

# GUJARAT TECHNOLOGICAL UNIVERSITY

## MECHANICAL ENGINEERING (19) ADVANCE WELDING TECHNOLOGY SUBJECT CODE: 2181927 B.E. 8<sup>TH</sup> SEMESTER

**Type of course:** Undergraduate

**Prerequisite:** Zeal to learn the Subject

**Rationale:** NA

**Teaching and Examination Scheme:**

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P		Theory Marks			Practical Marks			
			ESE (E)	PA (M)		PA (V)		PA (I)		
PA	ALA	ESE		OEP						
3	0	2	5	70	20	10	20	10	20	150

**Content:**

Sr. No.	Topic	Teaching Hours	% weightage
1.	<b>Introduction to welding and joining processes:</b> Introduction to consolidation processes, Classification of welding processes, some common concerns, types of fusion welds and types of joints, Design considerations, Heat effects, Weld ability and joint ability. Welding terms and definitions, welding positions, elements of and construction of welding symbols.	03	07
2.	<b>Welding Metallurgy:</b> a. <b>Fundamentals of physical metallurgy:</b> Need, phase diagrams: Fe-C, Al-Cu, Cu-Zn system, phase transformations in Fe-C system, TTT diagram, CCT diagram, carbon equivalent, Schaffer diagram, relevance of above in welding. b. <b>Solidification of weld metal:</b> Principle of solidification of weld metal, modes of solidification, effect of welding parameters on weld structure, grain refinement principle of weld metal, method of weld metal refinement, inoculation, arc pulsation, external excitation. c. <b>Heat affected zone and weld metal:</b> Transformations in HAZ of steel, factors affecting changes in microstructure and mechanical properties of HAZ, reactions in weld pool- gas metal reaction, slag metal reaction. d. <b>Metallurgical issue in weld joint:</b> Mechanisms, causes and remedy of cold cracking, solidification cracking, nonmetallic inclusions, lamellar tearing, hydrogen damage, banding, segregation.	08	19
3.	<b>Weld joint preparation and temperature control:</b> Checks prior to weld joint preparation, joint preparation checks, preheating and interpass heating, post weld heating, heating processes, post heat treatments, insulation of heated joints.	02	05

4.	Gas flame and Arc processes: Welding power sources (features) Oxy-fuel gas welding- processes, uses, advantages, and limitations <b>Consumable electrode Arc welding:</b> Shielded Metal Arc Welding, Flux cored Arc Welding, Gas Metal Arc Welding, Stud welding <b>Non-consumable electrode welding processes:</b> Gas tungsten arc welding, gas tungsten arc spot welding, plasma arc welding	07	17
5.	<b>Resistance and solid state welding processes:</b> <b>Theory of resistance welding:</b> Heating, pressure, current and current control, power supply. <b>Resistance welding processes:</b> Resistance spot welding, resistance seam welding, Projection welding. Advantages and limitations of resistance welding. <b>Solid state welding:</b> Forge welding, Forge-seam welding, cold welding, roll welding or roll bonding, Friction welding and Inertia welding, Friction-stir welding, Ultrasonic welding, Diffusion welding, Explosive welding.	06	14
6.	Other welding processes, brazing and soldering: Thermit welding, Electro-slag welding, Electron beam welding, Laser beam welding, Flash welding.	06	14
7.	<b>Weldment Inspection and Testing</b> a. <b>Codes governing welding inspection:</b> Structural welding code; ASME boiler and pressure vessel code, spot examination of welded joints, duties of the inspector, ASTM standards, API standards b. <b>Chemical, Metallurgical, and Mechanical testing of weldments:</b> Comparison of destructive and non-destructive tests, chemical tests, forms of corrosion, testing for corrosion resistance, metallographic tests. c. <b>Visual and liquid penetrant inspection:</b> Selection of NDT method, relationship of welding processes, discontinuities and inspection methods, visual inspection prior to, during and after welding, Liquid penetrant test. d. <b>Magnetic particle and Radiographic inspection:</b> Magnetic particle inspection, types of magnetizing currents, demagnetization, interpretation of patterns, non-relevant indications, radiographic sources, detectable discontinuities. e. <b>Ultrasonic inspection:</b> Criteria for successful implementation, test equipment and techniques, advantages, limitations. f. <b>Eddy current inspection, acoustic emissions, proof tests and leak tests:</b> Eddy current inspection, fundamentals, inspecting welded tubing and piping, applications, acoustic emissions, types of emissions, inspection of pressure vessels.	10	24

**Suggested Specification table with Marks (Theory):**

Distribution of Theory Marks				
Remembrance R Level	Understanding U Level	Application A Level	Analyse N Level	Evaluate E Level

**Legends: R: Remembrance; U: Understanding; A: Application and above Levels (Revised Bloom's Taxonomy)**

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

### **Reference Books:**

1. DeGarmo's Materials and processes in Manufacturing
2. Lancaster J F, "Metallurgy of welding", Allen and Unwin Co.
3. K Esterling, "Introduction to Physical Metallurgy",
4. "Welding Handbook", Volumes 1, 2 and 3, 9<sup>th</sup> edition, American Welding Society
5. Larry J and Jeffus L, "Welding Principles and Applications", 5<sup>th</sup> edition, Delmer Publications
6. Parmer R. S., 'Welding Engineering and Technology', Khanna Publishers, 1997
7. Hull., 'Non-Destructive Testing', ELBS Edition, 1991
8. AWS D1.1 Structural Welding Code
9. API 5L
10. API 1104
11. ASME Section VIII – Division 1,2
12. ASME Section IX
13. ASME Section II Part A and C

### **Course Outcome:**

After learning the course the students should be able to:

1. Students will understand the theoretical aspects of welding technology in depth.
2. Students will be able to intelligently select the appropriate welding process for a particular application.
3. Students will be able to describe the basic metallurgy of the melted and heat-affected zone of a metal or alloy.
4. Students will be able to identify the cause of welding defects and avoid them.
5. Students will be able to choose or adjust welding parameters and techniques to optimize the weldment properties.
6. Students will demonstrate their ability to check the weldment quality using various inspection and testing methods.
7. Completion of the course successfully will lead to an international or at least a national level certification endorsing the proficiency of the student in the subject area.

### **List of Experiments:**

1. Arc striking practice.
2. Edge preparation practice
3. Bead-on-plate welding
4. Effect of welding parameters on weld bead by
  - GTA welding
  - GMA welding
  - Manual metal arc welding
5. Microstructure observation of weldments
  - Carbon steel
  - Stainless steel
  - Aluminum alloy
  - Dissimilar joints

6. Practice for preparation of welding procedure specification.
7. Practice for preparation of procedure qualification record.
  
8. Practice for Welding application Plan.

**ACTIVE LEARNING ASSIGNMENTS:** Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.