Office: IT Building, Room: I413
Office Hrs: 12:00 – 13:00 (So, Tue, We)

Text Book: BASIC OF ENGINEERING DRAWING, A. Abu-Zarifa, IUG

Reference Books:
- Basic Technical Drawing, M.S. Samy Mousa, Maktabat El Yazji, 2000

Grading:
- Home works 25%
- Midterm 30%
- Final exam 45%
Technical Drawing with Engineering Graphics Frederick E.

Technical Drawing (13th Edition)
Frederick E. Giesecke
Unit 1
Introduction to Technical Drawing
**Engineers:** People who use technical means to solve problems. They design products, systems, devices, and structures to improve our living conditions.

**Technical Drawings:** a clear, precise language used in the design process for communicating, solving problems, quickly and accurately visualizing objects, and conducting analyses. A graphical representation of objects and structures is done using freehand, mechanical, or computer methods.
92% of the design process is graphical

The remaining 8% is mathematics and written communication

Breakdown of Engineer’s time

Who uses engineering graphics?
Development of Engineering Graphics

Multiview Drawings
Francesca (1420-92)
Artistic drawing vs. Technical drawing

What’s the difference?
**Drawing Tools**

<table>
<thead>
<tr>
<th>Item</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two mechanical pencils:</td>
<td>0.7 and 0.5 mm, or 0.5 and 0.3 mm combinations;</td>
</tr>
<tr>
<td>Pencil grades – HB and H</td>
<td></td>
</tr>
<tr>
<td>One compass and one divider</td>
<td></td>
</tr>
<tr>
<td>One set of 45- and 30/60-degree triangles</td>
<td></td>
</tr>
<tr>
<td>One scales (Metric unit) and T-Square</td>
<td></td>
</tr>
<tr>
<td>One protractor</td>
<td></td>
</tr>
<tr>
<td>A3 Paper format</td>
<td></td>
</tr>
<tr>
<td>One good eraser (and if you can afford, one erasing shield)</td>
<td></td>
</tr>
</tbody>
</table>
Drawing Tools
### Table 1.1 ANSI Standard Sheet Sizes

<table>
<thead>
<tr>
<th>Metric (mm)</th>
<th>U.S. Standard</th>
<th>Architectural</th>
</tr>
</thead>
<tbody>
<tr>
<td>A4 210 × 297</td>
<td>A-Size 8.5” × 11”</td>
<td>9” × 12”</td>
</tr>
<tr>
<td>A3 297 × 412</td>
<td>B-Size 11” × 17”</td>
<td>12” × 18”</td>
</tr>
<tr>
<td>A2 420 × 524</td>
<td>C-Size 17” × 22”</td>
<td>18” × 24”</td>
</tr>
<tr>
<td>A1 594 × 841</td>
<td>D-Size 22” × 34”</td>
<td>24” × 36”</td>
</tr>
<tr>
<td>A0 841 × 1189</td>
<td>E-Size 34” × 44”</td>
<td>36” × 48”</td>
</tr>
</tbody>
</table>

#### HARD
The hard leads are used for construction lines on technical drawings.

#### MEDIUM
The medium grades are used for general use on technical drawings. The harder grades are for instrument drawings and the softer for sketching.

#### SOFT
Soft leads are used for technical sketching and artwork but are too soft for instrument drawings.

HB and H
Alphabet of lines
Alphabet of lines cont.
Scales
Unit 2
Geometric Constructions

Compass and straightedge constructions
Regular Polygons

- **Inscribed**
- **Circumscribed**

1. **Triangular Polygons**
   - Triangle (a)

2. **Square Polygons**
   - Square (b)

3. **Pentagon Polygons**
   - Pentagon (c)

4. **Hexagon Polygons**
   - Hexagon (d)

5. **Heptagon Polygons**
   - Heptagon (e)

6. **Octagonal Polygons**
   - Octagon (f)
Figure 4-8

Bisecting a Line or a Circular Arc (§4.8).
Figure 4-9

Bisecting a Line with Triangle and T-square (§4.9).
Figure 4-10
Bisecting an Angle (§4.10).
1. Bisect radius OD at C
2. Strike arc AE, with C as center (Radius R)
3. Stricke arc EB, with A as center (Radius r)
4. Draw line AB
5. Set of distances AB around the circumference

A regular pentagon has all sides of equal length and all interior angles are equal measure (108°)
Figure 4-25
Drawing a Hexagon (§4.23).
Figure 4-28

ANY REGULAR POLYGON in A GIVEN CIRCUMSCRIBED CIRCLE
Figure 4.12
Drawing a Line Through a Point Parallel to a Line (§4.12).
Figure 4-38

Drawing Tangent Arcs (§4.35).
Figure 4-39

Drawing an Arc Tangent to an Arc and a Straight Line (§4.36).
Figure 4-40
Drawing an Arc Tangent to Two Arcs (§4.37).
Figure 4-41

Drawing an Arc Tangent to Two Ares and Enclosing One or Both (§4.38).
Figure 4-70

(Prob. 4.53) Rocker Arm.
Figure 4-69

(Prob. 4.52) Spanner.
Unit 3
Dimensioning Fundamentals
Dimensioning

• Orthographic and isometric views define the shape and general features of the object

• Dimensioning adds information that specifies
  – Size of the object
  – Location of features (e.g. holes)
  – Characteristics of features (e.g. depth and diameter of hole)

• Dimensions also communicate the tolerance (or accuracy) required
How are Objects Dimensioned?

• Objects are dimensioned based on two criteria:
  – Basic size of the object and size and locations of its features
  – Details of construction for manufacturing

• Defined Standards from ANSI (American National Standards Institute) exist
Scaling vs. Dimensioning

different

FULL

ALWAYS

FULL SIZE

6.5

HALF SIZE

6.5

QUARTER SIZE

6.5
Units of Measure

• Length
  – English: Inches, unless otherwise stated
    • Up to 72"
    • Feet and inches over 72"
  – SI: millimeter, mm

• Angle
  – degrees, minutes, seconds
Dimensioning – Terminology
Text Height and Standard Configurations

TEXT HEIGHT .125"

A  2.000
B  .500
C  .375
D  .125

User guidelines for hand drawings

Decimal dimensioning

6 mm MIN
10 mm MIN

64
Dimensioning Basic Shapes

• Rectangular Prism
Dimensioning Basic Shapes

Positive Cylinders
(solid)

Negative

Avoid dimensioning to hidden lines
Dimensioning Basic Shapes

- Cone
- Do not over dimension
Dimensioning Basic Shapes

- Frustum
Dimensioning Shows:

- **Width**
- **Depth**
- **Height**
- **R Radius**
- **Ø Diameter**
- **Angle**
Principles of Good Dimensioning

• The overriding principle of dimensioning is **CLARITY**

• Principles – not an infallible rule set, need to apply good judgment.

• See 6.13 in Technical Graphics
General Guidelines: **Clarity is the Goal**

- Place dimension in view that most clearly describes feature
- A view where a feature is hidden is generally NOT the most descriptive
- **Avoid** dimensioning to hidden lines.
General Guidelines: **Clarity is the Goal**

- Dimension Outside of View

*Avoid*  

*Good Practice*
General Dimensioning Guidelines

• Start with basic outside dimensions of the object
  – Height
  – Width
  – Depth

• Add dimension for location and size of removed features

• Add general and specific notes – such as tolerances
Practice Problem

How many Dimensions are needed?
Practice Problem

Answer: 8
Example Dimensioning

Step 1. Dimension basic outside dimensions:

- 1.25
- 2.00
- 1.00
- 4

- HEIGHT
- WIDTH
- DEPTH
Practice Problem

Given:
- Height: 2 mm
- Width: 2 mm
- Depth: 1.5 mm
- Hole Diameter: 1 mm
Practice Problem

Size: Ht, Wt, Depth, Hole Dia.
Location: Center of Hole

[Diagram showing dimensions and annotations]
Unit 4
Shap Description
(Orthographic Projection)
Even simple, primitive shapes often need several views to fully describe their topology.
Holes and cylinders may appear “True Shape and Size” (TSS), or foreshortened depending on the view in which they appear. (Foreshortened circles will appear as ellipses.)
Orthographic Projection

Orthographic projection (sometimes referred to as multi-view projection), is a geometric procedure used in the engineering disciplines to project multiple graphic images of three-dimensional objects, onto a single two-dimensional plane. The procedure is also called engineering drawing or drafting, and is the primary means of communication used by designers and engineers in the design process.

Multiple views in an orthogonal orientation (each rotated 90° from the other), is fundamental to the definition of feature and part characteristics such as size, location, orientation, and functional relationships.

The object can only be viewed from the front, top, right side, left side, back, or bottom. With the images indelibly fixed on the planes, and the box unfolded, the projected images or views would always be oriented orthographically, and aligned with each other, from view to view on the drawing.
Ortho means “at 90 degrees”, and is a form of parallel projection. Orthographic projections are used to show several views of the same object in one drawing set.
Orthographic Projection Theory

Observation of an object begins with the direction from which the object is to be viewed—the *line of sight*.
Orthographic Projection Theory

The viewing station for the observer is always an infinite distance from the object.

Viewing Station
at Infinity
Orthographic Projection Theory
The plane of projection is located between the viewing station and the object (third angle projection).
Orthographic Projection Theory

The line of sight is always normal to the plane of projection
Orthographic Projection Theory

The object may be located anywhere behind the plane of projection.
Orthographic Projection Theory

Because the observation location is at infinity, parallel visual rays extend from the object to the plane of projection, and produce the image on the projection plane.
The glass box concept theorizes that an object is suspended inside a six-sided glass cube (notice the use of hidden lines on the glass box, depicting lines that would not be visible from the given perspective).
As the object is viewed from a specific orientation (perpendicular to one of the sides of the cube) visual rays project from the object to the projection plane. These projectors are *always* parallel to each other.
The object’s image is formed on the *Frontal* projection plane by the pierce points of the visual rays.
The process is repeated to construct the right side view on the *profile plane*.
Similarly, the top view is projected to the *horizontal plane*.
For many three-dimensional objects, two to three orthographic views are sufficient to describe their geometry.
The box can be unfolded to show the multiple views in a single x-y plane.
Because the observation point is located at infinity, the integrity of feature size and location are maintained, and the views are oriented orthogonally in relationship to each other.
Notice that the projectors or extension lines, are perpendicular to the folding lines of the glass box. (Fold lines and extension lines are drawn very lightly, when used, and are *not* part of the finished drawing.)
Dimensional Data Can then be added to the drawing

*Notice the three basic line types:*

- **Solid** – A Visible Edge
- **Hidden** – An Invisible Edge
- **Center** – Center of a Cylinder (Internal or External)
The Glass Box Concept

Click on image to animate - click outside for next slide
ORIENTATION OF OBJECT FEATURES IN ORTHOGRAPHIC PROJECTION
Directional Orientation in Orthographic Projection

Two or three views of a 3-dimensional object are often sufficient for a complete definition of part geometry. Width and depth are displayed in the top view; height and width in the front view, height and depth in the side view.

Height = h
Width = w
Depth = d
DIRECTION AND ORIENTATION IN ORTHOGRAPHIC PROJECTION

(PRINCIPAL PROJECTION PLANES)
FIRST-ANGLE PROJECTION
Projection methods:

3\textsuperscript{RD} Angle (US Standard)

ISO (1\textsuperscript{ST} Angle Metric Standard)

NOTE:
Reverse construction methods work just as well in 1\textsuperscript{ST} Angle projection.
1st angle and 3rd angle Orthographics... The difference:
Unit 5
Creating Isometric Sketches
Introduction to Isometric Projection

• Isometric means equal measure
• All planes are equally or proportionately shortened and tilted
• All the major axes (X, Y, Z) are 120 degrees apart
Making an Isometric Sketch
Making an Isometric Sketch

Choose the longest dimension to be the width or the depth for optical stability.

Front view
Usage of the Grid Paper

Note the alignment of the axes.
Object for Practice
Blocking in the Object
Begin with Front Face
Blocking in the Object: Add Side Face

Side Face

Height

Depth
Blocking in the Object: Add Top Face
Adding Detail Cut Outs – Part 1
Adding Detail Cut Outs – Part 2
Adding Detail Cut Outs – Part 3
Darken Final Lines - Part 4
Isometric ellipses

- In an isometric drawing, the object is viewed at an angle, which makes circles appear as ellipses.
- Holes
- Cylinders
Ellipses Can be in Any of Three Planes

- Horizontal or top plane
- Major axis
- Minor axis
- Front plane
- Major axis
- Minor axis
- Profile plane

60° 30° 30° 60°
Sketching an Isometric Cylinder
Four Center Method of **Drawing** an Isometric Ellipse
Fig. 16.24  Steps in Drawing Four-Center Ellipse.
Unit 6
Missing Views
3-D Sketch from a Multi-view Drawing with Missing View

Construction the third View (Missing View)

Construction Isometric Sketches from Ortho Views
Missing Views

Square Grid

Isometric Grid
Create the Outline (Box) for Isometric View
Step 2

Draw known surfaces of Isometric view
Step 2 (contd)

Draw known surfaces of Isometric view
Step 2 (contd)
Draw known surfaces of Isometric view
Draw known surfaces of Isometric view
Step 3
Finalize
Isometric View
Step 4A
Add Outside Boundary
(width and depth from front and right side views)
Add Visible Lines
(for the Steps)
Add Hidden Line
Unit 7
Sectional Views
Section Views

• Section views are used when important hidden details are in the interior of an object.

• These details appear as hidden lines in one of the orthographic principal views; therefore, their shapes are not very well described by pure orthographic projection.
Types of Section Views

• Full sections
• Half sections
• Offset sections
• Broken-out sections
• Revolved sections
• Removed sections
Cutting Plane

- Section views show how an object would look if a cutting plane (or saw) cut through the object and the material in front of the cutting plane is removed.
Section Lines

- Section lines can be used to show different types of materials or different parts of the same material.

- Refer to Technical Graphics text for a complete list.
Full Section View

- In a full section view, the cutting plane cuts across the entire object.

- Note that hidden lines become visible in a section view.
Full Section View

- Show cutting plane in the top view
- Make a full section in the front view
- Note how the cutting plane is drawn and how the crosshatching lines mark the surfaces of material cut by the cutting plane.
Full Section View

- No hidden lines on the section view, if possible.

- Note: Interior lines behind cutting plane became visible.
Multiple Sectioned Views

Note the directions of arrows on the cutting plane.
Half Section View

• The cutting planes do not cut all the way through to the object.

• They cut only half way and intersect at the centerline.
Half Section View

Half Section used mainly for symmetric objects
Offset Sections

Offset sections are used to show interior features that do not lie along a straight line.
Offset Sections
Offset Sections

(A) Offset section view

(B) No!
Name the Three Types of Sections

• Full Section (half of the object is removed)
• Half Section (a quarter of the object is removed)
• Offset Section (the cutting plane line is drawn to pick up an object's features)
Broken Out Sections
Broken Out Sections

(C) Broken-out section view
Revolved Sections
Revolved Sections

Revolved sections show the shape of an object's cross-section superimposed on a longitudinal view.
Revolved Sections – Tubes
Revolved Sections – I Beam
Removed Sections

A removed section view is created by making a cross section, then moving it to an area adjacent to the view.
Removed Sections

• Removed sections are like revolved sections but moved aside.

• Note how they are named.
Unit 7
Introduction to AutoCad
OUTLINE

• Giving commands
• Object snap
• Zooming and panning
• Drawing 2D shapes
• Drawing 3D shapes
• Editing
How do we give a command?

- Command line

- Toolbars
  (view/Toolbars)

- Drop-down menus

You can pick any one(s) that you are comfortable with.
Final Exam

The Islamic University
Faculty of Engineering
What is OSNAP?

- Osnap (Object Snap) settings make it easier to select a 2d object’s points
  - Endpoint
  - Midpoint
  - Perpendicular
  - Center
  - Intersection
- Osnap will be active when AutoCAD is expecting you to pick a point on the working area
- Type osnap on your command window:
Zooming...

• You will need to zoom in and out while drawing with AutoCAD. This doesn't change your objects or UCS, only the way you see your working space. This can be done in many ways:
  
  1. Scroll bars
  2. Typing `z` or `zoom` in your command window.
     • All
     • Center
     • Dynamic
     • Extents
     • Previous
     • Scale
     • Window
Let's draw a LINE:

• remember that AutoCAD recognizes an object by its coordinates. You will need two given points to draw a line.

• You can start at a random point on your WCS for your FIRST POINT, but you should specify the coordinates of your SECOND POINT.
Lets draw a LINE (1):

1. Give the command
   – Type “line” on the command window, OR
   – Click on the line icon on the Draw toolbar, OR
   – Select Line on the Draw menu

2. Specify the first point (a)
   – Click on a random point on your working area (black space)

3. Specify the second point in relation to the first point
   – \(@distance<degrees\)
   – \(@5<30\)
Let's draw a LINE (2):

1. Hit F8 (ortho on)
2. Give the command
3. Specify the first point
4. Specify the second point in relation to the first point
   - Point the cursor to the left hand side. You will see that the cursor snaps only to $0^\circ$-$90^\circ$-$180^\circ$-$270^\circ$
   - Type 7 and hit enter
Let's draw a LINE (3):

If we know the coordinates of the line we want to draw, we can simply type them into the command line. (However, this mostly is not the case.)

1. Give the command
2. Specify the first point \((4,8,11)\)
3. Specify the second point \((5,11,23)\)
What else?

• Rectangle: two diagonal lines
  (pick first point, select the second one with relation to the first. @5<-33)

• Circle/Arc: center and radius

• Polygon: specify the number of edges and length of a side

A small tip: you can use the EXPLODE command for the tool to split the object into its components or lines
Editing...

- COPY

- MOVE

- MIRROR
More editing...

• STRETCH

• EXPLODE
Hatching

- Hatching is used to add shaded patterns to objects and shapes within an Autocad drawing. Hatch patterns can be used to indicate a material to be used, such as a concrete hatch. Alternatively it could be used to make an area of a drawing stand out.

- You will pick:
  - Pattern
  - Scale
  - Angle
  - points
We can create solids by extruding as well

- If you “extrude” a surface into the third dimension, you simply add a thickness in section. This basically is same as creating a “solid” object.