well on the page.

# Study Questions:

1. How do orthographic drawings show the object? What are they used for?

2. The orthographic drawings are based on what? In this type of projection where is the observer considered to be located? And what are the relations between the visual rays and the plane of projection?

3. What are the three most commonly used types of orthographic drawings? And their usage?

4. What is the significance of orthographic drawings in the manufacturing industry?

5. What is a sectional view? And what are the other names for a sectional view?

6. How is a sectional view created, and when is a sectional view needed?

**7.** What graphical elements are needed to draw a sectional view?

8. What are the two types of sectional views? Please write down the definitions.

9. What is an auxiliary view, what does an auxiliary view show, and how to draw it?

10. What are the three categories of pictorial drawings? In the projections related to these categories of pictorial drawings, where is the observer considered to be located, and what are the relations between the visual rays and the plane of projection?

11. Can perspective drawings be used as working drawings? Please explain the reasons.

12. In most cases, what are the perspective drawings used for?

13. What is a good way to understand the relations of views in the three-view projection?

14. How do you select the best views with the most favorable position of the object?

15. What are the four principle categories of engineering drawings, and what are they used for?

16. How does the Cartesian Coordinate System work? Describe it by sketching the three axis and placing the positive and negative values. What is the best way to remember how the Cartesian Coordinate System works ("the Right-hand Rule")?