ANNAMALAI UNIVERSITY

Annamalainagar

FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MANUFACTURING ENGINEERING

M.E. Welding Engineering (Two Year) Degree Programme

Choice Based Credit System

(Full - Time)

HAND BOOK

2017

DEPARTMENT OF MANUFACTURING ENGINEERING

VISION

To prepare students to be life-long learners and global citizens with successful careers in design, research, development, and management of systems in manufacturing and service organizations

MISSION

- A curriculum and educational experience designed and continuously improved through involvement and contribution of students, faculty, administrators, staff, and industry
- A well-focused research program funded at the local, regional , and national level
- A demonstrated competence and expertise in addressing the needs of industry and community at large

M.E. Welding Engineering

PROGRAMME EDUCATIONAL OBJECTIVES (PEO)

1. The graduates acquire ability to create model, design, synthesize and analyze essential welding skills, mechanism and automation system.
2. The graduates use their talent, self-confidence, knowledge and engineering practice which facilitate them to presume position of scientific and/or managerial leadership in their career paths.
3. The graduates apply their consciousness of moral, professional responsibilities and motivation to practice life-long learning in a team work environment.

PROGRAM OUTCOMES (PO)

Upon Completion of the two years of the Master of Welding Engineering Degree,

PO1: ASSIMILATION OF KNOWLEDGE

Acquire fundamental knowledge and understanding of welding processes and materials.

PO2: INTEGRATION OF KNOWLEDGE

Apply knowledge of materials to prescribe appropriate welding technique for specific applications;

PO3: USE OF MODERN TOOLS AND TECHNIQUES

Model and simulate welding processes to conduct experiments and analyze the performance using modern tools;

PO4: ETHICAL PRACTICES AND SOCIAL RESPONSIBILITIES

Understand the environmental issues related to each welding methods and try to develop ‘green and clean welding’ methods.

PO5: DESIGN AND DEVELOPMENT OF SOLUTIONS

Formulate relevant research problems; conduct experimental and/or analytical work and analyzing results using modern mathematical and scientific methods.

Mapping of PO with PEO					
PEOs / POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
PEO1	✓	✓		✓	
PEO2	✓		✓		✓
PEO3					✓

M.E. Welding Engineering (Full Time) Degree Programme
Choice Based Credit System (CBCS)

REGULATIONS

1. **Condition for Admission**

   Candidates for admission to the first year of the four-semester **M.E / M.Tech Degree programme in Engineering** shall be required to have passed B.E / B.Tech degree of Annamalai University or any other authority accepted by the syndicate of this University as equivalent thereto. They shall satisfy the condition regarding qualifying marks and physical fitness as may be prescribed by the syndicate of the Annamalai University from time to time. The admission for part time programme is restricted to those working or residing within a radius of **90 km** from Annamalainagar. The application should be sent through their employers.

2. **Branches of Study in M.E / M.Tech**

   The Branch and Eligibility criteria of programmes are given in **Annexure 1**

3. **Courses of study**

   The courses of study and the respective syllabi for each of the M.E / M. Tech programmes offered by the different Departments of study are given separately.

4. **Scheme of Examinations**

   The scheme of Examinations is given separately.

5. **Choice Based Credit System (CBCS)**

   The curriculum includes three components namely Professional Core, Professional Electives and Open Electives in addition to Thesis. Each semester curriculum shall normally have a blend of theory and practical courses.

6. **Assignment of Credits for Courses**

   Each course is normally assigned one credit per hour of lecture / tutorial per week and one credit for two hours or part thereof for laboratory or practical per week. The total credits for the programme will be 65.

7. **Duration of the programme**

   A student of **M.E / M.Tech** programme is normally expected to complete in four semesters for full-time / six semesters for part-time but in any case not more than four years for full-time / six years for part-time from the date of admission.

8. **Registration for courses**

A newly admitted student will automatically be registered for all the courses prescribed for the first semester, without any option. Every other student shall submit a completed registration form indicating the list of courses intended to be credited during the next semester. This registration will be done a week before the last working day of the current semester. Late registration with the approval of the Dean on the recommendation of the Head of the Department along with a late fee will be done up to the last working day. Registration for the Thesis Phase - I and II shall be done at the appropriate semesters.

9. Electives

The student has to select two electives in first semester and another two electives in the second semester from the list of Professional Electives. The student has to select two electives in third semester from the list of Open Electives offered by the department/ allied department. A student may be allowed to take up the open elective courses of third semester (Full Time program) in the first and second semester, one course in each of the semesters to enable them to carry out thesis in an industry during the entire second year of study provided they should register those courses in the first semester itself. Such students should meet the teachers offering those elective courses themselves-for clarifications. No specific slots will be allotted in the time table for such courses.

Further, the two open elective courses to be studied in III semester (Full Time programme) may also be credited through the SWAYAM portal of UGC with the approval of Head of the Department concerned. In such a case, the courses must be credited before the end of III Semester.

10. Assessment

The break-up of continuous assessment and examination marks for theory courses is as follows:

First assessment (Mid-Semester Test-I)	:	10 marks
Second assessment (Mid-Semester Test-II)	:	10 marks
Third Assessment	:	5 marks
End Semester Examination	:	75 marks

The break-up of continuous assessment and examination marks for Practical courses is as follows:

First assessment (Test-I)	:	15 marks
Second assessment (Test-II)	:	15 marks
Maintenance of record book	:	10 marks
End Semester Examination	:	60 marks

The thesis Phase I will be assessed for 40 marks by a committee consisting of the Head of the Department, the guide and a minimum of two members nominated by the Head of the Department. The Head of the Department will be the chairman. The number of reviews must be a minimum of three per semester. 60 marks are allotted for the thesis work and viva voce examination at the end of the third semester. The same procedure will be adopted for thesis Phase II in the fourth semester.

11. Student Counsellors (Mentors)

To help the students in planning their course of study and for general advice on the academic programme, the Head of the Department will attach a certain number of students to a member of the faculty who shall function as student counsellor for those students throughout their period of study. Such student counsellors shall advise the students, give preliminary approval for the courses to be taken by the students during each semester, monitor their progress in SWAYAM courses / open elective courses and obtain the final approval of the Head of the Department.

12. Class Committee

For each of the semesters of M.E / M.Tech programmes, separate class committees will be constituted by the respective Head of the Departments. The composition of the class committees from first to fourth semesters for Full time and first to sixth semesters for Part-time will be as follows:

- Teachers of the individual courses.
- A Thesis coordinator (for Thesis Phase I and II) shall be appointed by the Head of the Department from among the Thesis supervisors.
- A thesis review committee chairman shall be appointed by the Head of the Department
- One Professor or Associate Professor, preferably not teaching the concerned class, appointed as Chairman by the Head of the Department.
- The Head of the Department may opt to be a member or the Chairman.
- All counselors of the class and the Head of the Department (if not already a member) or any staff member nominated by the Head of the Department may opt to be special invitees.

The class committee shall meet **three** times during the semester. The first meeting will be held within two weeks from the date of class commencement in which the type of assessment like test, assignment etc. for the third assessment and the dates of completion of the assessments will be decided.

The second meeting will be held within a week after the completion of the first assessment to review the performance and for follow-up action.

The third meeting will be held after all the assessments but before the University semester examinations are completed for all the courses, and at least one week before the commencement of the examinations. During this meeting the assessment on a maximum of 25 marks for theory / 40 marks for practical and project work will be finalized for every student and tabulated and submitted to the Head of the Department for approval and transmission to the Controller of Examinations.

13. Temporary Break Of Study

A student can take a one-time temporary break of study covering the current semester and / or the next semester with the approval of the Dean on the recommendation of the Head of the Department, not later than seven days after the completion of the mid-semester test. However, the student must complete the entire programme within the maximum period of **four years for Full time / six years for Part time.**

14. Substitute Assessments

A student who has missed, for genuine reasons accepted by the Head of the Department, one or more of the assessments of a course other than the end of semester examination may take a substitute assessment for any one of the missed assessments. The substitute assessment must be completed before the date of the third meeting of the respective class committees.

A student who wishes to have a substitute assessment for a missed assessment must apply to the Head of the Department within a week from the date of the missed assessment.

15. Attendance Requirements

The students with 75% attendance and above are permitted to appear for the University examinations. However, the Vice Chancellor may give a rebate / concession not exceeding 10% in attendance for exceptional cases only on Medical Grounds.

A student who withdraws from or does not meet the minimum attendance requirement in a semester must re-register and repeat the same semester in the subsequent academic years.

16. Passing and declaration of Examination Results

All assessments of all the courses on an absolute marks basis will be considered and passed by the respective results passing boards in accordance with the rules of the University. Thereafter, the controller of examinations shall convert the marks for each course to the corresponding letter grade as follows, compute the grade point average (GPA) and cumulative grade point average (CGPA) and prepare the mark sheets.

90 to 100 marks	Grade ‘S’
80 to 89 marks	Grade ‘A’
70 to 79 marks	Grade ‘B’
60 to 69 marks	Grade ‘C’
55 to 59 marks	Grade ‘D’
50 to 54 marks	Grade ‘E’
Less than 50 marks	Grade ‘RA’
Withdrawn from the Examination	Grade ‘W’

A student who obtains less than 30 / 24 marks out of 75 / 60 in the theory / practical examinations respectively or is absent for the examination will be awarded grade RA.

A student who earns a grade of S, A, B, C, D or E for a course is declared to have successfully completed that course and earned the credits for that course. Such a course cannot be repeated by the student.\

A student who obtains letter grade RA / W in the mark sheet must reappear for the examination of the courses.

The following grade points are associated with each letter grade for calculating the grade point average and cumulative grade point average.

S - 10; A - 9; B - 8; C - 7; D - 6; E - 5; RA - 0

Courses with grade RA / W are not considered for calculation of grade point average or cumulative grade point average.

A student can apply for re-totaling of one or more of his examination answer papers within a week from the date of issue of mark sheet to the student on payment of the prescribed fee per paper. The application must be made to the Controller of Examinations with the recommendation of the Head of the Department.

After the results are declared, mark sheets will be issued to the students. The mark sheet will contain the list of courses registered during the semester, the grades scored and the grade point average for the semester.

GPA is the sum of the products of the number of credits of a course with the grade point scored in that course, taken over all the courses for the semester, divided by the sum of the number of credits for all courses taken in that semester.

CGPA is similarly calculated considering all the courses taken from the time of admission.

17. Awarding Degree

After successful completion of the programme, the degree will be awarded with the following classifications based on CGPA.

For First Class with Distinction the student must earn a minimum of 65 credits within four semesters for full-time / six semesters for Part time from the time of admission, pass all the courses in the first attempt and obtain a CGPA of 8.25 or above.

For First Class, the student must earn a minimum of 65 credits within two years and six months for full-time / three years and six months for Part time from the time of admission and obtain a CGPA of 6.75 or above.

For Second class, the student must earn a minimum of 65 credits within four years for full-time / six years for Part time from the time of admission.

18. Ranking Of Candidates

The candidates who are eligible to get the M.E /M.Tech degree in First Class with Distinction will be ranked on the basis of CGPA for all the courses of study from I to IV semester for M.E / M.Tech full-time / I to VI semester for M.E / M.Tech part-time.

The candidates passing with First Class and without failing in any subject from the time of admission will be ranked next to those with distinction on the basis of CGPA for all the courses of study from I to IV semester for full-time / I to VI semester for M.E / M.Tech part-time.

19. Transitory Regulations

If a candidate studying under the old regulations M.E. / M.Tech could not attend any of the courses in his/her courses, shall be permitted to attend equal number of courses, under the new regulation and will be examined on those subjects. The choice of courses will be decided by the concerned Head of the department. However he/she will be permitted to submit the thesis as per the old regulations. The results of such candidates will be passed as per old regulations.

The University shall have powers to revise or change or amend the regulations, the scheme of examinations, the courses of study and the syllabi from time to time.

ANNEXURE - I

S.No.	Department		Programme (Full Time & Part time)	Eligible B.E./B.Tech Programme *
1	**Civil Engineering**	i.	Environmental Engineering	B.E. / B.Tech – Civil Engg, Civil & Structural Engg, Environmental Engg, Mechanical Engg, Industrial Engg, Chemical Engg, BioChemical Engg, Biotechnology, Industrial Biotechnology, Chemical and Environmental Engg.
		ii.	Environmental Engineering & Management	
		iii.	Water Resources Engineering & Management	B.E. / B.Tech – Civil Engg, Civil & Structural Engg, Environmental Engg, Mechanical Engg, Agricutural anf irrigation Engg, Geo informatics, Energy and Environmental Engg.
2	**Civil & Structural Engineering**	i.	Structural Engineering	B.E. / B.Tech – Civil Engg, Civil & Structural Engg.
		ii.	Construction Engg. and Management	
		iii.	Geotechnical Engineering	
		iv.	Disaster Management & Engg.	
3	**Mechanical Engineering**	i.	Thermal Power	B.E. / B.Tech – Mechanical Engg, Automobile Engg, Mechanical Engg (Manufacturing).
		ii.	Energy Engineering & Management	B.E. / B.Tech – Mechanical Engg, Automobile Engg, Mechanical (Manufacturing) Engg, Chemical Engg
4	**Manufacturing Engineering**	i.	Manufacturing Engineering	B.E. / B.Tech – Mechanical Engg, Automobile Engg, Manufacturing Engg, Production Engg, Marine Materials science Engg, Metallurgy Engg, Mechatronics Engg, Industrial Engg.
		ii.	Welding Engineering	
		iii.	Nano Materials and Surface Engineering	B.E. / B.Tech – Mechanical Engg, Automobile Engg, Manufacturing Engg, Production Engg, Marine Materials science Engg, Metallurgy Engg, Chemical Engg
5	**Electrical Engineering**	i.	Embedded Systems	B.E. / B.Tech – Electrical and Electronics Engg, Control and Instrumentation Engg, Information technology, Electronics and communication Engg, Computer Science and Engg
		ii.	Smart Energy Systems	B.E. / B.Tech – Electrical and Electronics Engg, Control and Instrumentation Engg, Electronics and communication Engg,
		iii.	Power System	
		i.	Process Control & Instrumentation	B.E. / B.Tech – Electronics and Instrumentation Engg, Electrical

6	**Electronics & Instrumentation Engineering**			and Electornics Engg, Control and Instrumentation Engg, Instrumentation Engg
		ii.	Rehabilitative Instrumentation	B.E. / B.Tech – Electronics and Instrumentation Engg, Electrical and Electornics Engg, Electronics and communication Engg, Control and Instrumentation Engg, Instrumentation Engg, Bio Medical Engg, Mechatronics.
		iii.	Micro Electronics and MEMS	B.E. / B.Tech – B.E. / B.Tech – Electronics and Instrumentation Engg, Electrical and Electronics Engg, Electronics and communication Engg, Control and Instrumentation Engg, Instrumentation Engg, Bio Medical Engg, Mechatronics, Telecommunication Engg
7	**Chemical Engineering**	i.	Chemical Engineering	B.E. / B.Tech – Chemical Engg, Petroleum Engg, Petrochemical Technology
		ii.	Food Processing Technology	B.E. / B.Tech - Chemical Engg, Food Technology, Biotechnology, Biochemical Engg, Agricultural Engg.
		iii.	Industrial Bio Technology	B.E. / B.Tech - Chemical Engg, Food Technology, Biotechnology, Leather Technology
		iv.	Industrial Safety Engineering	B.E. / B.Tech – Any Branch of Engineering
8	**Computer Science & Engineering**	i.	Computer Science & Engineering	B.E. / B.Tech - Computer Science and Engineering, Information Technology, Electronics and Communication Engg, Software Engineering
9	**Information Technology**	i	Information Technology	B.E. / B.Tech - Computer Science and Engineering, Information Technology, Electronics and Communication Engg, Software Engineering
10	**Electronics & Communication Engineering**	i.	Communication Systems	B.E. / B.Tech - Electronics and Communication Engg, Electronics Engg.

*** AMIE in the relevant discipline is considered equivalent to B.E**

M.E. Welding Engineering (Two Year) Degree Programme
Choice Based Credit System (CBCS)

Courses of Study and Scheme of Examinations

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits
S e m e s t e r – I										
1	PC-I	WEEC101	Applied Mathematics	4	-		25	75	100	3
2	PC-II	WEEC102	Welding Processes - I	4	-		25	75	100	3
3	PC-III	WEEC103	Physical Metallurgy	4	-		25	75	100	3
4	PC-IV	WEEC104	Testing and Inspection of Weldments	4	-		25	75	100	3
5	PE-I	WEEE105	Professional Elective - I	4	-		25	75	100	3
6	PE-II	WEEE106	Professional Elective - II	4	-		25	75	100	3
7	PC Lab-I	WEEP107	Welding Processes Lab	-	-	3	40	60	100	2
			Total	**24**	**-**	**3**	**190**	**510**	**700**	**20**

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits
S e m e s t e r – II										
1	PC-V	WEEC201	Welding Processes – II	4	-	-	25	75	100	3
2	PC-VI	WEEC202	Welding Metallurgy	4	-	-	25	75	100	3
3	PC-VII	WEEC203	Design of Weldments	4	-	-	25	75	100	3
4	PC-VIII	WEEC204	Welding Codes and Standards	4	-	-	25	75	100	3
5	PE-III	WEEE205	Professional Elective - III	4	-	-	25	75	100	3
6	PE-IV	WEEE206	Professional Elective - IV	4	-	-	25	75	100	3
7	PC Lab-II	WEEP207	Weldability Testing & Evaluation Lab	-	-	3	40	60	100	2
8	Seminar	WEES208	Seminar		2	-	100	-	100	1
			Total	**24**	**-**	**3**	**190**	**510**	**700**	**21**

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits
S e m e s t e r – III										
1	OE-I	WEEE301	Open Elective - I	4	-	-	25	75	100	3
2	OE-II	WEEE302	Open Elective - II	4	-	-	25	75	100	3
3	Thesis	WEET303	Thesis Phase - I	-	4	-	40	60	100	4
4	Ind Train	WEEI304	Industrial Training *		*		100	-	100	2
			Total	**8**	**4**	**-**	**90**	**210**	**300**	**12**

Note: * - Four weeks during the summer vacation at the end of II Semester.

Sl. No.	Category	Course Code	Course	L	T	P	CA	FE	Total	Credits
S e m e s t e r – IV										
1	Thesis	WEET401	Thesis Phase - II	-	8	-	60	40	100	13
			Total	**-**	**8**	**-**	**40**	**60**	**100**	**13**

L- Lecture ; **P-** Practical; **T-** Thesis; **CA-** Continuous Assessment; **FE-** Final Examination

M.E. Welding Engineering (Part Time) Degree Programme
Choice Based Credit System (CBCS)

Subjects of Study and Scheme of Examinations

Sl. No.	Category	Course Code	Course	L	P	T	CA	FE	Total	Credits	Equivalent Course Code in M.E. Full Time
Semester – I											
1	PC-I	WLEC101	Applied Mathematics	4	-	-	25	75	100	3	WLEC101
2	PC-II	WLEC102	Welding Processes-I	4	-	-	25	75	100	3	WLEC102
3	PC-III	WLEC103	Physical Metallurgy	4	-	-	25	75	100	3	WLEC103
			Total	**12**	**-**	**-**	**75**	**225**	**300**	**9**	

Sl. No.	Category	Course Code	Course	L	P	T	CA	FE	Total	Credits	Equivalent Course Code in M.E. Full Time
Semester – II											
1	PC-IV	WLEC201	Welding Processes-II	4	-	-	25	75	100	3	WLEC201
2	PC-V	WLEC202	Welding Metallurgy	4	-	-	25	75	100	3	WLEC202
3	PC-VI	WLEC203	Design of Weldments	4	-	-	25	75	100	3	WLEC203
			Total	**12**	**-**	**-**	**75**	**225**	**300**	**9**	

Sl. No.	Category	Course Code	Course	L	P	T	CA	FE	Total	Credits	Equivalent Course Code in M.E. Full Time
Semester – III											
1	PC-VII	WLEC301	Weldability Testing & Evaluation	4	-	-	25	75	100	3	WLEC104
2	PE-I	WLEE302	Professional Elective I	4	-	-	25	75	100	3	WLEE105
3	PE-II	WLEE303	Professional Elective II	4	-	-	25	75	100	3	WLEE106
4	PC Lab-I	WLEP304	Welding Processes Lab	-	3	-	40	60	100	2	WLEP107
			Total	**12**	**3**	**-**	**115**	**285**	**400**	**11**	

Sl. No.	Category	Course Code	Course	L	P	T	CA	FE	Total	Credits	Equivalent Course Code in M.E. Full Time
Semester – IV											
1	PC-VIII	WLEC401	Welding Codes, Standards, Safety & Quality	4	-	-	25	75	100	3	WLEC204
2	PE-III	WLEE402	Professional Elective III	4	-	-	25	75	100	3	WLEE205
3	PE-IV	WLEE403	Professional Elective IV	4	-	-	25	75	100	3	WLEE206

4	PC Lab-II	WLEP404	Weldability Testing & Evaluation Lab	-	3	-	40	60	100	2	WLEP207
	Seminar	WLES405	Seminar		-	2	100		100	1	WLES208
			Total	**12**	**3**	**-**	**115**	**285**	**400**	**11**	

Sl. No.	**Category**	**Course Code**	**Course**	**L**	**P**	**T**	**CA**	**FE**	**Total**	**Credits**	**Equivalent Course Code in M.E. Full Time**
S e m e s t e r – V											
1	OE-I	WLEE501	Open Elective V	4	-	-	25	75	100	3	WLEE301
2	OE-II	WLEE502	Open Elective VI	4	-	-	25	75	100	3	WLEE302
3	Thesis	WLET503	Thesis – Phase I and Viva Voce	-	-	4	40	60	100	6	WLET303
	Ind Train	WLEI504	Industrial Training		*	-	100		100	2	WLEI304
			Total	**8**	**-**	**4**	**90**	**210**	**300**	**12**	

Sl. No.	**Category**	**Course Code**	**Course**	**L**	**T**	**P**	**CA**	**FE**	**Total**	**Credits**	**Equivalent Course Code in M.E. Full Time**
S e m e s t e r – VI											
1	Thesis	WLET601	Thesis-Phase II and Viva Voce	-	-	8	40	60	100	13	WLET401
			Total	**-**	**-**	**8**	**40**	**60**	**100**	**13**	

L- Lecture ; **P-** Practical; **T-** Thesis; **CA-** Continuous Assessment; **FE-** Final Examination

LIST OF PROFESSIONAL ELECTIVES

1 Mechanical Behaviour of Materials
2 Failure Analysis and Material Characterization
3 Welding Automation
4 Residual Stresses & Distortion
5 Welding Power Sources
6 Welding Application Technology
7 Repair Welding & Reclamation
8 Health, Safety & Environmental Aspects of Welding
9 Life Assessment of Welded Structures
10 Total quality management

LIST OF OPEN ELECTIVES

1 Advanced Materials Joining
2 Non-Destructive Testing
3 Corrosion Engineering
4 Additive Manufacturing
5 Surface Modification Techniques
6 Finite Element Analysis

SYLLABUS

FIRST SEMESTER

WEEC101	APPLIED MATHEMATICS	L	T	P
		4	0	0

COURSE OBJECTIVES:

- To acquaint the student with the concepts in ordinary differential equations and vector calculus.
- To introduce probability theory and statistics from a computational perspective
- To enable the students to use the concepts of Testing of hypothesis, regression, correlation & Design of experiments

Two dimensional heat flow in transient state both in rectangular and circular plate- Three dimensional heat flow in transient state – Laplace equations in Cartesian, cylindrical and spherical polar coordinate systems; Solution of boundary value problems in ordinary differential equation – Introduction – Method of Finite Differences – Boundary conditions which do not involve dy/dx – Boundary conditions which involve dy/dx.

Maxima and Minima of functions of two variables – Lagrange multipliers – Functionals – Strong and Weak variations- Variational notation – Euler Lagrange equation –Euler Lagrangian equations for functional with higher order derivatives – simultaneous Euler Lagrangian equations for functionals with several independent variables subject to constraints.

Introduction to probability theory – Random variable – Probability density and distribution functions – Standard distributions: Geometric, Hypergeometric, Binomial, Poisson, Normal, Log-Normal, Exponential, Gamma, Beta and Weibull distributions – Applications – Baye's Theorem – Chebysev's Theorem.

Sampling distributions of statistical parameters – Standard error – central limit theorem – t, F and Chi-square distributions - Estimation – Point estimation - Interval estimation for population means, standard deviation, proportion, difference in mean, ratio of standard deviations, proportions - Maximum likelihood estimation, least square estimation and bayesian estimation.

Experimental designs – completely randomised blocks– Latin square – Analysis of variance – Methods for one, two factor models, concepts of factorial design, fractional factorial design, response surface methods and designs.

REFERENCES:

1. M.K.Venkatraman, Higher Engineering Mathematics for Engineers, National Publishing Company, 1994.

2. M.R. Spiegel, Advanced Mathematics for Engineering Scientists, Mc Graw Hill, 1985.
3. Irwin Miller & John Freund, Probability and Statistics for Engineers, , Prentice Hall of India, 2001.
4. D.C.Montgomery and G.C.Runger, Applied Statistics and Probability for Engineers, John Wiley and Sons, USA, 1994.

COURSE OUTCOMES:

1. Understand the basic concepts of differential equations and complex variables.
2. Solve the real life problems and Engineering problems.
3. Acquire basic knowledge in probability and statistics
4. Know the basic merits and demerits of various statistical tools
5. Plan the experiments and analyse the data scientifically.

Mapping of Course Outcomes with Programme Outcomes					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓				
CO2		✓	✓		
CO3			✓		
CO4		✓		✓	
CO5				✓	✓

WEEC102	**WELDING PROCESSES -I**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES:

- To impart a sound understanding of principles of different fusion welding processes.
- To understand the effect of welding parameters on weld quality.
- To study the importance of allied welding processes.

Introduction to Arc Welding: Classification of welding processes, arc physics, arc initiation methods; Electrical properties of arc – static arc characteristics – Power sources and power source characteristics – Modes of metal transfer; Manual metal arc welding**:** Ingredients and function of flux covering, different types of electrodes and their applications, handling and storage of consumables.

Gas tungsten arc welding (GTAW): electrode polarity, shielding gas, use of DC suppression, arc starting and stopping, Modern developments: Pulsed GTAW, magnetic arc oscillation welding, hot wire GTAW, Activated GTAW, Plasma arc welding - Process characteristics, advantages and applications of above techniques.

Gas metal arc welding (GMAW): **c**onsiderations of electrode polarity, shielding gas and filler composition, CO_2 welding, flux cored arc welding; Variants of GMAW : Surface Tension Transfer (STT), Cold metal Transfer (CMT), Narrow groove GMAW welding - Process characteristics, advantages and applications of above techniques.

Submerged arc welding (SAW): Advantages and limitations, process variables and their effects, significance of flux-metal combination, modern developments; Electroslag welding and Electro gas welding: Principles, process variables, advantages, limitations and applications.

Allied Processes: Gas welding and cutting, flame characteristics, different kinds of flames and their areas of applications; Brazing: torch brazing and furnace brazing, wetting and spreading characteristics, Role of flux and characteristics constituents of flux, grouping and applications; Soldering: Hand soldering, flame soldering, furnace soldering, hot gas blanket soldering.

REFERENCES:

1. Welding Handbook (Welding Processes), Volume II, 8th Edition, American Welding Society (AWS), 1991.
2. Metals Hand Book (Welding and Brazing), Volume VI, 9th Edition, American Society for Metals, 1989.
3. Little, R.L., Welding and Welding Technology, Tata McGraw Hill, New Delhi, 1996.
4. Nadkarni S.V., 'Modern Arc Welding Technology', Oxford and IBH Publisher, 1996
5. Parmar R. S., 'Welding Processes and Technology', Khanna Publishers, 2011.

COURSE OUTCOMES:

1. Understand the principles of fusion welding processes.
2. Distinguish between consumable arc and non-consumable arc welding procesess
3. Select an appropriate welding process for specific applications.
4. Acquire knowledge on modern developments in welding techniques
5. Awareness about allied welding processes.

Mapping of Course Outcomes with Programme Outcomes					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓		✓		
CO2		✓	✓		
CO3			✓		✓
CO4	✓			✓	
CO5					✓

WEEC103	**PHYSICAL METALLURGY**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES:

- To understand the different types of crystal structures.
- To study the phase changes in various alloys.
- To understand the various types of heat treatment techniques.

Unit cell, Crystal systems, BCC, FCC & HCP structures, Crystallographic planes & direction, Miller indices, Crystal imperfections - point, line & area defects. Constitution of alloys, compounds & solid solutions, Gibbs phase rule, lever rule – Phase diagrams, isomorphous, eutectic, peritectic, eutectoid and peritectoid reactions.

Diffusion in Solids, Fick's laws – Solidification, Nucleation and grain growth - constitutional supercooling, formation of dendrites - Directional solidification, Micro segregation, Macro segregation, Porosity and inclusions - Metallography - metallurgical microscope - preparation of specimen, micro & macro examination. Grain size ASTM grain size number, grain size measurement.

Iron- Carbon equilibrium diagram - Classification of steels - Purpose of alloying, effect of important alloying elements; Isothermal transformation diagram - Time Temperature Transformation Diagram, Continuous cooling transformation diagrams

Heat treatment of steel: full annealing, stress relief annealing, spheroidzing, normalizing, Hardenability and Jominy end quench test- Austempering and martempering - case hardening, carburising, nitriding, cyaniding, and carbon nitriding, flame hardening, induction hardening, vacuum hardening and cryogenic treatment.

Strengthening Mechanisms: Solid solution strengthening, Grain boundary strengthening, Cold working, Strain Aging, Strain hardening, Fine particle strengthening, Fibre strengtherning, Martensitic Strengthening - Grain refinement, Hall-Petch relation**.**

REFERENCES:

1. Sydney, H., Avner, S.H., "Introduction to Physical Metallurgy", McGraw Hill, 2008.
2. Raghavan, V., "Materials Science & Engineering", Prentice Hall of India Pvt.Ltd, 2015.
3. Higgins, R.A., "Engineering Metallurgy - Part I, Applied Physical Metallurgy", ELBS., 1993.
4. Williams, D., "Material Science and Engineering", Callister Wiley India Pvt. Ltd, Revised Indian edition, 2007.
5. George E. Dieter., "Mechanical Metallurgy", McGraw Hill Book Company, New York, 1988.

COURSE OUTCOMES:

1. Understand the basics of crystal structure.
2. Acquire knowledge on phase diagrams.
3. Select the heat treatment methods for specific alloys.
4. Design the alloys for specific applications.
5. Develop mechanisms to strengthen metals and alloys.

Mapping of Course Outcomes with Programme Outcomes					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓	✓			
CO2		✓	✓		
CO3			✓	✓	
CO4	✓		✓		
CO5				✓	✓

WEEC104	**TESTING AND INSPECTION OF WELDMENTS**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES:

- To understand the various weld defects and cracks.
- To impart a sound understanding of various weldability test.
- To study the basics of non-destructive test.

Weld defects and cracks: arc welding defects, classifications of cracks - hot and cold cracks, orientation of weld cracks- weld metal crack, base metal crack- factor contributing, specific crack- cheveron, lamellar, reheat crack; Fabrication Weldability Test: Houldcroft Tests - Lehigh Restraint Test - Variable-Restraint (or Varestraint) Test - Murex Hot-Cracking Test - Root-Pass Crack Test.

Hydrogen Induced Cracking (HIC) Testing**:** Implant Test - RPI Augmented Strain Cracking Test - Controlled-Thermal-Severity (CTS) Test - Lehigh Slot Weldability Test - Wedge Test- Tekken Test - Gapped-Bead-on-Plate or G-BOP Test; Service Weldability Test: Tensile test, nick break test, bend test, impact test.

Corrosion Tests: General Corrosion and its testing - Pitting Corrosion and its Testing - Intergranular Corrosion and its testing - Stress Corrosion and its Testing; Standards, testing procedures, and importance of the above tests.

Liquid Penetrant Testing - Principles, types and properties of liquid penetrants, developers, advantages and limitations of various methods, Testing Procedure, Interpretation of results. Magnetic Particle Testing- Theory of magnetism, inspection materials Magnetisation methods, Interpretation and evaluation of test indications; Eddy Current Testing-Generation of eddy currents, Properties of eddy currents, Eddy current sensing elements, Probes, Instrumentation, Types of arrangement, Applications, advantages, Limitations, Interpretation/Evaluation.

Ultrasonic Testing-Principle, Transducers, transmission and pulse-echo method, straight beam and angle beam, instrumentation, data representation, A/Scan, B-scan, C-scan. Radiography Testing: Principle, interaction of X-Ray with matter, imaging, film and film less techniques, types and use of filters and screens, geometric factors, characteristics of films - graininess, density, speed, contrast, characteristic curves, Penetrameters, Exposure charts, Radiographic equivalence.

REFERENCES:

1. Nadkarni. S. V. "Modern Arc Welding Technology", Oxford IBH. 1996.
2. R.S.Parmar, Welding Engineering & Technology, Khanna Publishers, New Delhi, 2013.
3. Baldev Raj, T.Jayakumar, M.Thavasimuthu "Practical Non-Destructive Testing", Narosa Publishing House, 2009.
4. Ravi Prakash, "Non-Destructive Testing Techniques", 1st revised edition, New Age International Publishers, 2010.

COURSE OUTCOMES:

1. Understand the causes of various welding defects and prevention methods.
2. Acquire knowledge on weldability testing and procedures.
3. Select an appropriate weldability test for a specific application.
4. Design weldments against environmental damage.

5. Distinguish between destructive and non-destructive testing.

Mapping of Course Outcomes with Programme Outcomes					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓		✓		
CO2		✓		✓	
CO3		✓	✓		
CO4	✓			✓	
CO5				✓	✓

WEEP107	**WELDING PROCESSES LABORATORY**	**L**	**T**	**P**
		0	**0**	**3**

COURSE OBJECTIVES:

- To understand the various joint configuration in welding.
- To study the effect of welding parameters on joint characteristics.
- To get hands on experience on software packages related to welding.

1. Simple exercises to make butt, lap, fillet joints using SMAW, GMAW, FCAW and GTAW processes.
2. Studying the effect of electrode polarity on weld bead formation
3. Studying the effect of heat input on temperature distribution
4. Evaluating the performance of Power Source Characterisitics
5. Studying the effect of shielding gases on weld quality
6. Studying the effect of welding parameters of various processes such as SMAW, GMAW, FCAW, GTAW on bead geometry
7. Studying the effect of friction welding parameters on weld quality
8. Studying the effect of friction stir welding parameters on weld quality
9. Studying the effect of electrical resistance welding parameters on weld nugget formation
10. Predicting the temperature distribution during fusion welding process by SYSWELD software
11. Predicting the residual stress distribution during fusion welding process by COMSOL software

COURSE OUTCOMES:

1. Acquire practical knowledge on fusion and solid state welding processes.
2. Understand the effect of welding parameters on quality of welded joint.
3. Expertise on using welding software packages.
4. Analyse the experimental results using statistical tools

Mapping of Course Outcomes with Programme Outcomes					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓	✓			
CO2		✓	✓		

CO3			✓	✓	
CO4				✓	✓

SECOND SEMESTER

		L	T	P
WEEC201	**WELDING PROCESSES - II**	**4**	**0**	**0**

COURSE OBJECTIVES:

- To acquire fundamental knowledge on principles of solid state welding processes.
- To understand the effect of welding parameters on weld quality.
- To study the importance of advanced welding processes.

Electrical Resistance Welding: General principle- heat generation in resistance welding- Electrical Characteristics of Resistance welding; Thermal Characteristics of Resistance Welding Heat Balance; Spot welding: Principle, welding sequence- Solidification in Resistance Spot Welding-applications of spot welding. Projection welding and Seam welding - Process details and working principle – parameters and their effects on weld quality - applications.

Friction based processes: Introduction, working principle, difference between friction welding and inertia welding, Operation steps, Metallurgy of friction welded joints, Fibre flow in friction welding, Defect formation, Process parameters, Applications; Friction Stir Welding: Introduction-working principle, Operation steps, Metallurgy of FSW joints, Defect formation-Process parameters, Tool design, tool geometry and tool materials, Heat generation in FSW process, Variants of FSW process;

Ultrasonic welding: Principle of operation, Metallurgy of ultrasonic welds, welding equipment, welding variables, types of ultrasonic welds, materials ultrasonically welded, advantages, disadvantages and applications of ultrasonic welding. Diffusion welding: Principle, types, parameters, materials welded, advantages, limitations and applications of diffusion welding. Explosive welding: principle, mechanism, arrangements, explosives used, metallurgy of explosive welds, testing of explosive welded joints, advantages, limitations and applications of explosive welding.

Beam Welding Processes: Basics of Laser, types of Lasers, Gaseous systems: - CO_2 Laser welding; Solid state Laser welding; Laser beam characteristics – Continuous Wave lasers, Pulsed Laser, High power diode lasers (HPDL) and Fibre Lasers; Principles of operation, effect of parameters on weld quality, advantages, and limitations, applications. Electron beam welding: Fundamentals; Beam characteristics; Different degrees of vacuum, Heat generation and regulation, equipment details in typical set-up, Parameters and its effects on weld quality, advantages and disadvantages, applications, characteristics of electron beam welded joints.

Allied Processes: Principle and concept of narrow gap welding, under water welding, thermit welding. Process characteristics, advantages and applications of above techniques. Principles and concepts of Induction brazing, Dip brazing, Resistance brazing, Vacuum brazing; Adhesive Bonding; High Frequency Welding; MIAB welding; Microwave joining.

REFERENCES:

1. Resistance welding: Fundamentals and Applications, Hongyan Zhang and Jacek Senkara, Second Edition, CRC Press, 2011.
2. John Norrish. "Advanced welding processes Technologies and process control" Wood head Publishing and Maney Publishing. Cambridge, England. 2006.
3. Christopher Davis. "Laser Welding- Practical Guide". Jaico Publishing House. 1994.
4. Rajiv S. Mishra, Murray W. Mahoney, Friction Stir Welding and Processing, ASM International, 2007.

COURSE OUTCOMES:

Understand the variants of resistance welding processes.

1. Acquire knowledge on friction based processes.
2. Utilize advanced joining techniques for critical applications
3. Select an appropriate welding process for a specific application.

Mapping of Course Outcomes with Programme Outcomes					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓		✓		
CO2		✓			
CO3		✓		✓	
CO4			✓	✓	

WEEC 202	WELDING METALLURGY	L	T	P
		4	0	0

COURSE OBJECTIVES:

- To understand the different types of zones formed during welding.
- To study the weldability of carbon and stainless steels.
- To understand the weldability of non-ferrous alloys.

Heat flow in welding: temperature distribution in welding, heat flow equations, simple problems, metallurgical effects of heat flow in welding. Regions of a Fusion Weld, Fusion Zone, Solidification of Metals, Macroscopic Aspects of Weld Solidification, Microscopic Aspects of Weld Solidification, Unmixed Zone (UMZ), Partially Melted Zone (PMZ), Penetration Mechanism, Segregation Mechanism, Heat Affected Zone (HAZ), Recrystallization and Grain Growth.

Weldability of Carbon Steels: Significance of carbon equivalent number, important problems encountered in welding of HSLA steels, Q&T steels, Cr-Mo steels and remedial steps; Preheat and Post heat requirements. Austenite-to-Ferrite transformation in low-carbon, low-alloy steel welds, Microstructure development, Factors affecting microstructure.

Weldability of Stainless Steels: stainless steel classification, Schaffler diagram, Delong diagram, WRC diagrams, problems associated with welding of austenitic stainless steel, ferritic stainless steel, martensitic stainless steel and duplex stainless steels;

Classification of aluminium alloys – various processes used for aluminium welding-problems involved in aluminium welding – precaution and welding procedure requirements-CCT diagrams of aluminium alloys, Age hardening behaviour of aluminium welds. Classification of magnesium alloys – various processes used for magnesium welding-problems involved in magnesium welding – precaution and welding procedure requirements.

Classification of titanium alloys – various processes used for titanium welding- problems involved in titanium welding – precaution and welding procedure requirements; Classification of nickel alloys – various processes used for nickel welding- problems involved in nickel welding – precaution and welding procedure requirements; CCT diagrams of Ti and Ni base alloys. Microstructural features of Ti and Ni base alloy welds.

REFERENCES:

1. Sindo Kou, Welding metallurgy, 2nd edition, John Wiley & Sons, 2003
2. John C. Lippold, Damian J. Kotecki, Welding metallurgy and weldability of stainless steels, 2005.
3. Saferian.D, The Metallurgy of Welding, Pergamon Press, 1985.
4. Linnert G.E, Welding Metallurgy, Vol I & II, 4th edition, American Welding Society, 1994.
5. Kenneth Easterling, Introduction of Physical Metallurgy of Welding, 2nd Edition, Butterworth - Heinman, 1992.
6. Welding Engineering and Technology, R.S. Parmar, Khanna Publishers, 2013.

COURSE OUTCOMES:

1. Understand the interaction between heat and metals/alloys.
2. Predict the microstructure of different regions of a weldment.
3. Understand the weldability issues in ferrous and non-ferrous alloys.
4. Estimate the pre-heat, post heat and interpass temperatures for welding.
5. Select appropriate welding procedures to weld a specific alloy.

Mapping of Course Outcomes with Programme Outcomes					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓		✓		
CO2		✓	✓		
CO3			✓		
CO4				✓	
CO5					✓

WEEC 203	**DESIGN OF WELDMENTS**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES:

- To understand the basics of engineering mechanics.
- To understand the different types of joints and its effects.
- To study the life assessment and fracture mechanics concepts.

Introduction to Engineering Mechanics: Free body diagram- types of supports and their reactions, Requirements of stable equilibrium, Moment of a Couple, Moments of force about a point and an axis, Vectorial representation of moments and couples, Scalar component of a moment, Equilibrium of rigid bodies in Two and Three Dimensions, Free body diagram and equilibrium of trusses and frames.

Properties of Solids: Determination of Areas, first moment of area, Centroid of sections-Rectangle, circle, triangle, T-Section, I-Section, Angle section and Hollow section, Second and product moments of plane area – Rectangle, circle, triangle, T-Section, I-Section, Angle section and Hollow section, Parallel axis theorem, Perpendicular axis theorem, Polar moment of inertia, Mass moment of inertia- Thin plates and simple solids.

Types of weld joints, butt joint, lap joint, T-joint, cruciform joint, corner joint and edge joint, fillet and groove welds. complete and partial joint penetration, classification and types of grove welds, single and double fillet welds, combined partial joint penetration grove and fillet welds, size of fillet and grove welds, weld symbols, standard system of representation of welded joints, brazed and soldered joints.

Design of Welded Joints, Joint design based on stresses in the structure; Joint design for structural elements such as bars, beams, plates, slabs, columns, trusses, plate girders, cylindrical shells and pressure vessels and pipe lines. Design for flanged connections, structural hollow sections and branch connections; Welded joint design to control distortion and shrinkage, residual stresses and cracking.

Weld design for dynamic loading: Design for fluctuating and impact loading - dynamic behaviour of joints - stress concentrations - fatigue analysis - fatigue improvement techniques - permissible stress- life prediction. Principles and methods and practical approach for crack arresting; Concept of stress intensity factor - LEFM and EPFM concepts - brittle fracture-transition temperature approach - fracture toughness testing, application of fracture mechanics to fatigue, weldments design for high temperature applications.

REFERENCES:

1. Engineering Mechanics (Statics and Dynamics) by Mclean and Nelson (Schaum's Outline Series) McGraw-Hill Book Company
2. Engineering Mechanics by Irving H. Shames, Prentice-Hall of India, 4th ed., 2004.
3. Gray T. G. E. "Rational Welding Design", Butterworth's, 1982.
4. Bhattacharya M. "Weldment Design", Association of Engineers, 1991.
5. Radhakrishnan V. M. "Welding Technology and Design", Revised Second Ed., New Age International Publishers. 1998.
6. Hertzberg R. W. "Deformation and Fracture of Mechanics of Engineering Materials", John Wiley, 1996.
7. Dieter G. "Mechanical Metallurgy", Tata McGraw Hill, 1988.

COURSE OUTCOMES:

1. Acquire knowledge on mechanics of solids.
2. Understand the different configurations of the welds.
3. Estimate stresses acting on welded joints.
4. Apply fracture mechanics concepts to design the welds
5. Design a welded assembly for a specific application.

Mapping of Course Outcomes with Programme Outcomes					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓	✓			
CO2			✓		
CO3		✓		✓	
CO4				✓	
CO5				✓	✓

WEEC 204	**WELDING CODES AND STANDARDS**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES:

- To study the welding procedure specifications and procedure qualification records.
- To study the codes and standards related to welding and its testing.
- To improve the quality of welded components.

Welding Procedure Specification (WPS); Procedure Qualification Record (PQR); Essential Variables; supplementary essential and non-essential variables; Base Material Grouping: P numbers and Group numbers. Filler Metal Grouping: F number and A numbers. Introduction to ASME sec IX: Article I to IV.

Welding procedure qualification preparation of preliminary WPS; test plan: Preparation of test coupon/ welding of a test coupon welding parameter record; Post weld heat treatment and NDE; Marking, Machining and testing, evaluation of test result; Preparation of Procedure Qualification Record (PQR); Re-Write the WPS based on welding Parameter record and ASME Qualification range;

NACE MR0175 requirements - hardness test requirement and acceptance criteria; Additional requirement for API 6A, API 16A, API17D; Determination of pre heating and post weld heat treatment requirement based on ASME VIII.

Welding consumable testing as per ASME sec II C- All weld test (Tensile & Impact); Brief Introduction to AWS D1.1, API 1104, ISO – Procedure qualification and welder qualification requirements. Quality control: Welding Quality requirements, Quality Assurance, Quality Plan, Quality Standards for Welding;

Welder's Qualification based on ASME IX requirements; Selection and welding of a test coupon for welder qualification; qualification based on RT and bend test; qualification range; Continuity record; requalification Qualification based on first productive weld; Welder qualification based on IBR requirements. Welder Testing on different position of welding, Brief introduction and awareness on certification for welding inspector AWS, CWSIP, International Welding Engineers.

REFERENCES:

1. AWS D1.1 Structural Welding Code, 2011.
2. API 5L, 2009
3. API 1104, 2008
4. ASME Section VIII – Division 1, 2011.
5. ASME Section IX, 2011.
6. ASME Section II Part A and C, 2011.

COURSE OUTCOMES:

Acquire knowledge on welding procedures.

1. Prepare the procedure qualification record.
2. Select a consumable for a specific application.
3. Assure the quality of welded joints.
4. Understand the national and international codes and standards.

Mapping of Course Outcomes with Programme Outcomes					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓		✓		
CO2		✓			
CO3			✓		
CO4				✓	
CO5			✓		✓

WEEP 207	WELDABILITY TESTING & EVALUATION LABORATORY	L	T	P
		0	0	3

COURSE OBJECTIVES:

- To evaluate the mechanical properties of welded joints.
- To gain practical knowledge on hot and cold crack tests.
- To provide training on NDT instruments.

1. Tensile properties evaluation of welded joints
2. Impact toughness properties evaluation of welded joints
3. Microhardness survey across the weld cross section
4. Bend Test (side and face) on welded joints
5. All weld metal properties evaluation
6. Macro and Micro structure analysis of weldments
7. Implant Testing for Hydrogen Induced cracking
8. Controlled Thermal Severity Test
9. Flaw Detection by Ultrasonic Testing
10. Flaw Detection by Magnetic Particle Inspection
11. Flaw Detection by Eddy Current Testing
12. Study of RT Films

COURSE OUTCOMES:

Evaluate the mechanical properties of welded joints as per standards.

1. Characterize microstructural features using modern tools.
2. Acquire practical knowledge on weldability testing.
3. Inspect weld quality as per the standards.
4. Utilize NDT instruments to assess the damages in welded joints.

Mapping of Course Outcomes with Programme Outcomes					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓	✓			
CO2			✓		✓
CO3				✓	
CO4			✓		
CO5				✓	

WEES208	SEMINAR	L	T	P
		0	2	0

COURSE OBJECTIVES:

- To work on a technical topic related to Welding Engineering and acquire the ability of written and oral presentation
- To acquire the ability of writing technical papers for Conferences and Journals

The students will work for two periods per week guided by student counsellor. They will be asked to present a seminar of not less than fifteen minutes and not more than thirty minutes on any technical topic of student's choice related to Welding Engineering and to engage in discussion with audience. They will defend their presentation. A brief copy of their presentation also should be submitted. Evaluation will be done by the student counselor based on the technical presentation and the report and also on the interaction shown during the seminar.

COURSE OUTCOMES:

1. The students will be getting the training to face the audience and to interact with the audience with confidence.
2. To tackle any problem during group discussion in the corporate interviews.

Mapping of Course Outcomes with Programme Outcomes					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1					
CO2					

THIRD SEMESTER

WEET303	**THESIS PHASE – I**	**L**	**T**	**P**
		0	**4**	**0**

COURSE OBJECTIVES:

- To develop the ability to solve a specific problem right from its identification and literature review till the successful solution of the same.
- To train the students in preparing project reports and to face reviews and viva voce examination.

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

- Take up any challenging practical problems and find solution
- Learn to adopt systematic and step-by-step problem solving methodology

Mapping of Course Outcomes with Programme Outcomes					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓	✓			✓
CO2		✓		✓	

WEEI304	**INDUSTRIAL TRAINING**	**L**	**T**	**P**
		0	*****	**0**

COURSE OBJECTIVES:

- To train the students in the field work related the Welding Engineering and to have a practical knowledge in carrying out welding field related works.

- To train and develop skills in solving problems during execution of certain works related to Welding Engineering.

The students individually undergo a training program in reputed concerns in the field of Welding Engineering during the summer vacation (at the end of second semester for full – time / fourth semester for part – time) for a minimum stipulated period of four weeks. At the end of the training, the student has to submit a detailed report on the training he had, within ten days from the commencement of the third semester for Full-time / fifth semester for part-time. The students will be evaluated by a team of staff members nominated by head of the department through a viva-voce examination.

* - *Four weeks during the summer vacation at the end of II Semester.*

COURSE OUTCOMES:

1. The students can face the challenges in the practice with confidence.
2. The student will be benefited by the training with managing the situation arises during the execution of works related to Welding Engineering.

Mapping of Course Outcomes with Programme Outcomes					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1			✓	✓	
CO2				✓	✓

FOURTH SEMESTER

WEET401	**THESIS PHASE – II**	**L**	**T**	**P**
		0	**8**	**0**

COURSE OBJECTIVES:

- To develop the ability to solve a specific problem right from its identification and literature review till the successful solution of the same.
- To train the students in preparing project reports and to face reviews and viva voce examination.

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

- Take up any challenging practical problems and find solution
- Learn to adopt systematic and step-by-step problem solving methodology

Mapping of Course Outcomes with Programme Outcomes					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓	✓			✓
CO2		✓		✓	

WEEXXXX	MECHANICAL BEHAVIOUR OF MATERIALS	L	T	P
		4	0	0

COURSE OBJECTIVES:

- To impart a sound understanding of the tensile, hardness and toughness behaviour of materials.
- To understand the factors affecting the fatigue and fracture behaviour of materials.
- To study the time dependant mechanical behaviour of materials.

Tensile behaviour: Engineering stress-strain curve: Derivation of tensile strength, yield strength, ductility, modulus of elasticity, resilience and toughness from stress strain curves, comparison of stress-strain curves for different materials - True Stress - Strain Curve: true stress at maximum load, true fracture strain, true uniform strain, Necking strain - necking Criteria - Effect of strain rate, temperature and testing machine on flow properties - Notch tensile test - Tensile properties of steel, aluminium, titanium, magnesium and nickel base alloys**.**

Hardness & Toughness behaviour: Hardness Measurements: Brinnell hardness, Meyer's hardness, Vickers hardness, Rockwell hardness and Microhardness - Relationship between hardness and the flow curve - Hardness at elevated temperatures - Toughness measurements: Charpy, Izod and Instrumented Charpy - Transition Temprature Curves: significance, various criteria, metallurgical factors affecting the curves, Drop weight test, explosion crack starter test, Dynamic tear test and Robertson crack arrest test - Fracture Analysis Diagram.

Fatigue behaviour: Introduction: Stress cycles, S-N curves Goodman diagram, Soderberg diagram, Gerbar diagram - Cyclics stress strain curve - Low cycle fatigue - Strain life Equation - Fatigue mechanisms - High cycle fatigue - Effect of following parameters on Fatigue: mean stress, stress concentration, specimen size, surface roughness, residual stress, microstructure and temperature. Fatigue crack propagation - Fatigue under combined stresses - Cumulative fatigue damage - Design for fatigue.

Fracture behaviour: Types of fracture in metals: ductile and brittle fracture - Theoretical cohesive strength of metals - Griffith theory - Metallographic aspects of fracture - Fractography - Notch effect - Concept of fracture curve - Fracture under Combined Stresses - Environment sensitive fracture: hydrogen embrittlement, stress corrosion cracking - Fracture mechanics: strain energy release rate, stress intensity factor, crack deformation modes, fracture toughness testing, plastic zone size correction, crack opening displacement, J-integral and R-curve.

Time dependant mechanical behaviour: Creep curve - Stress rupture Test - Structural changes during creep - Mechanisms of creep deformation - Deformation mechanisms maps - Activation energy for steady state creep - Fracture at elevated temperature - Introduction to high temperature alloys - Predication of long time properties - Creep under combined stresses - Creep- Fatigue Interaction.

REFERENCES:

1. George E.Dieter, Mechanical Metallurgy, Tata McGraw – Hill Education Pvt.Ltd, 3rd Edition. New Delhi, 2014.

2. Hertzberg R.W., Richard W. Hertzberg , Richard P. Vinci , Jason L. Hertzberg, Deformation and Fracture Mechanics of Engineering Materials, John Wiley & Sons, Inc., 5th Revised Edition, New York, 2012.
3. Thomas Courtney. H, Mechanical Behavoiur of Materials, McGraw Hill 2nd Edition, 2005.
4. M.A.Meyers and K K.Chawla, Mechanical Behavior of Materials, Cambridge University Press, 2009
5. H. Kuhn and D. Medlin , Metals Handbook, Mechanical Testing, Vol.8, American Society for Metals, Metals Park, Ohio, 2000
6. Broek.D, Elementary Engineering Fracture Mechanics, 4th Edition.,Martinus Nijhoff Publishing , The Hague, 2008

COURSE OUTCOMES:

Understand the mechanical behaviour of metals;

1. Protect the metals from fatigue damage.
2. Understand the environmental factors affecting the mechanical behaviour of materials
3. Evaluate the high temperature properties of metals.
4. Design the metals for specific applications;

Mapping of Course Outcomes with Programme Outcomes					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓		✓		
CO2		✓		✓	
CO3			✓		
CO4				✓	
CO5			✓		✓

WEEXXXX	**FAILURE ANALYSIS & MATERIALS CHARACTERIZATION**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES:

- To understand different types of failures and its prevention.
- To understand the working principles of optical and electron microscopy.
- To study about the X-ray diffraction techniques.

Types of failure, causes and classification of failures, Classification and identification of various types of fractures. Stages of failure analysis: Site visit, Collect background information, Sample removal and testing protocol, Sample removal, Cleaning, and storage, Chemical analysis, Testing.

Fracture characteristics revealed by microscopy, characteristics of ductile and brittle fracture, factors affecting fatigue failures, creep failures, creep-fatigue failures, corrosion-fatigue failures, stress corrosion failures; Failure of weldments - reasons for failures, procedures for weld failure analysis; Some case studies of weld failures in aerospace, shipbuilding, petroleum industries, oil & gas, food processing, paper & pulp, pressure vessels & piping, power plants, etc.

Optical Metallography - Macro examination, principle and working of optical microscope, specimen preparation, optical properties - numerical aperture, resolving power, depth of focus, depth of field, aberrations in optical microscopes and their remedial measures, different microscopic techniques-dark field microscopy, phase-contrast microscopy, polarized light microscopy, interference microscopy, high temperature microscopy; quantitative metallography.

Techniques of Electron Microscopy - Transmission electron microscope - specimen preparation, imaging modes, applications, selected area diffraction; Scanning electron microscope - operating modes and applications, electron probe micro analyser - qualitative and quantitative analysis, Atomic force microscopy, field ion microscopy - principle, instrumentation and applications.

X Ray Diffraction Techniques: Bragg's law – Diffraction methods – Laue, rotating crystal and powder methods. Intensity of diffracted beams – structure factor calculations. Diffractometer – general feature and optics – proportional scintillating and Geiger counters. X-ray diffraction application in the determination of crystal structure, lattice parameter and residual stress – quantitative phase estimation. Surface Chemical Analysis Techniques: - Auger Electron Spectroscopy–principle, instrumentation and applications in metallurgy.

REFERENCES:

1. Metals Hand Book, Failure Analysis and Prevention, Vol. 11, ASM, 2002.
2. Rolfe and Barsom, Fracture and Fatigue control in structures, Prentice Hall, 1992.
3. Angelo P C, "Materials Characterization", Reed Elsevier India Pvt Ltd, 2013.
4. Whan R E (Ed), ASM Handbook, Volume 10, Materials Characterisation ", ASM international, USA, 1986.
5. Phillips V A, "Modern Metallographic Techniques and their Applications", Wiley Eastern, 2001.
6. Cullity B D., Stock S R "Elements of X-ray Diffraction", Prentice Hall, Inc 2001.

COURSE OUTCOMES:

1. Differentiate different types of failures in metals.
2. Identify the causes for various failures.
3. Acquire knowledge on characterization tools.
4. Understand the environmental factors promoting the failures.
5. Select an appropriate tool to analyse a specific failure.

Mapping of Course Outcomes with Programme Outcomes					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1		✓			✓
CO2			✓		
CO3	✓			✓	
CO4			✓		
CO5		✓			

WEEXXXX	**WELDING AUTOMATION**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES:

- To impart a sound understanding of automated devices used for welded structures.
- To study the importance of computer integrated manufacturing.
- To acquire knowledge on design and control of robots in welding.

Automated devices for welded structures**-** Pre assembly and tacking by welding distortion by welding and its prevention tolerances welded structure and the concept of automated devices complexity of devices for pre assembly and mechanization/automation in welding. Mechanisation of pipes and tubes - Butt welding, TIG orbital welding of thin and thick Members; MIG/MAG orbital welding induction pressure welding, flush butt welding tube-tube-plate welding

Mechanisation in welding: Mechanisation of flat / circular joints thin / thick sheets (Resistance weld/arc weld) mechanization of I beams (arc welding) longitudinal circumferential SA welding (roller blocks, column booms, flux supports) circular / spherical welding joints (rotating tables positioners) manufacture of welding longitudinal welded pipes by induction, TIG, plasma and SA welding a spiral welded pipes.

Concept of automation lines **-** The tolerances and welding procedures and quality, auxillary equipment (fixture, transport, electrical, pneumatic, hydraulic) welding procedures for automation. Automatic lines for welding, automation of track wheels, automation of pipe's spiral welding.

Introduction to CIM: An overview of CIM – Significance of CIM; Flexible Manufacturing System (FMS): Definition – Components – Types – Flexibilities – Materials Handling and storage system: Conveyors: Types – Automated Guided Vehicle (AGV): Types, Guidance and Routing – Automated Material Handling and Storage system (AS/RS) – FMS Layouts – Benefits of FMS; Group Technology (GT): Part family – Parts classification and coding – Cellular Manufacturing – Benefits of GT.

Industrial Robotics: Automation and Robotics – Robot Anatomy, Joint motions – End effectors: Grippers and Tools – Robotic sensors – Robot vision system – Robot programming – Robot cell: Types – Design and control; Robotics in welding **-** The concept of robotics, the robot design and its applications for welding, welding procedures adequate for robotics, programming of robot's welding tolerances of assemblies for robot welding, auxillary devices for robot welding, new generation of welding robots, self-alignment by current arc variation, light spot leading system.

REFERENCES:

1. The Procedure Handbook for Arc Welding", Lincoln Electric. USA, 2012.
2. Welding Handbook, Vol. 3, 7th edn., American Welding Society, 1998.
3. Kozyrev, "Industrial Robots Handbook", Mir Publishers, Moscow, 2011.
4. Mikell P. Groover, Automation, Production Systems and Computer Integrated Manufacturing, Prentice-Hall of India Pvt. Ltd., New Delhi, 2002.
5. Mikell P. Groover, Mitchell Weiss, Roger N. Nagel and Nicolas G. Odery, Industrial Robotics: Technology, Programming and Applications, McGraw-Hill Book Co., 1986.

COURSE OUTCOMES:

Understand the working principles of automated devices.

1. Improve the welding performance through automation.
2. Apply the robots in critical components welding.
3. Design an automation layout for specific component fabrication.
4. Integrate computers, robots and welding processes.

Mapping of Course Outcomes with Programme Outcomes					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓			✓	
CO2		✓			
CO3			✓		
CO4				✓	
CO5		✓			✓

		L	T	P
WEEXXXX	**RESIDUAL STRESSES AND DISTORTION**	**4**	**0**	**0**

COURSE OBJECTIVES:

- To impart a sound knowledge on mechanisms of residual stress and distortion.
- To study the factors affecting residual stresses.
- To study the different methods of residual stress and distortion measurements.

Residual stresses: types of residual stresses, mechanisms of residual stress formation, control of residual stresses and measurement and calculation of residual stresses, Residual Stress Pattern, Causes of residual stress- -residual stresses in different joints- Methods of relieve stress.

Factors affecting Residual stress: Effect of welding parameters on heat distribution-calculation of peak temperatures- thermal cycles- cooling rate and solidification- Residual stresses and their distribution in welds- influence of residual stresses in static and dynamic loading- Distortion in weldments.

Residuals Stress measurement Methods: Deep-Hole Drilling, Incremental Centre-Hole Drilling, Neutron Diffraction, Contour, Ring Core, Sachs Boring, Slitting, Synchrotron Diffraction, Ultrasound and X-ray Diffraction.

Distortion: types of distortion-longitudinal, transverse, angular, bowing, causes of distortion-heat input, restraint, inherent stresses in parent metal. Control of distortion-joint design, assembly procedure-pre-setting method: restrained method, welding procedure, welding process, type and size of electrode welding rod and wire, number of sequence of runs, size of deposit and welding position- welding current and welding speed, welding sequence and techniques- Other Techniques for Distortion Control.

Correction of distortion: manual, use of press, local heating - hot shrinkage, use of heat strip, use of heat triangle, Concept of residual stresses. Distortion in cutting-factors causing distortion, examples of distortion in cutting. Distortion control techniques in cutting-immersion in water, flushing behind the cut, simultaneous cutting, wedging, step cutting, welding behind the cut, locking the scrap.

REFERENCES:

1. Welding Technology for Engineers, Eds. Baldev Raj, V. Shankar,A.K. Bhaduri, Narora Publishing House, 3 rd Reprint,2009
2. V. M. Radhakrishnan, "Welding Technology and Design", Revised Second Ed., New Age International Publishers.
3. A Guide to Designing Welds – J.G. Hicks, Woodhead Publising Ltd., 2001.
4. The Science and Pratice of Welding, Vol-1 : Welding Science and Technology, 1996.
5. Messler R.W., **"**Principles of Welding**",** John Wiley & Sons, 1999.

COURSE OUTCOMES:

1. Understand the causes of residual stresses and distortion.
2. Estimate the residual stresses and distortion in the welded joints.
3. Design the weld joint with minimum residual stress and distortion.

Mapping of Course Outcomes with Programme Outcomes					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1			✓	✓	
CO2		✓			✓
CO3			✓		

WEEXXXX	**WELDING POWER SOURCES**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES:

- To impart a sound understanding of electrical characteristics of welding power sources.
- To study the importance of various power sources.
- To measure the heat input during welding process.

Electrical discharges in gases. Discharge characteristic curve- Uses of electric arc- Three zones in arc - Cathode zone - Thermionic emission Work function for different metals - Plasma column –ionization potential of different gases – Distribution of potential across arc. Simplified voltage current characteristic of electric arc. Effect of arc length , shielding gas on arc voltage- Heat generation and distribution- forces affecting metal transfer-pinch effect- arc force due to shape of arc- modes of metal transfer.

Need for welding power source. Classification of welding power sources based on Construction type- Generators (Motor driven and engine driven) –Transformers (Moving coil Moving core) Rectifiers (Diode and SCR based) – Transistorised and Inverter type; Classification based on output characteristics- Drooping and Flat-Interaction of electric arc with different output characteristic of power source. Self-regulation of arc length with flat characteristic-Different methods of control of volt-ampere characteristics, OCV and short circuit current control, use of chokes and saturable reactors.

MMAW- Generators-rectifiers modern inverter –hot start ; TIG- DC Pulsed DC Square wave AC –Slope-up slope-down of current -HF unit; MIG/CO2 –Rectifiers -Electronic controls- spatter control- pulsed MIG- STT; SAW- DC AC Tandem arc; Plasma Arc- Transferred Arc and Non transferred arc; Duty cycle of welding power source –Estimating duty cycles for different welding currents; Arc starting methods for MMAW. TIG MIG SAW and Plasma ARC.

Measurement of welding current and voltage-welding speed- heat input calculations; Efficiency of different welding processes; Temperature measurement using RTD, Thermo couple and thermal chalk; Stress and strain measurement using strain gauges Quarter Half and Full bridge configurations; Arc welding analyser; Furnace temperature control ; Pre heat and post weld heat treatment equipments; Noise level measurement for hazards

Furnace temperature control Difference between mechanization and automation; Need for weld seam tracking- Methods of seam tracking- self guided- sensor based – using arc as sensor-laser sensor; Long seam – circseam welding – orbital welding of pipes- 3D curved joints in pipes; Introduction to robots- rectangular – cylindrical – gantry type - articulated arms

REFERENCES:

1. Welding Handbook (Welding Processes), Volume II, 8th Edition, American Welding Society (AWS), 1991.
2. Richardson V. D., ‘ Rotating Electric Machinery and Transformer Technology’, Prentice Hall of India, 1978
3. Parmar R. S., ‘Welding Processes and Technology’, Khanna Publishers, 1997
4. Say M. G. Ed., Electrical Engineering Reference Book, 1973
5. Siemens Aklengesel, Chart Electrical Engineering Hand Book, 1987
6. S.V.Nadkarni, Modern Arc Welding Technology, Oxford-IBH Publisher, 1996.

COURSE OUTCOMES:

1. Understand the electrical aspects of welding power sources.
2. Classify and characterize welding power sources.
3. Acquire knowledge on instruments used for testing power sources.
4. Measure the heat input and efficiency of different welding processes.
5. Select an appropriate power source for a specific application.

Mapping of Course Outcomes with Programme Outcomes					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1			✓		
CO2		✓			
CO3	✓			✓	
CO4			✓		
CO5					✓

WEEXXXX	**WELDING APPLICATION TECHNOLOGY**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES:

- To study the applications of welding in process and fabrication industries.
- To impart sound knowledge on recent trends and developments in welding.

- To understand the need of field welding in pressure vessel applications.

Heat exchanges, power cycle piping, super heaters, reheaters, economiser, auxiliary pipes, materials, processes and testing/inspection

Materials, processes, fabrication techniques and field welding for pressure vessel applications

Materials, processes, fabrication and construction, use of automatic welding and systems in automobile industry, automation

Oil and gas industry, materials, processes, fabrication, inspection and testing, case studies, recent trends and developments

Materials, processes, fabrication, inspection and testing, reasons for stringent quality control measures in nuclear industry

REFERENCES:

1. American Welding Society, 'Guide for Steel Hull Welding', 1992
2. Gooch T. S., 'Review of Overlay Welding Procedure for Light Water Nuclear Pressure Vessels', American Welding Society, 1991
3. Winter Mark H., 'Materials and Welding in Off-Shore Constructions', Elsevier, 1986
4. Welding Institute Canada, 'Welding for Challenging Environments', Pergamon Press, 1996

COURSE OUTCOMES:

1. Acquire sound knowledge on recent trends and developments in welding.
2. Understand the fabrication procedures employed in various industries.
3. Select appropriate material, welding process, consumable and procedures to fabricate a component.
4. Assure weld quality of welded components as per the standards.

Mapping of Course Outcomes with Programme Outcomes					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓				
CO2			✓		
CO3		✓			
CO4				✓	

WEEXXXX	**REPAIR WELDING & RECLAMATION**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES:

- To understand the various causes of failures and its prevention methods.
- To study the different repair welding techniques.
- To study the importance of hard facing techniques.

Engineering aspects of repair, aspects to be considered for repair welding, techno-economics, repair welding procedures for components made of steel casting and cast iron, full-mould process, AWA bath tub test for cast iron repair, special procedures to avoid post-repair stress relief heat treatment, half bead, temper bead techniques, usage of Ni base filler metals.

Damaged bends in gas transmission pipe lines, heat exchanger repair techniques – explosive expansion, plugging, etc., creep damaged high temperature components, repair of cracked petroleum pressure vessel/ reactor.

Types of wear, wear resistant materials, selection of materials for various wear applications, reclamation surfacing techniques. Selection of welding processes for reclamation.

Integrating repair/maintenance into on-going operation, radiation protection, steam generators repair, plugging.

Hardfacing, Cladding, Overlaying by shielded metal arc welding, gas metal arc welding, flux cored arc welding, gas tungsten arc welding, submerged arc welding, gas welding, plasma transferred arc welding, laser welding; consumables for weld surfacing, dilution measurement, microstructural features, Applications.

REFERENCES:

1. "Recommended Practice for Repair Welding and Fabrication Welding of Steel Casting", Steel Foundry Research Foundation, 1981.
2. Nagendra Reddy A., "Maintenance Welding Made Easy", Jaico Publishing House, 1997.
3. Lim Cottrel C., The Welding Institute, "Welding Cast Irons", 1991.
4. "Weld Surfacing and Hardfacing", The Welding Institute, 1987.

COURSE OUTCOMES:

1. Understand the significance of repair welding.
2. Select a suitable repair welding technique for specific damage.
3. Prescribe suitable consumables to enhance the life of the components.

Mapping of Course Outcomes with Programme Outcomes					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1		✓			
CO2	✓				✓
CO3			✓		

WEEXXXX	**HEALTH, SAFETY & ENVIRONMENTAL ASPECTS IN WELDING**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES:

- To understand the needs of safety in welding.
- To study the causes and controlling of welding pollutions.
- To understand the techniques available to control the welding fumes.

Introduction to health and safety requirements Survey of safety and environmental aspects, risk assessment, Hazards of electric power, Electro-magnetic fields, Connecting of equipments, , Protective clothing and equipment, Health effects of grinding (vibration and dust).

Cylinder storage and handling, Oxygen environment enrichment, Health and safety requirements for each welding processes, Ergonomics, Commonly occurring accidents & Prevention Methods; Special risks for automated processes.

Welding fume emission, Exposure limits (Maximum Allowable Concentration) MAC and UEL (Upper Exposure Limit) values, Ventilation filters and fume extraction (type of equipment and airflow), Determination of acceptable emissions, Tests for measuring emissions, Noise levels and ear protection, Standards and regulations; Problems with shielding gases, Radiation and eye protection.

Pollution: Definition - Cause, effects and control measures of Air pollution - Water pollution - Soil pollution - Marine pollution- Noise pollution - Thermal pollution - Nuclear hazards - Solid waste Management: Causes, effects and control measures of urban and industrial wastes - Role of an individual in prevention of pollution. Environmental ethics: Issues and possible solutions - Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust.

Wasteland reclamation - Consumerism and waste products - Environment Protection Act - Air (Prevention and Control of Pollution) Act - Water (Prevention and control of Pollution) Act - Wildlife Protection Act - Forest Conservation Act - Issues involved in enforcement of environmental legislation; Role of Information Technology in Environment and human health.

REFERENCES:

1. Trivedi R.K., Handbook of Environmental Laws, Rules Guidelines, Compliances and Stadards, Vol I and II, Enviro Media (R)
2. Trivedi R. K. and P.K. Goel, Introduction to air pollution, Techno-Science Publication (TB)
3. Miller T.G. Jr. Environmental Science, Wadsworth Publishing Co. (TB)
4. Mhaskar A.K., Matter Hazardous, Techno-Science Publication (TB)

COURSE OUTCOMES:

1. Reduce the risks of accidents during welding.
2. Select suitable protective methods to reduce welding emission.
3. Awareness on health hazards to welders
4. Understand the prevention and control of air pollution.

Mapping of Course Outcomes with Programme Outcomes					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓		✓		
CO2		✓			
CO3				✓	
CO4		✓			✓

WEEXXXX	LIFE ASSESSMENT OF WELDED STRUCTURES	L	T	P
		4	0	0

COURSE OBJECTIVES:

- To predict the life of the welded components.
- To study the different failure mechanisms.
- To evaluate the structural integrity of welded structures.

Historical evolution and operation of power plants and petrochemical plants – general description, temperature, pressures and materials, failure in plants, 0 –definition of failure.

Weld metal toughness evaluation methods, significance of Ductile to Brittle Transition Temperature (DBTT), Linear Elastic Fracture Mechanics (LEFM) approach, Elastic Plastic Fracture Mechanics (EPFM) approach, temper embrittlement, hydrogen embrittlement.

Mechanisms, parametric extrapolation techniques – LM, OSD, MII, MB and MCM, design rules, cumulative damage, crack growth models, Remaining Life Assessment (RLA) methodology for bulk and localized damages.

High and low cycle fatigue, Coffin-Manson relationship, creep fatigue interaction, effect of hold time, frequency strain concentration, environment, rupture ductility, damage rules and life prediction, design rules for creep fatigue (CF), linear damage summation, failure mechanism maps, thermal fatigue (TF), thermal-mechanical fatigue (TMF), thermal fatigue (TF), thermal-mechanical fatigue (TMF), thermal-mechanical fatigue life prediction, crack growth in fatigue.

Materials, damage mechanisms and RLA of boiler tubes, header, steam pipes, roots, steam casings, valves and steam chests, steam turbines blades, high temperature bolts, Non-destructive assessment methods for extent of creep damage, replication, creep pipes, principles of micro-thermography, effective temperature determination by implanting diffusion couples, life prediction of petroleum pressure vessel materials for hydrogen service, materials of construction, integrity consideration of pressure vessel shells and cladding, improved alloys of RLA techniques, Arkhausen Noise.

REFERENCES:

1. Viswanathan. R, "Damage Mechanisms and Life Assessment of High Temperature Components", American Society for Metals, 1989.
2. Das. A. K. "Metallurgy of Failure Analysis", Tata McGraw Hill, 1993.
3. Karl Hauffe, "Oxidation of Metals", Plenum Press, 1981.
4. Viswanathan R. "Life Assessment and Improvement of Turbo-generators Rotors or Fossil Plants", Pergamon Press, 1985.

COURSE OUTCOMES:

1. Understand the deformation and damage mechanics of welded structure.
2. Acquire knowledge on different life assessment tools.
3. Estimate the remaining life of the welded components.
4. Derive life assessment procedures for a specific welded component.
5. Utilize different techniques to enhance the life of the components.

Mapping of Course Outcomes with Programme Outcomes					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓				✓
CO2		✓			
CO3			✓		
CO4		✓		✓	
CO5					✓

		L	T	P
WEEXXXX	**TOTAL QUALITY MANAGEMENT**	**4**	**0**	**0**

COURSE OBJECTIVES:

- To discuss the different views of quality and to appreciate the importance of product quality;
- To provide a knowledge understand a framework summarizing the philosophical elements and generic tools of TQM;
- To provide an understanding of the role of quality control and Acceptance sampling plans in organizations.

Concepts of TQM – Dimensions of Quality - Deming, Crosby and Juran's Philosophies – Barriers to TQM - Quality system – ISO 9000:2000, ISO 14000 Quality system standards - Quality costs, Seven tools for Quality Control, Seven tools for Quality management, Quality Function Deployment (QFD) – Taguchi loss function

Statistical Process Control: Control charts for attributes and count of defects – p chart, np chart, c chart, u chart. $\bar{X}$ chart, R chart, σ chart – process capabilities studies (C_p and C_{pk}) – Concept of Six sigma.

Special control charts – Group control chart, sloping control chart, moving averages and moving ranges control charts, coefficient of variation control chart.

Acceptance sampling plans for attributes: Concepts – Difference between inspection and quality control - single sampling plan - OC curve.

Reliability Engineering: Definition – Bath tub curve - MTBF – MTTF - System reliability with components in series, parallel– FTA, FMECA.

REFERENCES:

1. Introduction to Statistical Quality Control, Montgomery D.C., John Wiley, 1994.
2. Statistical Quality Control, Gupta R.C., Khanna Pub., 1998.
3. Amitava Mitra, "Fundamentals of quality control and improvement", prentice hall, 2nd edition, 1998
4. Besterfield, "Total Quality Management", Pearson Education, 2nd Edition, 2003.
5. Mahajan,M., " Statistical Quality Control", dhanpat rai & co.,pvt ltd, 2010
6. Concepts in Reliability Engineering, Srinath L.S., Eastwest Press Ltd., 1991. IS 397 Part I, II and III, IS 2500

COURSE OUTCOMES:

1. Understand the core features of the total quality management in terms of various dimensions of quality.
2. Measure the cost of poor quality and process effectiveness and efficiency to track performance quality and to identify areas for improvement
3. Develop an understanding on quality management philosophies and frameworks
4. Develop the ability to apply the tools of quality control and quality management.
5. Understand proven methodologies to enhance management processes, such as benchmarking and business process reengineering, lean manufacturing.

Mapping of Course Outcomes with Programme Outcomes					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓			✓	
CO2		✓			✓
CO3					
CO4	✓		✓		
CO5				✓	

WEEXXXX	**ADVANCED MATERIALS JOINING**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES:

- To select the joining methods for non-metals.
- To understand joint integrity of advanced materials.
- To understand the need for joining of dissimilar materials.

Introduction - options for joining composites - joining of organic (polymer) matrix composites - joining of metal-matrix composites - joining of ceramic-matrix composites - joining carbon, graphite, or carbon-carbon composites - achieving maximum joint integrity between composites.

Basic joining for ceramics and glasses - mechanical joining of ceramics - adhesive bonding, brazing, welding and soldering of ceramics - other methods for joining ceramics to ceramics - welding and fusing of glasses - cementing and adhesive bonding of glasses - soldering of glasses and solder glasses.

The challenges of joining polymeric materials - joining of thermosetting polymers - joining of thermoplastic polymers - joining elastomeric polymers or elastomers - joining structural or rigid plastic foams - joining dissimilar polymers.

Joining of electronic materials - Joining of magnetic materials: processes used, joint design, precautions required, problems encountered, remedial steps to be taken, Testing and evaluation of joint qualities.

Need for joining dissimilar materials - joining metals to ceramics - joining metals to glasses - joining of metals to polymers - joining of metals to composites - joining of ceramics to polymers - joining of ceramics to composites.

REFERENCES:

1. Messler, Warren Savage, "Joining of Advanced Materials", Butterworth-Heinemann publications, 1993.
2. Welding Handbook (Welding Processes), Volume II, 8th Edition, American Welding Society (AWS), 1991.
3. Matthews, F.L., Joining Fibre-Reinforced Plastics, London: Elsevier Applied Science, 1987.
4. Schwartz, Mel M., Ceramic Joining, Metals Park, Ohio: ASM International, 1990.

COURSE OUTCOMES:

Understand the various methods for joining composite materials.

1. Improve the joint qualities of advanced materials.
2. Understand the difficulties in joining of newer materials.
3. Select an appropriate technique to join a newer material.

Mapping of Course Outcomes with Programme Outcomes					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓		✓		
CO2		✓			
CO3			✓		
CO4		✓			

WEEXXXX	**NON-DESTRUCTIVE TESTING**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES:

- To understand the difference between destructive and non-destructive testing.
- To study the various non-destructive testing methods.
- To understand the application non-destructive testing in welding.

Non Destructive Testing Versus Mechanical testing, Overview of the Non Destructive Testing Methods for the detection of manufacturing defects as well as material characterisation. Relative merits and limitations, Various physical characteristics of materials and their applications in NDT., Visual inspection – Unaided and aided.

Liquid Penetrant Testing - Principles, types and properties of liquid penetrants, developers, advantages and limitations of various methods, Testing Procedure, Interpretation of results. Magnetic Particle Testing- Theory of magnetism, inspection materials Magnetisation methods, Interpretation and evaluation of test indications, Principles and methods of demagnetization, Residual magnetism.

Thermography- Principles, Contact and non contact inspection methods, Techniques for applying liquid crystals, Advantages and limitation - infrared radiation and infrared detectors, Instrumentations and methods, applications. Eddy Current Testing-Generation of eddy currents, Properties of eddy currents, Eddy current sensing elements, Probes, Instrumentation, Types of arrangement, Applications, advantages, Limitations, Interpretation/Evaluation.

Ultrasonic Testing-Principle, Transducers, transmission and pulse-echo method, straight beam and angle beam, instrumentation, data representation, A/Scan, B-scan, C-scan. Phased Array Ultrasound, Time of Flight Diffraction. Acoustic Emission Technique –Principle, AE parameters, Applications.

Principle, interaction of X-Ray with matter, imaging, film and film less techniques, types and use of filters and screens, geometric factors, Inverse square, law, characteristics of films - graininess, density, speed, contrast, characteristic curves, Penetrameters, Exposure charts, Radiographic equivalence. Fluoroscopy- Xero-Radiography, Computed Radiography, Computed Tomography

REFERENCES:

1. Baldev Raj, T.Jayakumar, M.Thavasimuthu Practical Non-Destructive Testing, Narosa Publishing House, 2009.
2. Ravi Prakash, Non-Destructive Testing Techniques, 1st revised edition, New Age International Publishers, 2010.
3. ASM Metals Handbook, Non-Destructive Evaluation and Quality Control, American Society of Metals, Metals Park, Ohio, USA, Volume-17, 2007.
4. Paul E Mix, Introduction to Non-destructive testing: a training guide, Wiley, 2 Edition New Jersey, 2005.

COURSE OUTCOMES:

1. Understand the principle of non-destructive testing methods.
2. Acquire knowledge on limitations and merits of each technique.
3. Determine the location of sub surface cracks.
4. Use of modern tools to assess the weld quality.
5. Select a suitable non-destructive test method for a specific application.

Mapping of Course Outcomes with Programme Outcomes					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓				
CO2		✓		✓	
CO3	✓		✓		
CO4				✓	
CO5					✓

WEEXXXX	**CORROSION ENGINEERING**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES:

- To understand the basics of various forms of corrosion.
- To study the mechanisms of various corrosion and its prevention.
- To study the various types corrosion tests.

Corrosion Principle: Introduction – Electrochemical Aspects-Electrochemical Reactions – Polarization – Passivity. Environmental effects: Effect of Oxygen and Oxidizers – Effects of

Velocity – Effects of Temperature – Effects of Corrosive Concentration – Effects of Galvanic Coupling

Primary Corrosion Types**:** Galvanic or two-metal corrosion, Pitting corrosion, Intergranular corrosion, Oxidation: Pilling - Bedworth Ratio – Electrochemical and Morphological Aspects of Oxidation – Oxide Defect Structure – Oxidation Kinetics – Effect of Alloying – Catastrophic Oxidation – Internal Oxidation.

Secondary Corrosion Types: Crevice corrosion: Environmental Factors – Mechanism – Combating Crevice Corrosion – Filiform Corrosion. Selective leaching: Dezincification: Characteristics – Dezincification, Erosion corrosion, Cavitation Damage – Fretting Corrosion. Stress corrosion: Crack Morphology – Stress Effects – Time to Cracking – Environmental Factors – Metallurgical Factors – Mechanisms.

Corrosion Testing: Introduction – Classification – Purpose – Materials and Specimens – Surface Preparation – Measuring and Weighing – Exposure Techniques – Duration – Planned-Interval Tests – Aeration – Cleaning Specimens After Exposure – Temperature – Standard Expressions form Corrosion Rate – Warren Test – Pitting – Stress Corrosion – NACE Test Methods – Slow-Strain-Rate Tests – Linear Polarization – AC Impedance-Small-Amplitude Cyclic Voltammetry.

Corrosion Prevention: Metals and Alloys – Metal Purification – Non metallics; Changing Mediums – Inhibitors Cathodic and anodic protection: Cathodic Protection – Anodic Protection – Comparison of Anodic and Cathodic Protection. Coatings: Metallic and other Inorganic Coatings – Organic Coatings – Corrosion Control Standards – Failure Analysis.

REFERENCES:

1. Corrosion Engineering, Mars G. Fontana, Tata Mc Graw-Hill. New Delhi, 2008.
2. Fundamentals of Corrosion, Philip A Schweitzer, Taylor and Francis, USA, 2008.
3. Sydney, H., Avner, S.H., Introduction to Physical Metallurgy, McGraw Hill, 2008.

COURSE OUTCOMES:

1. Assess the effects of environmental factors on corrosion.
2. Understand the mechanism of various corrosion methods.
3. Select suitable prevention technique to combat corrosion.

Mapping of Course Outcomes with Programme Outcomes					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1		✓		✓	
CO2	✓		✓		
CO3		✓			

WEEXXXX	**ADDITIVE MANUFACTURING**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES:

- To understand the basics of additive manufacturing.
- To select the proper tools for additive manufacturing.

- To study the guidelines for process selection.

Introduction to Additive Manufacturing: Introduction to AM, AM evolution, Distinction between AM & CNC machining, Advantages of AM, AM process chain: Conceptualization, CAD, conversion to STL, Transfer to AM, STL file manipulation, Machine setup, build , removal and clean up, post processing.

Classification of AM processes: Liquid polymer system, discrete particle system, molten material systems, solid sheet system.

Design for AM: Motivation, DFMA concepts and objectives, AM unique capabilities, Exploring design freedoms, Design tools for AM, Part Orientation, Removal of Supports, Hollowing out parts, Inclusion of Undercuts and Other Manufacturing Constraining Features, Interlocking Features, Reduction of Part Count in an Assembly, Identification of markings/ numbers etc.

Guidelines for process selection: Introduction, selection methods for a part, challenges of selection, example system for preliminary selection, production planning and control AM Applications: Functional models, Pattern for investment and vacuum casting, Medical models, art models, Engineering analysis models, Rapid tooling, new materials development, Bi-metallic parts, Re-manufacturing. Application examples for Aerospace, defense, automobile, Bio-medical and general engineering industries

Post processing of AM parts: Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non-thermal and thermal techniques. Future Directions of AM: Introduction, new types of products and employment and digiproneurship.

REFERENCES:

1. Chua Chee Kai, Leong Kah Fai, “Rapid Prototyping: Principles & Applications”, World Scientific, 2003.
2. Ian Gibson, David W Rosen, Brent Stucker., “Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing”, Springer, 2010
3. Ali K. Kamrani, Emand Abouel Nasr, “Rapid Prototyping: Theory & Practice”, Springer,2006.
4. D.T. Pham, S.S. Dimov, Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer 2001.

COURSE OUTCOMES:

1. Understand the Importance of AM in Manufacturing.
2. Acquire sound knowledge in different AM Technologies.
3. Select suitable materials for AM.
4. Select Different methods for Post-processing of AM parts.
5. Understand the Future Directions of AM

Mapping of Course Outcomes with Programme Outcomes					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓		✓		
CO2		✓			
CO3			✓		
CO4		✓			
CO5				✓	

WEEXXXX	**SURFACE MODIFICATION TECHNIQUES**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES:

- To understand the needs of surface modification technique.
- To study the effect of process parameters of various thermal spray techniques.
- To study the applications of surface modification technique.

Welding Assisted Processes: Hardfacing, Cladding, Overlaying by Shielded metal arc welding, flux cored arc welding, submerged arc welding, gas tungsten arc welding, plasma transferred arc welding, laser beam welding techniques, consumables for weld surfacing, dilution measurement, microstructural features, Friction surfacing processes

Thermal Spray Techniques: Principles, Process Parameters, Coating Properties and Applications of: Flame Spraying (FS) - Spray and Fuse Coating (S&F) - Detonation-Gun Spraying (D-GUN) - High-Velocity Oxy-Fuel (HVOF) Spraying, High Velocity Air Fuel Spraying (HVAF), Arc Spraying (AS) - Atmospheric Plasma Spraying (APS) - Vacuum Plasma Spraying (VPS) - Cold-Gas Spraying Method (CGSM) - Electro Spark Coating (ESC)

Plating Processes: Fundamentals of Electro deposition, plating of nickel, chromium, tin and copper - pulsed plating – electroless plating - electrochemical conversion coating, metallizing, selective plating for repair, Hard anodizing.

Diffusion Processes: Principle of diffusion processes - Bording, Aluminising, Siliconising, Chromising, Sursulf - Selection of diffusion processes - Characteristics of diffused layer - micro structure and micro hardness evaluation - properties and applications.

Allied Processes: Laser beam hardening/ glazing, Laser Surface Melting, Laser Surface alloying, Laser Cladding, Electron beam hardening, Physical vapor deposition, Thermal evaporation, Arc vaporization, Sputtering, Ion plating - Chemical vapor deposition – Proprieties and applications of thin coatings.

REFERENCES:

1. Surface Engineering for Wear Resistance, Kenneth G.Budinski, Prentice Hall, Englewood Cliff, 2000.
2. Surface Engineering, ASM Metals Handbook, Ohio, 2004
3. Friction and Wear of Materials, Emest Rabinowicz, John Wiley & Sons, New York, 2004.

4. Welding technology and processes, R.S. Parmar, Khanna publishers, New Delhi, 2006.
5. Science and Engineering of Thermal Spray Coatings, Lech Pawlowski, Springer Verlag Publications, Berlin, 2005.

COURSE OUTCOMES:
1. Improve the surface properties through surface modification techniques.
2. Understand the principles of various surface modification techniques
3. Enhance the life of the components through advanced surface modification process.
4. Select suitable surface modification technique for specific applications.

Mapping of Course Outcomes with Programme Outcomes					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1	✓			✓	
CO2		✓			✓
CO3			✓		
CO4		✓			

WEEXXXX	**FINITE ELEMENT ANALYSIS**	**L**	**T**	**P**
		4	**0**	**0**

COURSE OBJECTIVES:
- To understand the basics of finite element method.
- To study about the different solving methods.
- To understand the application of FEM in welding.

Historical Background – Basic concepts of FEM - Boundary conditions-Fundamentals of stress-strain relationships, Strain vs Displacement relations-Temperature effects, Weighted residual methods – Introduction to variational formulation :Ritz method – Galerkin method – Solution of algebraic equations- Gaussian elimination- Significance and applications of FEM.

One dimensional problems, Finite element modeling- Coordinates and shape functions - Interpolation - Derivation and assembly of finite element equations - Potential energy approach - Assembly of global stiffness matrix and load vector - Treatment of Boundary conditions- Quadratic shape functions- Example problems.

Constant strain triangular element- axisymmetric solids subjected to axisymmetric loads - two dimensional isoparametric elements-numerical integration – Poissons and Laplaces equation – Element Matrices and Vectors – Lagrangian Interpolation Polynomials-Illustrative examples.

Applications in welding: Data acquisition in Lab view, Incorporation of latent heat- Transient analysis, Time stepping procedure-Predication of grain structure- Models for Welding heat sources- Double ellipsoidal model, Gaussian surface model.

Computer Implementations: An overview of commercial packages- Preprocess- Mesh generation, Adapative meshing, boundary conditions - Input of data- Material properties-

Updating the values - remeshing - Post processing – Validation - One dimensional heat conduction: Simple heat transfer problems

REFERENCES:

1. Segerline L.J., "Applied Finite Element Analysis", John Wiley, 1984.
2. Rao. S.S., "Finite Element Method in Engineering", Pergamon Press, 1996.
3. Chandrupatla and Belagundu, "Finite Elements in Engineering", PHI, 2001.
4. John A. Goldak, Mehdi Akhlaghi, "Computational Welding Mechanics", Springer, 2011.
5. Cook, Rober Davis etal., "Concepts and Applications of Finite Element Analysis", John Wiley and Sons, 1999.
6. Buchaman. G.R., Schaum's "Outline of Finite Element Analysis", McGraw-Hill Company, 1994.

COURSE OUTCOMES:

1. Understand the basic concept and applications of FEM.
2. Analyze the various stresses of acting on the welded joint through FEM.
3. Estimate heat distribution during welding by FEM.
4. Evaluate effect of input parameters on the output responses.
5. Apply a suitable FE method for a specific problem

Mapping of Course Outcomes with Programme Outcomes					
COs/POs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**
CO1		✓			
CO2	✓			✓	
CO3			✓		
CO4				✓	
CO5		✓			✓