

Bloom's Taxonomy Levels: 1. Remember 2. Understand 3. Application 4. Analysis 5. Evaluation 6. Creation

Programme Name: ME(Metallurgical & Materials)(Welding Technology) Regular Programme

Programme Specific Outcome (PSO) Students will be able to

PSO 1 Understand and acquire fundamental knowledge of welding processes for various Materials.

PSO 2 Apply knowledge of various materials to prescribe suitable welding technique for specific applications in welding industry.

PSO 3 Able to model and simulate welding processes in various industries to conduct experiments and analyze the performance using modern tools through dissertation projects.

PSO 4 Expertise to find out the root cause of real world failures in industry and to determine the remaining life of the system.

PSO 5 Endowed technical competency, entrepreneurship, ethics, interdisciplinary working skill and contribute society philanthropically.

Syllabus of Courses

	The Maharaja Sayajirao University of Baroda Faculty Technology and Engineering Department of Metallurgical & Materials Engineering					Academic Year				2020-21		
ME (Metallurgical & Materials)(Welding Technology) Regular Programme												
Year	I	Core / Elective / Foundation Code: MME2124 Subject: Advance Welding And Health & Safety				Credits / Hours per week				4		
Semester	I	Year of Introduction: 2006 Year of Syllabus Revision: 2016				Maximum Marks / Grade				100		
Mode of Transaction		Lectures										
Course Outcome (CO) CO1-Understand about different advanced welding processes CO2-Learning of new safety equipments required CO3-Study of health & safety concerns CO4- Understanding modeling in welding processes												
Unit No.	Topic/Unit			Contact Hours	Weightage (%)	BT Level	CO	PSO	Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional(R)/Global (G)	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV)and	

								developmental needs	Professional Ethics (PE)
1	SOLID PHASE WELDING: Fundamental principles of pressure welding, problems and solutions. Induction pressure, friction, ultrasonic and explosion welding - principles of operation and applications. Special consideration of friction stir welding and diffusion bonding - principles, process characteristics and applications. Solid phase welding of dissimilar materials.	7	14.3	1,2	1	1,2	Emp	G	ES,HV
2	ELECTRON BEAM WELDING: Heat generation and regulation, equipment details, EBW in different degrees of vacuum, special application possibilities, advantages and disadvantages.	8	16.3	1,2,3	1	2,3			
3	LASER BEAM WELDING: Physics of lasers, types of lasers, operation of laser, welding setup, recent developments in CO ₂ ; Nd-YAG and diode lasers. Application of laser welding to steels, Al and Mg alloys, dissimilar materials. Hybrid welding systems using the laser beam, e.g. laser-MIG.	6	12.2	2,3	1	3,4			
4	LASER HYBRID WELDING PROCESSES, NARROW GAP Welding, ADVANCES IN GTAW/GMAW/SAW PROCESSES (Including Robots)	6	12.2	3,4,5	1	3			
5	SELECTION OF WELDING EQUIPMENTS & CONSUMABLES, REPAIR WELDING PROCESSING	6	12.2	5,6	1,2	1,2,5			
6	MODELLING IN WELDING	6	12.2	4,5,6	4	3,5			
7	HEALTH & SAFETY IN WELDING (PART-I): Selection and installation of equipment, safe handling of equipment, fire prevention, eye and face Protection, respiratory protection, ventilation, protective extra clothing, electric shock, safety analysis;	4	8.2	5,6	2,3	4,5			
8	HEALTH & SAFETY IN WELDING (PART-II): planning for welding operations, production control, planning for welding processes, pre-production control., planning for welding processes, pre-production	6	12.2	1,2	2,3	2,3,5			

	planning routing, scheduling; activating, monitoring, materials management in welding, inventory control; basic aspects of financial management and man power planning.								
	TOTAL	49 Hours	100%						
Reference Books									
1	Bathy J., 'Industrial Administration and Management', 1984								
2	PendarJ. A., 'Welding Projects – ADesign Approach', 1977								
3	Welding Institute U.K., 'Standard Data for Arc Welding', 1994								

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ME (Metallurgical & Materials)(Welding Technology) Regular Programme											
Year	I	Core / Elective / Foundation Code: MME2122 Subject: Experimental & Quantitative Techniques				Credits / Hours per week				4	
Semester	I	Year of Introduction: 2006 Year of Syllabus Revision:				Maximum Marks / Grade				100	
Mode of Transaction		Lectures and Tutorials									
Course Outcome (CO) CO1-To enable students about learning new qualitative technologies CO2-Study about new metallographic microscopes CO3-Study on X ray diffraction & electron microscopy CO4- Study on different tests											
Unit No.	Topic/Unit			Contact Hours	Weightage (%)	BT Level	CO	PSO	Elements of Employability (Emp)/ Entrepreneurship (Ent)/	Relevance to Local (L)/ National (N)/ Regional(R)/Global	Relation to Gender (G), Environment and Sustainability (ES),

							Skill Development (SD)	(G) developmental needs	Human Values (HV)and Professional Ethics (PE)
1	METALLOGRAPHIC TECHNIQUES (Part 1): Numerical aperture, limit of resolution, depth of field and depth of focus - lens defects and correction- bright field and dark field illumination –	5	10	1,2	1,2	1,2,4	Emp& SD	G	HV,PE
2	METALLOGRAPHIC TECHNIQUES (Part 2): polarised light, phase contrast, interference contrast and fringe mode, opaque stop, hot stage, in-situ techniques, quantitative metallography, specimen preparation techniques.	6	12	2,3,5	1,2	2,4,5			
3	X-RAY DIFFRACTION TECHNIQUES: Powder, rotating crystal and Laue methods, stereographic projections and reciprocal lattice; X-ray residual stress measurement.	6	12	2,3,6	3,4	1,3,5			
4	ELECTRON MICROSCOPY (Part 1): Construction and operation of TEM - diffraction effects and image formation, specimen preparation techniques; elemental analysis by wavelength dispersive and energy dispersive systems	7	14	1,2,5	3,4	1,2,3			
5	ELECTRON MICROSCOPY (Part2): Construction and operation of SEM - analysis of fractured surfaces.	6	12	1,2,6	3,4	2,3,5			
6	ADVANCED CHEMICAL AND THERMAL ANALYSIS METHODS: X-ray fluorescence, spectrometry, Auger spectroscopy, DTA, DSC and TGA.	6	12	1,3,6	4	1,2,4			
7	EXPERIMENTAL STRESS ANALYSIS: Stress analysis by strain gauging, high temperature strain gauge technique, photoelasticity and holography.	7	14	4,6	4	3,4			
8	Tensile Test, Bend Test, Hardness Test, Corrosion Test.	7	14	1,5,6	4	4,5			
	TOTAL	50 Hours	100%						
	TEXT BOOKS:								

	1. Smallman R. E., 'Modern Physical Metallurgy', 4th Edition, Butterworths, 1985
	2. Philips V. A., 'Modern Metallographic Techniques and their Applications', Wiley Interscience, 1971
	3. Cullity B. D., 'Elements of X-ray Diffraction', 4th Edition, Addison Wiley, 1978
	4. Loretto M. H., 'Electron Beam Analysis of Materials', Chapman and Hall, 1984
	REFERENCES:
	1. Thomas G., 'Transmission Electron Microscopy of Metals', John Wiley, 1961
	2. Thomas G., Michael J.G, 'Transmission Electron Microscopy of Materials', John Wiley, 1979
	3. Amdinckx S., 'Modern Diffraction and Imaging Techniques in Materials Science', North Holland, 1970

		The Maharaja Sayajirao University of Baroda Faculty Technology and Engineering Department of Metallurgical & Materials Engineering				Academic Year		2020-21		
ME (Metallurgical & Materials)(Welding Technology) Regular Programme										
Year		I	Core / Elective / Foundation Code: : MME2122L Subject: Experimental & Quantitative Techniques Laboratory				Credits / Hours per week		4	
Semester		I	Year of Introduction: 2006 Year of Syllabus Revision:				Maximum Marks / Grade		50	
Mode of Transaction			Laboratory Experiments, discussion and viva							
No.	Experiment					Contact Hr	Weightage (%)	BT Level	CO	PSO
1	Exp;1					2	15	1,2,3	CO1	1,2,3
2	Exp:2					2	15	2,3	CO2	2,3,4
3	Exp:3					2	15	4	CO3	3,4
4	Exp:4					2	15	4,5	CO4	5
5	Exp:5					2	10	4,6	CO2	4,5
6	Exp:6					2	10	5,6,	CO4	3,4

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Syllabus of Courses

	The Maharaja Sayajirao University of Baroda Faculty Technology and Engineering Department of Metallurgical & Materials Engineering					Academic Year			2020-21		
ME (Metallurgical & Materials)(Welding Technology) Regular Programme											
Year	I	Core / Elective / Foundation Code: MME2127 Subject: MECHANICAL BEHAVIOUR OF MATERIALS				Credits / Hours per week			4		
Semester	I	Year of Introduction: 2006 Year of Syllabus Revision:				Maximum Marks / Grade			100		
Mode of Transaction		Lectures and Tutorials									
Course Outcome (CO) CO1-Study about the dislocation and strength of materials CO2-Different strengthening mechanisms & its tests CO3- Fracture mechanics of the material CO4-Understand about fatigue & creep mechanism											
Unit No.	Topic/Unit			Contact Hours	Weightage (%)	BT Level	CO	PSO	Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional(R)/Global (G) developmental	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV)and Professional Ethics (PE)

								needs	
1	MECHANICS OF DEFORMATION(Part 1) : Strength of materials- basic assumptions, elastic and plastic behavior, stress–strain relationship for elastic behavior, elements of plastic deformation of metallic materials	6	12	1,2,3	1	1,3,5	Emp	G	HV,PE
2	MECHANICS OF DEFORMATION (Part 2): Mohr’s circle, yielding theories -Von mises yielding criterion and maximum-shear-stress/ Tresca criterion, failure criteria under combined stresses.	6	12	2,3	1	2,3,4			
3	THEORY OF DISLOCATIONS: Elements of theory of plasticity, dislocation theory properties of dislocation, stress fields around dislocations, elementary dislocation interactions. Application of dislocation theory to work hardening	7	14	4,5,6	1,2	1,2,4			
4	STRENGTHING MECHANISM : Solid solution strengthening, grain boundary strengthening, dispersion hardening, Some concepts on Design of Steel	6	12	5,6	2,3	3,4,5			
5	FRACTURE AND FRACTURE MECHANICS (Part 1): Features of ductile and brittle fracture - ductile to brittle transition temperature- Charpy and Izod testing, significance of DBTT, ECT, NDT and FATT	8	16	1,3,4	3,4	4,5			
6	FRACTURE AND FRACTURE MECHANICS (Part 2): elements of fractography - Griffith’s theory and brittle fracture - Irwin - Orowan modification - stress intensity factor and fracture toughness - linear elastic and yielding fracture mechanics - crack opening displacement and J integral - experimental determination of KIC critical COD and J integral. Relevance to Welding Defects & Their Characterization	7	14	1,2	3	1,2,3			
7	FATIGUE: Characteristics of fatigue failure, initiation and propagation of fatigue cracks, mechanisms of fatigue failure, factors affecting fatigue strength and methods of improving fatigue behaviour - fatigue testing - Wohlers test, results of the fatigue test,	6	12	2,3,4	3,4	4,5			

	statistical analysis of fatigue data, fracture mechanics of fatigue crack propagation, corrosion fatigue. Relevance to welded Structure								
8	CREEP: Introduction to creep - creep mechanisms, creep curve, variables affecting creep, presentation and practical application of creep data, accelerated creep testing, and time-temperature parameters for conversion of creep data, development of creep resistant alloys, creep testing - high temperature material problem, stress rapture test, parametric approaches in presenting creep data - Larsen Miller parameter - Manson Hafred parameter. Relevance to Metallurgy of welded joints	4	8	5,6	3,4	5			
	TOTAL	50 Hours	100%						
Reference Books									
1	Dieter G. E., ‘Mechanical Metallurgy’, 3rd Edition, McGraw Hill, 1988								
2	Suryanarayana, ‘Testing of Metallic Materials’, Prentice Hall India, 1979.								
3	Rose R. M., Shepard L. A., Wulff J., ‘Structure and Properties of Materials’, Volume III,4th Edition, John Wiley, 1984								

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ME (Metallurgical & Materials)(Welding Technology) Regular Programme											
Year	I	Core / Elective / Foundation Code: MME2126 Subject: NDT & FAILURE ANALYSIS				Credits / Hours per week			4		
Semester	I	Year of Introduction: 2006 Year of Syllabus Revision:				Maximum Marks / Grade			100		
Mode of Transaction		Lectures and Tutorials									
Course Outcome (CO) CO1- To become familiar with NDT techniques and to get exposed to the concept and procedure associated with failure analysis CO2 -To understand different tests and standards for the specific process CO3-To learn about the failure analysis of the component CO4- Understanding new techniques for NDT											
Unit No.	Topic/Unit			Contact Hours	Weightage (%)	BT Level	CO	PSO	Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional(R)/Global (G) developmental	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV)and Professional Ethics (PE)

								needs	
1	LPT, MPT: Visual examination; liquid penetrant testing – procedure; penetrant testing materials, penetrant testing method – sensitivity; application and limitations; magnetic particle testing; definition and principle; magnetizing technique, procedure, equipment sensitivity and limitation; Application & Acceptance Standards	6	11.8	1,2	1,2	1,2,3	SD	G	HV
2	RADIOGRAPHY – basic principle, electromagnetic radiation in film, radiographic imaging, inspection techniques, applications, limitations, real time radiography, safety in industrial radiography. Application & Acceptance Standards	7	13.7	2,3	1,2	2,3,4			
3	EDDY CURRENT: Eddy current testing – principle, instrument techniques, sensitivity application, limitation; ultrasonic testing – basic properties of sound beam, Application & Acceptance Standards	5	9.8	3,4	1,2	4,5			
4	ULTRASONIC TECHNIQUES: ultrasonic transducers, inspection methods, technique for normal beam inspection, flaw characterization technique, ultrasonic flaw detection equipment modes of display, immersion testing, advantage, limitations; Application & Acceptance Standards	8	15.7	1,4	1,2	2,5			
5	Acoustic emission testing – principles of AET and techniques.	6	11.8	2,4	4	2,3			
6	SELECTION OF NDT METHODS- VE, LPT, MPT, ECT, RT, UT, AET and thermography; selection of instrumentation for various NDT methods; reliability in NDT.	7	13.7	5,6	1,2,4	3,5			
7	FAILURE ANALYSIS – I :Failure analysis – methodology; approaches, tools and techniques of failure analysis; modes of failure; failure data retrieval; procedural steps for investigation of a failure for failure analysis.	6	11.8	1,6	3,4	3,4,5			
8	FAILURE ANALYSIS – II: Improvements (design, material) derived from failure analysis; two case studies; application of	6	11.8	2,6	3,4	1,3,5			

	fracture mechanics concepts to design for safety.								
	TOTAL	51 Hours	100%						
Reference Books									
1	Baldev Raj, Jayakumar T., Thavasimuthu M., 'Practical Non-Destructive Testing', Narosa Publishing, 1997								
2	Das A.K., 'Metallurgy of Failure Analysis', TMH, 1992								
3	Hull., 'Non-Destructive Testing', ELBS Edition, 1991								

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ME (Metallurgical & Materials)(Welding Technology) Regular Programme										
Year		I	Core / Elective / Foundation Code : MME2126L Subject: NDT and Failure Analysis Laboratory				Credits / Hours per week		4	
Semester		I	Year of Introduction: 2006 Year of Syllabus Revision:				Maximum Marks / Grade		50	
Mode of Transaction			Laboratory Experiments, discussion and viva							
No.	Experiment					Contact Hr	Weightage (%)	BT Level	CO	PSO
1	Exp:1					2	15	1,2,3	CO1	1,2,3
2	Exp:2					2	15	2,3	CO2	2,3,4
3	Exp:3					2	15	4	CO3	3,4
4	Exp:4					2	15	4,5	CO4	2,3,5
5	Exp:5					2	10	4,6	CO2	4,5
6	Exp:6					2	10	5,6,	CO4	3,4

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ME (Metallurgical & Materials)(Welding Technology) Regular Programme											
Year	I	Core / Elective / Foundation Code: MME2123 Subject: Physical Metallurgy				Credits / Hours per week				4	
Semester	I	Year of Introduction: 2006 Year of Syllabus Revision:				Maximum Marks / Grade				100	
Mode of Transaction		Lectures and Tutorials									
Course Outcome (CO) CO1- Understand about the basics of physical metallurgy CO2-study about different transformation of phases CO3-Study about different phase diagrams and its properties CO4- Understanding of different phase transformation mechanisms CO5-Entry of other developed metals & alloys CO6-Learning of designing of materials and strengthening mechanisms											
Unit No.	Topic/Unit			Contact Hours	Weightage (%)	BT Level	CO	PSO	Elements of Employability (Emp)/ Entrepreneurship (Ent)/	Relevance to Local (L)/ National (N)/ Regional(R)/Global	Relation to Gender (G), Environment and Sustainability (ES),

							Skill Development (SD)	(G) developmental needs	Human Values (HV) and Professional Ethics (PE)
1	<u>Crystallography (Part 1)</u> : Elements of crystal structure, space lattice, unit cell. Types of crystal structure, packing factor, indexing of crystal planes and directions.	8	16.7	1,2	2,3	1,2,3	Emp	G	ES,PE
2	<u>Crystallography (Part 2)</u> : Defects in crystals: vacancies and dislocations. Polycrystalline aggregates, crystal orientation, grain boundaries. Concepts of slip and twinning, dislocation movement and plastic flow.	9	18.8	2,3,4	1,2	2,3,4			
3	<u>Phase Diagrams</u> : Concepts of alloying, simple examples of binary phase diagrams. Phase transformations, thermodynamic and kinetic considerations, concepts of diffusion. Nucleation and growth, features of solidification	7	14.6	3,4,6	2,3,4	4,5			
4	<u>Physical metallurgy of steels</u> : Iron-Carbon diagram, phases and microconstituents, phase changes during slow cooling of steels of different carbon contents, lever rule and room temperature microstructures. Types of heat treatment of steels. Effects of rapid cooling on transformations in steels, formation of bainite and martensite, their characteristics. Tempering of martensite. Concept of TTT and CCT diagrams, hardenability, effects of alloying elements and carbon content on them	8	16.7	4,5	1,2,3	3,4,5			
5	<u>Strengthening Mechanisms</u> : Work hardening, solid solution strengthening, strengthening by heat treatment, precipitation hardening, grain refinement.	8	16.7	4,5,6	2,3,4,6	4,5			
6	<u>Engineering Materials</u> : Carbon steels, low-alloy steels, HSLA steels, stainless steels, tool steels, ultrahigh-strength steels, high-strength aluminium alloys, titanium alloys and nickel alloys	8	16.7	2,3,4	1,2,3,6	2,3			
	TOTAL	48	100%						

		Hours							
Reference Books									
1	Leslie W. C., 'Physical Metallurgy of Steels', McGraw Hill, 1982								
2	Raghavan V., 'Physical Metallurgy (Principles and Practice)', Prentice-Hall, 1983								
3	Clark D. S. and Varney W. R., 'Physical Metallurgy for Engineers', CBS, 1987								
4	Flemings M. C., 'Solidification Processing', McGraw Hill, 1974								

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Year	I	Core / Elective / Foundation Code: MME2123L Subject:Physical Metallurgy Laboratory				Credits / Hours per week		02		
Semester	I	Year of Introduction: 2006 Year of Syllabus Revision:				Maximum Marks / Grade		50		
Mode of Transaction		Laboratory Experiments, discussion and viva				PSO7 is common for all experiments				
No.	Experiment					Contact Hr	Weightage (%)	BT Level	CO	PSO
1	Exp;1					2	15	1,2,3	CO1	1,2,3
2	Exp:2					2	15	2,3	CO2	2,3,4
3	Exp:3					2	15	4	CO3	3,4
4	Exp:4					2	15	4,5	CO4	5
5	Exp:5					2	10	4,6	CO5	3,5
6	Exp:6					2	10	5,6,	CO6	3,4
7	Exp:7					2	10	4,5,6	CO6	4,5
8	Tutorial : 1					2	5	2,3,4	CO6	3,4,5
9	Tutorial :2					2	5	3,4,5	CO6	5

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ME (Metallurgical & Materials) (Welding Technology) proramme									
Year	I	Core / Elective / Foundation Code: MME2228 Subject: Corrosion of Weldments	Credits / Hours per week	04 Hrs/ week					
Semester	II	Year of Introduction: 2006 Year of Syllabus Revision:	Maximum Marks / Grade	100 Marks					
Mode of Transaction		Lectures, PPT, Tutorials, Factory Visit, Videos etc							
Course Outcome (CO) CO1 Basic introduction to corrosion engineering, Kinetics of corrosion reaction. CO2 Different type of polarization in corrosion, Deviation from equilibrium. CO3 Surface protection of materials using inhibitors, their types and applications. CO4 Study of Corrosion occurring at high temperature in different environment. CO5 Study of wet corrosion, Corrosion of materials in wet environment. CO6 Surface protection or Corrosion prevention methods of metals and alloys. CO7 Conventional Corrosion testing methods. CO8 Innovation in different type corrosion testing methods based on standard and its applications. CO9 Innovative Corrosion Monitoring Technique									
Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO	Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional(R)/Global (G) developmental needs	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV)and Professional Ethics (PE)
1	GENERAL REVIEW OF THE	5	10.2	1,2	CO1	1,2	Emp,Ent.SD	G	G,ES,HV, PE

	PRINCIPLES of electrochemistry applied to corrosion such as Single Electrode Potential, E.M.F. series, Nernst equation, over potential.								
2	KINETICS OF ELECTROCHEMICAL REACTION.: Hydrogen & oxygen evolution. Polarization, Anodic and cathodic polarizations & Mixed potential theory	6	12.2	1,2,3	CO2	3,4			
3	TYPES OF CORROSION : galvanic, pitting, crevices, intergranular, KLA, selective leaching. Stress corrosion, erosion corrosion, cavitations damage, corrosion fatigue, Hydrogen damage High temperature corrosion, oxidation corrosion with flue gases	6	12.2	4,5	CO3	4,5			
4	METHODS OF COMBATING: corrosion with special reference to metallic and non-metallic coatings. Improvement in design. Cladding, Advances in cathodic and anodic protection techniques. Corrosion resistant alloys in brief (Austenitic, martensitic & ferritic stainless steel, Nickel alloys, copper alloys & titanium alloys).	6	12.2	6,7	CO4	1,2,3,4			
5	CORROSION TESTING (PART-I): General corrosion testing: weight loss method, Accelerated tests such as potentiodynamic testing & salt spray test Intergranular corrosion testing: ASTM A262 practice A to E, Electro chemical Potentio- kinetic Reactivation (EPR) test	7	14.3	1.3	CO5	1,2,3			
6	CORROSION TESTING (PART –II) Pitting Corrosion Testing: cyclic polarization test, Pitting and Crevice Corrosion testing by ASTM G 48 standard Stress Corrosion Cracking Testing: Proof Ring test, slow strain rate testing & evaluation of Stress-Corrosion-Cracking Resistance of Metals and Alloys by ASTM G 36 standard	6	12.2	1,2,3	CO6	3,4			
7	CASE STUDY of failure of various components of chemical & petrochemical industries, oil & refinery industries, off shore industry & nuclear industries under SCC, IGC,	7	14.3	1,2	CO7	3,4			

	Pitting Corrosion fatigue, hydrogen damage & High temperature corrosion.								
8	WELDMENTS CORROSION and its control in various alloy systems : Factors governing weldments corrosion, carbon steels, alloy steels, ASS, DSS, Al alloys.(L&T)	6	12.2	3,4	CO8	1,2,3,4			
	TOTAL	49 Hours	100%						
Reference Books									
1	Corrosion Engineering – Mars G. Fontana and Norbert D. Green, Mcgraw-Hill International Book Company, New Delhi.								
2	Corrosion and Corrosion Control – An Introduction to Corrosion Science & Engineering – Herbert H. Uhlig. John Wiley & Sons Inc., New York.								
3	Corrosion – Vol. 1 & 2 – L.L. Shreir, R.A. Jarman& G.T. Burstein, Butterworth Heinemann, U.K								

		The Maharaja Sayajirao University of Baroda Faculty Technology and Engineering Department of Metallurgical & Materials Engineering				Academic Year		2020-21		
ME (Metallurgical & Materials) (Welding Technology)										
Year		I	Core / Elective / Foundation Code: MME228L Subject: Corrosion of weldments Laboratory				Credits / Hours per week		3	
Semester		II	Year of Introduction: 2006 Year of Syllabus Revision:				Maximum Marks / Grade		50	
Mode of Transaction			Laboratory Experiments, discussion and viva							
No.	Experiment					Course Code	BT Level	CO	PSO	
1	Corrosion rate measurement using weight loss method						4	CO7	1,2	
2	Electroplating of copper						3,4,5	CO7	2,4	
3	Potentio-dynamic Testing						1 to 5	CO8	2,3,5	
4	Cyclic Polarization Testing						1 to 5	CO8	4,5	
5	EPR Testing						1to 5	CO8	1-5	
6	EIS Testing						1 to 5	CO9	2,4,5	
7	IGC standard practice						1,2,6	CO8	5	
8	Salt Spray Test						1,2,4,6	CO7	1,3	

Bloom's Taxonomy Levels:

1. Remember 2. Understand 3. Application 4. Analysis 5. Evaluation 6. Creation

Programme Name: ME (Metallurgical & Materials) (Welding Technology) Regular Programme**Programme Specific Outcome (PSO)** Students will be able to

PSO 1 Understand and acquire fundamental knowledge of welding processes for various Materials.

PSO 2 Apply knowledge of various materials to prescribe suitable welding technique for specific applications in welding industry.

PSO 3 Able to model and simulate welding processes in various industries to conduct experiments and analyze the performance using modern tools through dissertation projects.

PSO 4 Expertise to find out the root cause of real world failures in industry and to determine the remaining life of the system.

PSO 5 Endowed technical competency, entrepreneurship, ethics, interdisciplinary working skill and contribute society philanthropically.

Syllabus of Courses

	The Maharaja Sayajirao University of Baroda Faculty Technology and Engineering Department of Metallurgical & Materials Engineering	Academic Year	2020-21						
ME (Metallurgical & Materials) (Welding Technology) proramme									
Year	I	Core / Elective / Foundation Code: MME2225 Subject: Design of Weldments	Credits / Hours per week	04 Hrs/ week					
Semester	II	Year of Introduction: 2006 Year of Syllabus Revision:	Maximum Marks / Grade	100 Marks					
Mode of Transaction		Lectures, PPT, Tutorials, Factory Visit, Videos etc							
Course Outcome (CO) CO1 Basic introduction of various design used for welding CO2 Understanding of various stress on weld CO3 Understanding of fracture mechanics and Residual stress CO4 Type of Distortion									
Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO	Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional(R)/Global (G) developmental needs	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV)and Professional Ethics (PE)
1	DESIGN BASICS: Type of joints, joint efficiency, factor of safety, symbols, selection of edge preparation, design considerations, types of loading	6	11.8	1,2	CO1	1,2	Emp,Ent,SD	G	PE,HV
2	STATIC LOADING: Permissible stress,	6	11.8	3,4	CO2	3,4			

	allowable defects, computation of stresses in welds, weld size calculation, code requirement for statically loaded structures. .								
3	DYNAMIC LOADING Design for fluctuating and impact loading - dynamic behavior of joints - stress concentrations	6	11.8	3,4	CO2	4,5			
4	FATIGUE ANALYSIS fatigue improvement techniques - permissible stress - life prediction.	7	13.7	3,4,5	CO2	4,5			
5	FRACTURE MECHANICS: Concept of stress intensity factors - LEFM and EPFM concepts	7	13.7	3,4,,5	CO3	3,4			
6	BRITTLE FRACTURE- Mechanism, transition temperature approach - fracture toughness testing, application of fracture mechanics to fatigue.	6	11.8	3,4,5	CO3	2,3,4			
7	RESIDUAL STRESSES: Welding residual stresses - causes, occurrence, effects and measurements - thermal and mechanical relieving; origin and causes	7	13.7	4,5,6	CO3	4,5			
8	DISTORTION: Types of distortion - factors affecting distortion - distortion control methods - prediction - correction, jigs, fixtures and positioners.	6	11.8	2,3,4	CO4	1,3,5			
	TOTAL	51 Hours	100%						

Text Books

1	Omer W. B., 'Design of Weldments', James.F. Lincoln Arc Welding Foundation, 1991
2	Gray T. G. E. 'Rational Welding Design', Butterworths, 1982
3	Hertzberg R.W., 'Deformation and Fracture of Mechanics of Engineering Materials', John Wiley, 1996
4	Saferian D., 'The Metallurgy of Welding', Chapman and Hall, 1985
5	Dieter G., 'Mechanical Metallurgy', Tata McGraw Hill, 1988

Reference Books:

1	Guerey T.R., 'Fatigue of Welded Structure', CambridgeUniversity Press, 1979
2	David Broek, 'Elementary Engineering Fracture Mechanics', SujthoffNoordhoof, 1978
3	Rolfe T., Barsom J., 'Fracture and Fatigue Control of Structure - Applications of Fracture Mechanics', Prentice Hall, 1977

Bloom's Taxonomy Levels:

1. Remember 2. Understand 3. Application 4. Analysis 5. Evaluation 6. Creation

Programme Name: ME (Metallurgical & Materials) (Welding Technology) Regular Programme**Programme Specific Outcome (PSO)** Students will be able to

PSO 1 Understand and acquire fundamental knowledge of welding processes for various Materials.

PSO 2 Apply knowledge of various materials to prescribe suitable welding technique for specific applications in welding industry.

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PSO 4 Expertise to find out the root cause of real world failures in industry and to determine the remaining life of the system.

PSO 5 Endowed technical competency, entrepreneurship, ethics, interdisciplinary working skill and contribute society philanthropically.

Syllabus of Courses

		The Maharaja Sayajirao University of Baroda Faculty Technology and Engineering Department of Metallurgical & Materials Engineering					Academic Year		2020-21			
ME (Metallurgical & Materials) (Welding Technology) proramme												
Year		I	Core / Elective / Foundation Code: MME2227 Subject: Manufacturing Technology				Credits / Hours per week			04 Hrs/ week		
Semester		II	Year of Introduction: 2006 Year of Syllabus Revision:				Maximum Marks / Grade			100 Marks		
Mode of Transaction			Lectures, PPT, Tutorials, Factory Visit, Videos etc									
Course Outcome (CO) CO1 Introduction of various manufacturing technology CO2 Understanding of various manufacturing process CO3 Application of various manufacturing process CO4 Understanding of surface treatment CO5 Understanding of logistics CO6 Understanding of Material handling												
Unit No.	Topic/Unit				Contact Hours	Weightage (%)	BT Level	CO	PSO	Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional(R)/Global (G) developmental needs	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV)and Professional Ethics (PE)
1	Cutting (Flame & Plasma)				4	8	1,2,3	CO1	1,2	Emp,Ent,SD	N,G	PE,HV,ES
2	Rolling (Hot, Warm, Cold): Theory and practice, different types of machine and				5	10	3,4	CO2	2,4			

	accessories.								
3	Forging: Classification of forging, drop and press forging, forging equipment, calculation of forging pressure & loads, Metallurgical Variables associates with forging. Forging defects	5	10	4,5	CO2	5			
4	Pressing (Die-Punch, Spinning)	5	10	3,4,5	CO2	2,3			
5	Drawing L : Tube drawing, wire drawing, Dry and wet wire drawing, wire drawing equipment & Pipe / Tube Bending	5	10	3,4,5	CO2	2,3,5			
6	Extrusion : Direct and indirect extrusion, variables in extrusion, flow patterns in direct and indirect extrusion, hydrostatic extrusion	5	10	3,4,5	CO2	4,5			
7	Fabrication: Various fabrication operations, Circular seam set ups, Nozzle cut-outs and set ups, Elevations, orientations, etc. Quality aspects – preheat, visual, arc, strikes, Welder trace ability, documentation ,Good engineering practices (General and SS fabrication)	3	6	3,4,5	CO2	3,4			
8	Weld repairs – defects marking and repairs	3	6	3,4	CO3	3,4			
9	Machining	3	6	3,4,5,6	CO3	3,5			
10	Tube to tube sheet joints, expansion and welding	3	6	3,4,5,6	CO3	4,5			
11	Material Handling: Concepts ,Tools & Tackles ,Safety	3	6	3,4,5,6,	CO6	4,5			
12	Surface Treatment & Painting: Blasting & Painting ,Passivation	3	6	4,5,6	CO4	4,5			
13	Logistics: Road Transportation Marine / Sea Transportation	3	6	4,5,6	CO5	3-5			
	TOTAL	50 Hours	100%						

Reference Books

1	Bathy J. Industrial Administration and Management, 1984
2	Pender J. A., ‘Welding Prejects – A Design Appoach; 1977
3	Welding Institute U.K ‘Standard Data for Arc Welding’ 1994
4	Jean Cornu, ‘Advanced Welding Systems’, Volume II and III, Jaico Publishing House, 1994
5	Welding Hand Book, Volume I and Iv, 7 th Edition, American Welding Society, 1980 Vill V. I., ‘Friction Welding of Metals’ American Welding Society, 1989.
6	Schwartz M. “Brazing – for the Engineering Technology, Chapman and Hall, 1995
7	Manko H.H., ‘Solders and Soldering, 2 nd edition, McGraw Hill, 1979

Text Books :

1	Schwartz M. 'Materials and Applications – Metal Joining Manual', Mc Graw Hill., 1979.
2	Nadkarni S. V., 'Modern Arc Welding Technology', Oxford IBH Publishers, 1996
3	Christopher Davis, 'Laser Welding – A Practical Guide', Jaico Publishing House, 1994
4	Parmar R S, Welding Engg and Tech, Khana Publishers, 1997

		The Maharaja Sayajirao University of Baroda Faculty Technology and Engineering Department of Metallurgical & Materials Engineering			Academic Year		2020-21	
ME (Metallurgical & Materials) (Welding Technology) Regular Programme								
Year		I	Core / Elective / Foundation Code: MME2227L Subject: Manufacturing Technology Laboratory			Credits / Hours per week		02 (Practical)
Semester		II	Year of Introduction: 2006 Year of Syllabus Revision:			Maximum Marks / Grade		50 (TW/VIVA)
Mode of Transaction			Laboratory Experiments, discussion and viva					
No.	Experiment			Contact Hr	Weightage (%)	BT Level	CO	PSO
1	Exp:1			2	15	1,2,3	CO1	1,2,3
2	Exp:2			2	15	2,3	CO2	2,3,4
3	Exp:3			2	15	4	CO3	3,4
4	Exp:4			2	15	4,5	CO4	4,5
5	Exp:5			2	10	4,6	CO5	5
6	Exp:6			2	10	5,6,	CO6	3,4
7	Exp:7			2	10	4,5,6	CO6	4,5
8	Tutorial : 1			2	5	2,3,4	CO6	5
9	Tutorial :2			2	5	3,4,5	CO6	3,5

Bloom's Taxonomy Levels:

1. Remember 2. Understand 3. Application 4. Analysis 5. Evaluation 6. Creation

Programme Name: ME (Metallurgical & Materials) (Welding Technology) Regular Programme**Programme Specific Outcome (PSO)** Students will be able to

PSO 1 Understand and acquire fundamental knowledge of welding processes for various Materials.

PSO 2 Apply knowledge of various materials to prescribe suitable welding technique for specific applications in welding industry.

PSO 3 Able to model and simulate welding processes in various industries to conduct experiments and analyze the performance using modern tools through dissertation projects.

PSO 4 Expertise to find out the root cause of real world failures in industry and to determine the remaining life of the system.

PSO 5 Endowed technical competency, entrepreneurship, ethics, interdisciplinary working skill and contribute society philanthropically.

Syllabus of Courses

		The Maharaja Sayajirao University of Baroda Faculty Technology and Engineering Department of Metallurgical & Materials Engineering		Academic Year		2020-21			
ME (Metallurgical & Materials) (Welding Technology) proramme									
Year	I	Core / Elective / Foundation Code: MME226 Subject: Welding codes and Standards		Credits / Hours per week		04 Hrs/ week			
Semester	II	Year of Introduction: 2006 Year of Syllabus Revision: 2016		Maximum Marks / Grade		100 Marks			
Mode of Transaction		Lectures							
Course Outcome (CO) CO1 Introductions of codes CO2 Application code and Standard CO3 understanding of Code and Standard									
Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO	Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional(R)/Global (G) developmental needs	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV)and Professional Ethics (PE)
1	Code, Standard, specifications their requirement various types	6	12.5	1,2	CO1	1,2	Emp,Ent,SD	N,G	HV,PV
2	STRUCTURAL WELDING CODES: Design requirements, allowable stress values, workmanship and inspection	6	12.5	2,3	CO2	2,3,			
3	PETROLEUM PIPING FABRICATION:	6	12.5	2,3,4	CO2	3,4			

	Process and product standards for manufacturing of pipe – welding procedure and welder qualification, field welding and inspection.								
4	PRESSURE VESSEL FABRICATION: Design requirements, fabrication methods, joint categories, welding and inspection, post weld heat treatment and hydro testing, (ASME Sec VIII-1 & 2).	6	12.5	2,3,4	CO2	5			
5	WELDING PROCEDURE: Welding procedure specification, procedure qualification records.	5	10.4	2,3,4	CO2	3,4,5			
6	WELDER QUALIFICATION: Performance qualification, variables.	6	12.5	2,3,4	CO2	4,5			
7	MATERIALS: Introduction to materials standard and testing of materials, consumables testing and qualification as per ASME / AWS requirements.	7	14.6	4,5	CO3	3,4			
8	CONSUMABLES: Types of consumables	6	12.5	4,5	CO3	5			
	TOTAL	48 Hours	100%						

Text Books

1	AWS D1.1 Structural Welding Code
2	API 5L
3	API 1104
4	ASME Section VIII – Division 1,2
5	ASME Section IX
6	ASME Section II Part A and C

Bloom's Taxonomy Levels:

1. Remember 2. Understand 3. Application 4. Analysis 5. Evaluation 6. Creation

Programme Name: ME (Metallurgical & Materials) (Welding Technology) Regular Programme**Programme Specific Outcome (PSO)** Students will be able to

PSO 1 Understand and acquire fundamental knowledge of welding processes for various Materials.

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Syllabus of Courses

	The Maharaja Sayajirao University of Baroda Faculty Technology and Engineering Department of Metallurgical & Materials Engineering	Academic Year	2020-21						
ME (Metallurgical & Materials) (Welding Technology) proramme									
Year	I	Core / Elective / Foundation Code: MME2224 Subject: Welding Metallurgy	Credits / Hours per week	04 Hrs/ week					
Semester	II	Year of Introduction: 2006 Year of Syllabus Revision: 2016	Maximum Marks / Grade	100 Marks					
Mode of Transaction		Lectures, PPT, Tutorials, Factory Visit, Videos etc							
Course Outcome (CO) CO1 Understanding the basic concept of weldability CO2 Learn about the variousheat flow in welding CO3 Understand the metallurgical reactions in weld pool CO4 Understand the basic concept solidification in welding CO5 Understand the metallurgy of heat affected zone CO6 Understand different cracking occurred during and after welding CO7 Understand the basic concept of various tests in welding CO7 Understand the basic concept of dissimilar metal welding									
Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO	Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional(R)/Global (G) developmental needs	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV)and Professional Ethics (PE)

1	THERMAL CYCLES Heat flow - temperature distribution-cooling rates - influence of heat input, joint geometry, plate thickness, preheat, significance of thermal severity number.	7	14	1,2	CO1	1,3	Emt,SD,Emp	N,G	HV,ES,PE
2	SOLIDIFICATION Epitaxial growth - weld metal solidification - columnar structures and growth morphology- effect of welding parameters - absorption of gases - gas/metal and slag/metal reactions.	8	16	2,3,4	CO2	2,4			
3	WELDING METALLURGY OF FERROUS MATERIALS Phase transformations- weld CCT diagrams - carbon equivalent-preheating and post heating-weldability of low alloy steels, welding monograms	6	12	2,3,4	CO3	1,3,5			
4	Welding of QT steels	5	10	3,4	CO4	2,4,5			
5	Welding of stainless steels (austenitic, ferritic, martensitic, duplex and PH stainless steels), use of Schaffler and Delong diagrams, welding of cast irons – microstructures, defects and remedial measures.	6	12	3,4,5	CO4	2,5			
6	WELDING METALLURGY NON FERROUS MATERIALS: Welding of Cu, Al, Ti and Ni alloys – processes, difficulties, microstructures, defects and remedial measures.	5	10	3,4,5	CO5	1,5			
7	WELD DEFECTS : Origin - types - process induced defects, - significance - remedial measures, Hot cracking - cold cracking - lamellar tearing - reheat cracking.	6	12	3,4,5	CO6	2,4,5			
8	WELDABILITY TESTS - effect of metallurgical parameters. Different types of Weld ability Tests	7	14	3,4,5	CO7	4,5			
	TOTAL	50 Hours	100%						

Text Books

1	Granjon H., 'Fundamentals of Welding Metallurgy', Jaico Publishing House, 1994
2	Kenneth Easterling, 'Introduction to Physical Metallurgy of Welding', 2nd Edition, Butterworth Heinmann, 1992
3	Saferian D., 'The Metallurgy of Welding', Chapman and Hall, 1985
4	Jackson M. D., 'Welding Methods and Metallurgy', Griffin, London, 1967

Reference Books:

1	Norman Bailey, 'Weld ability of Ferritic Steels', Jaico Publishing House, 199
2	Kou S., 'Welding Metallurgy', John Wiley, 1987

		The Maharaja Sayajirao University of Baroda Faculty Technology and Engineering Department of Metallurgical & Materials Engineering					Academic Year		2020-21		
		ME (Metallurgical & Materials)(Welding Technology) Regular Programme									
Year		I	Core / Elective / Foundation Code: MME2224L Subject: Welding Metallurgy Laboratory					Credits / Hours per week		02 Hrs/ week	
Semester		II	Year of Introduction:2006 Year of Syllabus Revision:					Maximum Marks / Grade		50 Marks	
Mode of Transaction			Tutorials and Experiments								
No.	Experiment						Contact Hr	Course Code	BT Level	CO	PSO
1	Introduction to welding and weld joints						2	15	1,2	CO2	4,5
2	Study and observation of shielded metal arc welding process						2	15	2,4,5	CO1	2,3,4
3	Study and observation of tungsten arc welding process						2	15	2,4,5	CO1	3,4,5
4	Study and observation of MIG/MAG process						2	15	2,4,5	CO1	4.5
5	Study and observation of gas welding/ gas cutting						2	10	1,2,3	CO3,CO4	1,2
6	Microstructure observation of resistance spot welded sample to measure the ferrite content in ASS welded samples						2	10	1,2,6	CO4,CO6	5
7	Microstructure observation of various grades of ASS welded samples						2	10	1,2,3	CO1, CO3, CO6	4,5
8	Observation of submerged arc welding and electrostatic strip cladding process						2	5	1,2,3,4	CO3,CO4	4,5
9	Microstructure observation of various welding defects.						2	5	2,3,4	CO4,CO6	3,4,5

Bloom's Taxonomy Levels:

1. Remember 2. Understand 3. Application 4. Analysis 5. Evaluation 6. Creation

Programme Name: ME (Metallurgical & Materials) (Welding Technology) Regular Programme**Programme Specific Outcome (PSO)** Students will be able to

PSO 1 Understand and acquire fundamental knowledge of welding processes for various Materials.

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Syllabus of Courses

	The Maharaja Sayajirao University of Baroda Faculty Technology and Engineering Department of Metallurgical & Materials Engineering	Academic Year	2020-21						
ME (Metallurgical & Materials) (Welding Technology) proramme									
Year	I	Core / Elective / Foundation Code: MEC2251 Subject: Welding Process and welding Economy	Credits / Hours per week	04 Hrs/ week					
Semester	II	Year of Introduction: 2006 Year of Syllabus Revision: 2016	Maximum Marks / Grade	100 Marks					
Mode of Transaction		Lectures, PPT, Tutorials, Factory Visit, Videos etc							
Course Outcome (CO) CO1 introduction of solid state welding process CO2 Understanding of solid state welding CO3 Understanding of Brazing and Soldering CO4 Understating of surface treatment CO5 Overview of welding cost									
Unit No.	Topic/Unit	Contact Hours	Weightage (%)	BT Level	CO	PSO	Elements of Employability (Emp)/ Entrepreneurship (Ent)/ Skill Development (SD)	Relevance to Local (L)/ National (N)/ Regional(R)/Global (G) developmental needs	Relation to Gender (G), Environment and Sustainability (ES), Human Values (HV)and Professional Ethics (PE)
1	RESISTANCE WELDING: Principle of contact resistance, spot welding process	6	12.2	1,2,3	CO1	1,2,3	Emp,Ent,SD	N,G	HV,ES,PE

	variables and their effects, choice of electrode material, spot welding of dissimilar combinations. Spot, Seam and projection welding. Upset and flash butt welding.								
2	SOLID STATE WELDING PROCESSES: Diffusion Welding, Explosion Welding, Friction Welding, Ultrasonic Welding (Principles, Process characteristics, Applications)	6	12.2	2,3,4	CO2	2,3,4			
3	BRAZING: Wetting and spreading characteristics, capillary flow, joint design and fixturing, heat sources for brazing, brazing fillers, fluxes and atmospheres, vacuum brazing, applications of brazing.	6	12.2	3,4	CO3	3,4			
4	SOLDERING: Heating for soldering, fabrication of PCBs and ICs, other applications.	6	12.2	3,4	CO3	2,3			
5	SURFACING: Thermal spraying plasma spraying laser surface alloying and modification, spraying to improve wear resistance and corrosion resistance, CVD, PVD and ion implantation, Cladding and its applications. Electro Slag & Submerged Arc Strip Cladding, Narrow Gap Welding , Tandem/Twin-head Welding, Tube-tube sheet welding, Hot wire TIG, 2G-SAW	6	12.2	3,4,5	CO4	3,4,5			
6	FACTORS INFLUENCING WELDING COST: Welding design, selection of electrodes, size, type and metal recovery, electrode efficiency, stub thrown away, over welding and joint, fit - up welding position operation factor, jigs, fixtures, positioners, operator efficiency.	7	14.3	3,4	CO5	3,4			
7	ESTIMATION OF WELDING TIME :Need for time standards, definition of standard time, various methods of computing standard time, analytical calculation, computerization of time standards.	6	12.2	2,3,4	CO5	3,4,5			
8	COSTING FOR WELDING: Definition of terms, composition of welding costs, cost of consumables, labour cost, cost overheads, formulae for total cost, cost curves for different processes like CO2 , SAW, ESW, etc., mechanization in welding, job shop operation Factors influencing welding Cost	6	12.2	2,3,4	CO5	5			
	TOTAL	49	100%						

		Hours						
Reference Books								
1	Bathy J. Industrial Administration and Management, 1984							
2	Pender J. A., ‘Welding Preojects – A Design Appoach; 1977							
3	Welding Institute U.K ‘Standard Data for Arc Welding’ 1994							
4	Jean Cornu, ‘Advanced Welding Systems’, Volume II and III, Jaico Publishing House, 1994							
5	Welding Hand Book, Volume I and Iv, 7 th Edition, American Welding Society, 1980 Vill V. I., ‘Friction Welding of Metals’ American Welding Society, 1989.							
6	Schwartz M. “Brazing – for the Engineering Technology, Chapman and Hall, 1995							
7	Manko H.H., ‘Solders and Soldering, 2 nd edition, McGraw Hill, 1979							
Text Books :								
1	Schwartz M. ‘Materials and Applications – Metal Joining Manual’, Mc Graw Hill., 1979.							
2	Nadkarni S. V., ‘Modern Arc Welding Technology, Oxfird IBH Publishers, 1996							
3	Christopher Davis, ‘Laser Welding – A Practical Gudide, Jaico Publishing House, 1994							
4	Parmar R S. Welding Enggg and Tech, Khana Publishers, 1997							