GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering
Level: Diploma
Branch: Metallurgy Engineering
Course / Subject Code : DI03021021
Course / Subject Name : Joining of Metals

w. e. f. Academic Year:	2024-25
Semester:	3rd
Category of the Course:	PCC

Prerequisite:	To effectively study the subject Joining of Metals, students are expected to have a fundamental understanding of basic physical metallurgy, including phase diagrams, crystal structures, and the basic properties of metals and alloys. A solid grasp of mechanical properties such as tensile strength, hardness, ductility, and impact resistance is essential for understanding material behavior during welding. Familiarity with engineering drawing, particularly the interpretation of different workshop layouts, is also important. Additionally, prior exposure to basic workshop practices such as the use of common tools, adherence to safety procedures, and proper material handling will enable students to engage more confidently with the practical aspects of the subject.
Rationale:	Diploma Metallurgy Engineers are expected not only to supervise joining operations in manufacturing workshops but also to take the initiative in selecting appropriate processes and materials based on the specific requirements of different metals and alloys. As metal joining is a vital manufacturing route for various fabrication operations, this subject emphasizes the knowledge and understanding of different joining processes and equipment, their underlying principles, and their respective advantages and limitations. It also covers the basic concepts of weldability and highlights welding hazards related to the environment, human health, and safety. Therefore, it is a key course, and mastery of it is essential for students of metallurgy.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
01	Remember basic welding terminologies and understand the significance of metal joining processes.	R, U
02	Understand principles of soldering, brazing, and fusion welding (Gas and Arc), and apply them to select suitable joining techniques.	R, U, A
03	Illustrate principles of resistance welding, advanced welding techniques and apply them to select suitable joining techniques.	R, U, A
04	Identify welding defects & its preventive methods and importance of weldability, safety, WPS, PQR, WPQ, and standards.	U, A

**Revised Bloom's Taxonomy (RBT)*

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Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA(M)	PA(I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	1.1 Importance and Classification of Metal Joining Processes 1.2 Introduction to Welding and Classification of Welding Processes, Importance of Welding Over other Manufacturing Processes 1.3 Types of Joints, Types of Welds, Edge Preparation and Welding Position 1.4 Basic Terminology in Welding; Weld Bead Dimensions, Different Zones of Weldments, Filler Metal, Heat Input, Interpass Temperature, Preheating, Post Heating.	05	10
2.	2.1 Basic Principle of Soldering, Operational Steps in Soldering Process, Advantages – Disadvantages and Applications. 2.2 Basic Principle of Brazing, Operational Steps in Brazing, Types of different Brazing Methods, Principles of Braze Weld, Advantages – Disadvantages and Applications. 2.3 Soldering and Brazing Alloys 2.4 Comparison of Soldering and Brazing, Comparison of Soldering and Brazing with Welding	07	20
3.	3.1 Concept of Fusion Welding Processes 3.2 Gas Welding; Principle Operation, Types of Gas Welding Flames, Gas Welding Techniques, Gas Welding Equipment, Advantages and Disadvantages 3.3 Basic Concept of Arc: Arc Initiation, Electrode Polarity and its Effect, Physics of Arc and Power Source Characteristics 3.4 Arc Welding: Shielded Metal Arc Welding, Gas Tungsten arc Welding, Gas Metal Arc Welding, Sub Merged Arc Welding, Plasma Arc Welding (Principle, Operation, Equipment, Advantages and Disadvantages, Application only)	15	30

4.	4.1 Principle of Resistance, Types of Resistance Welding (Principle, Operation, Equipment, Advantages and Disadvantages, Application only) 4.2 Electron Beam Welding (EBW) and Laser Beam Welding (LBW) Process (Principle, Operation, Advantages and Disadvantages, Application only) 4.3 Concept of Solid State Welding Processes: Friction, Explosion, Ultrasonic, Forge, Diffusion (Principle, Operation, Advantages and Disadvantages, Application only) 4.4 Advance Welding Processes: Hot Wire TIG, FCAW/MCAW, FSW, Under Water Welding 4.5 Thermit Welding	12	25
5	5.1 Welding Defects: Causes and Prevention 5.2 Importance of WPS, PQR, WPQ, Codes, Standards and Specification 5.3 Importance of Human health and Safety aspects in welding 5.4 Concept of Weldability	06	15
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
25	**33**	**42**	**-**	**-**	**-**

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1	Welding Process & Technology	R. S. Parmar	Khanna Publishers, New Delhi, 2003 ISBN: 9788174091260, 8174091262
2	Welding Engineering & Technology	R. S. Parmar	Khanna Publishers, New Delhi, 2004 ISBN: 9788174090287, 8174090282
3	Welding Technology	O. P. Khanna	Dhanpat Rai Publications Ltd., New Delhi, 2010 ISBN: 9383182555, 978-9383182558
4	Metallurgy of Welding, Soldering and Brazing	J. F. Lancaster	George Allen and Unwin, London, 1970 ISBN: 0046690042, 978-0046690045
5	Modern Arc Welding Techniques	S. V. Nadkarni	Ador Welding Ltd., 2008 ISBN: 8120416767, 978-8120416765

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
6	ASM Handbook: Welding, Brazing and Soldering Volume 6	D. L. Olson, T. A. Siewert, S. Liu, G. R. Edwards	ASM International, 1993 ISBN: 978-0-87170-382-8
7	New Developments in Advanced Welding	Nasir Ahmed	Woodhead Publishing Limited, England, 2007 ISBN: 9781845690892
8	Advanced Welding Processes – Technologies and Process Control	John Norrish	Woodhead Publishing Limited, England, 2006 ISBN: 978-1-84569-130-1, 978-1-84569-170-7
9	Advances in Welding Technologies for Process Development	J. Vora, V. J. Badheka	CRC Press, 2019 ISBN: 9780367656515

(b) Open source software and website:

1. http://www.iws.org.in/
2. http://www.asme.org
3. http://www.aws.org
4. http://www.ewf.be
5. http://www.astm.org
6. https://www.youtube.com/watch?v=-SA4D098u-Q
7. https://www.youtube.com/watch?v=XJ1Loh7eF-A
8. https://www.youtube.com/watch?v=elmDvqdeMKI
9. https://www.youtube.com/watch?v=urjzoypLphk
10. https://www.youtube.com/watch?v=uO5pVLOAmD4
11. https://www.youtube.com/watch?v=twUAa5LWUvk
12. https://www.youtube.com/watch?v=TPSQJXqSwTg
13. https://www.youtube.com/watch?v=slAwIfM2kJY
14. https://www.youtube.com/watch?v=pZ4-na5JxNw
15. https://www.youtube.com/watch?v=svd64WNW8So
16. https://www.youtube.com/watch?v=n5bssD7GTlc

Suggested Course Practical List:

Sr. No.	TUTORIAL Outcomes	Unit No.	Approx. Hrs. Required
1	Identify the various joint, weld, edge preparation and position of welding.	I	02
2	Perform Soldering and Brazing process for a given material.	II	02

Sr. No.	TUTORIAL Outcomes	Unit No.	Approx. Hrs. Required
3	Identify the various parts of Gas Welding Set-up and demonstrate & perform Gas Welding Process. (Minimum 2 different Materials)	III	04
4	Identify the various parts of Manual Metal Arc Welding Set-up and demonstrate & perform Manual Metal Welding Process. (Minimum 2 different Materials)	III	04
5	Identify the various parts of Gas Tungsten Arc Welding Set-up and demonstrate & perform Gas Tungsten Arc Welding Process. (Minimum 2 different materials)	III	04
6	Identify the various parts of Gas Metal Arc Welding Set-up and demonstrate & perform Gas Metal Arc Welding Process. (Minimum 2 different materials)	III	04
7	Identify the various parts of Spot Resistance welding Set-up and demonstrate & perform Spot Resistance Welding Process. (Minimum 2 different Materials)	IV	04
8	Identify the various parts of Submerged Arc Welding Process, Electron Beam Welding and Laser Beam Welding machine.	IV	02
9	Identify the welding defects and its causes and remedies.	VI	02
10	Identify the safety gadgets used in welding.	VI	02
	Total		30

List of Laboratory/Learning Resources Required:

- Soldering Station
- Gas Welding Setup
- Arc Welding Setup for SMAW, GMAW and GTAW
- Resistance Spot welding set-up
- Standard Welded Specimens
- Industrial Safety Gadgets

Suggested Project List:

- Preparation of a Standard Steel Cube.
- Preparation of Phone stand from scrap metal
- Make a Simple Industrial Pencil Holder
- Make a Welding Table Torch Holder
- Creating a welding electrodes storage container
- Preparations of Different weld joints.
- Preparation of Models showing welding positions
- SMD component soldering

Suggested Activities for Students:

Other than the classroom and laboratory learning, following are the suggested student-related co-curricular activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group

- Make a model/chart for individual Joining processes.
- Make a chart for hand tools, safety gadgets used in welding and prepare a safety slogan for welding.
- Prepare safety plan to be used in the event of an accident.
- Develop a checklist for precaution prior to use of welding or cutting equipment.
- Perform/compare microstructure of welds prepared using different welding processes for a particular metals and alloys.
- Industrial Visit of fabrication industries / Manufacturing Industries.
- Group discussion on environmental issues and control in the fabrication industries.

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