Anthropometry and Workstation Design
Anthropometry

anthropos- man
-metria measuring

Anthropometry: measurement and use of human dimensions
Concepts

- Populations (of individuals from whom data is obtained / for whom it is intended)
  - General
  - By age
  - By gender
  - By occupation
  - By other criteria

- Samples
  - Stratified
  - Random
  - Exhaustive/complete

- Anthropometric Data

- Data Tabulation
  - Percentile
  - Distribution Parameters
  - Exhaustive Lists
Worker Stature (1)

Probability Density

Stature (in)
Worker Stature (2)

Probability Density

Stature (in)

60  62  65  70

0.05 5%
Worker Stature (3)
Worker Stature (4)

Probability Density

Stature (in)

60  65  70

0.95  95%  70.5
Cumulative Probabilities

\[ \% \leq s \]

\[ s = \text{stature (in.)} \]

<table>
<thead>
<tr>
<th>Stature</th>
<th>Percentile</th>
</tr>
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<tbody>
<tr>
<td>62</td>
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<tr>
<td>66.5</td>
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<td>70.5</td>
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Body Dimensions

• Static (Structural)
  – Body at rest

• Dynamic (Functional)
  – Body moving
Human Dimensions (1)
Human Dimensions (2)

- Sitting height, erect (2)
- Elbow rest height (6)
- Thigh clearance height (7)
- Knee height (4)
- Buttock popliteal length (9)
- Buttock-knee length (8)
- Popliteal height (5)
Human Dimensions (3)

Sitting height, normal (3)
Human Dimensions (4)

Elbow-to-elbow breadth (10)

Seat breadth (11)
## Anthropometric Data

### Selected Structural Body Dimensions and Weights of Adults

<table>
<thead>
<tr>
<th>Body Feature</th>
<th>Dimension, in</th>
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<td></td>
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<td>Female, percentile</td>
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<td>5th</td>
<td>50th</td>
<td>95th</td>
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<td>11.0</td>
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<td>6.9</td>
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<td>9 Buttock-popliteal height</td>
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<td>10 Elbow-to-elbow breadth</td>
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<td>16.5</td>
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<td>19.3</td>
<td>12.3</td>
<td>15.1</td>
<td>19.3</td>
<td>12.3</td>
<td>15.1</td>
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<td>11 Seat breadth</td>
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<td>14.0</td>
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<td>12.3</td>
<td>14.3</td>
<td>17.1</td>
<td>12.3</td>
<td>14.3</td>
<td>17.1</td>
<td>12.3</td>
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<tr>
<td>12 Weight</td>
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<td>166</td>
<td>217</td>
<td>104</td>
<td>137</td>
<td>199</td>
<td>104</td>
<td>137</td>
<td>199</td>
<td>104</td>
<td>137</td>
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</table>

Weight given in pounds

Source: U.S. Public Health Service, 1965
Text Anthropometric Measures

**FIGURE 10.3**

**FIGURE 10.4**
### TABLE 10.2  Anthropometric Data (unit: inches)

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Males</th>
<th>Females</th>
<th>Population Percentiles, 50/50 Males/Females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50th percentile ± 1S.D.</td>
<td>50th percentile ± 1S.D.</td>
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<tr>
<td>Standing</td>
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</tr>
<tr>
<td>1. Forward Functional Reach</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>a. includes body depth at shoulder</td>
<td>32.5</td>
<td>1.9</td>
<td>29.2</td>
</tr>
<tr>
<td>b. acromial process to function pinch</td>
<td>26.9</td>
<td>1.7</td>
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<tr>
<td>c. abdominal extension to functional pinch</td>
<td>(24.4)</td>
<td>(3.5)</td>
<td>(23.8)</td>
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<td>2. Abdominal Extension Depth</td>
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<tr>
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<td>(41.3)</td>
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<td>4. Tibial Height</td>
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<td>1.1</td>
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<td>5. Knuckle Height</td>
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<td>2.80</td>
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<td>6. Elbow Height</td>
<td>43.5</td>
<td>1.8</td>
<td>40.4</td>
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<tr>
<td></td>
<td>(45.1)</td>
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<td>(42.2)</td>
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<td>7. Shoulder Height</td>
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<td>(57.6)</td>
<td>(3.1)</td>
<td>(56.3)</td>
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<tr>
<td>8. Eye Height</td>
<td>64.7</td>
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<td>9. Stature</td>
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<td></td>
<td>(69.9)</td>
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<td>(64.8)</td>
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<tr>
<td>10. Functional Overhead Reach</td>
<td>82.5</td>
<td>3.3</td>
<td>78.4</td>
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</table>
### TABLE 10.2 Anthropometric Data (unit: inches)

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Males 50th percentile ± S.D</th>
<th>Females 50th percentile ± S.D.</th>
<th>Population Percentiles, 50/50 Males/Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seated</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Thigh Clearance Height</td>
<td>5.8 ± 0.6</td>
<td>4.9 ± 0.5</td>
<td>4.3 / 4.3 / 5.3 / 5.3 / 6.5</td>
</tr>
<tr>
<td>12. Elbow Rest Height</td>
<td>9.5 ± 1.3</td>
<td>9.1 ± 1.2</td>
<td>7.3 / 7.3 / 9.3 / 9.3 / 11.4</td>
</tr>
<tr>
<td>13. Midshoulder Height</td>
<td>24.5 ± 1.2</td>
<td>22.8 ± 1.0</td>
<td>21.4 / 23.6 / 23.6 / 26.1</td>
</tr>
<tr>
<td>14. Eye Height</td>
<td>31.0 ± 1.4</td>
<td>29.0 ± 1.2</td>
<td>27.4 / 29.9 / 29.9 / 32.8</td>
</tr>
<tr>
<td>15. Sitting Height, Normal</td>
<td>34.1 ± 1.5</td>
<td>32.2 ± 1.6</td>
<td>32.0 / 34.6 / 34.6 / 37.4</td>
</tr>
<tr>
<td>16. Functional Overhead Reach</td>
<td>50.6 ± 3.3</td>
<td>47.2 ± 2.6</td>
<td>43.6 / 48.7 / 54.8</td>
</tr>
<tr>
<td>17. Knee Height</td>
<td>21.3 ± 1.1</td>
<td>20.1 ± 1.9</td>
<td>18.7 / 20.7 / 22.7</td>
</tr>
<tr>
<td>18. Popliteal Height</td>
<td>17.2 ± 1.0</td>
<td>16.2 ± 0.7</td>
<td>15.1 / 16.6 / 18.4</td>
</tr>
<tr>
<td>19. Leg Length</td>
<td>41.4 ± 1.9</td>
<td>39.6 ± 1.7</td>
<td>37.3 / 40.5 / 43.9</td>
</tr>
<tr>
<td>20. Upper-Leg Length</td>
<td>23.4 ± 1.1</td>
<td>22.6 ± 1.0</td>
<td>21.1 / 23.0 / 24.9</td>
</tr>
<tr>
<td>21. Buttocks-to-Popliteal Length</td>
<td>19.2 ± 1.0</td>
<td>18.9 ± 1.2</td>
<td>17.2 / 19.1 / 20.9</td>
</tr>
<tr>
<td>22. Elbow-to-Fit Length</td>
<td>14.2 ± 0.9</td>
<td>12.7 ± 1.1</td>
<td>12.6 / 14.5 / 16.2</td>
</tr>
<tr>
<td></td>
<td>(14.6) (1.2)</td>
<td>(13.0) (1.2)</td>
<td>(11.4) (13.8) (16.2)</td>
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<tr>
<td>23. Upper-Arm Length</td>
<td>14.5 ± 0.7</td>
<td>13.4 ± 0.4</td>
<td>12.9 / 13.8 / 15.5</td>
</tr>
<tr>
<td></td>
<td>(14.6) (1.0)</td>
<td>(13.3) (0.8)</td>
<td>(12.1) (13.8) (16.0)</td>
</tr>
<tr>
<td>24. Shoulder Breadth</td>
<td>17.9 ± 0.8</td>
<td>15.4 ± 0.8</td>
<td>14.3 / 16.7 / 18.8</td>
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</tbody>
</table>

17
### TABLE 10.2 (continued)

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<th>Measurement</th>
<th>Males 50th percentile ± 1S.D.</th>
<th>Females 50th percentile ± 1S.D.</th>
<th>Population Percentiles, 50/50 Males/Females</th>
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<td>10.5 ± 0.5</td>
<td>9.5 ± 0.4</td>
<td>8.9, 10.0, 11.2</td>
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<td>27. Foot Breadth</td>
<td>3.9 ± 0.2</td>
<td>3.5 ± 0.2</td>
<td>32, 3.7, 4.2</td>
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<td>Hand</td>
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<td>28. Hand Thickness</td>
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<td>Metacarpal III</td>
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<td>1.1 ± 0.1</td>
<td>1.0, 1.2, 1.4</td>
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<td>7.2 ± 0.4</td>
<td>6.7, 7.4, 8.0</td>
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<td>30. Digit Two Length</td>
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<td>31. Hand Breadth</td>
<td>3.4 ± 0.2</td>
<td>3.0 ± 0.2</td>
<td>2.8, 3.2, 3.6</td>
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<td>5.0 ± 0.4</td>
<td>4.4 ± 0.4</td>
<td>3.8, 4.7, 5.6</td>
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<tr>
<td>33. Breadth of Digit One</td>
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</tr>
<tr>
<td>Interphalangeal Joint</td>
<td>0.9 ± 0.05</td>
<td>0.8 ± 0.05</td>
<td>0.7, 0.8, 1.0</td>
</tr>
<tr>
<td>34. Breadth of Digit Three</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Interphalangeal Joint</td>
<td>0.7 ± 0.05</td>
<td>0.6 ± 0.04</td>
<td>0.6, 0.7, 0.8</td>
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<td>35. Grip Breadth, Inside</td>
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<td>Diameter</td>
<td>1.9 ± 0.2</td>
<td>1.7 ± 0.1</td>
<td>1.5, 1.8, 2.2</td>
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<td>36. Hand Spread, Digit One</td>
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<tr>
<td>to to Two, 1st Phalangeal</td>
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<td>3.9 ± 0.7</td>
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<td>Joint</td>
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<td>37. Hand Spread, Digit One</td>
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<td>to Two, 2nd Phalangeal Joint</td>
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<td>Measurement</td>
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<td>Females</td>
<td>Population Percentiles, 50/50 Males/Females</td>
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<tr>
<td></td>
<td>50th percentile ± 1.0 S.D.</td>
<td>50th percentile ± 1.0 S.D.</td>
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<tr>
<td>Head</td>
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<td>38. Head Breadth</td>
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<td>39. Interpupillary Breadth</td>
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<td>Other Measurements</td>
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<td>41. Flexion-Extension, Range of Motion of Wrist, Degrees</td>
<td>134</td>
<td>141</td>
<td>108</td>
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<td>42. Ulnar-Radial Range of Motion of Wrist, Degrees</td>
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<td>67</td>
<td>41</td>
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<tr>
<td>43. Weight, in Pounds</td>
<td>183.4</td>
<td>146.3</td>
<td>105.3</td>
</tr>
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</table>
Other Static Dimensions

- Chest Depth
- Head Length
- Interpupillary Distance
- Eye Height
- Hand Thickness
- Hand Length
- Foot Breadth
Dynamic Dimensions: Types of Movement

- Flexion - Bending
- Extension - Extending, straightening
- Adduction - Movement toward midline
- Abduction - Movement away from midline
- Lateral rotation - Rotation outward
- Medial rotation - Rotation inward
- Pronation - Rotation downward
- Supination - Rotation upward
Right Hand Grasping Reach Envelope (1)
Right Hand Grasping Reach Envelope (2)
## Shirt-Sleeved Grasping Reach: Horizontal Boundaries, 20-in. Level

<table>
<thead>
<tr>
<th>Angle (degree)</th>
<th>Min</th>
<th>Percentile (in.)</th>
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</thead>
<tbody>
<tr>
<td></td>
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<td>25.50</td>
</tr>
<tr>
<td>R15</td>
<td>27.25</td>
<td>28.00</td>
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<td>R30</td>
<td>29.00</td>
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<tr>
<td>R60</td>
<td>31.50</td>
<td>32.00</td>
</tr>
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</table>
Other Dynamic/Functional Dimensions

- Prone length, height
- Squatting height
- Overhead reach
- Thumb-tip reach
- Standing forward reach
- Standing lateral reach
Right Hand Static Force

Maximal (100%) Grip Distance
75% Grip Distance
50% Grip Distance
0 Grip Distance
-30 Grip Distance
-60 Grip Distance
-90 Grip Distance
Maximal Right-Handed Static Forces
Exerted on a Vertical Hand-Grip
By Standing Subjects (Feet parallel, 12 in. apart)

<table>
<thead>
<tr>
<th>Angle (degree)</th>
<th>Location of the handgrip</th>
<th>At percentage of maximal grip distance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>50%</td>
</tr>
<tr>
<td>Push, horizontal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>16</td>
</tr>
<tr>
<td>0</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>-30</td>
<td></td>
<td>28</td>
</tr>
<tr>
<td>-60</td>
<td></td>
<td>28</td>
</tr>
<tr>
<td>Pull, horizontal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>19</td>
</tr>
<tr>
<td>0</td>
<td></td>
<td>23</td>
</tr>
<tr>
<td>-30</td>
<td></td>
<td>28</td>
</tr>
<tr>
<td>-60</td>
<td></td>
<td>23</td>
</tr>
</tbody>
</table>

Force in lb
Other Muscle Power Data

- Prone position data
- Thumb / finger
- Leg, foot
- etc
Use of Anthropometric Data

- Determine relevant dimension / parameter
- Define user population
- Select range of users to be accommodated/excluded
- Extract data from appropriate source
- Apply correction factors (for clothing, personal equipment)
- Apply dimension to design
Designing for Clearance

Design for the Large Person

Design for the Large Person
Designing for Reach

Design for the Small Person
Design for Adjustability

- Adjust
  - Work place
  - Worker position
  - Workpiece
  - Tool (e.g., adjustable handles)
Other Design

Design for the Average Person
Design Principles

- Design for the large person (clearance)
- Design for the small person (reach)
- Design for the average person (other)
- Designing for adjustability
Workstation Design
Workstation Components (1)

- Enclosure (e.g., cab)
- Doors / doorways
- Windows
- Seats / supports
- Lighting fixtures
- Heating, ventilating, and air conditioning equipment
- Life support equipment
Workstation Components (2)

- Material handling equipment (in, within, out)
- Storage facilities
- Work surfaces
- Tools
- Materials
- Fixtures, work holding devices
- Displays
- Controls
Workstation Components (3)

- Computers and other electronics
- Reference materials
- Communication equipment
- Personal protective equipment
- Personal items
- etc.
Workstation Design Considerations

- Ergonomic considerations
- Sensory and perceptual considerations
- Working memory considerations
- Knowledge considerations
- Cognition considerations
- Motor considerations
- Workstation Considerations
- Workload considerations
- Safety and health considerations
Ergonomic Considerations: General

- Accommodation of large persons (e.g., 95th pctl males)
  - body
  - body parts
- Accessibility by small persons (e.g., 5th pctl females)
- Adjustability to suit range of persons (e.g., 5th pctl females through 95th pctl males)
Ergonomic Considerations: Work Surfaces

- Slanted work surfaces
- At/below elbow height (e.g., 2” below elbow)
- Adequate thigh clearance
Ergonomic Considerations: Seating (1)

- Provide lumbar support.
- Back at moderate angle (10° - 30° from vertical - backward-sloping).
- Seat pan should slope forward slightly.
- Seat pan/back angle 95° - 120°.
Ergonomic Considerations: Seating (2)

- Set seat height for small people.
- Set seat width for large people.
- Provide for weight concentration on ischial tuberosities.
- Provide for adjustability.
- When back support not used, minimize lumbar flexion (higher, forward-sloping seat).
Ergonomic Considerations: Movement

- Acceptable directions: consistent with
  - Body posture
  - Body position
  - Natural joint motion

- Acceptable forces

- Cumulative trauma disorder risk factors minimized
  - Frequency
  - Force
  - Joint angles
  - Temperature
Sensory and Perceptual Considerations

- Apply appropriate design/selection principles & guidelines (covered before):
  - text displays
  - dynamic visual displays
  - analog displays
    - quantitative
    - qualitative (check reading)
  - digital displays
  - status indicators
  - auditory displays
Working Memory Considerations

- Minimize capacity requirements
  - \( \leq 9 \) “chunks”
- Minimize duration requirements
  - \(< 20 \text{ sec}\)
- Provide memory aids as appropriate
Knowledge Considerations

- Consider both novice and expert
- Provide for adequate training
- Provide job performance aids
Cognition Considerations

- Consider issues of
  - selective attention
  - focused attention
  - divided attention (timesharing, multitasking)
  - sustained attention (vigilance)
  - decision biases
  - human error
Motor Considerations

• General
  – Require only reasonable accuracy and speed.
  – Consider speed/accuracy tradeoff.
  – Provide appropriate feedback.

• Apply appropriate control design/selection principles & guidelines.

• Apply appropriate hand tool design/selection principles & guidelines.
Workstation Considerations: General

- Design for
  - visibility outside workstation (if appropriate)
  - visibility inside workstation (displays, controls, etc.)
  - accessibility of primary controls
  - accessibility of secondary controls
  - body member support
  - body member clearance
  - clearance for clothing & personal equipment
  - restraint (if appropriate)
  - protection from injury
  - ease, speed, safety of entry & exit
  - consistency throughout
Workstation Considerations: Arrangement

• Arrangement rules (prioritized)
  - Accommodate primary visual tasks.
  - Place controls for primary visual tasks (see next slide).
  - Preserve control / display relationships, e.g.,
    • population stereotypes
    • up-increase
    • Warrick’s
  - Arrange by sequence of use.
  - Arrange by frequency of use.
  - Arrange to be consistent with other systems.
Control Placement

**FIGURE 10.7**
Control Grouping

- Component clusters, spacing between groups
- Borders around groups
- Groups in recessed areas
- Groups in raised areas
- Color or shading around group
- Groups on inclined areas
- Groups on separate modules
Workstation Considerations: Environment

- Provide adequate illumination.
- Provide appropriate thermal environment.
- Control vibration.
- Provide for acceleration.
Workload Considerations

• Design for reasonable physical workload:
  – reasonable energy expenditures
  – appropriate work-rest cycles
  – appropriate automation

• Design for reasonable mental workload:
  – reasonable mental demands
  – appropriate monitoring, decision making, & control automation
Safety and Health Considerations

- Control hazards:
  - chemical
  - biological
  - radiation
  - pressure
  - noise
  - mechanical
  - electrical
- Provide fire detection/suppression.
- Provide personal protection equipment, as appropriate.
Facilitating the Workstation Design Process

OSU/IME Human Factors Design and Evaluation Checklist

Human Factors Engineering Design and Evaluation Checklist

[ ] Design of: ________________________________

[ ] Evaluation of: ________________________________

Human Factors Engineer: ________________________________

Date: ________________________________

Revised April 9, 2007