Why GD&T?

- Ensures interchangeability of parts during mating / assembly
- Saves money by avoiding unnecessary over-tolerancing
- Avoids (legal, machining, inspection) ambiguity
- Contributes to functional gauging of surfaces and features by establishing datums of importance
- Influences order of manufacturing steps

ASME Y14.5M
Dimensions

Dimension

- Basic dimension: $\phi 1.50$
- Tolerance based on global tolerances in title block

Bilateral (I)

- Bilateral: $\phi 1.50^{+.05}_{-.05}$
- Upper and lower limits

Bilateral (II)

- Bilateral: $\phi 1.50^{+/-0.05}$
- Tolerance based on global tolerances or specified by GD&T callout
Dimensions

**Limit**

\[ \phi 1.55 \]
\[ \phi 1.45 \]

**Max**

\[ \phi 1.50 \text{ MAX} \]

**Min**

\[ \phi 1.50 \text{ MIN} \]

Useful for defining min. dimensions when max. would not interfere with feature / part utility
# Geometric Control Symbols

<table>
<thead>
<tr>
<th>Type</th>
<th>Geometric Characteristics</th>
<th>Pertains To</th>
<th>Basic Dimensions</th>
<th>Feature Modifier</th>
<th>Datum Modifier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Form</td>
<td>Straightness</td>
<td>ONLY individual</td>
<td></td>
<td>Modifier not</td>
<td>NO datum</td>
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<tr>
<td></td>
<td>Circularity</td>
<td>feature</td>
<td></td>
<td>applicable</td>
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<tr>
<td></td>
<td>Flatness</td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>Cylindricity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Profile</td>
<td>Profile (Line)</td>
<td>Individual or related</td>
<td></td>
<td></td>
<td>RFS implied unless MMC or LMC is stated</td>
</tr>
<tr>
<td></td>
<td>Profile (Surface)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orientation</td>
<td>Angularity</td>
<td>ALWAYS related feature(s)</td>
<td></td>
<td>RFS implied unless MMC or LMC is stated</td>
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<tr>
<td></td>
<td>Perpendicularity</td>
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<td></td>
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<tr>
<td></td>
<td>Parallelism</td>
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<tr>
<td>Location</td>
<td>Position</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Concentricity</td>
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<td></td>
<td>Symmetry</td>
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</tr>
<tr>
<td>Runout</td>
<td>Circular Runout</td>
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<td></td>
<td>Only RFS</td>
<td>Only RFS</td>
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<tr>
<td></td>
<td>Total Runout</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Adapted from Oberg’s Machinery Handbook
Establishing Datums
Establishing Datums

Surface Plate

Right Angle Plate
Coordinate Measuring Machines (CMMS)

Automated

Hand Operated
Form (Straightness, —)

All points that lie between two lines (upper and lower boundary) when measuring a line profile
Form (Circularity, ○)

All points of a plane perpendicular to a common axis are equidistant from that axis.
Form (Cylindricity, /\)

All points of the surface of a surface of revolution are equidistant from a common axis
Form (Flatness, □)

The distance between all elements in one plane when measured with reference to a reference plane.
Profile (Line, \(\text{\textcircled{}}\) or Surface, \(\text{\textcircled{\textcircled{}}}\))

This distance between all points of a line profile or surface profile between two surfaces of the shape of the idealized surface.
Orientation (Angularity, $\angle$)

The tolerance zone defined by two parallel planes or a cylinder at a specified angle from the datum plane
Orientation (Perpendicularity, _) 

The tolerance zone of two parallel plates perpendicular to a datum within which a feature must lie
Orientation (Parallelism, // )

The tolerance zone of two parallel plates parallel to a datum within which a feature must lie
Location (Position, ⦿)

The exact location of a point, line, or surface in relation to another datum
Location (Concentricity, ◯)

The position of an axis in relation to another datum axis.
Runout (Circular, ↑, and Total, ↔)

The deviation of the profile of an axisymmetric feature from a control (datum) axis
Lathe Terminology
Workholding (Collets)

Collets are located in the drawer in (or next to) the lathe

Collets sizes are selected based on the stock size
Workholding (3- and 4-Jaw Chucks)

3-Jaw Chucks
• Self-centering and quick clamping
• Cannot hold irregularly shaped work pieces

4-Jaw Chucks
• Admits square stock
• Off-center turning
• Mounting subject to eccentricities
The tailstock is used to hold the workpiece with a guide or to drill holes.
Tooling

Facing/turning (carbide insert)

Part-off tool
Tool Post

The tool post connects the tool holder (tool) to the carriage.
Turning Operations

- **Turning**
- **Facing**
- **Parting off**
- **Grooving**
- **Thread cutting**

**Turning**

- **Facing**

- **Parting off**

- **Grooving**

- **Thread cutting**
Turning Operations

3-Jaw chuck and boring bar
Turning Operations

Peck drilling
Spindle Speed [RPM] = \frac{4 \times \text{Cutting Speed [SFPM]}}{\text{Tool Diameter [in.]}}

Spindle Speed [RPM] = \frac{4 \times \text{Cutting Speed [SFPM]}}{\text{Part Diameter [in.]}}
Feeds and Speeds

You set this

Feed Rate \left[ \frac{\text{in}}{\text{min}} \right] = \text{Chip Load} \ [\text{in.}] \times \text{x Spindle Speed} \ [\text{RPM}]

Determined by the speed equation

Roughing = 0.005”
Finishing = 0.001 – 0.002”
Feeds and Speeds

- Roughing
- Finishing

Part Diameter (in) vs. Speed (RPM) x 1000 vs. Feed (in./min.)
Cutting Slots with the Mill

High speed steel slitting saws

- Slow speed (300 – 500 RPM)
- Conventional milling (avoid pulling at workpiece)