**Lesson Plan**

**Course Title:** Flexible Manufacturing

**Session Title:** Precision Measurement

**Performance Objective:**
After completing this lesson, the students will be able to demonstrate they understand basic precision measurements and how to measure with a digital caliper by completing the Measurement Worksheet.

**Specific Objectives:**
- Identify the terminology of measurements.
- Demonstrate measurements skills.
- Demonstrate proficiency in calculating feed and speeds.

**Preparation**

**TEKS Correlations:**
This lesson, as published, correlates to the following TEKS. Any changes/alterations to the activities may result in the elimination of any or all of the TEKS listed.

**Flexible Manufacturing:**
- 130.327(c)(3)(C)  
  ...select algebraic and geometric principles and formulas required for precision measuring operations.
- 130.327(c)(4)(A)  
  ...analyze the resources found in The Machinery's Handbook and various American Welding Society specification and code reference books;
- 130.327(c)(8)(A)  
  ...use mathematics in precision measuring operations;
- 130.327(c)(9)(A)  
  ...analyze the types, sizes, and properties of sheet metal materials;
### Interdisciplinary Correlations:

#### Algebra I:

- **111.32(b)(1)(D)(E)**
  - …represent relationships among quantities using concrete models, tables, graphs, diagrams, verbal descriptions, equations, and inequalities; and
  - …interpret and make decisions, predictions, and critical judgments from functional relationships.

#### Algebra II:

- **111.33(b)(10)(D)(E)**
  - …determine the solutions of rational equations using graphs, tables, and algebraic methods;
  - …determine solutions of rational inequalities using graphs and tables;

### Occupational Correlation (reference: O*Net – [www.onetonline.org](http://www.onetonline.org)):

**Commercial and Industrial Designers** 27-1021.00

Similar Job Titles: Designer, Industrial Designer, Product Engineer, Design Engineer, Product Designer, Mechanical Designer, Product Development Engineer,

**Tasks:**
- Prepare sketches of ideas, detailed drawings, illustrations, artwork, or blueprints, using drafting instruments, paints and brushes, or computer-aided design equipment.
- Modify and refine designs, using working models, to conform to customer specifications, production limitations, or changes in design trends.
- Direct and coordinate the fabrication of models or samples and the drafting of working drawings and specification sheets from sketches.

**Soft Skills:**
- Active Listening; Critical thinking; Complex problem Solving; Judgment and Decision Making

### Teacher Preparation:

The teacher needs to review the Precision Measurement presentation. The teacher may want to have some different pieces of material for the students to measure and some precision measurement tools to show. The teacher should print the Measurement Worksheet, Measurement Chart, and Precision Measurement Worksheet for each student.

### References:

- American Welding Society
  - [http://www.aws.org/technical/errata/A2.4errata.pdf](http://www.aws.org/technical/errata/A2.4errata.pdf)
Instructional Aids:
1. Precision Measurement presentation
2. Precision Measurement Tools
3. Measurement Worksheet key
4. Measurement Chart
5. Precision Measurement Worksheet key

Materials Needed:
1. Measurement Worksheet for each student
2. Measurement Chart for each student
3. Precision Measurement Worksheet for each student
4. Pencil or pen
5. Paper

Equipment Needed:
1. Computer
2. Data Projector

Learner Preparation:
Understanding of basic measurement

Introduction (LSI Quadrant I):
SAY: The flexible manufacturing lab is equipped with metal or engine lathes and vertical milling machines.
SAY: These machines are capable of making parts to precision dimensions.
ASK: Have any of you had to measure less than a 1/16 of an inch? (Allow all students a chance to answer.)
ASK: When do you think you would need to use this type of measurement? (Allow all students a chance to answer.)
SAY: Let’s look at the presentation and then examine some of the measurement tools we have.
SHOW: Precision Measurement presentation and tools.

Outline

Outline (LSI Quadrant II):
Instructors can use the presentation, slides, handouts, and note pages in conjunction with the following outline.

<table>
<thead>
<tr>
<th>MI</th>
<th>Outline</th>
<th>Notes to Instructor</th>
</tr>
</thead>
</table>
|    | 1. Introduction to Precision Measurement  
    |     A. Explanation of measurements  
<pre><code>|     B. Comparison of customary and metric | Begin Precision Measurement presentation. |
</code></pre>
<table>
<thead>
<tr>
<th></th>
<th>measurement systems</th>
<th>Slides 1-4 explain the two measurement systems.</th>
</tr>
</thead>
<tbody>
<tr>
<td>II.</td>
<td>Customary System of Measurement</td>
<td>Slides 5-13 The teacher should review the customary measurement system divisions and examples of how to read a ruler.</td>
</tr>
<tr>
<td></td>
<td>A. Basic divisions of an inch</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B. Examples of measurement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C. Reading a ruler</td>
<td></td>
</tr>
<tr>
<td>III.</td>
<td>Precision Measurement Tools</td>
<td>Slides 14-23 The teacher should explain the need for precision measurements and measuring tools used in the lab. The teacher should distribute and explain the Measurement Chart handout on fractions/decimals/metric equivalents</td>
</tr>
<tr>
<td></td>
<td>A. Explanation of precision measurement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B. Digital caliper information</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C. Measurement chart</td>
<td></td>
</tr>
<tr>
<td>IV.</td>
<td>Feed and Speeds of Machining</td>
<td>Slides 24-31 The teacher should describe the reason to figure the feed and speed for each project. The teacher should help students with basic math calculation.</td>
</tr>
<tr>
<td></td>
<td>A. Explanation of feed and speeds</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B. How to figure</td>
<td></td>
</tr>
<tr>
<td>V.</td>
<td>Handouts</td>
<td>The students will complete the two handouts and turn in to be graded.</td>
</tr>
<tr>
<td></td>
<td>A. Measurement Worksheet</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B. Precision Measurement Worksheet</td>
<td></td>
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</tbody>
</table>
Guided Practice (LSI Quadrant III):
The teacher guides the students through the Precision Measurement presentation and class discussion about reading a ruler.

Independent Practice (LSI Quadrant III):
The students will practice measuring with a digital caliper.

Summary

Review (LSI Quadrants I and IV):

Question: Why is it important to know how to calculate different measurements?
Answer: While machining a part you will have to figure the different depths of cuts and speeds of cutting.

Question: Is it important to be able to read precision measurements tools? If so, why?
Answer: It is important because some parts need to be machined to a precise size.

Evaluation

Informal Assessment (LSI Quadrant III):
The student will measure different items in the lab to practice using the digital caliper.

Formal Assessment (LSI Quadrant III, IV):
The students will complete the Precision Measurement Worksheet and Measurement Worksheet for a grade.

Extension

Extension/Enrichment (LSI Quadrant IV):
The students could research other measurements and cutting speeds.
Measurement Worksheet

1. ________ 2. ________ 3. ________ 4. ________ 5. ________
6. ________ 7. ________ 8. ________ 9. ________ 10. ________
11. ________ 12. ________ 13. ________ 14. ________
15. ________ 16. ________ 17. ________ 18. ________ 19. ________
Measurement Worksheet Key

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7/16</td>
<td>2</td>
<td>13/16</td>
<td>3</td>
</tr>
<tr>
<td>6</td>
<td>2 and 1/4</td>
<td>7</td>
<td>2 and 1/2</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>1 and 9/16</td>
<td>5</td>
<td>1 and 15/16</td>
<td>9</td>
</tr>
<tr>
<td>10</td>
<td>3 and 13/16</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

11. Inside Jaws
12. Lock Knob
13. LCD Display
14. Beam Graduations
15. Depth Gauge
16. Outside Jaws
17. Mode Button
18. On / Off Button
19. Zero Adjusting Button
Measurement Chart

Fractions / Decimals / Metric Equivalents

<table>
<thead>
<tr>
<th>Fraction</th>
<th>Decimal</th>
<th>Metric</th>
<th>Fraction</th>
<th>Decimal</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/16</td>
<td>0.0625</td>
<td>1.587</td>
<td>9/16</td>
<td>0.5625</td>
<td>14.287</td>
</tr>
<tr>
<td>1/8</td>
<td>0.125</td>
<td>3.175</td>
<td>5/8</td>
<td>0.625</td>
<td>15.875</td>
</tr>
<tr>
<td>3/16</td>
<td>0.1875</td>
<td>4.762</td>
<td>11/16</td>
<td>0.6875</td>
<td>17.462</td>
</tr>
<tr>
<td>1/4</td>
<td>0.250</td>
<td>6.350</td>
<td>3/4</td>
<td>0.750</td>
<td>19.050</td>
</tr>
<tr>
<td>5/16</td>
<td>0.3125</td>
<td>7.937</td>
<td>13/16</td>
<td>0.8125</td>
<td>20.637</td>
</tr>
<tr>
<td>3/8</td>
<td>0.375</td>
<td>9.525</td>
<td>7/8</td>
<td>0.875</td>
<td>22.225</td>
</tr>
<tr>
<td>7/16</td>
<td>0.4375</td>
<td>11.113</td>
<td>15/16</td>
<td>0.9375</td>
<td>23.812</td>
</tr>
<tr>
<td>1/2</td>
<td>0.500</td>
<td>12.700</td>
<td>1</td>
<td>1.0000</td>
<td>25.400</td>
</tr>
</tbody>
</table>

Sheet Metal Gauge Size Chart

Standard Steel Gauge

<table>
<thead>
<tr>
<th>Gauge</th>
<th>Inch</th>
<th>Metric</th>
<th>Gauge</th>
<th>Inch</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>0.2391</td>
<td>6.073</td>
<td>18</td>
<td>0.0478</td>
<td>1.204</td>
</tr>
<tr>
<td>6</td>
<td>0.1943</td>
<td>4.935</td>
<td>20</td>
<td>0.0359</td>
<td>0.912</td>
</tr>
<tr>
<td>8</td>
<td>0.1644</td>
<td>4.176</td>
<td>22</td>
<td>0.0299</td>
<td>0.759</td>
</tr>
<tr>
<td>10</td>
<td>0.1345</td>
<td>3.416</td>
<td>24</td>
<td>0.0239</td>
<td>0.607</td>
</tr>
<tr>
<td>12</td>
<td>0.1046</td>
<td>2.657</td>
<td>26</td>
<td>0.0179</td>
<td>0.455</td>
</tr>
<tr>
<td>14</td>
<td>0.0747</td>
<td>1.897</td>
<td>28</td>
<td>0.0149</td>
<td>0.378</td>
</tr>
<tr>
<td>16</td>
<td>0.0598</td>
<td>1.519</td>
<td>30</td>
<td>0.0120</td>
<td>0.305</td>
</tr>
</tbody>
</table>

Cutting Speed Chart

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Feet per Minute</th>
<th>Meter per Minute</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild Steel</td>
<td>100-125</td>
<td>30-38</td>
</tr>
<tr>
<td>Cast Iron (medium)</td>
<td>60-80</td>
<td>18-24</td>
</tr>
<tr>
<td>Alloy Steels</td>
<td>65-120</td>
<td>20-37</td>
</tr>
<tr>
<td>Carbon Steel</td>
<td>70-130</td>
<td>21-40</td>
</tr>
<tr>
<td>Stainless Steels</td>
<td>75-130</td>
<td>23-40</td>
</tr>
<tr>
<td>Bronzes</td>
<td>80-150</td>
<td>80-150</td>
</tr>
<tr>
<td>Aluminum</td>
<td>250-350</td>
<td>75-210</td>
</tr>
<tr>
<td>Brass</td>
<td>300-700</td>
<td>90-210</td>
</tr>
</tbody>
</table>
Precision Measurement Worksheet

Convert the following fractions to equivalent decimals

1. \( \frac{1}{2} \) = _____________
2. \( \frac{3}{4} \) = _____________
3. \( \frac{1}{8} \) = _____________
4. \( \frac{1}{4} \) = _____________
5. \( \frac{7}{8} \) = _____________
6. \( \frac{1}{16} \) = _____________
7. \( \frac{3}{8} \) = _____________
8. \( \frac{9}{16} \) = _____________
9. \( \frac{15}{16} \) = _____________
10. \( \frac{3}{16} \) = _____________

Add the following measurements

11. 0.250 + 0.500 = ______________
12. 0.125 + 0.250 = ______________
13. 0.500 + 0.250 = ______________
14. 0.75 + 0.125 = ______________
15. 0.500 + 0.375 = ______________
16. 0.0625 + 0.125 = ______________
17. 0.3125 + 0.0625 = ______________
18. 0.4375 + 0.500 = ______________
19. 0.625 + 0.0625 = ______________
20. 0.500 + 0.750 = ______________

Calculate the revolutions per minute for the following parts. (Use the chart for the cutting speeds for the material.)

21. The material is brass with a diameter of 2.25 inches.

22. The material is aluminum with a diameter of 3.5 inches.

23. The material is mild steel with a diameter of 3.5 inches.

24. The material is mild steel with a diameter of \( \frac{3}{4} \) of an inch.

25. The material is carbon steel with a diameter of \( \frac{3}{8} \) of an inch.
Precision Measurement Worksheet Key

Convert the following fractions to equivalent decimals

1. \( \frac{1}{2} = 0.500 \)
2. \( \frac{3}{4} = 0.750 \)
3. \( \frac{1}{8} = 0.125 \)
4. \( \frac{1}{4} = 0.250 \)
5. \( \frac{7}{8} = 0.875 \)
6. \( \frac{1}{16} = 0.0625 \)
7. \( \frac{3}{8} = 0.375 \)
8. \( \frac{9}{16} = 0.5625 \)
9. \( \frac{15}{16} = 0.9375 \)
10. \( \frac{3}{16} = 0.1875 \)

Add the following measurements

11. \( 0.250 + 0.500 = 0.750 \)
12. \( 0.125 + 0.250 = 0.375 \)
13. \( 0.500 + 0.250 = 0.750 \)
14. \( 0.750 + 0.125 = 0.875 \)
15. \( 0.500 + 0.375 = 0.875 \)
16. \( 0.0625 + 0.125 = 0.1875 \)
17. \( 0.3125 + 0.0625 = 0.3750 \)
18. \( 0.4375 + 0.500 = 0.9375 \)
19. \( 0.625 + 0.625 = 1.250 \)
20. \( 0.250 + 0.750 = 1.000 \)

Calculate the revolutions per minute for the following parts. (Use the chart for the cutting speeds for the material.)

21. The material is brass with a diameter of 2.25 inches.
   \[ \text{RPM} = \frac{300 \times 4}{2.25} \text{ RPM} = 533 \]

22. The material is aluminum with a diameter of 3.5 inches
   \[ \text{RPM} = \frac{250 \times 4}{3.5} \text{ RPM} = 285 \]

23. The material is mild steel with a diameter of 3.5 inches.
   \[ \text{RPM} = \frac{100 \times 4}{3.5} \text{ RPM} = 114 \]

24. The material is mild steel with a diameter of \( \frac{3}{4} \) of an inch.
   \[ \text{RPM} = \frac{100 \times 4}{0.75} \text{ RPM} = 533 \]

25. The material is carbon steel with a diameter of \( \frac{3}{8} \) of an inch.
   \[ \text{RPM} = \frac{70 \times 4}{0.375} \text{ RPM} = 746 \]