

Dimensioning and Tolerancing



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
—★—
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Learning Objectives

- After completing this chapter, you will
 - Explain ASME Y14.5M
 - Identify common dimensioning systems
 - Understand fundamental tenets of dimensioning
 - Apply general, specific, and delta notes
 - Apply draft angles
 - Understand symbology
 - Surface finish
 - Tolerancing



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Part I

Definitions and ASME Y14.5M



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

ASME Y14.5M

- Standard adopted by ANSI
- Published by ASME
 - 345 East 47th Street, New York, NY 10017
- Entitled “Dimensioning and Tolerancing”
- ASME Y14.1M
 - Controls general dimensional tolerances
 - In titleblock
 - In general notes



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Definitions

- Size dimension
 - May be placed directly on feature
 - May be a note
 - Identify length, width, or depth of feature
- Location dimension
 - Relationship of features of an object



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Definitions

- Actual size
 - Produced size
 - Measured after production
- Allowance
 - Tightest possible fit between two mating parts
 - MMC(external feature)-MMC(internal feature)
- Basic dimension
 - Theoretically exact size
 - Rectangle around numerical value



Definitions

- Bilateral tolerance
 - Variance in two directions from specified dimension
- Datum
 - Theoretically exact surface, plane, axis, center plane, point
 - Dimensions for related features established



Definitions

- Datum feature
 - Actual feature of part
 - Used to establish a datum
- Dimension
 - Numerical value
 - Describes size, shape, location, geometry, or surface texture
- Feature
 - Any physical portion of an object



Definitions

- Geometric tolerance
 - Control form, profile, orientation, location, and runout
- Least material condition (LMC)
 - Lower limit for external feature
 - Upper limit for internal feature



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Definitions

- Limits of dimension
 - Largest and smallest boundaries
 - Related to tolerance of dimension
- Maximum material condition (MMC)
 - Largest limit for external feature
 - Smallest limit for internal feature



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Definitions

- Nominal size
 - General identification
 - Stock size
 - Thread diameter
- Reference dimension
 - Used for information purposes only
 - Without tolerances
 - Enclosed in parentheses



Definitions

- Specified dimension
 - From which limits are calculated
- Tolerance
 - Total permissible variation in size or location
- Unilateral tolerance
 - Variation in only one direction



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Definitions

- Notes
 - Identify size with more than a numerical value
 - Two types
 - General
 - Relate to entire drawing
 - Local
 - Connected to specific features



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

The diagram illustrates the standard conventions for dimensioning in engineering drawing. It shows a mechanical part with various dimensions and their corresponding labels:

- ARROWHEAD**: The pointed end of a dimension line.
- DIMENSION TEXT**: The numerical value of the dimension, represented as $X.X$.
- EXTENSION LINE EXTENSION**: The part of the extension line that extends beyond the dimension line.
- EXTENSION LINE**: The line that extends from the feature being dimensioned to the dimension line.
- LEADER SHOULDER**: The horizontal part of a leader line.
- LEADER LINE**: The line used to point to a specific feature, such as a hole or fillet.
- $\phi X.X$** : Dimension for the diameter of a hole.
- $RX.X$** : Dimension for the radius of a fillet or arc.
- DIMENSION LINE**: The line that indicates the extent of the dimension.
- CENTERLINE SPACE**: The space between the centerline and the dimension line.
- CENTERLINE OFFSET**: The offset of the centerline from the dimension line.
- CENTER DASH**: The dashed part of the centerline.
- ANGULAR DIMENSION LINE ARC**: The arc used to indicate an angle.
- X°** : Dimension for an angle.
- EXTENSION LINE OFFSET**: The offset of the extension line from the dimension line.
- DIMENSION LINE GAP**: The gap between the dimension line and the extension line.



Dimension Components

- Dimension lines
 - Indicate length of dimension
 - Thin lines capped with arrowheads
 - Broken along length to provide space for dimension value
 - Gap is commonly .06 inch
- Angular dimension line
 - Arc with center of the arc from vertex of angle



Dimension Components

- Dimension text
 - Normally .12 inch high
 - Centered in dimension line space
- Leader line
 - Thin line
 - Connects specific note to feature
 - Any angle between 15 and 75 degrees
 - Preferably 45 degrees

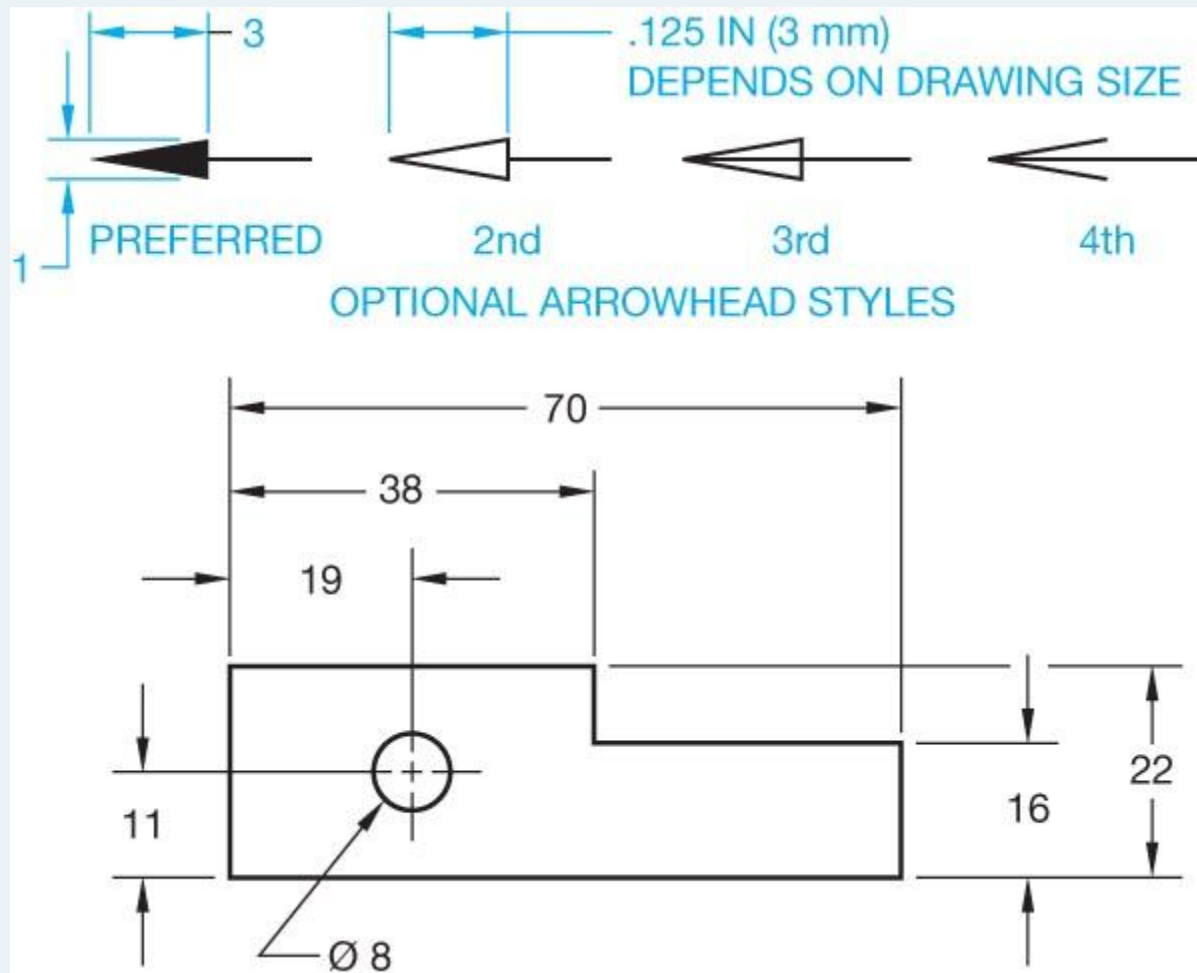


Dimension Components

- Arrowheads
 - Cap dimension line and leader line
 - Three times as long as high
 - .125 inch long typically
- Extension lines
 - Establish extent of dimension
 - Thin lines
 - Offset .06 inch from object
 - Extend .12 inch past last dimension line



Dimension Components



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Dimension Components

- Center dash
 - Part of centerline
 - Thin line
 - Drawn .12 inch
- Centerline space
 - Commonly .06 inch
 - Space between long and short dashes of centerline



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Part II

Dimensioning Systems



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
—★—
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Unidirectional Dimensioning

- Commonly used in mechanical drafting
- All numbers, figures, and notes read from bottom
 - Lettered horizontally on page



e.resource™ for

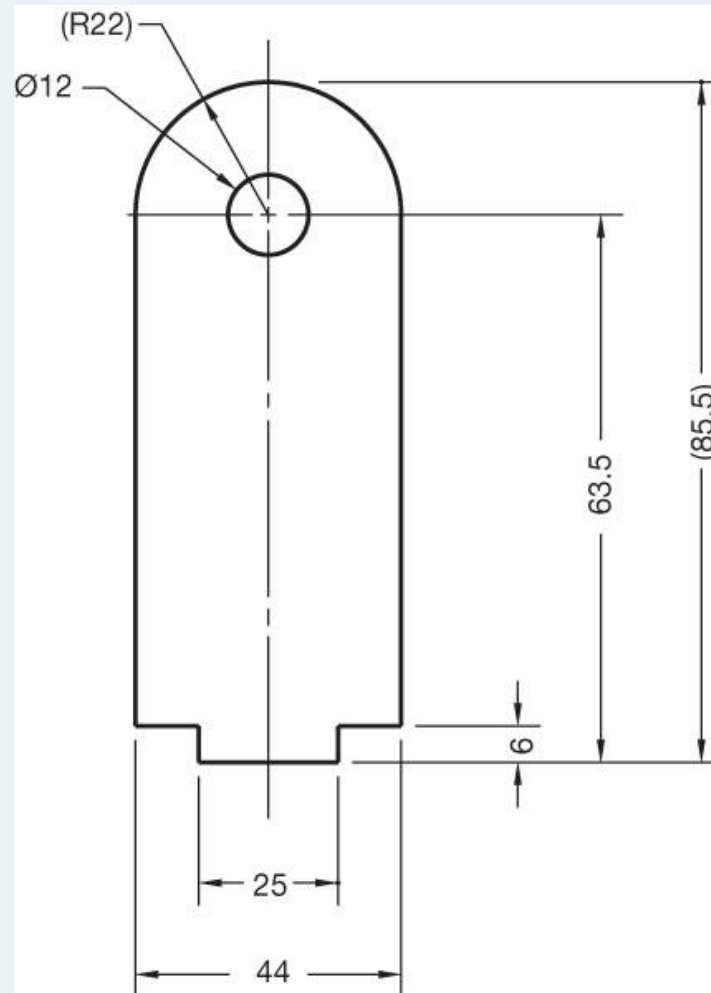
Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Unidirectional Dimensioning



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Aligned Dimensioning

- Read from
 - Bottom
 - Horizontal dimension
 - Right
 - Vertical dimension



e.resource™ for

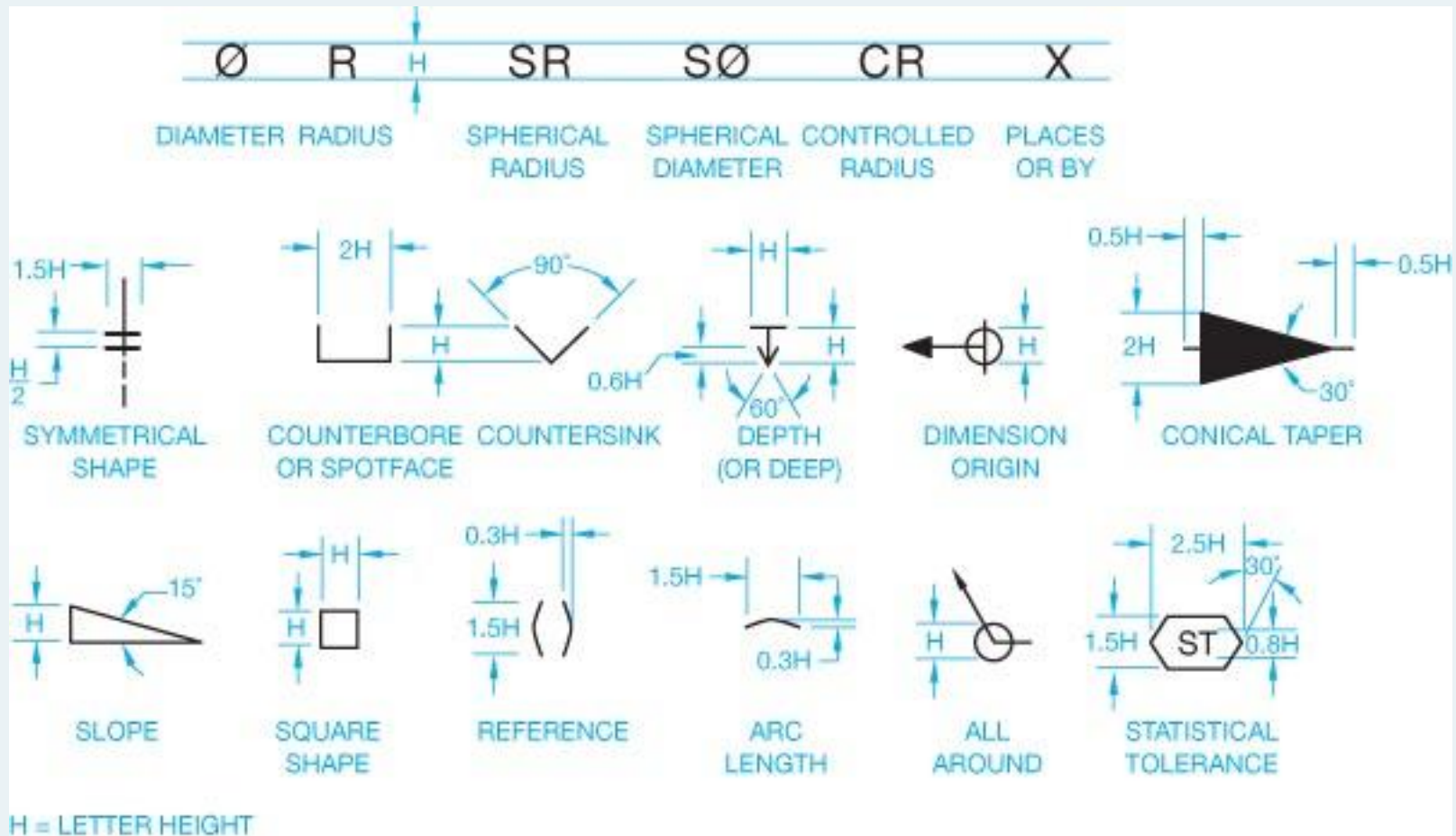
Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Aligned Dimensioning



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Tabular Dimensioning

- Size and location dimensions in table
 - X, Y, and Z axes defined
 - Features related to table by symbols



e.resource™ for

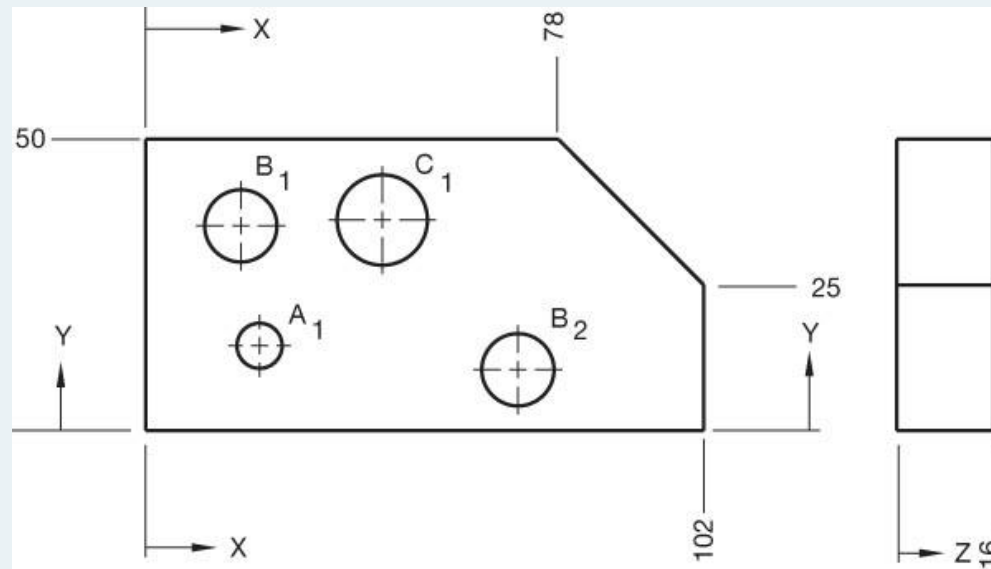
Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Tabular Dimensioning



HOLE SYMBOL	HOLE DIA	LOCATION		DEPTH Z
		X	Y	
A ₁	6	15	14	THRU
B ₁	9	12	38	9
B ₂	9	57	7	12
C ₁	12	43	38	THRU



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Arrowless Dimensioning

- Ordinate dimensioning
- Features keyed to a table
- Location dimensions
 - Established with extension lines
 - Determined by datums



e.resource™ for

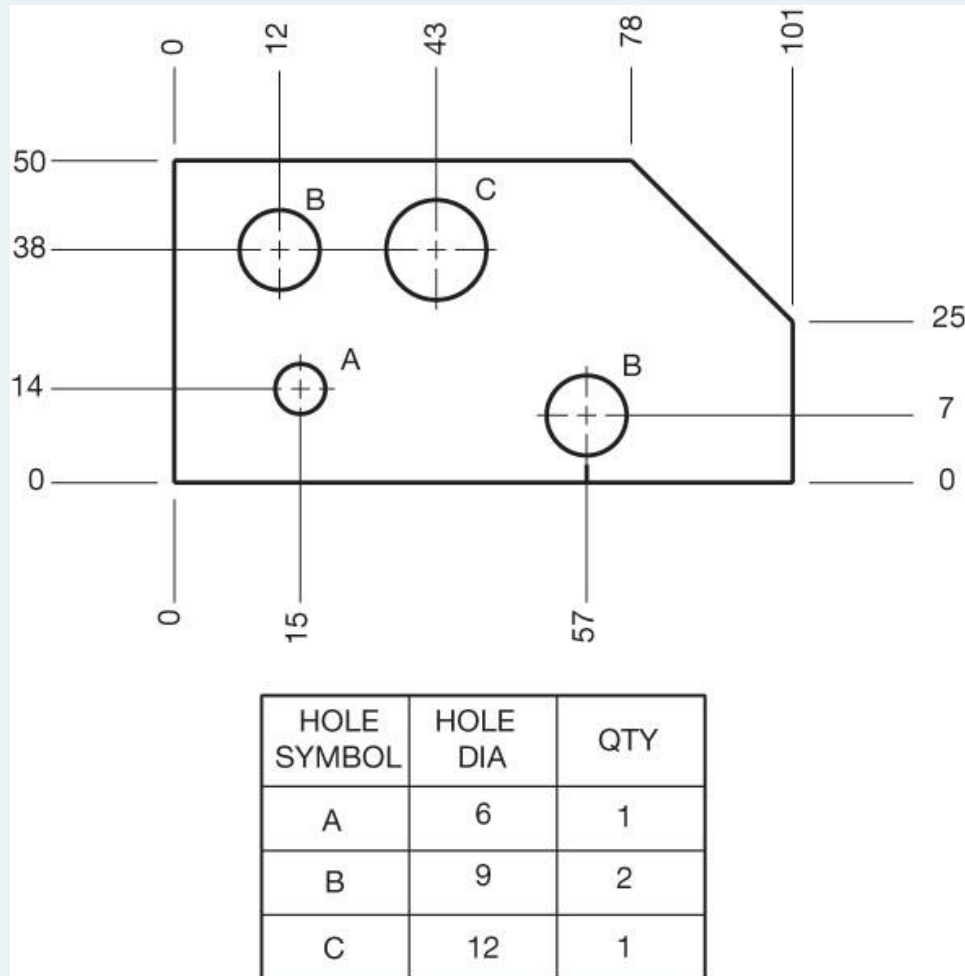
Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Arrowless Dimensioning



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Chart Drawings

- Used when
 - Part or assembly has one or more dimensions that change
 - Dependent on application
- Variable dimension labeled with letter
- Commonly used in vendor or specification catalogs



e.resource™ for

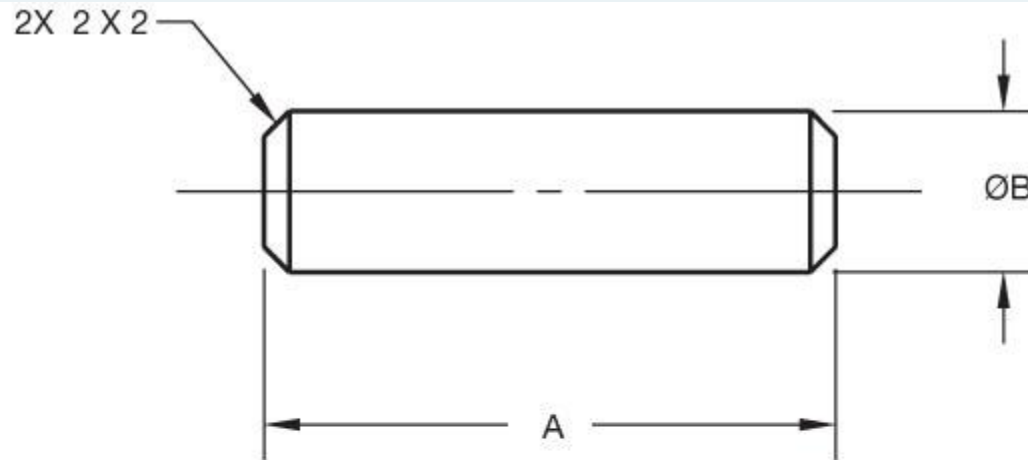
Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Chart Drawings



LENGTH A	B=20.3	B=38.1	B=50.8	B=57.2
	PART NO.	PART NO.	PART NO.	PART NO.
76	DP20.3-76.2	DP38.1-76.2	DP50.8-76.2	DP57.2-76.2
101	DP20.3-101.6	DP38.1-101.6	DP50.8-101.6	DP57.2-101.6
127	DP20.3-127	DP38.1-127	DP50.8-127	DP57.2-127
152	DP20.3-152.4	DP38.1-152.4	DP50.8-152.4	DP57.2-152.4



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Part III

Dimensioning Rules



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Decimal Points

- Leading zeros
 - Only for metric values less than one
 - E.g., 0.08 mm
- Specified dimension
 - Same number of decimal places as tolerance



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Fractions

- Separate whole numbers from fractions with dash
 - E.g. 1-5/8, not 1 5/8
- Use stacked fractions whenever possible



Chain Dimensioning

- Point-to-point dimensioning
 - Dependent on previous dimension(s)
 - Avoid tolerance buildup
- Overall dimension
 - Critical
 - Stands independent in relationship to other dimensions
- Let one dimension “float”



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Preferred Dimensioning

- Avoid crossing extension lines
 - With other extension lines
 - Do not break when they cross
 - With dimension lines
 - Over arrowheads
 - Break when they cross
- Avoid dimensioning over or through an object



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Preferred Dimensioning

- Avoid
 - Dimensioning to hidden features
 - Unnecessarily long extension lines
 - Using object lines as extension lines
- Dimension between views when possible
- Group adjacent dimensions
- Dimension to view that provide best shape description



Preferred Dimensioning

- Dimension multiple features of the same size with a note
 - Specifies the number of “like” features
- Point leader arrow to center of circle
- Dimension circles with diameters
- Dimension arcs and fillets with radii



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Location Dimensions

- Rectangular shapes
 - Located to sides
- Symmetrical features
 - Located to centerline or centerplane
- Cylindrical features
 - Given to center of feature
 - Dimension in view where they appear as circles



e.resource™ for

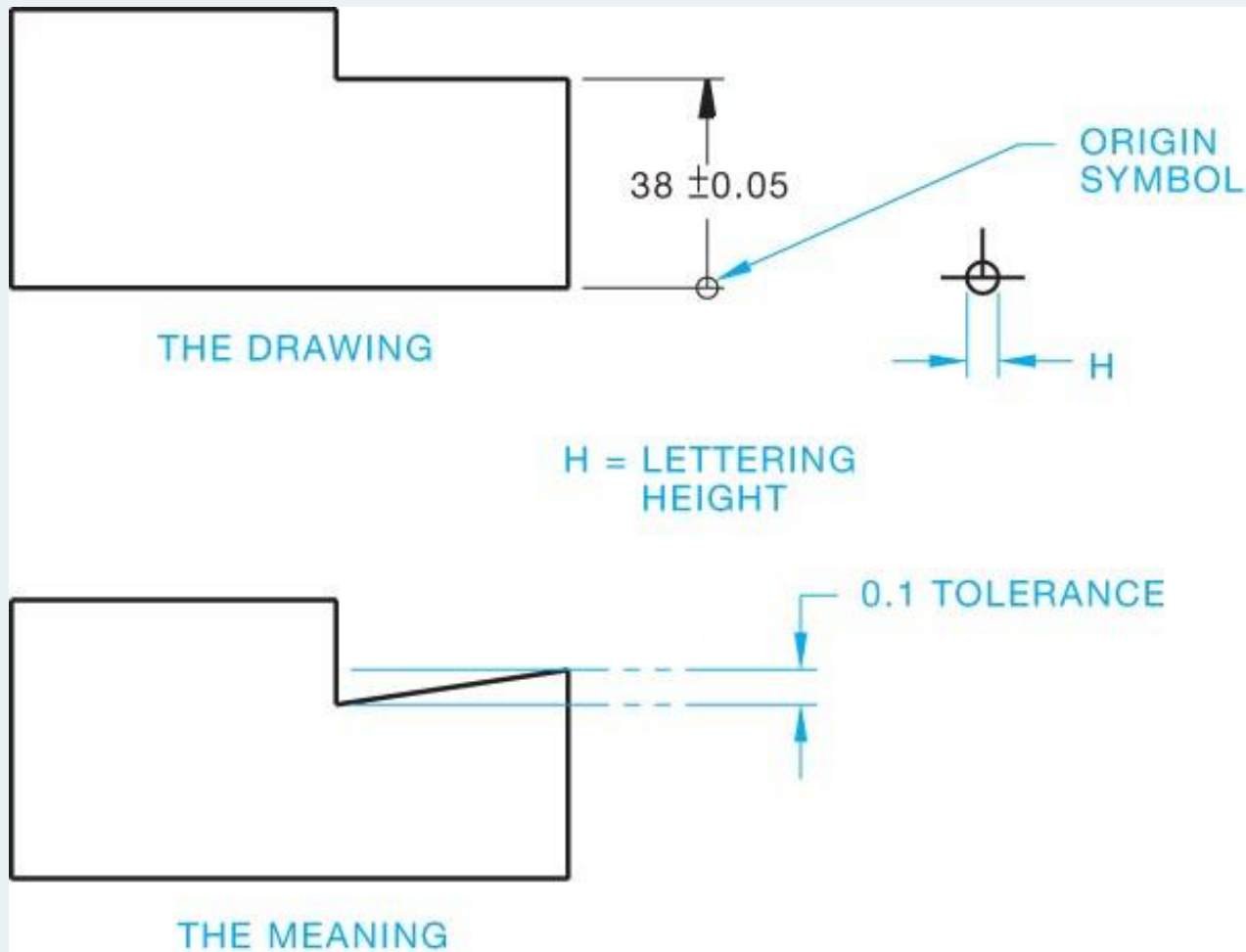
Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Dimension Origin



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Part IV

Notes and Symbols



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

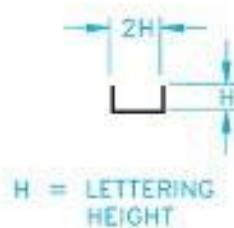
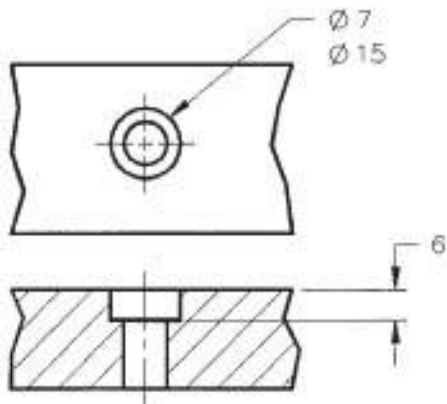
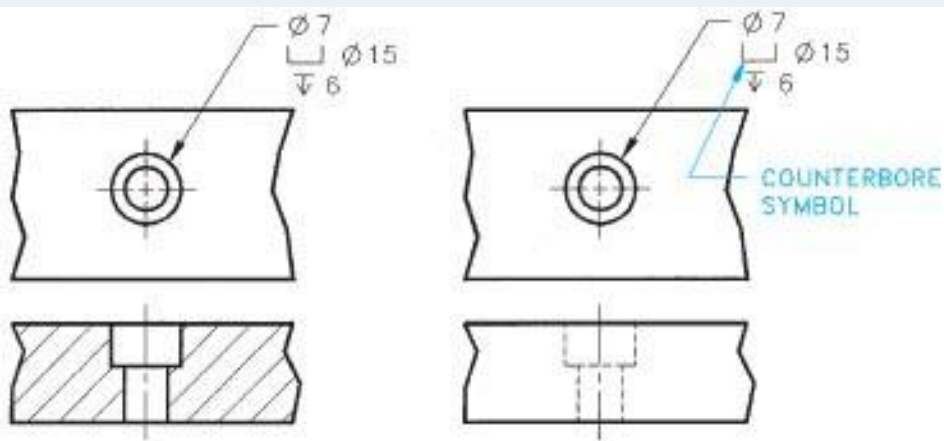
Copyright © 2007 Thomson Delmar Learning

Counterbore

- Machine a diameter below part surface
 - Bolt head may be recessed
- Symbol
 - Same as for spotface



Counterbore



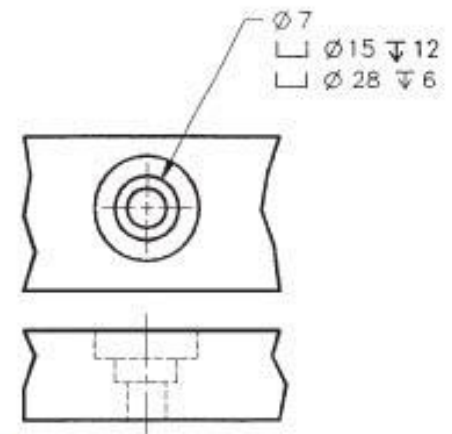
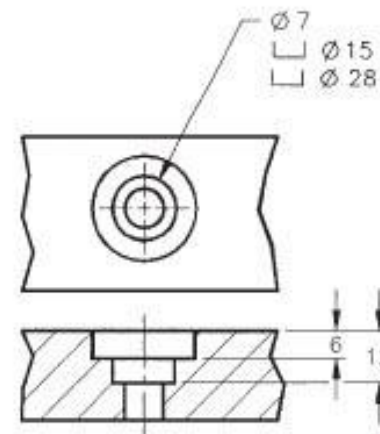
(a)

$\varnothing 7$
 $\varnothing 15$ $\nabla 6$

(b)

$\varnothing 7$
 $\varnothing 15$ $\nabla 6$

(c)



(d)



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
 DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Countersink

- Counterdrill
- Recess head of fastener below part surface



e.resource™ for

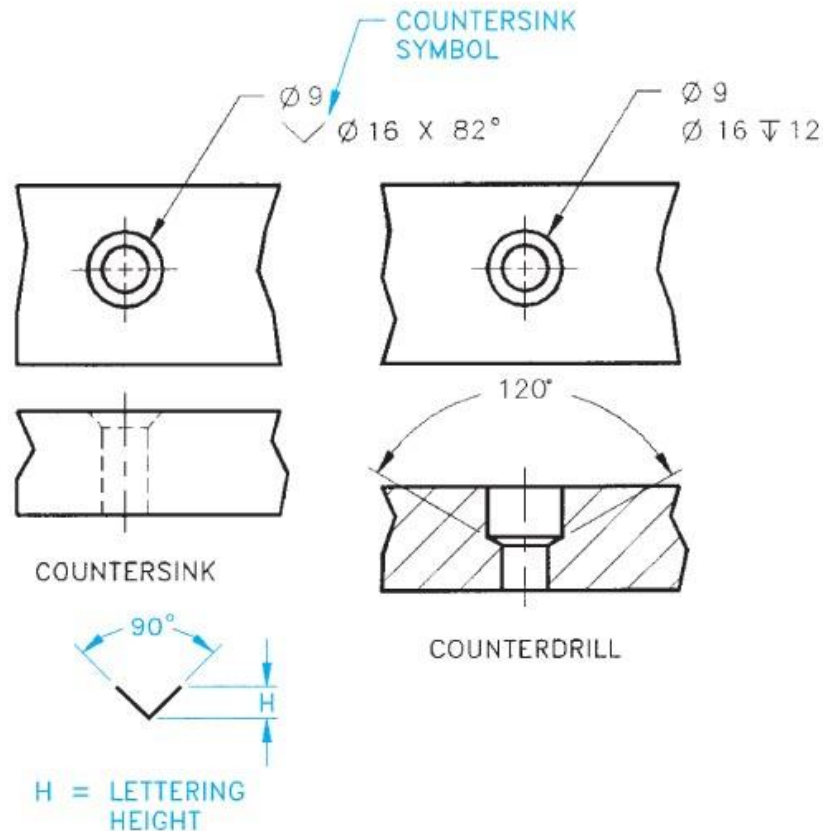
Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Countersink



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Slots

- Full radius
 - Dimension one of three ways
- End radius $>$ feature width
 - Dimension end radii
 - Dimension feature width
 - Dimension feature length



e.resource™ for

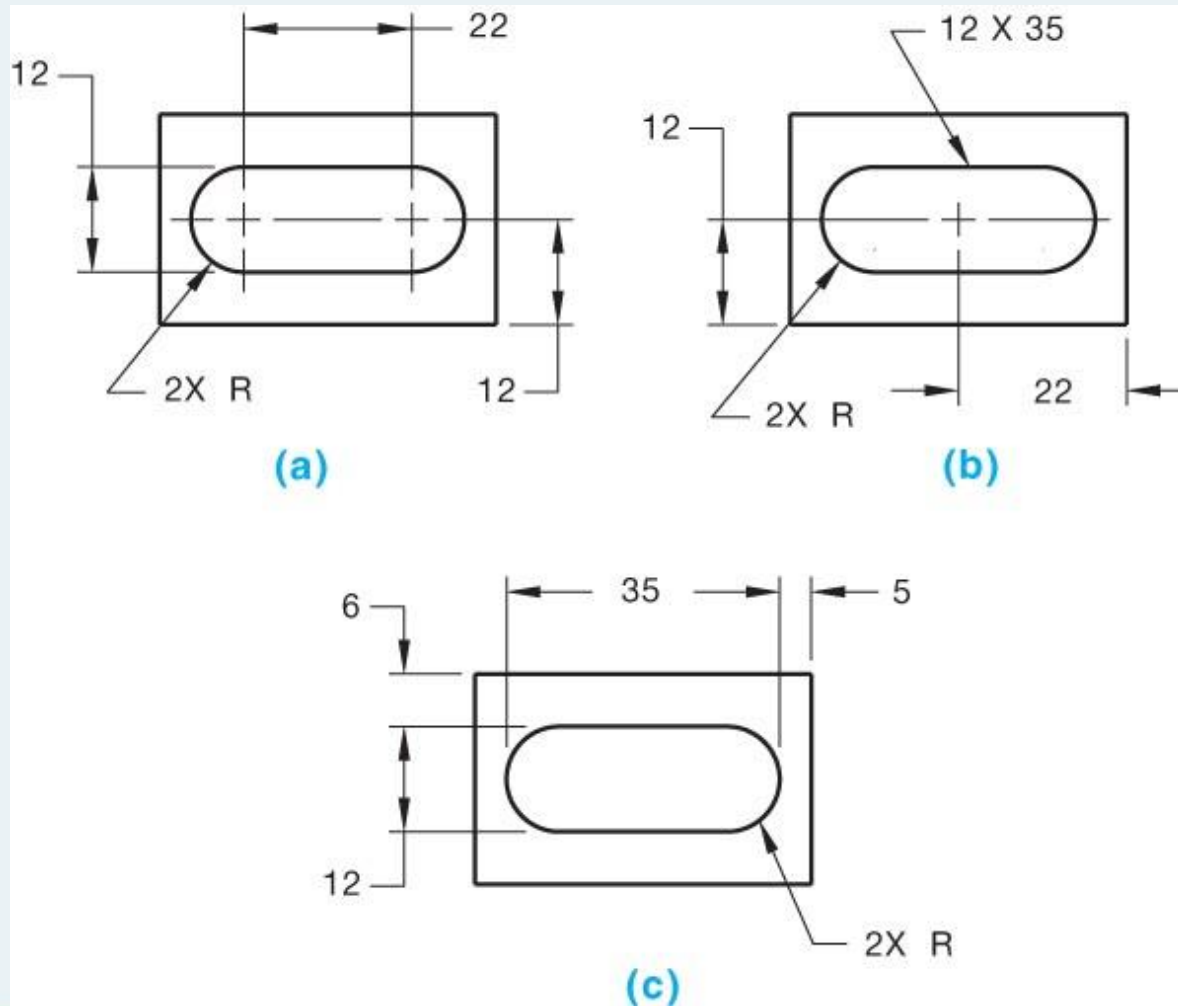
Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Slots



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Surface Finishes

- When object surfaces are machined to certain specification
- May appear in a general note
- May be connected to specific surface with leader
- FAO
 - Finish all over



e.resource™ for





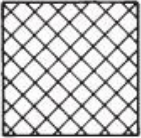







Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Surface Finishes

ILLUSTRATION	DEFINITION	SYMBOL
	PARALLEL TO EDGE OF INDICATED SURFACE	
	PERPENDICULAR TO EDGE OF INDICATED SURFACE	
	ANGULAR IN BOTH DIRECTION TO INDICATED EDGE	
	CIRCULAR RELATIVE TO CENTER	
	MULTIDIRECTIONAL	
	RADIAL RELATIVE TO CENTER	



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Surface Finishes

MICROMETERS	ROUGHNESS HEIGHT RATING MICRO INCHES	SURFACE DESCRIPTION	PROCESS
25 ✓	1000 ✓	VERY ROUGH	SAW AND TORCH CUTTING, FORGING, OR SAND CASTING.
12.5 ✓	500 ✓	ROUGH MACHINING	HEAVY CUTS AND COARSE FEEDS IN TURNING, MILLING, AND BORING.
6.3 ✓	250 ✓	COARSE	VERY COARSE SURFACE GRIND, RAPID FEEDS IN TURNING, PLANING, MILLING, BORING, AND FILING.
3.2 ✓	125 ✓	MEDIUM	MACHINING OPERATIONS WITH SHARP TOOLS, HIGH SPEEDS, FINE FEEDS, AND LIGHT CUTS.
1.6 ✓	63 ✓	GOOD MACHINE FINISH	SHARP TOOLS, HIGH SPEEDS, EXTRA-FINE FEEDS AND CUTS.
0.80 ✓	32 ✓	} HIGH-GRADE MACHINE FINISH	EXTREMELY FINE FEEDS AND CUTS ON LATHE, MILL, AND SHAPERS REQUIRED. EASILY PRODUCED BY CENTERLESS, CYLINDRICAL, AND SURFACE GRINDING.
0.40 ✓	16 ✓		
0.20 ✓	8 ✓	VERY FINE MACHINE FINISH	FINE HONING AND LAPPING OF SURFACE.
0.050 0.100 ✓	2 - 4 ✓	EXTREMELY SMOOTH MACHINE FINISH	EXTRA-FINE HONING AND LAPPING OF SURFACE, MIRROR FINISH.
0.025 ✓	1 ✓	SUPER FINISH	DIAMOND ABRASIVES.



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

General Notes

- Material specifications
- Dimensions
- General tolerances
- Confidential note, copyrights, patents
- Drawn by
- Scale
- Date
- Part name



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

General Notes

- Drawing size
- Part number
- Number of revisions
- Type of projection (first or third)
- Standard reference (e.g., ANSI/ASME)
- General machining, finish, or paint specifications
- Identification of “like” features



e.resource™ for


Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Delta Notes

- Triangle placed on a drawing
 - Commonly, next to a dimension
 - Hexagons and circles also used
- Cross-references a general note by number
- E.g, 2.625 
 - This dimension should refer to general note #1



Part V

Tolerancing



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
—★—
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Calculating Tolerances

- For example
 - 22.0 ± 0.1
 - Upper limit
 - 22.1
 - Lower limit
 - 21.9
 - Tolerance
 - 0.2



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Fit Tables - ANSI

- RC
 - Running clearance
- LC
 - Locational clearance
- LT
 - Transitional clearance
- LN
 - Locational interference
- FN
 - Force fit



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Fit Tables - ISO

- Hole basis
 - Clearance Fit
 - H11/c11
 - H9/d9
 - H8/f7
 - H7/g6
 - H7/h6



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Fit Tables - ISO

- Hole basis
 - Transition fit
 - H7/k6
 - H7/n6
 - Interference fit
 - H7/p6
 - H7/s6
 - H7/u6



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
—★—
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning

Summary

- Use conventional dimensioning practices
 - Continuity
 - Accuracy
 - Ease of interpretation
- Specify tolerances that are appropriate for part application and machining ability



e.resource™ for

Engineering Drawing and Design

Fourth Edition

THOMSON
DELMAR LEARNING

Copyright © 2007 Thomson Delmar Learning