The Detailed Design Review

(Graphics Communications in Preparation of the Manufacturing Drawings)

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MECH463

Overview

- What is Graphics Communications?
- Alphabet of Lines
- Multiview Projections
- Sectional Drawings
- Dimensioning Terminology and Rules
- Basics of Tolerancing in the Drawings
- Brief Review of Working Drawings
- Conclusion

What is Graphics Communications?

Graphics communication – is a precise and clear language with definite rules

Engineering drawings, along with models are parts of graphics communications

To be successful in implementation of your design into a real working prototype you have to follow these rules!

Because in engineering 92 % of the design processes are graphically based

The other 8 % are divided between:

- ***Mathematics***
- ***Written communications***
- ***Verbal communications***

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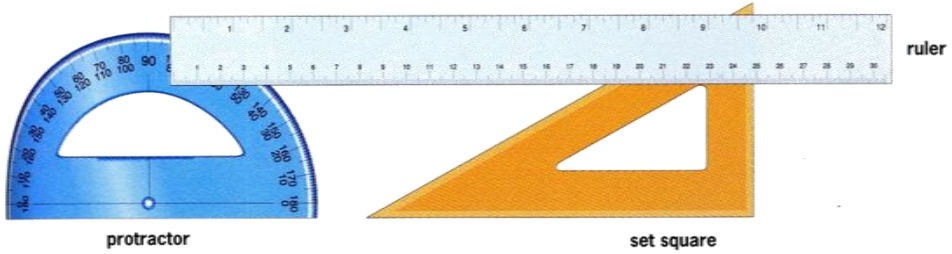
Drawing Tools

Traditional tools will continue to be useful for sketching and rough layout work; however, good CAD software can create virtually any type of technical drawing.

Traditional tools



Computer Aided Design

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Alphabet of Lines

What is the main image, which you are using in your projects?

ASME International

It is a line!

The alphabet of lines is a set of standard linetypes established by the American Society of Mechanical Engineers (ASME) for technical drawings

Two line weights are sufficient to follow the standards: a 0.6 mm and a 0.3 mm

Alphabet of Lines (cont'd)

Alphabet of lines

Center lines are used:

- to represent symmetry - to represent paths of motion

- to mark the centers of circles and the axes of symmetry

Break lines are used **to show where an object is broken to save drawing space or reveal interior features**

Break lines come in two forms:

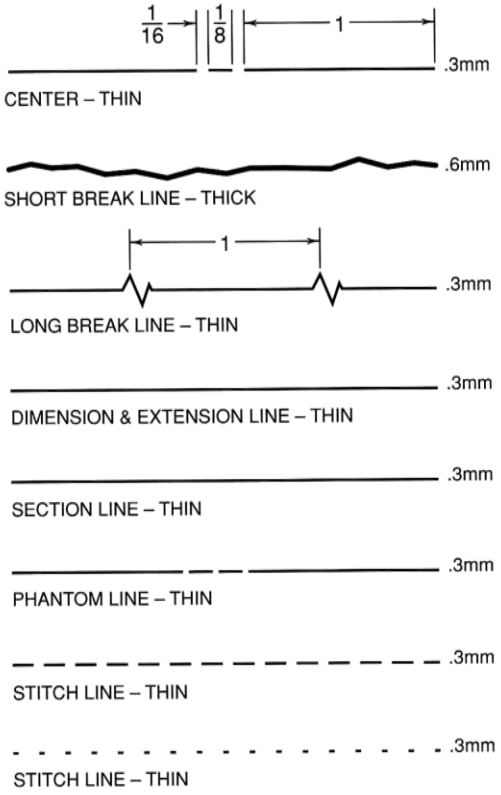
- a freehand thick line and

- a long, ruled thin line with zigzags

Dimension and extension lines are used **to indicate the sizes of features on a drawing**

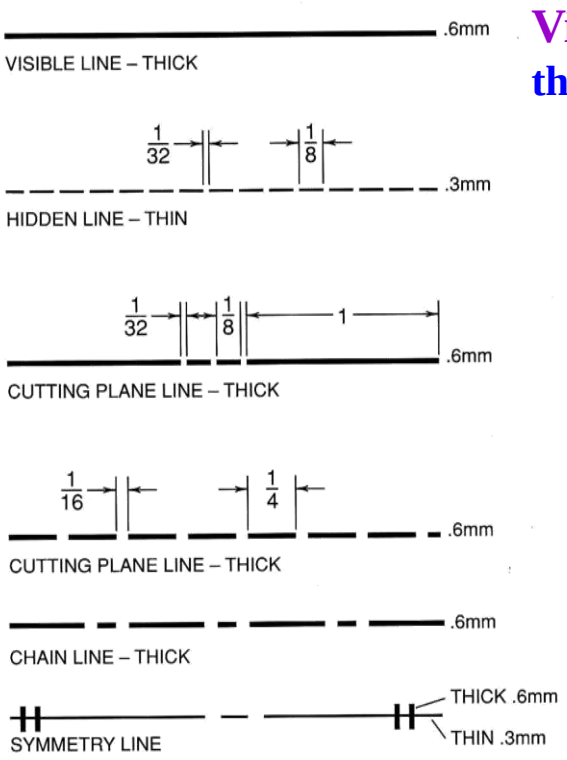
Section lines are used **in section views to represent surfaces of an object cut by a cutting plane**

Phantom lines are used **to represent a movable feature in its different positions**



Alphabet of Lines (cont'd)

Alphabet of lines



Visible lines are used **to represent features that can be seen in the current view**

Hidden lines are used **to represent features that cannot be seen in the current view**

Cutting plane lines are used **in section drawings to show the locations of cutting planes**

There are also lines used in some particular cases:

Stitch lines - to indicate a sewing or stitching process

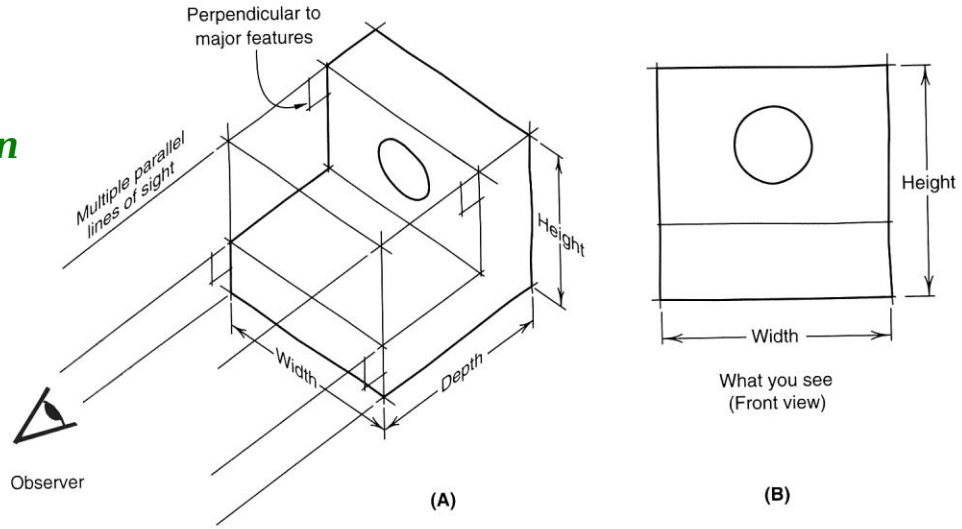
Chain lines - to indicate additional treatment for a surface

Symmetry lines - as an axis of symmetry of a particular view

Multiview Projections

The most common practice in mechanical design is to produce Multiview drawings based on parallel projection techniques

A multiview drawing is a collection of flat 2-D drawings which together give an accurate representation of the overall object



In a multiview projection each view concentrates on only two dimensions of the object, so particular features can be shown with a minimum of distortion

Multiview Projections (cont'd)

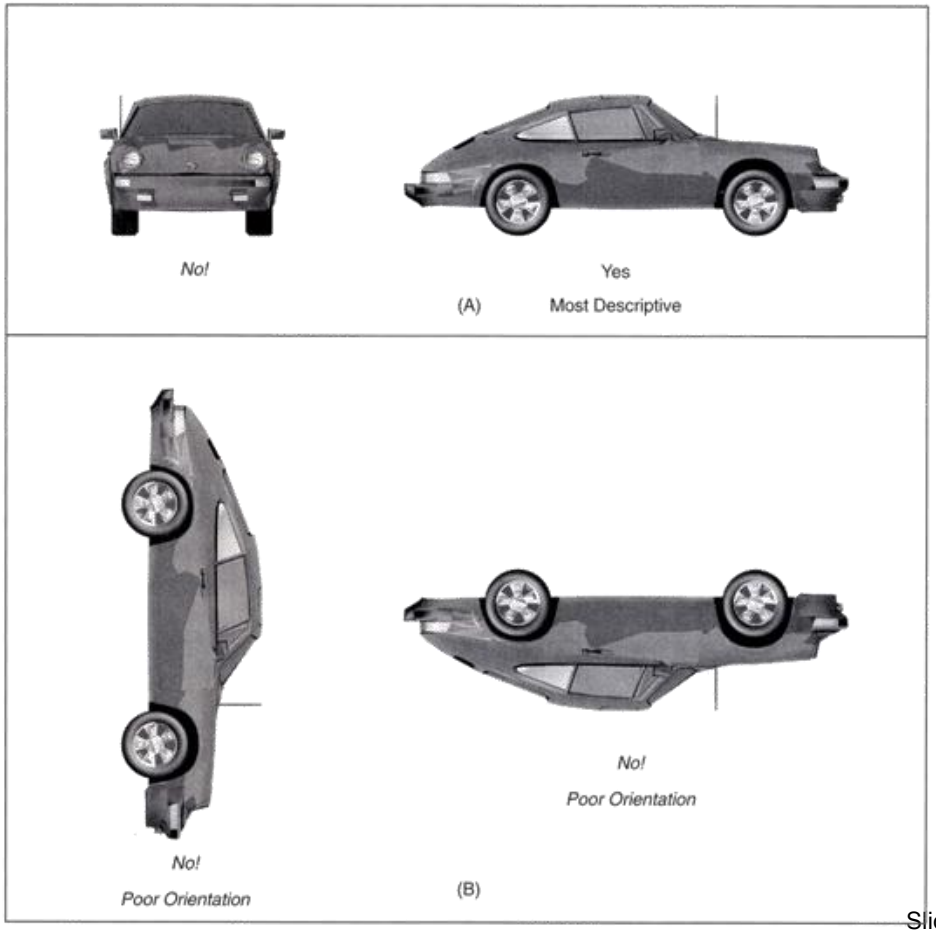
Selection of Front View

The selection and orientation of the front view is an important first step

The front view must be chosen as the most descriptive of the object

for a car it is a side view

The object must be properly oriented in the view, which is based on its function



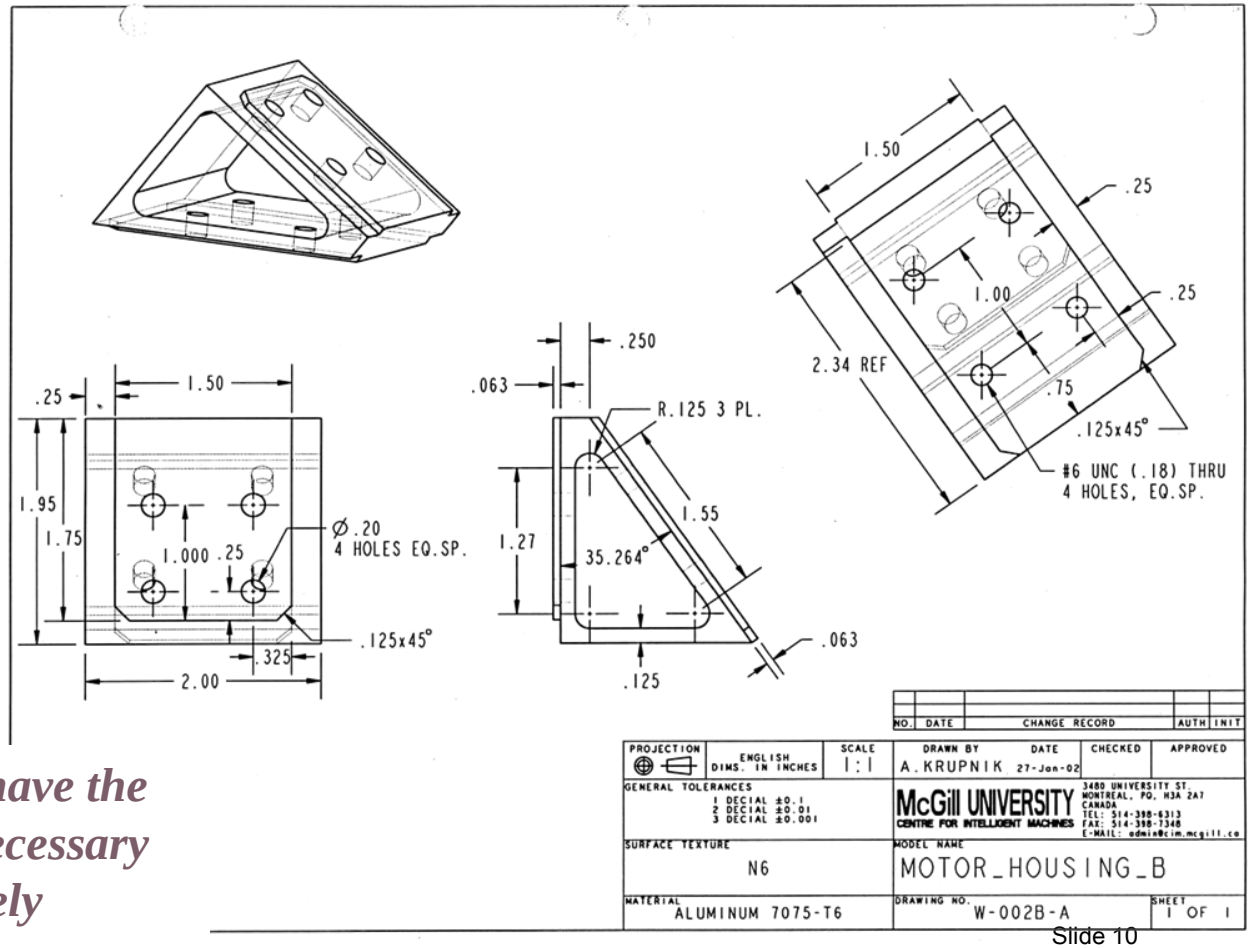
Multiview Projections (cont'd)

Selection of the projections

Thus, to choose the views:

1. Identify the most descriptive or important features of the object

2. Determine the views that best represent those features

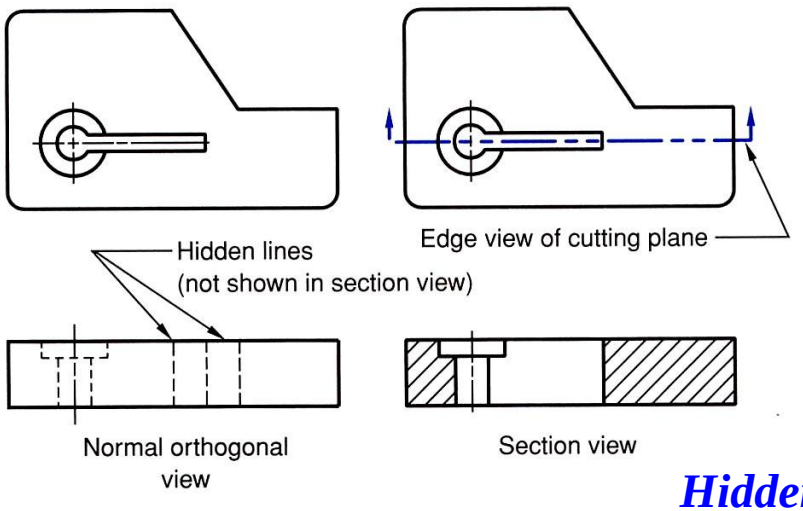


A multiview drawing should have the minimum number of views necessary to describe an object completely

Sectional Drawings

Section views are used to improve clarity and show interior features of parts and structures

Normal & Section Views



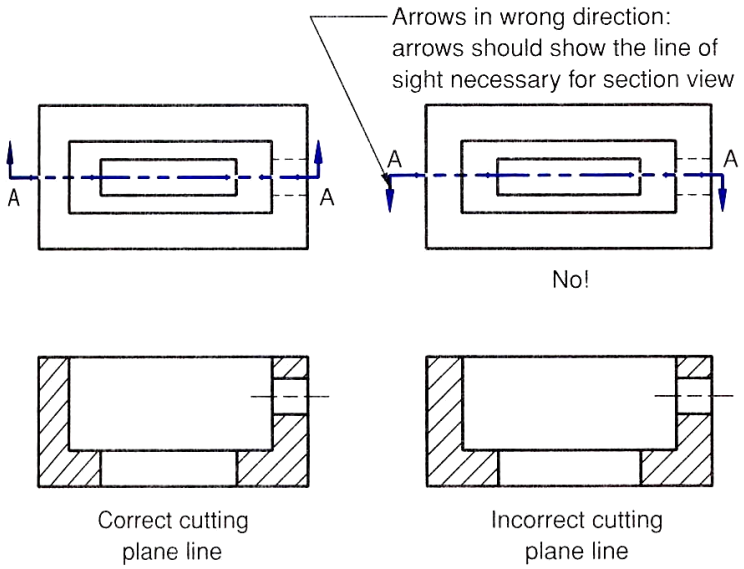
A reason for creating a section view is the elimination of hidden lines so that a drawing can be more easily visualized

Hidden lines, which are lying in the section plane, become visible, and hidden lines which are beyond the section plane are not shown at all

Sectional Drawings (cont'd)

Placement of Section View

➢ **A section view is created by passing an imaginary cutting plane vertically through the center of the part.**



➢ **The cutting plane line is placed in the view where the cutting plane appears on edge.**

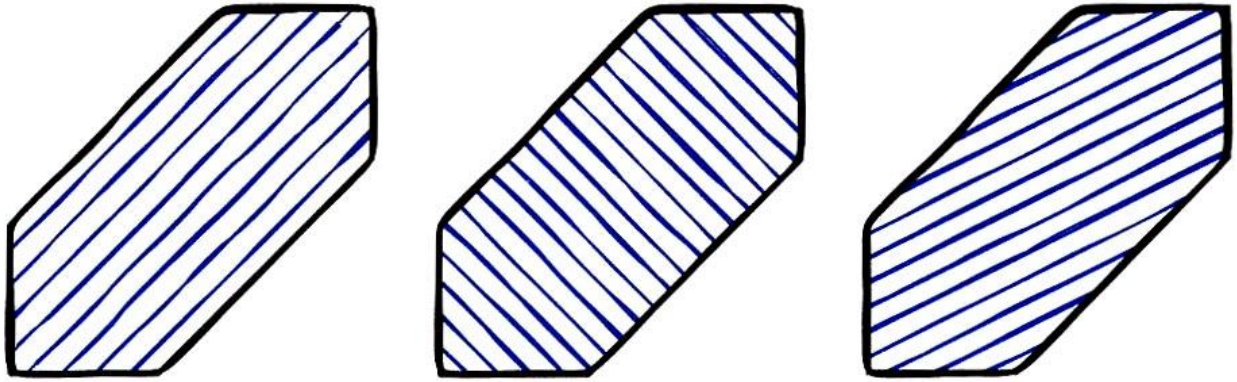
➢ **The arrows represent the direction of the line of sight for the section view, which should indicate the correct side view for the sectioned drawing.** ***Normally it is a view from the bottom of a drawing.***

Sectional Drawings (cont'd)

Section Line Placement

The type of section line used to represent a surface varies according to the type of material

The general-purpose section line symbol used in most section view drawings is that of *cast iron*



(A) Avoid! (B) Avoid! (C) Preferred

✓ ***Section lines should not run parallel or perpendicular to the visible outline.***

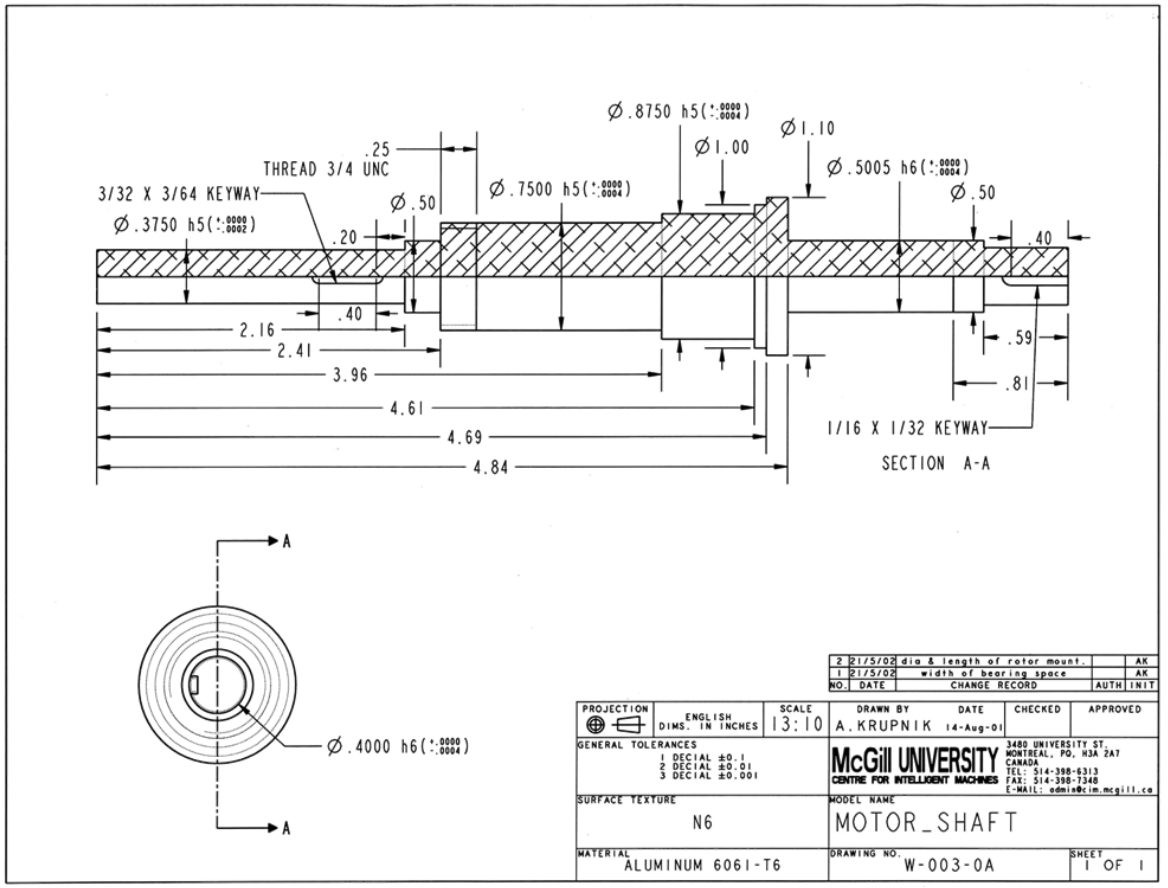
✓ ***If the visible outline to be sectioned is drawn at a 45-degree angle, the section lines are drawn at a different angle, such as 30 degrees.***

Sectional Drawings (cont'd)

Sample of Section View

- All the surfaces touched by the cutting plane are marked with section lines
- When all the surfaces are the same part, the section lines are identical and are drawn in the same direction

It is possible to show just half of the section view instead of the whole section.



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Dimensioning

Terminology

❖ **Once the shape of a part is defined with an orthographic drawing (i.e. in projections), the size information is added in the form of dimensions.**

❖ **Dimensioning a drawing also identifies the tolerance (or accuracy) required for each dimension.**

➢ **The unit of measurement for dimensioning should be in accordance with the policy of the user. On a drawing for use in American industry for manufacturing, all dimensions are in *inches*, unless otherwise stated.**

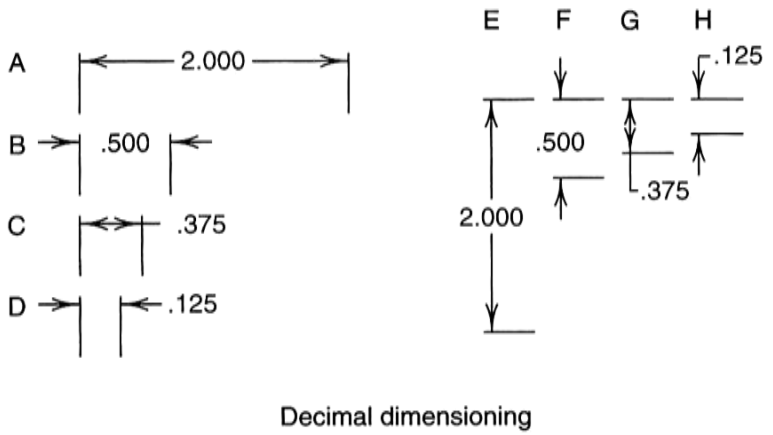
➢ **Most countries outside of the United States, including Canada, use the metric system of measure, or the international system of units (SI), which is based on the meter.**
The common metric unit of measure on engineering drawings is the *millimeter*, abbreviated as *mm*.

Dimensioning (cont'd)

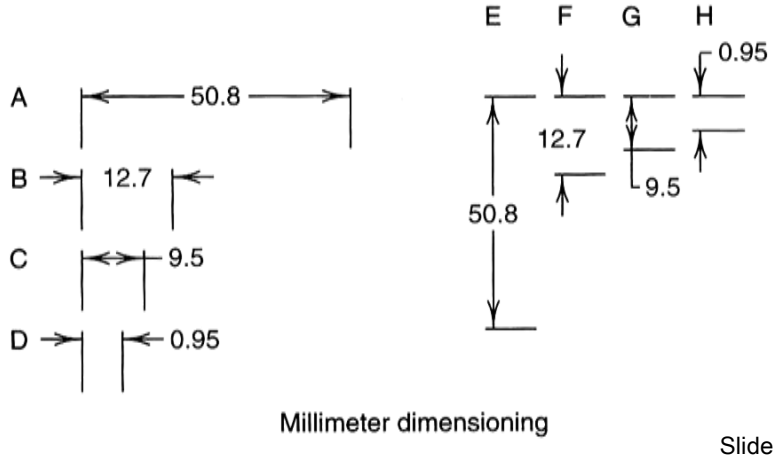
Dimension Text Placement

Text of the dimensions can be placed in different ways:

- ***dimension inside the extension lines, with arrows inside or outside; and***
- ***dimensions outside of the extension lines, with arrows again inside or outside.***



Decimal dimensioning



Millimeter dimensioning

Dimensioning (cont'd)

Size Dimension

The dimensions can be classified by types of size:

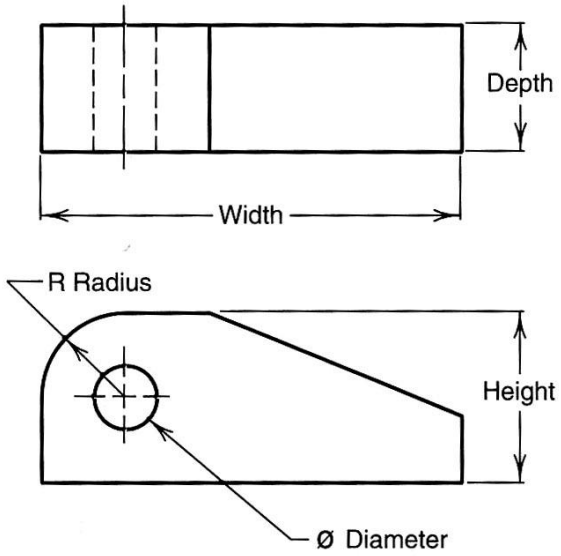
***Horizontal*—the left-to-right distance relative to the drawing sheet. Here the *width* is the only horizontal size dimension.**

***Vertical*—the up and down distance relative to the drawing sheet. Here the *height* and the *depth* are both vertical dimensions, even though they are in two different directions on the part.**

***Diameter*—the full distance across a circle, measured through the center.**

***Radius*—the distance from the center of an arc to any point on the arc. Radius is usually used on arcs less than half circles.**

Size Dimensions: Height, Depth & Diameter

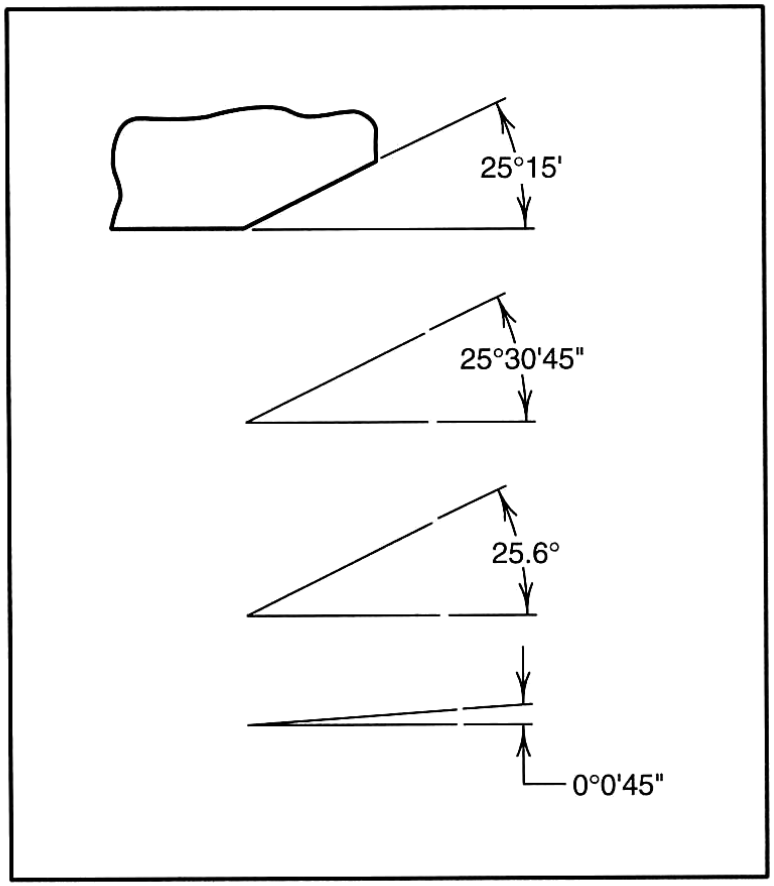


Dimensioning (cont'd)

Angular units

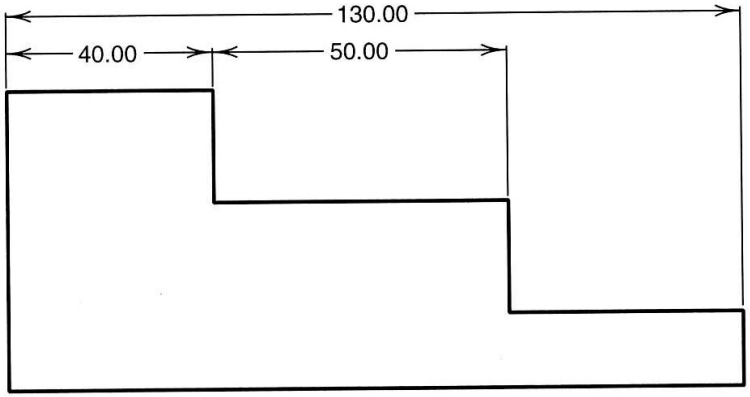
- Angular dimensions are shown either in decimal degrees or in degrees, minutes, and seconds

- Where only minutes and seconds are specified, the number of minutes or seconds are preceded by the 0

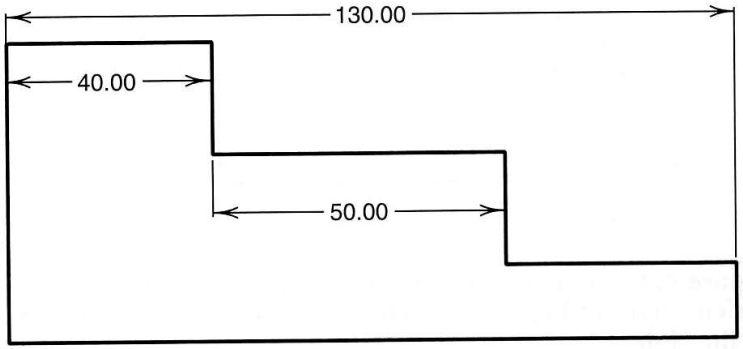


Dimensioning (cont'd)

Group Dimensions



(A) Yes



(B) No!

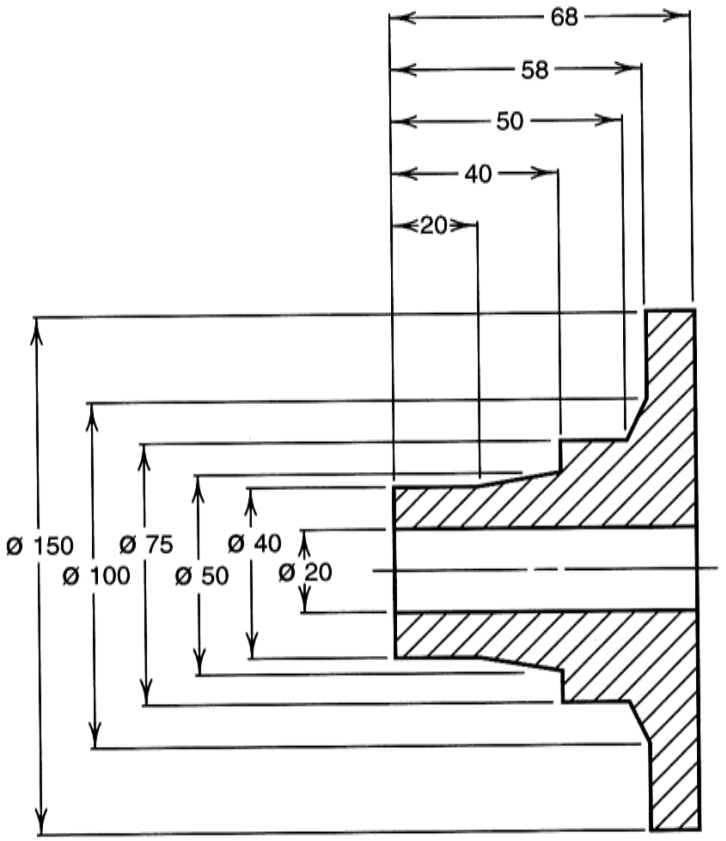
In standard practice, dimensions are grouped on a drawing for uniform experience. Avoid using object lines as extension lines for a dimension

Dimensions can be placed in parallel or in series – one after another

Dimensioning (cont'd)

Stagger Dimensions

The general practice is to stagger the dimension text on several parallel dimensions

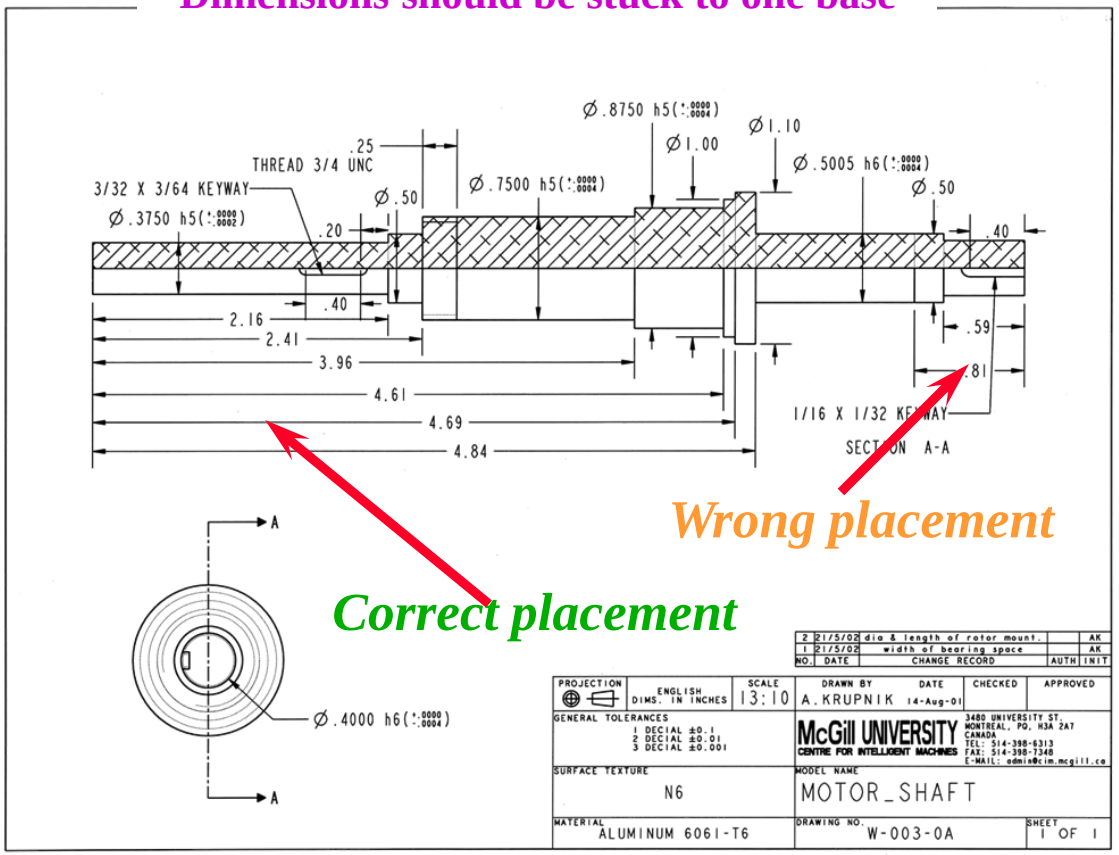


Dimensioning (cont'd)

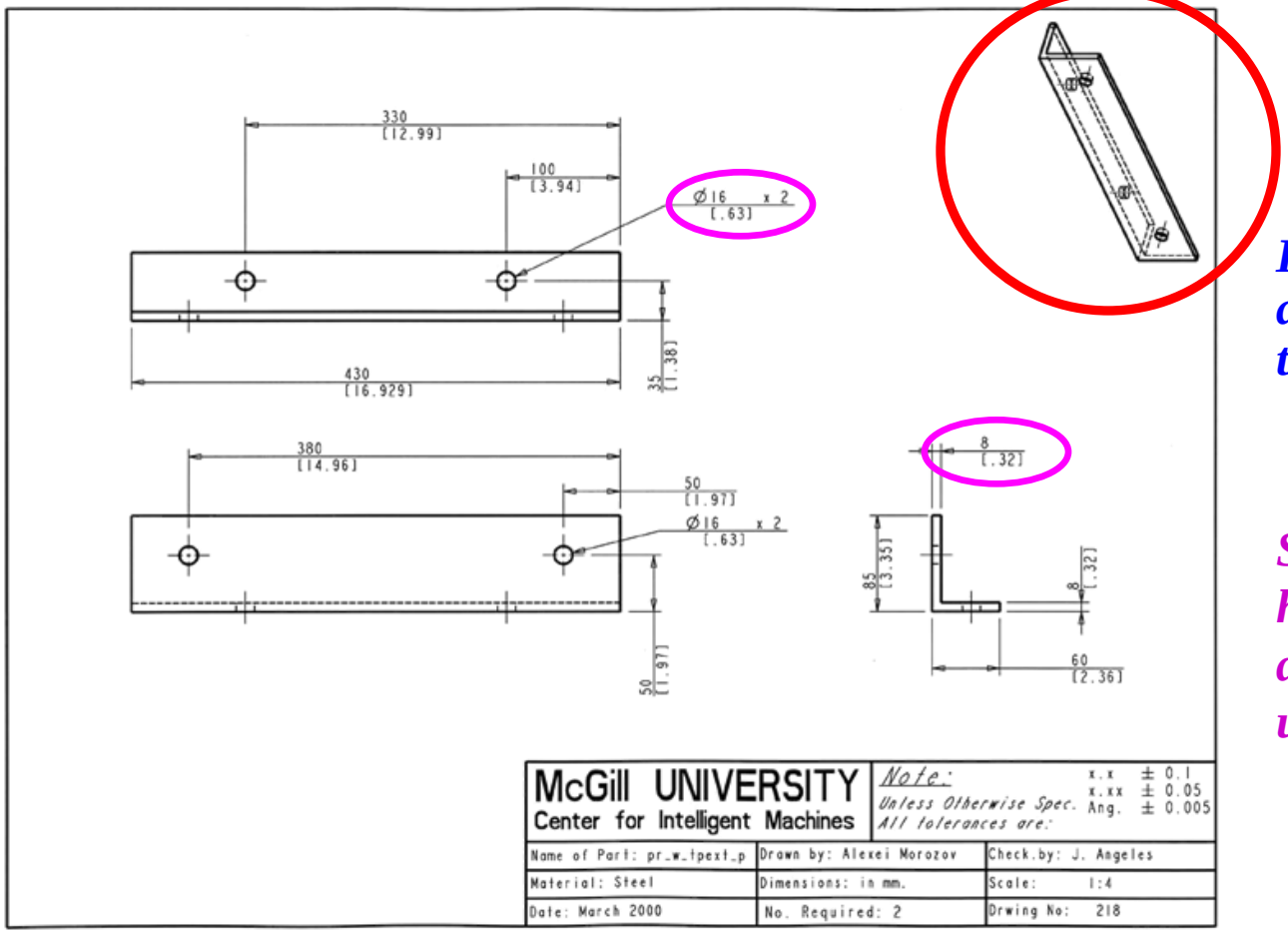
- The first dimension in a raw should be stuck to a base line

- The base surface is the external surface of the part, which has to be machined first

Dimensions should be stuck to one base



Dimensioning (cont'd)



It is also good to have an isometric view of the part on its drawing

Sometimes, you will have to place dimensions in two units simultaneously!

Principles of good dimensioning

The supreme principle of dimensioning is clarity!

1. ***Each feature of an object is dimensioned once and only once***
2. ***Dimensions should be placed in the most descriptive view of the feature***
3. ***Dimensions should specify only the size of a feature. The manufacturing method should only be specified if it is a mandatory design requirement***
4. ***Angles shown on drawings as right angles are assumed to be 90 degrees unless otherwise specified, and they need not be dimensioned***
5. ***Dimensions should be located outside the boundaries of the object whenever possible***

Principles of good dimensioning (cont'd)

6. *Dimension lines should be aligned and grouped where possible to promote clarity and uniform appearance*
7. *Crossed dimension lines should be avoided whenever possible*
8. *The space between the first dimension line and the object should be at least 0.4 inch (10 mm). The space between dimension lines should be at least 0.24 inch (6 mm)*
9. *There should be a visible gap between the object and the origin of an extension line*
10. *Extension lines should extend 0.12 inch (3 mm) beyond the last dimension line*

Principles of good dimensioning (cont'd)

11. *Extension lines should be broken if they cross or are close to arrowheads*
12. *Dimensions should be oriented to be read from the bottom of the drawing*
13. *Diameters are dimensioned with a numerical value preceded by the diameter symbol*
14. *Radii are dimensioned with a numerical value preceded by the radius symbol*
15. *When a dimension is given to the center of an arc or radius, a small cross is shown at the center*

Tolerancing

***Tolerance** is the total amount a dimension may vary and is the difference between the maximum and minimum limits*

It is impossible to make everything to an exact size

Tolerances are used on production drawings:

✓ ***to control the manufacturing process more accurately***

&

✓ ***to control the variation between mating parts.***

General tolerances are given in a note or as part of the title block

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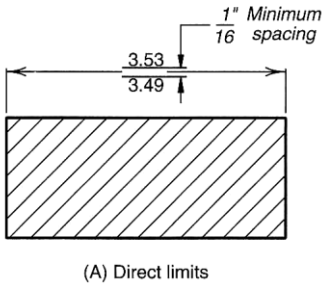
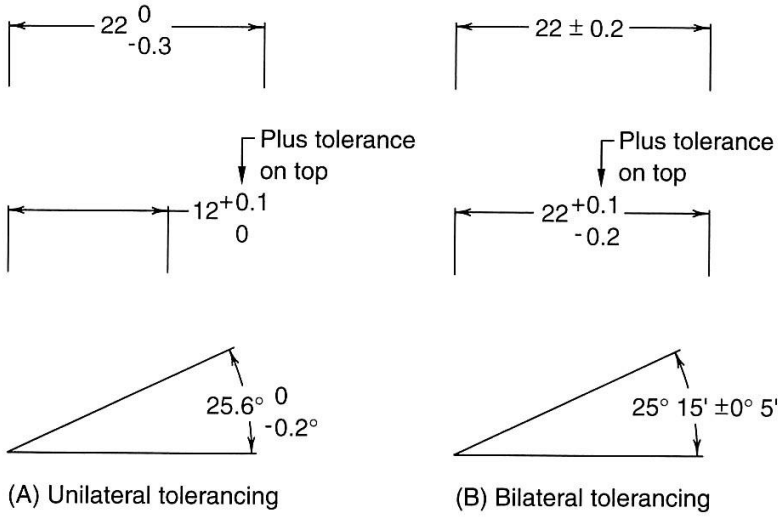
Tolerancing (cont'd)

Numeric Tolerancing



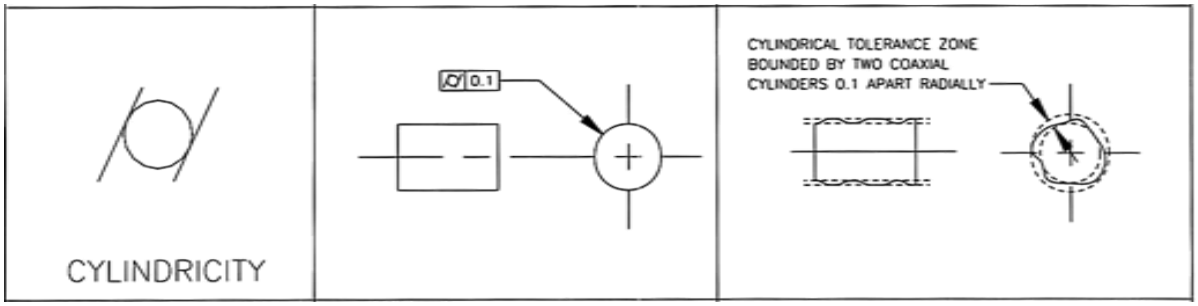


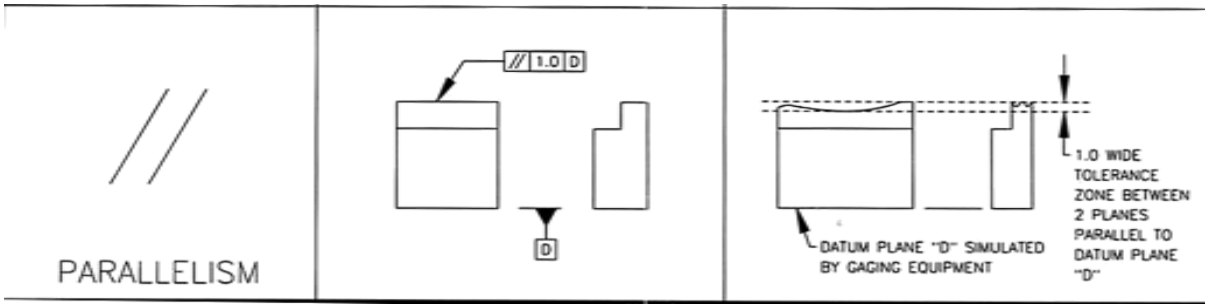
✓ **Tolerances are presented as direct limits or as tolerance values. Direct limits is ASME preferred method.**

✓ **Tolerances can be unilateral and bilateral (Represented by plus and minus tolerance system)**

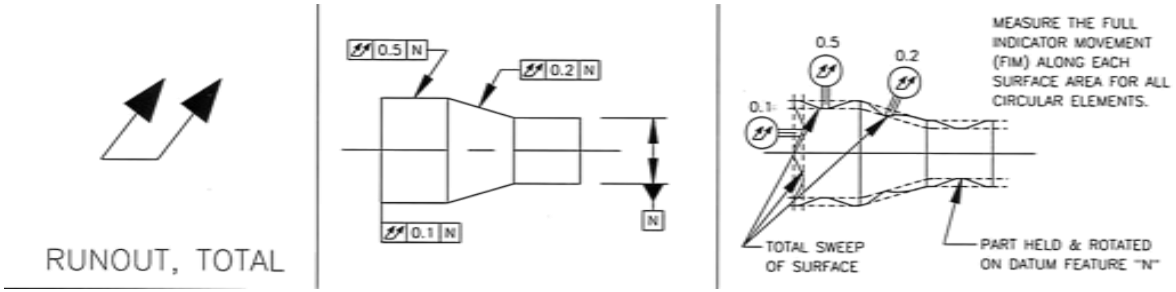
Tolerancing (cont'd)

Geometric Tolerancing





Purpose:
to describe the geometry of a part in general or one of its surfaces



Working Drawings

***Working drawings** are the complete set of standardized drawings specifying the manufacture and assembly of a product based on its design.*

Generally, a complete set of working drawings for an assembly includes:

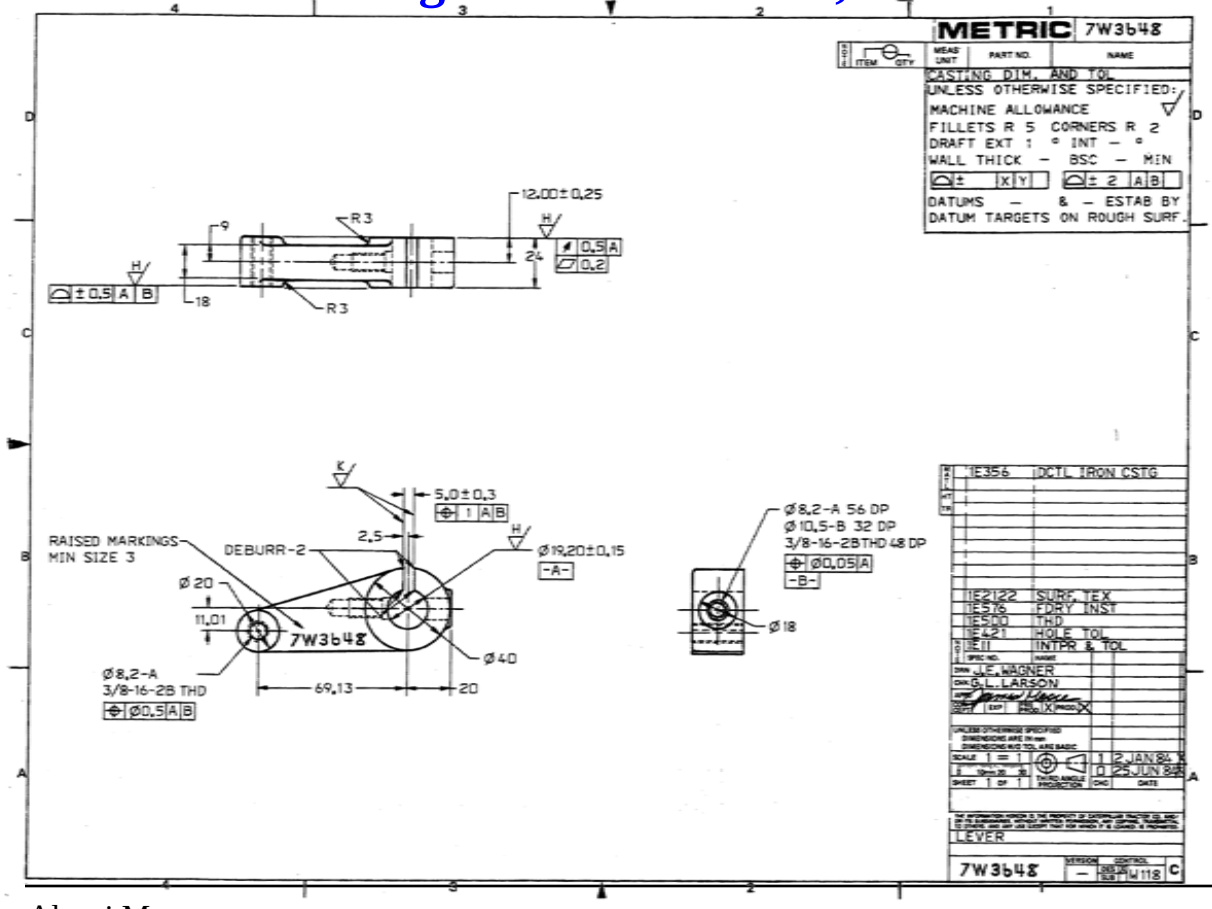
1. Detail drawings of each non-standard part
2. An assembly or subassembly drawing showing all the standard and non-standard parts in a single drawing
3. A bill of materials (BOM)
4. A title block

The two main types of the drawings in this set are:

- *A Detailed Drawing*
- *An Assembly Drawing*

Working Drawings (cont'd)

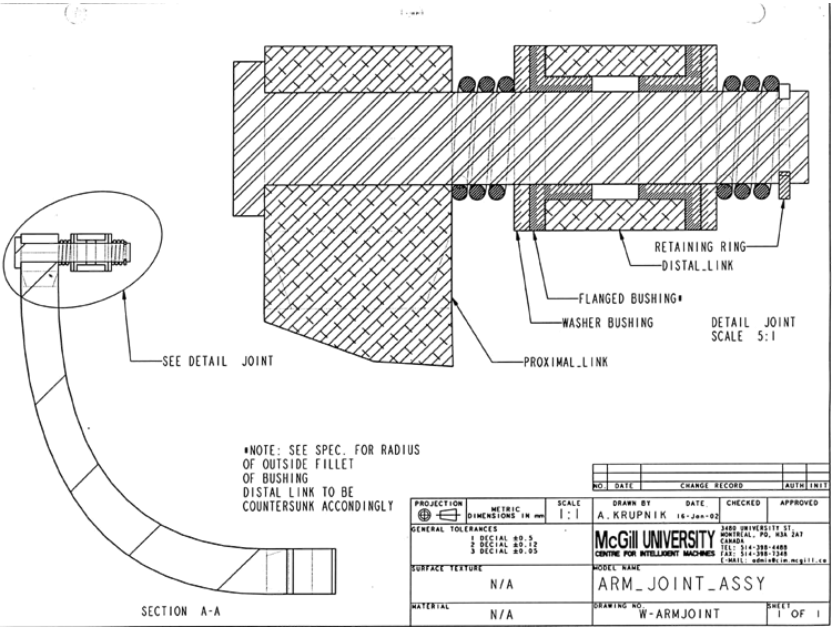
Detailed Drawing is a dimensioned, multi-view drawing of a single part



Detail drawings are produced from design sketches or extracted from 3-D computer models, and describe the part's shape, size and material

Working Drawings (cont'd)

Assembly Drawing shows how each part of a design is put together



An assembly drawing normally consists of:

- All the parts, drawn in their operating position
- A part list or bill of materials (BOM)
- Leader lines with balloons, assigning each part a detail number, or just with the name of a part, if the assembly is not too big
- Machining and assembling operations and critical dimensions related to these functions

Working Drawings (cont'd)

Don't forget about the bill of material, showing

- ❑ *parts drawings' numbers*
- ❑ *the description or name of the part,*
- ❑ *the quantity needed for a single assembly, and*
- ❑ *the catalog number if it is standard part, or material*

BILL OF MATERIALS

PROJECT: M3 - AGILE WRIST Date: **21-May-02**

SUB-ASSEMBLY	DRW NO.	PART NAME	QTY	MATERIAL	LAST REV
BASE	W-001	BASE_PETAL	1	ALUMINUM 7075-T6	14-Aug-01
MOTOR_I	W-002A	MOTOR_HOUSING_A	3	ALUMINUM 6061-T6	21-May-02
	W-002B	MOTOR_HOUSING_B	3	ALUMINUM 7075-T6	27-Jan-02
	W-003	MOTOR_SHAFT	3	ALUMINUM 7075-T6	21-May-02
	W-007	BRAKE_FLANGE	3	ALUMINUM 6061-T6	22-Aug-01
LINK_I	W-004*	PROXIMAL_LINK	3	ALUMINUM 7075-T6	26-Dec-01
	W-005S	PIN_SHORT	3	STEEL	
	W-005L	PIN_LONG	3	STEEL	
	W-006*	DISTAL_LINK	3	ALUMINUM 7075-T6	26-Dec-01
END_EFFECTOR	W-008	END_EFFECTOR	1	ALUMINUM 6061-T6	14-Aug-01
JIGS	W-J01	CUBE_JIG	1	ALUMINUM	6-Jan-02

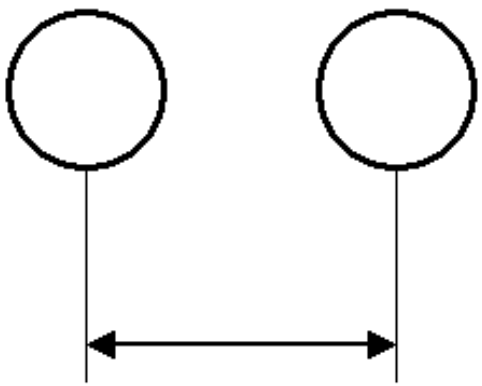
NOTE: DRAWING NUMBERS ARE USED IN NAMING OF DRAWING FILES
Drawing file format: PRO/E 20
File Location on the CIM network: **~alexk/drawings/agilewrist/model_**
*Drawing number + J: Process plan drawing.

Unchanged
Maj Rev/New
Dim. Change
Layout Only

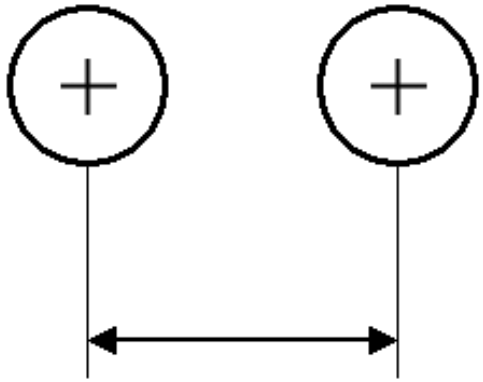
Notes: N/A

Attachments

Most Common Errors



Wrong

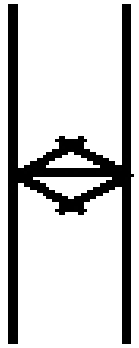


Correct

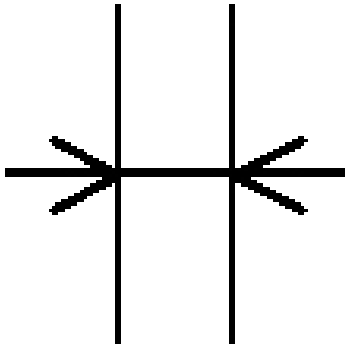
When a dimension is given to the center of an arc or radius, a small cross must be shown at the center

Attachments

Most Common Errors



Wrong

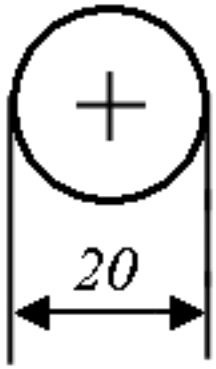


Correct

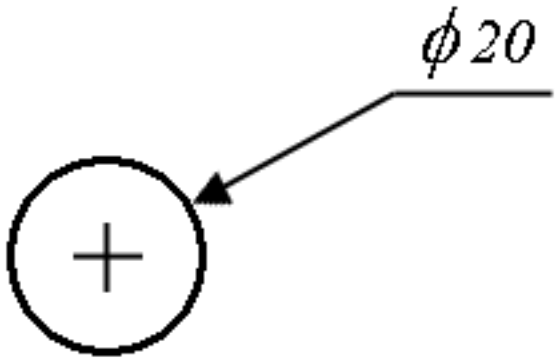
Dimension arrows should not intersect

Attachments

Most Common Errors



Undesirable



Correct

Diameter dimension should be shown with a leader line and arrow

Attachments

Most Common Errors

Wrong **Correct**

Hidden lines of the object must be shown with broken lines

Evolution of Mark Calculation (2003/2004)

$$M = M_{Base} + S_1 + S_2 + S_3 + S_4 + S_5$$

$$S_1 = \frac{k_1}{E_{orig} / N_{dr}}$$

E_j – *number of original & total errors*

$$S_2 = \frac{k_1}{E_{total} / N_{dr}}$$

N_{dr} – *number of drawings*

$M_{Base} = 10$

$$S_3 = k_3 \times Bom$$

k_i – *weight coefficients*

$$S_4 = k_4 \times N_{dr}$$

Bom – Bill of material mark

S_5 – *additional correction (based on general effect)*

Attachments

Evolution of Mark Calculation (2006/2007)

$$M = M_B + S_1 + S_2 + S_3 + S_4 + S_5 + S_6 + S_7 + S_8$$

- ***S_5 – Drawings structure***

  (for example, Upper level assembly – Lower level assembly – Detailed drawings)
- ***S_6 – Interplay & communications between team members***

  (Uniformity of appearance of all drawings of the team)
- ***S_7 – Appearance*** *(Clarity & neatness)*
- ***S_8 – Complexity of drawings***

Attachments

Evolution of Mark Calculation (2010/2011)

- **No Base Mark anymore!**

  - **Original & total mistakes normalized to the number of drawings**
  - **Drawings structure**
  - **Consistency**
  - **Bill of Materials & Title Block**
  - **View Organization & Appearance**
  - **Drawing complexity**

  8/10

  - **Material Cost & Delivery**
  - **Gantt Chart**

  2/10

Conclusion 1

Don't forget!

✓ ***Before you start your design make sure that you clearly understand all terminology otherwise you will be risking to waste your time!***

Example: Solar Array Envelope – is not the "envelope" but rather folded system of an accordion like continuum type.

Conclusion 2

Don't forget!

✓*Always remember about the logic of your assembly*

In a CAD program it is easy to assemble anything in any order, however in reality all components must follow in an algoristic order to be assembled in a proper way!

Conclusion 3

Don't forget!

✓ ***Always remember about the real size of your mechanism***

On the screen you can increase or decrease the view as you wish, in a most convenient way, but in a real prototype a gap may appear smaller than you have seen it on the monitor.

Conclusion 4

Don't forget!

- ✓ ***In your drawings I will estimate not your project or a mechanism, but only the amount and quality of your work on the drawings***

It may be a nuclear reactor or just a mouse trap – both will have absolutely equal rights!

Fundamentals of Graphics Communication,
Gary R. Bertoline and Eric N. Wiebe,
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Cecil Jensen, Jay D. Helsel, and Dennis R. Short,
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