A. **TITLE:** Metallurgy and Testing

B. **COURSE NUMBER:** WELD 112

C. **CREDIT HOURS** (Hours of Lecture, Laboratory, Recitation, Tutorial, Activity):

   - # Credit Hours: 3
   - # Lecture Hours per Week: 0
   - # Lab Hours per Week: 4 hours per week
   - Other per Week: 0

   Course Length (# of Weeks): 15

D. **WRITING INTENSIVE COURSE:** No

E. **GER CATEGORY:** N/A

F. **SEMESTER(S) OFFERED:** Spring

G. **COURSE DESCRIPTION:**

   In this course, students learn the basic metallurgy knowledge needed for welding including heat treating. Metal and weld testing processes are also covered.

H. **PRE-REQUISITES/CO-REQUISITES:**

   a. Pre-requisite(s): None
   
   b. Co-requisite(s): None
   
   c. Pre- or co-requisite(s): None
## I. STUDENT LEARNING OUTCOMES:

<table>
<thead>
<tr>
<th>Course Student Learning Outcome [SLO]</th>
<th>PSLO</th>
<th>GER</th>
<th>ISLO</th>
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<tbody>
<tr>
<td>a. Demonstrate a practical understanding of welding based on atomic bonding, diffusion, and phase diagrams.</td>
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<td>2CA</td>
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<td>b. Describe the basic principles of phase change and solidification of metals as well as strengthening mechanisms in metals.</td>
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<td>2CA</td>
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<td>c. Describe how weld variables such as pool shape, travel speed, and cooling rate affect weld microstructure and subsequent properties.</td>
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<td>2CA</td>
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### KEY

<table>
<thead>
<tr>
<th>ISLO #</th>
<th>Institutional Student Learning Outcomes [ISLO 1 – 5]</th>
<th>ISLO &amp; Subsets</th>
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<tbody>
<tr>
<td>1</td>
<td>Communication Skills</td>
<td></td>
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<tr>
<td></td>
<td>Oral [O], Written [W]</td>
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<td>2</td>
<td>Critical Thinking</td>
<td></td>
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<td></td>
<td>Critical Analysis [CA], Inquiry &amp; Analysis [IA], Problem Solving [PS]</td>
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<td>3</td>
<td>Foundational Skills</td>
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</tbody>
</table>
| 4 | Social Responsibility  
Ethical Reasoning [ER], Global Learning [GL],  
Intercultural Knowledge [IK], Teamwork [T] |
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<td>5</td>
<td>Industry, Professional, Discipline Specific Knowledge and Skills</td>
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J. **APPLIED LEARNING COMPONENT:**  
Yes______  No___X____

If Yes, select one or more of the following categories:

- Classroom/Lab____
- Internship____
- Clinical Practicum____
- Practicum____
- Service Learning____
- Community Service____
- Civic Engagement____
- Creative Works/Senior Project____
- Research____
- Entrepreneurship____

(program, class, project)
K. **TEXTS:** N/A


M. **EQUIPMENT:** N/A

N. **GRADING METHOD:** A-F

O. **SUGGESTED MEASUREMENT CRITERIA/METHODS:**
   - Homework
   - Quizzes
   - Tests

P. **DETAILED COURSE OUTLINE:**

Content is divided into 14 weeks. Introduction to GMAW/FCAW, & Welding Safety

1. Basic Principles
   - Types of Atomic Bonds
   - Metallic Bonding
   - Elastic Modulus

2. Crystal Structure and Defects
   - Defects in Metals
   - Solid Solutions
   - Line and Planar Defects

3. Phase Diagrams
   - Types of Phase Diagrams
   - Microstructural Evolution

4. Diffusion
   - Diffusion in Metals
   - Interdiffusion of 2 Metals
   - Diffusion in Weld Zones

5. Strengthening Mechanisms
   - Solid Solution Strengthening
   - Strain Hardening
   - Precipitation Hardening
6. Basics of Welding Metallurgy
   a. Microstructure & Properties
   b. Metallurgical Processes
   c. The Fusion Zone

7. Dilution
   a. Calculation of Dilution
   b. Dilution in Aluminum Alloys

8. The Fusion Zone
   a. Surface Tension/Fluid Flow
   b. Types of Nucleation
   c. Heterogeneous Nucleation
   d. Epitaxial Nucleation at Fusion boundary

9. Welding Parameters
   a. Effect of Travel Speed
   b. Effect of GL, R, and Composition
   c. Effect of Cooling Rate
   d. Weld Metal Epitaxial Nucleation

10. Fusion Zone & Boundaries
    a. Solidification Grain and Subgrain Boundaries
    b. Migrate Grain Boundary
    c. Partially Melted Zone (PMZ)

11. Microstructure/Mechanical Properties
    a. Microstructure of 6061-T6 Aluminum Alloy
    b. Unmixed Zone (UMZ)
    c. Partially Melted Zone (PMZ)

12. Boundaries in Weld Zone
    a. Grain Boundary Liquation in the PMZ
    b. The “True” Heat Affected Zone (HAZ)
    c. Effect of Recrystallization on Mechanical Properties

13. Residual Stresses
    a. Factors Influencing Residual Stresses
    b. Fundamental Types of Distortion
    c. Microhardness Testing

14. Mechanical Testing of Welds
    a. Tensile Testing Welds
    b. Stress-Strain Curves
    c. Bend Tests
    d. Fractography

Q. LABORATORY OUTLINE: N/A