Name of Institute: IITE
Name of Faculty: Mr. Monil Salot

Course code: MME0603
Course name: Electrometallurgy and Corrosion

Pre-requisites: Metallurgical Thermodynamics
Credit points: 4
Offered Semester: 6

Course Coordinator

Full Name: Monil Salot
Department with siting location: Ground Floor Met Lab 4
Telephone:+91-9428600336
Email: monilsalot.mt@indusuni.ac.in
Consultation times: 3;45 – 4:20

Course Lecturer

Full Name: Monil Salot
Department with siting location: Ground Floor Met Lab 4
Telephone:+91-9428600336
Email: monilsalot.mt@indusuni.ac.in
Consultation times: 3;45 – 4:20

Students will be contacted throughout the Session via Mail with important information relating to this Course.

Course Objectives

By participating in and understanding all facets of this Course a student will:

1) To be knowledgeable of the influence of a material's composition and microstructure on its corrosion performance.
2) To be knowledgeable of the effect of an electrolyte's composition on the corrosion of metals.
3) To be able to identify materials that will exhibit adequate corrosion resistance in a particular environment.
4) To be able to propose economically viable remedial actions that will eliminate or reduce corrosion to a tolerable level.

Course Outcomes (CO)

CO 1: Reproduce the relationship between rates of electrochemical reactions and the potential drop across interfaces [BT-1]
CO 2: Explain the effect of electrolyte composition on corrosion of metals [BT-2]
CO 3:Experimentally determine the corrosion rate of the metal or alloy [BT-3]
CO 4: Analyse the influence of materials composition and microstructure on its corrosion performance [BT-4]
CO 5: Evaluate the causes for various types of corrosion, including uniform corrosion, galvanic corrosion, crevice corrosion, pitting corrosion, intergranular corrosion and various modes of environmentally assisted cracking [BT-5]
CO 6: Propose economically viable remedial actions which will eliminate or reduce the corrosion to a tolerable level [BT-6]

Course Outline

The proposed course deals with thermodynamics and kinetics of corrosion. It deals with various forms of corrosion and prevention techniques to combat corrosion.

Method of delivery

(Face to face lectures, self study material, Active Learning Techniques)

Study time

3 lectures + 2 hours Laboratory per week

CO-PO Mapping (PO: Program Outcomes)

Electrometallurgy and Corrosion (MT0602)												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	1	-	-	1	-	-	-	-	1
CO2	3	3	1	2	-	1	1	-	-	-	-	1
CO3	3	2	1	1	1	-	-	-	-	-	-	2
CO4	3	3	2	2	1	-	-	-	-	-	-	1
CO5	3	2	1	1	2	-	-	-	-	-	-	1
CO6	2	3	3	2	-	1	1	-	-	-	-	2
MT0602	**2.8**	**2.6**	**1.6**	**1.5**	**1.3**	**1**	**1**	**-**	**-**	**-**	**-**	**1.3**

Blooms Taxonomyand Knowledge retention(For reference)

(Blooms taxonomy has been given for reference)

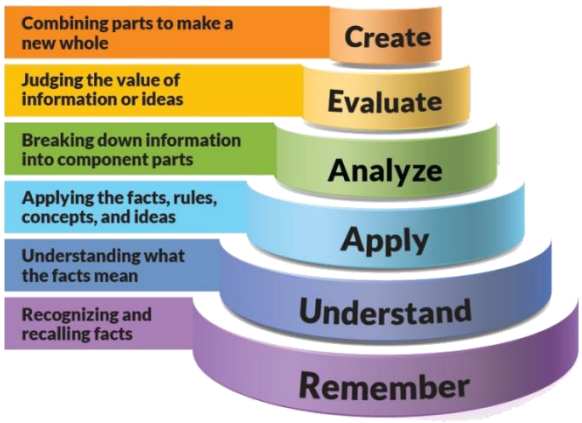

Figure 1: Blooms Taxonomy

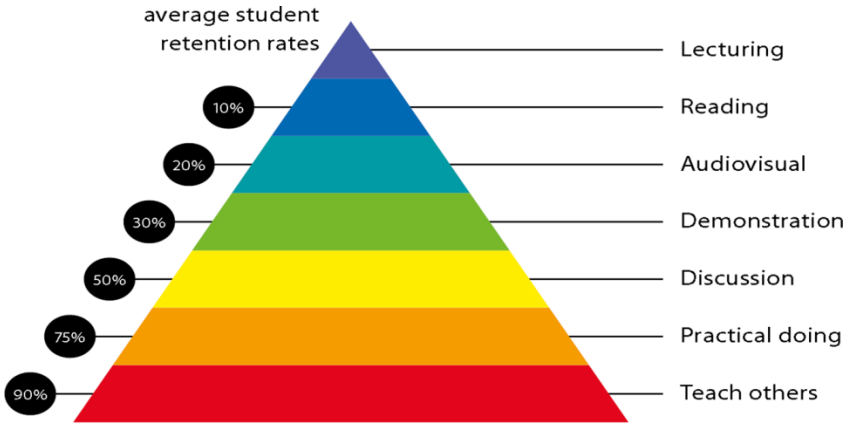

Figure 2: Knowledge retention

Graduate Qualities and Capabilities covered

(Qualities graduates harness crediting this Course)

General Graduate Qualities	Specific Department of _____Graduate Capabilities
Informed Have a sound knowledge of an area of study or profession and understand its current issues, locally and internationally. Know how to apply this knowledge. Understand how an area of study has developed and how it relates to other areas.	**1 Professional knowledge, grounding & awareness**
Independent learners Engage with new ideas and ways of thinking and critically analyze issues. Seek to extend knowledge through ongoing research, enquiry and reflection.	**2 Information literacy, gathering & processing**

Find and evaluate information, using a variety of sources and technologies. Acknowledge the work and ideas of others.	
Problem solvers Take on challenges and opportunities. Apply creative, logical and critical thinking skills to respond effectively. Make and implement decisions. Be flexible, thorough, innovative and aim for high standards.	**4 Problem solving skills**
Effective communicators Articulate ideas and convey them effectively using a range of media. Work collaboratively and engage with people in different settings. Recognize how culture can shape communication.	**5 Written communication** **6 Oral communication** **7 Teamwork**
Responsible Understand how decisions can affect others and make ethically informed choices. Appreciate and respect diversity. Act with integrity as part of local, national, global and professional communities.	**10 Sustainability, societal & environmental impact**

Practical work:

Corrosion rate measurement, Study of Pitting corrosion, Electroplating, Effect of current density on Anodizing

Lecture/tutorial times

***Please Refer to Time Table for Lecture Timings, Circulated Separately**

Example:

Lecture	Room LH 3
Lecture	Room LH 3
Lecture	Room LH 3
Practicals	Room Lab 2
Practicals	Room Lab 2

Attendance Requirements

The University norms states that it is the responsibility of students to attend all lectures, tutorials, seminars and practical work as stipulated in the Course outline. Minimum

attendance requirement as per university norms is compulsory for being eligible for mid and end semester examinations.

Details of referencing system to be used in written work

Text books

1. M. G. Fontana and N. D. Greene, "Corrosion Engineering", McGraw Hill Higher Education, 2nd Edition, 1978, ISBN: 9780070214613.

Additional Materials

1. P. C. Mukherjee, "Fundamentals of Metal Casting Technology", Oxford & IBH, 1st Edition, 1988, ISBN: 9788120403635.
2. D. A. Jones, "Principles and Prevention of Corrosion", Pearson, 2nd Edition, 1995, ISBN: 9780133599930.
3. H. H. Uhlig and R. W. Revie, "Corrosion and Corrosion Control", Wiley-Interscience, 4th Edition, 2008, ISBN: 9780471732792.
4. L. L. Shreir, "Corrosion: Volume 1", Newnes-Butterworth, 2nd Edition, 1976, ISBN: 9780408001090.
5. G. T. Burstein, L. L. Shreir and R. A. Jarman, "Corrosion: Volume 2", Butterworth-Heinemann, 3rd Edition, 1994, ISBN: 9780750610773.
6. M. Pourbaix, "Atlas of Electrochemical Equilibria in Aqueous Solutions", NACE International, 1st Edition, 1974, ISBN: 0915567989.
7. J. O. M. Bockris and A. K. N. Reddy, Modern Electrochemistry: Volume I", Springer, 2nd Edition, 1998, ISBN: 9780306455544.
8. J. O. M. Bockris and A. K. N. Reddy, Modern Electrochemistry: Volume II", Springer, 1970 Edition, 1973, ISBN: 9780306250026.

Web Resources

1. NPTEL Online Course on "Advances in Corrosion Engineering" (http://nptel.ac.in/courses/113108051/)

ASSESSMENT GUIDELINES

Your final course mark will be calculated from the following:

Example:

Mid Semester Examination- 40%
Assignments- 10%
Presentation- 5%
Class Participation and Attendance- 5%
End Semester Examination- 40%

SUPPLEMENTARY ASSESSMENT

Students who receive an overall mark less than 40% in mid semester or end semester will be considered for supplementary assessment in the respective components (i.e mid semester or end semester) of semester concerned. Students must make themselves available during the supplementary examination period to take up the respective components (mid semester or end semester) and need to obtain the required minimum 40% marks to clear the concerned components. ***Examination and Assessment to be carried out as per university policy***

Practical Work Report/Laboratory Report:

A report on the practical work is due the subsequent week after completion of the class by each group.

Late Work

Late assignments will not be accepted without supporting documentation. Late submission of the reports will result in a deduction of -1% of the maximum mark per calendar day

Format

All assignments must be presented in a neat, legible format with all information sources correctly referenced. **Assignment material handed in throughout the session that is not neat and legible will not be marked and will be returned to the student.**

Retention of Written Work

Written assessment work will be retained by the Course coordinator/lecturer for two weeks after marking to be collected by the students.

University and Faculty Policies

Students should make themselves aware of the University and/or Faculty Policies regarding plagiarism, special consideration, supplementary examinations and other educational issues and student matters.

Plagiarism - Plagiarism is not acceptable and may result in the imposition of severe penalties. Plagiarism is the use of another person's work, or idea, as if it is his or her own - if you have any doubts at all on what constitutes plagiarism, please consult your Course coordinator or lecturer. Plagiarism will be penalized severely.

Do not copy the work of other students.
Do not share your work with other students (except where required for a group activity or assessment)

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Course schedule (subject to change)

	Week #	Topic & contents	CO Addressed	Teaching Learning Activity (TLA)
	Weeks 1	Basics of Electrochemistry, Basics of Corrosion, Why does corrosion occur?, Faradays' laws of electrolysis	CO1-CO6	BB, PPT
	Weeks 2	Current efficiency, current density, Concept of electrode potentials, Emf Series, Galvanic Series	CO1-CO6	BB, PPT
	Week 3	Thermodynamics of Electrode Processes, Nernst's Equation, Pourbiax Diagram for Metal Water System, Applications and Limitations.	CO1-CO6	BB, PPT
	Week 4	Kinetics of Electrode Processes, over voltage, Activation Polarization, Concentration Polarization, Mixed Potential Theory	CO1-CO6	BB, PPT
	Week 5	Evan's Corrosion Diagram, Passivation Curve, The relevance of corrosion studies – forms of corrosion, Uniform Corrosion	CO1-CO6	BB, PPT
	Week 6	Galvanic Corrosion, Crevice Corrosion, Pitting Corrosion, Intergranular Corrosion	CO1-CO6	BB, PPT
	Week 7	Selective Leaching, Erosion Corrosion, Stress corrosion cracking, Hydrogen Damage	CO1-CO6	BB, PPT
	Week 8	High Temperature Corrosion in Different Atmosphere, Effect of Doping, Coating Methods for High Temperature Corrosion Protection, Pilling Bedworth Ratio and its applications.	CO1-CO6	BB, PPT
	Week 9	Principles of Protection, Selection of Suitable Design, Inhibition	CO1-CO6	BB, PPT
	Week 10	Coating Methods, Anodic protection, Cathodic protection	CO1-CO6	BB, PPT
	Week 11	Classification and mechanism of electrodeposition processes, Electroplating of copper, nickel and chromium, Electroless plating, Anodising, Galvanizing	CO1-CO6	BB, PPT
	Week 12	Environment affecting corrosion, Effect of soil, Effect of chemicals, Effect of moisture and atmospheric gases	CO1-CO6	BB, PPT
	Week 13	Effect of temperature and velocity, Metallurgical factors, Corrosion Rate Measurements	CO1-CO6	BB, PPT
	Week 14	Physical and Electrochemical Methods such as ASTM standard methods A262 Practice A to E	CO1-CO6	BB, PPT
	Week 15	Specific Corrosion Applications: Marine Industry, Automobile Industry, Petrochemical Industry and Chemical Industry	CO1-CO6	BB, PPT

Program Map for Metallurgical Engineering Department

Sem	Subjects
1st	Calculus; Engineering Physics; Workshop; Material Science; Environmental Science; Material Science (OE); Technical Communication
2nd	Differential Equations and Linear Algebra; Engineering Chemistry; Metallurgy for Non Metallurgists (OE); Structural Properties and Physics of Materials; Engineering Graphics; Advanced Material and Application (OE); Business Communication and Presentation Skills
3rd	Probability, Statistics and Numerical Methods; Management for Engineers; Human Values and Professional Ethics; Mineral Processing; Metallurgical Thermodynamics; Internship-1; Physical Metallurgy
4th	Iron Making; Transport Phenomena; Metal Casting and Solidification (OE); Recycled Materials (OE); Heat Treatment Principles and Practices; Soft Skill and Interpersonal Comm.; Personality Credit-1
5th	Foundry Technology; Steel Making; Fuel Furnace and Refractories (EL); Environmental Pollution and its Control in Met. Ind. (EL); Non Ferrous Extractive Metallurgy; Plastic Deformation of Metals; Energy Economy and Waste Management- (OE); Internship-2
6th	Metal Forming; Phase Transformation; Powder Metallurgy (Elective-1); Modelling of Metallurgical Processes (Elective-1); Electrometallurgy and Corrosion; Ind. Ceramics and Polymers (El-2); Nano Technology (OE); Metal Joining Processes; Composite Materials (EL-2); Personality Credit-2
7th	Metal Testing and Characterization; Alloy Design (EL); Advanced Ferrous Metallurgy (EL); Surface (EL); Internship-3; Non Destructive Testing (EL) and (OE); Material Testing and Standards; Selection of Material & Failure analysis (EL) & (OE); Advanced Foundry Technology (EL)
8th	Project

Subject: Electrometallurgy and Corrosion								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0603**			Semester: **VI**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)-Theory**	**Continuous Internal Evaluation (CIE)-Practical**	**Total**
3	0	2	4	16/40	16/40	24/60	24/60	200

Course Objectives

1. To be knowledgeable of the influence of a material's composition and microstructure on its corrosion performance.
2. To be knowledgeable of the effect of an electrolyte's composition on the corrosion of metals.
3. To be able to identify materials that will exhibit adequate corrosion resistance in a particular environment.
4. To be able to propose economically viable remedial actions that will eliminate or reduce corrosion to a tolerable level.

CONTENTS

UNIT-I

[10 hours]

Basics of Electrochemistry

Faradays' laws of electrolysis, current efficiency, current density, electrode potentials, Thermodynamics and Kinetics of Electrode Processes- Polarization Curves, Concept of Over-Potential, Kinetics of Passivity and Transpassivity, Nernst's Equation, EMF Series, Evan's Corrosion Diagram, Galvanic Series. Pourbiax Diagram for Metal Water System, Applications and Limitations.

UNIT-II

[10 hours]

Forms of Corrosion

The relevance of corrosion studies, forms of corrosion, Uniform Corrosion, Galvanic Corrosion, Crevice Corrosion, Pitting Corrosion, Intergranular Corrosion, Selective Leaching, Erosion Corrosion, stress cracking corrosion, Hydrogen Damage.

High Temperature Corrosion

High Temperature Corrosion in Different Atmosphere, Effect of Doping, Alloying Elements, Coating Methods for High Temperature Corrosion Protection, Pilling Bedworth Ratio and its applications.

UNIT-III

[10 hours]

Corrosion Protection

Principles of Protection, Selection of Suitable Design, Inhibition, Coating Methods, Anodic protection and Cathodic protection.

Electro deposition

Classification and mechanism of electrodeposition processes. Electroplating of copper, Nickel and Chromium. Principles of Alloy plating and electroless plating, Anodising, Galvanizing.

UNIT-IV

[10 hours]

Factors affecting Corrosion

Environment affecting corrosion, effects of soil, chemicals, moisture and atmospheric Gases,temperature and velocity, metallurgical factors.

Corrosion Testing

Physical and Electrochemical Methods such as ASTM standard methods A262 Practice A to E and their equivalents, Surface Preparation, Exposure Technique, Corrosion Rate Measurements.

Material Selection to Combat Corrosion

Specific Corrosion Applications Such as Marine Industry, Petrochemical Industry, High Temperature Service, Chemical Industry, Automobile, High Temperature & High Pressure corrosion in Industries.

Electrometallurgy and Corrosion Lab (List of Experiments)

Experiment No.	Title
1	To prepare the samples for corrosion testing.
2	To determine corrosion rate of given sample by weight loss method in H_2SO_4 Solution.
3	To determine corrosion rate of given sample by weight loss method in NaCl solution.
4	To determine corrosion rate of sample by weight loss method in HCl solution.
5	Comparative study of corrosion rate by weightless method for different acid solutions.
6	To study and perform IGC corrosion of stainless steel.
7	Determination of Inter granular corrosion susceptibility by microstructure evaluation.
8	To study and observe galvanic corrosion of two metals.
9	Observation of effect of anodic area and type of material on galvanic corrosion of metals.
10	To perform & observe pitting corrosion in stainless steel.
11	To study & perform the effect of current density on anodic dissolution.
12	To perform the electroplating of copper on a given base metal.
13	To perform the Anodizing of Aluminum in H_2SO_4 Solution.
14	To study and perform cathodic protection of a metal by sacrificial anode method.
15	To Study corrosion rate by Tafel Extrapolation method.

Course Outcomes

1. To understand the origin of the difference in electrical potential across an interface, in particular, metal/electrolyte interface.
2. To understand the relationship between rates of electrochemical reactions and the potential drop across interfaces.
3. To understand the causes of and the mechanisms of various types of corrosion, including uniform corrosion, galvanic corrosion, crevice corrosion, pitting corrosion, intergranular corrosion, and various modes of environmentally assisted cracking.

Text Books

1. M. G. Fontana and N. D. Greene, "Corrosion Engineering", McGraw Hill Higher Education, 2nd Edition, 1978, ISBN: 9780070214613.

Reference Books

1. D. A. Jones, "Principles and Prevention of Corrosion", Pearson, 2nd Edition, 1995, ISBN: 9780133599930.
2. H. H. Uhlig and R. W. Revie, "Corrosion and Corrosion Control", Wiley-Interscience, 4thEdition, 2008, ISBN: 9780471732792.
3. L. L. Shreir, "Corrosion: Volume 1", Newnes-Butterworth, 2nd Edition, 1976, ISBN: 9780408001090.
4. G. T. Burstein, L. L. Shreir and R. A. Jarman, "Corrosion: Volume 2", Butterworth-Heinemann, 3rdEdition, 1994, ISBN: 9780750610773.
5. M. Pourbaix, "Atlas of Electrochemical Equilibria in Aqueous Solutions", NACE International, 1st Edition, 1974, ISBN: 0915567989.
6. J. O. M. Bockris and A. K. N. Reddy, Modern Electrochemistry: Volume I", Springer, 2nd Edition, 1998, ISBN: 9780306455544.
7. J. O. M. Bockris and A. K. N. Reddy, Modern Electrochemistry: Volume II", Springer, 1970 Edition, 1973, ISBN: 9780306250026.

Web Resources

1. NPTEL Online Course on "Advances in Corrosion Engineering" (http://nptel.ac.in/courses/113108051/)

Name of Institute: Institute of Technology and Engineering
Name of Faculty: Dr.Sujoy Chaudhury

Course code: **MME0601**
Course name: **Metal Forming**
Pre-requisites: Plastic deformation of Metals
Credit points: 4
Offered Semester: 6th Semester

Course Coordinator (weeks XX - XX)
Full name:Dr.Sujoy Chaudhury
Department with siting location: Physical Metallurgy Lab (lab 3 in ground floor)
Telephone: 84699 43117
Email: sujoychaudhury.mt@indusuni.ac.in
Consultation times: 4.15-5.00PM

Course Lecturer (weeks xx - XX)
Full name: Dr.Sujoy Chaudhury
Department with siting location: Physical Metallurgy Lab (lab 3 in ground floor)
Telephone: 84699 43117
Email: sujoychaudhury.mt@indusuni.ac.in
Consultation times: 4.15-5.00PM

Students will be contacted throughout the Session via Mail with important information relating to this Course.

Course Objectives

By participating in and understanding all facets of this Course a student will:

1) To provide knowledge about the basic concepts of deformations and energy requirements.
2) To understand different methods of deformations to produce various shapes.
3) To teach them various strengthening mechanism of metals

Course Outcomes (CO)

CO 1: Describe the plastic deformation of metals in terms of stress-strain diagram [BT-1]
CO 2: Recognize the fundamentals and various factors contribution towards metal forming [BT-2]
CO 3: Illustrate various forging and rolling process [BT-3]
CO 4: Select the appropriate process for component making from the conventional and Un-conventional metal forming techniques [BT-4]
CO 5: Predict the root causes and remedies of extruded and drawn components failure [BT-5]
CO 6: Design the various steps involved in Manufacturing process [BT-6]

- **Design the various steps involved in Manufacturing process [BT-6]**

Course Outline

(Key in topics to be dealt)
Introduction to Metal forming
Rolling
Forging
Extrusion
Drawing
Sheet metal forming
Advanced metal forming

Method of delivery

Interactive lectures, Power point presentation, Problem solving

Study time

5 classes per week

CO-PO Mapping (PO: Program Outcomes)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
C0 1	3	1	1	2								1
C0 2	3	2	1	2								1
C0 3	2	3	1	1								1
C0 4	3	3	2	1	1		1				1	1
C0 5	3	2	2	2								2
C0 6	2	3	1	2			1					1
MME0601	2.7	2.3	1.3	1.7	1		1				1	1.2

Blooms Taxonomy and Knowledge retention (For reference)

(Blooms taxonomy has been given for reference)

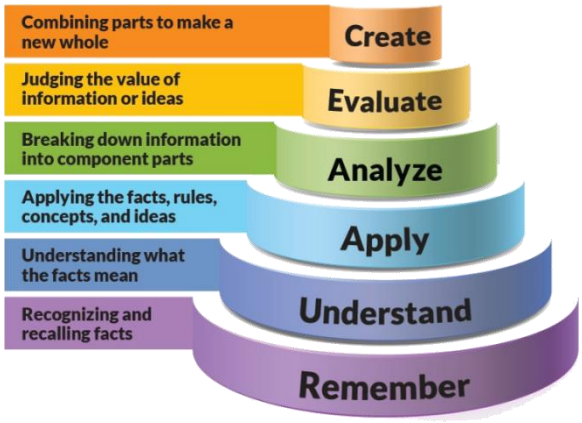


Figure 1: Blooms Taxonomy

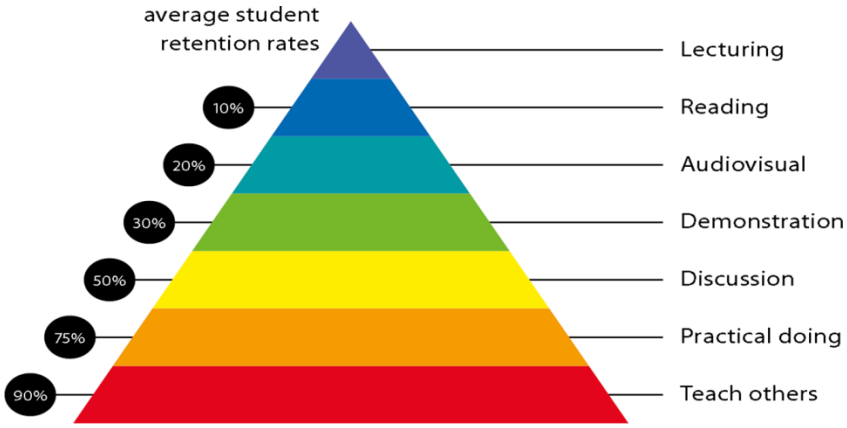


Figure 2: Knowledge retention

Graduate Qualities and Capabilities covered

(Qualities graduates harness crediting this Course)

General Graduate Qualities	Specific Department of _____Graduate Capabilities
Informed Have a sound knowledge of an area of study or profession and understand its current issues, locally and internationally. Know how to apply this knowledge. Understand how an area of study has developed and how it relates to other areas.	**1 Professional knowledge, grounding & awareness**
Independent learners Engage with new ideas and ways of thinking and critically analyze issues. Seek to extend knowledge through ongoing research, enquiry and reflection. Find and evaluate information, using a variety of sources and technologies. Acknowledge the work and ideas of others.	**2 Information literacy, gathering & processing**
Problem solvers Take on challenges and opportunities. Apply creative, logical and critical thinking skills to respond effectively. Make and implement decisions. Be flexible, thorough, innovative and aim for high standards.	**4 Problem solving skills**
Effective communicators Articulate ideas and convey them effectively using a range of media. Work collaboratively and engage with people in	**5 Written communication** **6 Oral communication** **7 Teamwork**

different settings. Recognize how culture can shape communication.	
Responsible Understand how decisions can affect others and make ethically informed choices. Appreciate and respect diversity. Act with integrity as part of local, national, global and professional communities.	**10 Sustainability, societal & environmental impact**

Practical work:

(Mention what practical work this Course involves)

Lecture/tutorial times

(Give lecture times in the format below)

Example:

Lecture	Monday	9.00 – 09.55 am	Room Lab 1
Tutorial	Monday	2.25 – 04.15 am	Room Lab 1
Lecture	Wednesday	1.30 – 02.25 am	Room Lab 1
Lecture	Tuesday	2.25 – 03.20 am	Room Lab 1

Attendance Requirements

The University norms states that it is the responsibility of students to attend all lectures, tutorials, seminars and practical work as stipulated in the Course outline. Minimum attendance requirement as per university norms is compulsory for being eligible for mid and end semester examinations.

Details of referencing system to be used in written work

Text books

1. Mechanical Metallurgy by G. E. Dieter, SI Metric Editions, McGraw-Hill Book Company, 1988.

Additional Materials

1) Manufacturing Technology (Foundry, Forming and Welding) by P. N. Rao, TMH, 2007.
2) Metal Forming: Mechanics and Metallurgy by William F. Hosford and Robert M. Caddell, PTR Prentice-Hall (USA), 2011
3) Handbook of Metal Forming by K. Lange (Editor-in-Chief), Springer Verlag (Germany), 1985.

ASSESSMENT GUIDELINES

Your final course mark will be calculated from the following:

Example:		
MSE	40%	CIE
Attendance	5%	
Seminar	5%	
Project	10%	
Final exam (*closed book*)	40%	

SUPPLEMENTARY ASSESSMENT

Students who receive an overall mark less than 40% in mid semester or end semester will be considered for supplementary assessment in the respective components (i.e mid semester or end semester) of semester concerned. Students must make themselves available during the supplementary examination period to take up the respective components (mid semester or end semester) and need to obtain the required minimum 40% marks to clear the concerned components. **Examination and Assessment will be carried out as per CoE instruction.**

Practical Work Report/Laboratory Report:

A report on the practical work is due the subsequent week after completion of the class by each group.

Late Work

Late assignments will not be accepted without supporting documentation. Late submission of the reports will result in a deduction of 10% of the maximum mark per calendar day

Format

All assignments must be presented in a neat, legible format with all information sources correctly referenced. **Assignment material handed in throughout the session that is not neat and legible will not be marked and will be returned to the student.**

Retention of Written Work

Written assessment work will be retained by the Course coordinator/lecturer for two weeks after marking to be collected by the students.

University and Faculty Policies

Students should make themselves aware of the University and/or Faculty Policies regarding plagiarism, special consideration, supplementary examinations and other educational issues and student matters.

Plagiarism - Plagiarism is not acceptable and may result in the imposition of severe penalties. Plagiarism is the use of another person's work, or idea, as if it is his or her own - if you have any doubts at all on what constitutes plagiarism, please consult your Course coordinator or lecturer. Plagiarism will be penalized severely.

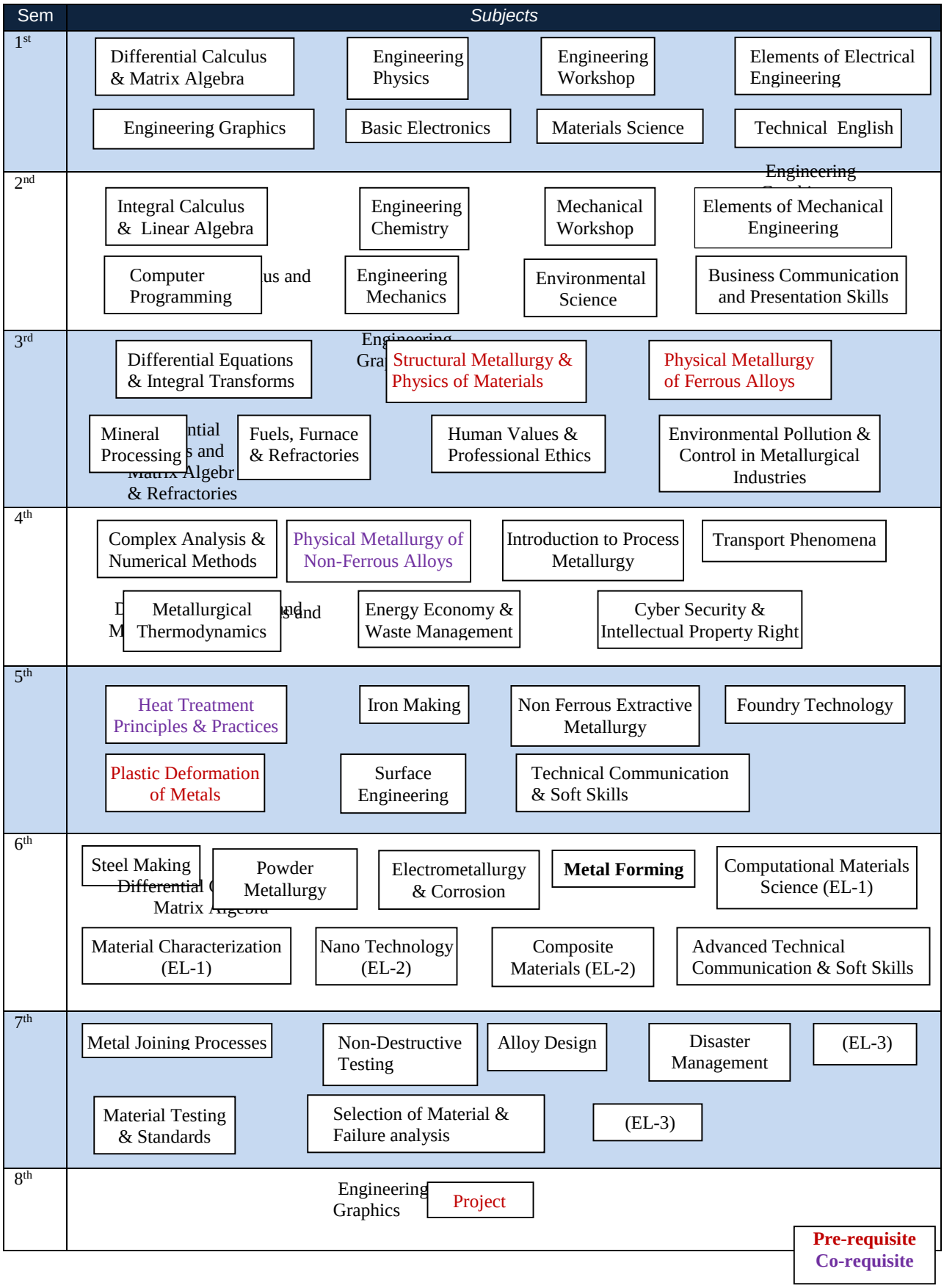
Do not copy the work of other students.
Do not share your work with other students (except where required for a group activity or assessment)

Course schedule (subject to change)

(Mention quiz, assignment submission, breaks etc as well in the table under the Teaching Learning Activity Column)

	Week #	Topic & contents	CO Addressed	Teaching Learning Activity (TLA)
	Weeks 1	Introduction to metal forming & classification of Metal forming	1	Interactive teaching using PPT and block board
	Weeks 2	Temperature in metal working, Hot working, cold working, warm working, strain rate effect	2,3	Interactive teaching using PPT and block board
	Week 3	Metallurgical structure and non-metallic inclusion on the manufacturing process, workability, residual stresses, Annealing of cold worked metals	*2,3*	Interactive teaching using PPT and block board
	Week 4	Yield criteria, Von-Mises equation, Mechanics of metal working and flow curve for materials.	1,2	Interactive teaching using PPT and block board
	Week 5	**Forging:** Classification of forgoing processes, Forging equipment and operations, Open die forging, Closed die forging, Plane strain forging analysis	2	Interactive teaching using PPT and video
	Week 6	Forging defects, Metallurgical variables associated with forging, Powder metallurgy forging, Residual stresses in forging.	*2*	Interactive teaching using PPT and block board
	Week 7	**Rolling:** Terminology of rolled products, Different kinds of rolling mills, Deformation zone in rolling, Neutral point, Angle of bite, Forward slip, Roll flattening, Rolling variables, Hot rolling	1,2	Interactive teaching using PPT and video
	Week 8	Cold rolling, Rolling of blooms billets, slabs, plates, strips, sheets, bars, rods & light section, Lay out of different mills for rolling of above products, Elementary roll pass design, Forces and geometrical relationships in rolling, Defects in rolled products.	2	Interactive teaching using PPT and block board
	Week 9	**Extrusion:** Classification of extrusion processes, Direct and indirect extrusion, Impact extrusion, Hydrostatic extrusion, Extrusion equipment	*1*	Interactive teaching using PPT and video
	Week 10	Extrusion ratio, Process variables, Lubrication & defects in extrusion, Derivation of extrusion pressure,	2	Interactive teaching using

		Extrusion of tubing, Production of seamless pipe and tubing.		PPT and block board
	Week 11	**Drawing:** Rods, wires and tubes: Theory and practice of wire drawing, Wire drawing equipment, Variables in wire drawing, Defects in formed products.	1,2	Interactive teaching using PPT and video
	Week 12	**Sheet metal working:** Shearing, Blanking, Bending, Stretch forming, Deep drawing, Spinning, Piercing, Swaging, Embossing, Coining,	2	Interactive teaching using PPT and video
	Week 13	High energy rate forming, explosive forming, electromagnetic forming, electro hydraulic forming, formability diagrams, Super-plasticity.	2	Interactive teaching using PPT and video


Sem
Subjects
1st
Differential Calculus & Matrix Algebra
Engineering Physics
Engineering Workshop
Elements of Electrical Engineering
Engineering Graphics
Basic Electronics
Materials Science
Technical English
2nd
Integral Calculus & Linear Algebra
Engineering Chemistry
Mechanical Workshop
Elements of Mechanical Engineering
Computer Programming
Engineering Mechanics
Environmental Science
Business Communication and Presentation Skills
3rd
Differential Equations & Integral Transforms
Structural Metallurgy & Physics of Materials
Physical Metallurgy of Ferrous Alloys
Mineral Processing
Fuels, Furnace & Refractories
Human Values & Professional Ethics
Environmental Pollution & Control in Metallurgical Industries
4th
Complex Analysis & Numerical Methods
Physical Metallurgy of Non-Ferrous Alloys
Introduction to Process Metallurgy
Transport Phenomena
Metallurgical Thermodynamics
Energy Economy & Waste Management
Cyber Security & Intellectual Property Right
5th
Heat Treatment Principles & Practices
Iron Making
Non Ferrous Extractive Metallurgy
Foundry Technology
Plastic Deformation of Metals
Surface Engineering
Technical Communication & Soft Skills
6th
Steel Making
Powder Metallurgy
Electrometallurgy & Corrosion
Metal Forming
Computational Materials Science (EL-1)
Material Characterization (EL-1)
Nano Technology (EL-2)
Composite Materials (EL-2)
Advanced Technical Communication & Soft Skills
7th
Metal Joining Processes
Non-Destructive Testing
Alloy Design
Disaster Management
(EL-3)
Material Testing & Standards
Selection of Material & Failure analysis
(EL-3)
8th
Engineering Graphics
Project
Pre-requisite
Co-requisite

Subject: Metal Forming								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0601**			Semester: **VI**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	1	0	4	16/40	0	24/60	0	100

Course Objectives

1. To provide knowledge about the basic concepts of deformations and energy requirements.
2. To understand different methods of deformations to produce various shapes.
3. To teach them various strengthening mechanism of metals.

CONTENTS

UNIT-I

[10 hours]

Fundamentals of metal working: Yield criteria, Von-Mises equation, Classification of metal forming processes, Mechanics of metal working, Flow curve for materials, Temperature in Metal Working, Hot working, Cold working & Warm working, Strain rate effect of metallurgical structure and non-metallic inclusion on the manufacturing process, Workability, Residual stresses, Annealing of cold-worked metals.

UNIT-II

[10 hours]

Forging: Classification of forgoing processes, Forging equipment and operations, Open die forging, Closed die forging, Plane strain forging analysis, Forging defects, Metallurgical variables associated with forging, Powder metallurgy forging, Residual stresses in forging.

Rolling: Terminology of rolled products, Different kinds of rolling mills, Deformation zone in rolling, Neutral point, Angle of bite, Forward slip, Roll flattening, Rolling variables, Hot rolling, Cold rolling, Rolling of blooms billets, slabs, plates, strips, sheets, bars, rods & light section, Lay out of different mills for rolling of above products, Elementary roll pass design, Forces and geometrical relationships in rolling, Defects in rolled products. Galvanizing of cold rolled products.

UNIT-III

[10 hours]

Extrusion: Classification of extrusion processes, Direct and indirect extrusion, Impact extrusion, Hydrostatic extrusion, Extrusion equipment, Extrusion ratio, Process variables, Lubrication &defects in extrusion, Derivation of extrusion pressure, Extrusion of tubing, Production of seamless pipe and tubing.

Drawing: Rods, wires and tubes: Theory and practice of wire drawing, Wire drawing equipment, Variables in wire drawing, Defects in formed products.

UNIT-IV

[10 hours]

Sheet metal working: Shearing, Blanking, Bending, Stretch forming, Deep drawing, Spinning, Piercing, Swaging, Embossing, Coining, High energy rate forming, explosive forming, electromagnetic forming, electro hydraulic forming, formability diagrams, Super-plasticity.

Advancement of metal forming processes: Advanced and newer trend of incremental forming.

Course Outcomes

1. To solve different numerical pertaining to different metal forming techniques.
2. To apply the concepts of forming processes and discern the effect of variables on the productivity.
3. To solve practical example on the testing.

Text Books

1. G. E. Dieter, "Mechanical Metallurgy", McGraw-Hill, 3rd Edition, 2013, ISBN: 9781259064791.

Reference Books

1. P. N. Rao, "Manufacturing Technology (Foundry, Forming and Welding)", Tata McGraw Hill Education Private Limited, 4th Edition, 2013, ISBN: 9789383286614.
2. W. F. Hosford and R. M. Caddell, "Metal Forming: Mechanics and Metallurgy", Cambridge University Press, 4th Edition, 2014, ISBN: 9781107670969.
3. K. Lange, "Deformation Handbook of Metal Forming", Society of Manufacturing Engineers, New Edition, 1985, ISBN: 9780872634572.

Web Resources

1. NPTEL MOOC Course on "Forming" (http://nptel.ac.in/courses/112106153/)
2. EdX Online Course on "Mechanical Behavior of Materials" (https://courses.edx.org/courses/MITx/3.032x/3T2014/info)
3. NPTEL MOOC Course on "Fundamentals of Material Processing - I" (https://onlinecourses.nptel.ac.in/noc17_mm09/preview)
4. NPTEL MOOC Course on "Fundamentals of Material Processing - I" (https://onlinecourses.nptel.ac.in/noc16_mm11/preview)
5. EdX Online Course on "Fundamentals of Manufacturing Processes" (https://www.edx.org/course/fundamentals-manufacturing-processes-mitx-2-008x)
6. NPTEL MOOC Course on "Manufacturing Process Technology I & II" (https://onlinecourses.nptel.ac.in/noc17_me03/preview)

Name of Institute: Indus Institute of Technology & Engineering

Name of Faculty: Dr. Sujoy Chaudury

Course Code: **MME0604**

Course Name: **Metal Joining Processes**

Pre-requisites: Physcial Metallurgy, Heat treatment principle and practices

Credit points: 04

Offered Semester: VII

Course Coordinator (weeks 01–15)

Full Name: Dr. Sujoy Chaudhury

Department with sitting location: Lab 3, Ground, Bhanwar Building

Telephone: 84699 43117

Email: sujoychaudhury.mt@indusuni.ac.in

Consultation times: 4:15 PM – 5.00 PM

Course Lecturer (weeks 01–15)

Full Name: Dr. Sujoy Chaudhury

Department with sitting location: Lab 3, Ground, Bhanwar Building

Telephone: 84699 43117

Email: sujoychaudhury.mt@indusuni.ac.in

Consultation times: 4:15 PM – 5.00 PM

Students will be contacted throughout the session personally and/or via e-mail with important information relating to this course.

Course Objectives

Course Objectives

1. To understand the basics & importance of joining processes.

2. To understand the various types of joining operations used in the industries.

3. To co-relate the basic machine products with the of product applicability & use skills for specific joining processes.

Course Outcomes

CO 1: Recall all the terms and definitions in Metal joining process.(BT-1)
CO 2: Explain the theories represent different process parameters of metal joining process.(BT-2)
CO 3: Apply the knowledge of different welding process to weld various metal parts.(BT-3)
CO 4: Analyze the strength of joints and ability to detect defects. (BT-4)
CO 5: Evaluate different parameters for efficient gas welding, arc welding, resistance welding and soldering. (BT-5)
CO 6: Formulate a welded structure according to AWS and ISO parameters and welding specification.(BT-6)

4.1 Program Outcomes (PO's)

Engineering Graduates will be able to:

- **PO1** **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
- **PO2** **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
- **PO3** **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
- **PO4** **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
- **PO5** **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
- **PO6** **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
- **PO7** **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
- **PO8** **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
- **PO9** **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10 Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11 Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12 Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Course Outline

Metal joining process is a course of 4 hours credit. This course will enable the student to understand and apply basic principles in the different types of metal joining and welding process and parameters.

Method of delivery

Face to face lectures

Study time

4 Hour Lecture per week

CO-PO Mapping (PO: Program Outcomes)

Mapping CO's with PO's

Metal Joining Processes (MME0604)												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	-	-	-	-	-	-	-	1	-	3
CO2	3	2	-	-	-	-	-	-	1	-	-	1
CO3	2	3	-	-	-	-	-	-	-	-	-	2
CO4	2	3	-	2		-	-	-	2	-	-	1
CO5	2	-	-	1	1	-	-	-	-	-	-	3
CO6	1	1	1	2	1	-	-	-	1	1	-	2
MME0604	**2.2**	**2.2**	**1**	**1.7**	**1**	**-**	**-**	**-**	**1.3**	**1**	**-**	**2**

1-Lightly Mapped 2- Moderately Mapped 3- Highly Mapped

Blooms Taxonomyand Knowledge retention(For reference)

(Blooms taxonomy has been given for reference)

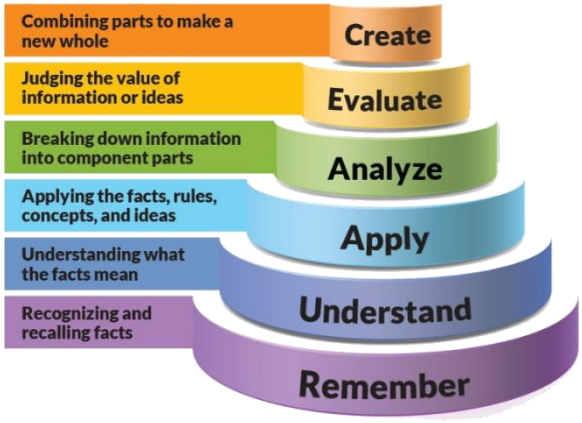


Figure 1: Blooms Taxonomy

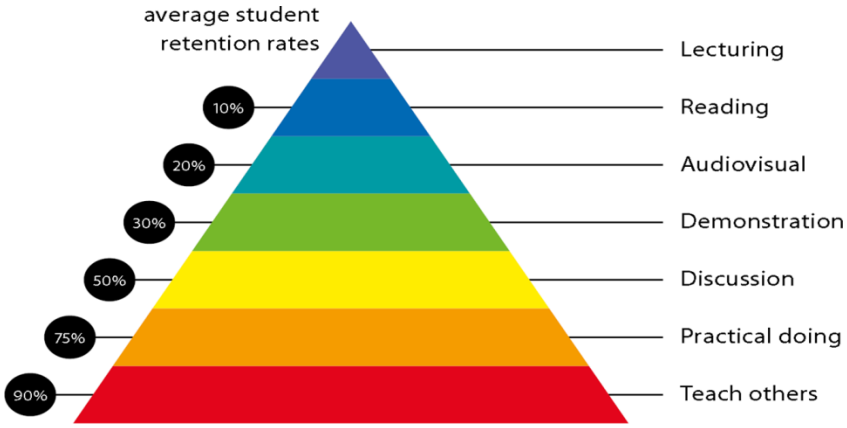


Figure 2: Knowledge retention

Graduate Qualities and Capabilities covered

(Qualities graduates harness crediting this Course)

General Graduate Qualities	Specific Department of _____Graduate Capabilities
Informed Have a sound knowledge of an area of study or profession and understand its current issues, locally and internationally. Know how to apply this knowledge. Understand how an area of study has developed and how it relates to other areas.	**1 Professional knowledge, grounding & awareness**

Independent learners Engage with new ideas and ways of thinking and critically analyze issues. Seek to extend knowledge through ongoing research, enquiry and reflection. Find and evaluate information, using a variety of sources and technologies. Acknowledge the work and ideas of others.	**2 Information literacy, gathering & processing**
Problem solvers Take on challenges and opportunities. Apply creative, logical and critical thinking skills to respond effectively. Make and implement decisions. Be flexible, thorough, innovative and aim for high standards.	**4 Problem solving skills**
Effective communicators Articulate ideas and convey them effectively using a range of media. Work collaboratively and engage with people in different settings. Recognize how culture can shape communication.	**5 Written communication** **6 Oral communication** **7 Teamwork**
Responsible Understand how decisions can affect others and make ethically informed choices. Appreciate and respect diversity. Act with integrity as part of local, national, global and professional communities.	**10 Sustainability, societal & environmental impact**

Practical work:

(Mention what practical work this Course involves)

YES

Lecture/tutorial times

(Give lecture times in the format below)

Lecture	Tues day	11.10-12.10 AM
Lecture	Wednesday	02.00-03.00 PM
Lecture	Friday	09.00-09.55 AM
Lab	Monday	2.00 4.15PM

Attendance Requirements

The University norms states that it is the responsibility of students to attend all lectures, tutorials, seminars and practical work as stipulated in the Course outline. Minimum attendance requirement as per university norms is compulsory for being eligible for mid and end semester examinations.

Details of referencing system to be used in written work

Text Books

1. J. F. Lancaster, "The Metallurgy of Welding, Brazing and Soldering", George Allen and Unwin, 2nd Edition, 1970, ASIN: B000OA77G6.

2. D. R. Milner and R. L. Apps, "Introduction to Welding and Brazing", Elsevier, 1st Edition, 1968, ISBN: 9780080123066.

Reference Books

1. P. N. Rao, "Manufacturing Technology (Foundry, Forming and Welding)", Mcgraw Hill Higher Education, 3rd Edition, 2008, ISBN: 9780070087989

2. J. F. Lancaster, "The Physics of Welding", Pergamon Press, 2nd Edition, 1986, ISBN: 9780080340760.

3. R. S. Parmar, "Welding Processing and Technology", Khanna Publishers, 2nd Edition, 2003, ISBN: 9788174091260.

4. O. P. Khanna, "A Textbook of Welding Technology", Dhanpat Rai Publications, 2013 Edition, 2013, ISBN: 9788189928360.

5. ASM International, "ASM Handbook - Vol. 6", ASM International, 10th Edition, 1993, ISBN: 9780871703828.

Web Resources

1. NPTEL MOOC Course on "Joining Technologies for Metals"

(https://onlinecourses.nptel.ac.in/noc17_me09/preview)

ASSESSMENT GUIDELINES

(a) CIE 60 marks (40 marks mid semester examination + 20 marks internal evaluation)

Components of internal evaluation includes (05 marks as attendance bonus for all students having attendance > 80%)+(05 marks for presentation)+(10 marks for assignment or case studies, 02 assignments per course).

(b) End Semester 40 marks.

SUPPLEMENTARY ASSESSMENT

Students who receive an overall mark less than 40% in mid semester or end semester will be considered for supplementary assessment in the respective components (i.e., mid semester or end semester) of semester concerned. Students must make themselves available during the supplementary examination period to take up the respective components (mid semester or end semester) and need to obtain the required minimum 40% marks to clear the concerned components.

Practical Work Report/Laboratory Report:

A report on the practical work is due the subsequent week after completion of the class by each group.

Late Work

Late assignments will not be accepted without supporting documentation. Late submission of the reports will result in a deduction of -% of the maximum mark per calendar day.

Format

All assignments must be presented in a neat, legible format with all information sources correctly referenced. **Assignment material handed in throughout the session that is not neat and legible will not be marked and will be returned to the student.**

Retention of Written Work

Written assessment work will be retained by the Course coordinator/lecturer for two weeks after marking to be collected by the students.

University and Faculty Policies

Students should make themselves aware of the University and/or Faculty Policies regarding plagiarism, special consideration, supplementary examinations and other educational issues and student matters.

Plagiarism - Plagiarism is not acceptable and may result in the imposition of severe penalties. Plagiarism is the use of another person's work, or idea, as if it is his or her own - if you have any doubts at all on what constitutes plagiarism, please consult your Course coordinator or lecturer. Plagiarism will be penalized severely.

Do not copy the work of other students.

Do not share your work with other students (except where required for a group activity or assessment).

Courseschedule(subject to change)

(Mention quiz, assignment submission, breaksetcas well in the table under the Teaching Learning Activity Column)

Weeks	Topic & contents	CO Addressed	Teaching Learning Activity (TLA)
Week01	History, Importance of metal joining processes, Classification of metal joining processes - Classification based on application of filler material & without filler material	CO1	BB/PPT
Week02	Source of energy, fusion and pressure welding processes, joint design and edge preparation	CO1	BB/PPT
Week 03	Physics of arc, characteristic of arc. Welding positions.	CO1, CO2	BB/PPT
Week 04	Soldering and brazing: Difference between both the processes, consumables used, methods of brazing, fluxes used, and their purpose and flux residue treatment, comparison with welding process.	CO1, CO2	BB/PPT

Week 05	Metal transfer, forces acting on the arc, different modes of metal transfer, heat flow in metals, prediction of heating and cooling rates	CO1, CO2	BB/PPT
Week 06	. Manual metal arc(MMA) or shielded metal arc (SMA) welding, Submerged arc welding (SAW), Gas metal arc welding (GMAW) or MIG/MAG welding	CO1, CO2	BB/PPT
Week 07	TIG welding, Plasma Arc welding: Principle, Equipment requirement, electrodes for welding of structural steels,	CO1, CO2	BB/PPT
Week 08	Electrode coating classification, process description, shielding gases, advantages and disadvantages, application of processes.	CO1, CO2	BB/PPT
Week 09	Resistance welding, general principle of heat generation in resistance welding, application of resistance welding processes	CO1, CO2	BB/PPT
Week 10	Process details and working principle of spot, seam, and projection welding,	CO1, CO2	BB/PPT
Week 11	Electrode materials, shapes of electrodes, electrode cooling, selection of welding currents, voltages.	CO1, CO2	BB/PPT
Week 12	Other welding processes like Electron beam welding, Laser beam welding	CO1, CO2	BB/PPT
Week 13	Friction welding, Friction Stir Welding explosive welding,	CO1, CO2, CO4	BB/PPT
Week 14	Ultrasonic welding, diffusion welding, Electroslag and Electro gas welding etc. Weldability and defects: introduction	CO1, CO2, CO4	BB/PPT
Week 15	Weldability test, Weldability of ferrous and non ferrous materials, joining metallurgy of the dissimilar metals, clad metals etc., Welding defects.	CO1, CO2, CO3	BB/PPT

PROGRAM MAP FOR BACHELOR OF ENGINEERING

Sem	Subjects
1st	Calculus; Engineering Physics; Workshop; Material Science; Environmental Science; Material Science (OE); Technical Communication
2nd	Differential Equations and Linear Algebra; Engineering Chemistry; Metallurgy for Non Metallurgists (OE); Structural Properties and Physics of Materials; Engineering Graphics; Advanced Material and Application (OE); Business Communication and Presentation Skills
3rd	Probability, Statistics and Numerical Methods; Management for Engineers; Human Values and Professional Ethics; Mineral Processing; Metallurgical Thermodynamics; Internship-1; Physical Metallurgy
4th	Iron Making; Transport Phenomena; Metal Casting and Solidification (OE); Recycled Materials (OE); Heat Treatment Principles and Practices; Soft Skill and Interpersonal Comm.; Personality Credit-1
5th	Foundry Technology; Steel Making; Fuel Furnace and Refractories (EL); Environmental Pollution and its Control in Met. Ind. (EL); Non Ferrous Extractive Metallurgy; Plastic Deformation of Metals; Energy Economy and Waste Management- (OE); Internship-2
6th	Metal Forming; Phase Transformation; Powder Metallurgy (Elective-1); Modelling of Metallurgical Processes (Elective-1); Electrometallurgy and Corrosion; Ind. Ceramics and Polymers (El-2); Nano Technology (OE); Metal Joining Processes; Composite Materials (EL-2); Personality Credit-2
7th	Metal Testing and Characterization; Alloy Design (EL); Advanced Ferrous Metallurgy (EL); Surface (EL); Internship-3; Non Destructive Testing (EL) and (OE); Material Testing and Standards; Selection of Material & Failure analysis (EL) & (OE); Advanced Foundry Technology (EL)
8th	Project

Subject: **Metal Joining Processes**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0604**			Semester: **VI**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	2	4	16/40	16/40	24/60	24/60	200

Course Objectives

1. To understand the basics & importance of joining processes.
2. To understand the various types of joining operations used in the industries.
3. To correlate the basic machine products with the of product applicability & use skills for specific joining processes.

CONTENTS

UNIT-I

[10 hours]

History, Importance of metal joining processes, Classification of metal joining processes - Classification based on application of filler material & without filler material, source of energy, fusion and pressure welding processes, joint design and edge preparation, physics of arc, characteristic of arc. Welding positions. Welding Symbols, Soldering and brazing: Difference between both the processes, consumables used, methods of brazing, fluxes used, and their purpose and flux residue treatment, comparison with welding process.

UNIT-II

[10 hours]

Metal transfer, forces acting on the arc, different modes of metal transfer, heat flow in metals, prediction of heating and cooling rates. Manual metal arc(MMA) or shielded metal arc (SMA) welding, Submerged arc welding (SAW), Gas metal arc welding (GMAW) or MIG/MAG welding, TIG welding, Plasma Arc welding: Principle, Equipment requirement, electrodes for welding of structural steels, electrode coating classification, process description, shielding gases, advantages and disadvantages, application of processes.

UNIT-III

[10 hours]

Resistance welding, general principle of heat generation in resistance welding, application of resistance welding processes. Process details and working principle of spot, seam, and projection welding, electrode materials, shapes of electrodes, electrode cooling, selection of welding currents, voltages. Gas welding, electron beam welding, and laser beam welding.

UNIT-IV

[10 hours]

Other welding processes: Friction welding, friction stir welding, explosive welding, ultrasonic welding, diffusion welding, electroslag and electro gas welding etc. Weldability and defects: introduction, weldability test, weldability of ferrous and non-ferrous materials, joining metallurgy of the dissimilar metals, cladding and hard facing metals, welding for additive manufacturing etc., welding defects. Inspection and testing methods.

Metal Joining Processes Lab (List of Experiments)

Experiment No.	Title
1	To study the edge preparation and preparation of different types of weld joints
2	To study effect of proportion of oxygen and acetylene on the gas welding flame
3	To study the effect of welding parameters on weld quality by SMAW welding
4	Characterization of weldments prepared by SMAW
5	Preparation of joints using Tungsten Inert Gas welding
6	Characterization of weldments prepared by TIG
7	Preparation of joints using Metal Inert Gas welding
8	Characterization of weldments prepared by MIG
9	Preparation of different type of joints uses spot welding and butt welding
10	Characterization of weldments prepared by spot and butt welding
11	To study the effect of rpm on weld microstructure by friction welding
12	Characterization of weldments prepared by friction welding
13	To study the effect of gas flow rate on weld quality by MIG welding
14	Application of welding Gauge
15	Effect of GTAW parameters on weld bead morphology

Course Outcomes

1. To develop the capability to analyze and select the various criteria of quality joining of the metals.
2. To implement effectively and accurately the suitable joining process to improve the efficiency & life of the product / Machines.
3. To learn various quality dimensions of joints, cost factor, factor of safety etc.
4. To understand the advance processes of joining& its applicability.

Text Books

1. J.F. Lancaster, "The Metallurgy of Welding, Brazing and Soldering", George Allen and Unwin, 2nd Edition, 1970, ASIN: B000OA77G6.

2. D.R. Milner and R.L. Apps, "Introduction to Welding and Brazing", Elsevier, 1st Edition, 1968, ISBN: 9780080123066.

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2. J. F. Lancaster, "The Physics of Welding", Pergamon Press, 2nd Edition, 1986, ISBN: 9780080340760.

3. R. S. Parmar, "Welding Processing and Technology", Khanna Publishers, 2nd Edition, 2003, ISBN: 9788174091260.

4. O.P. Khanna, "A Textbook of Welding Technology",Dhanpat Rai Publications, 2013 Edition, 2013, ISBN: 9788189928360.

5. ASM International, "ASM Handbook - Vol. 6", ASM International, 10th Edition, 1993, ISBN: 9780871703828.

Web Resources

1. NPTEL MOOC Course on "Joining Technologies for Metals"

(https://onlinecourses.nptel.ac.in/noc17_me09/preview)

Name of Institute: IITE
Name of Faculty: Gaurav Awasthi

Course code: MME0607
Course name: Nano Technology
Pre-requisites: Physics, Chemistry and Material Science
Credit points: 4
Offered Semester: 6

Course Coordinator (weeks XX - XX)
Full Name: Gaurav Awasthi
Department with sitting location: Third Floor staff room
Telephone:9909709727
Email: gauravavasthi.mt@indusuni.ac.in
Consultation times: 4:15 – 5:00PM

Course Lecturer (weeks xx - XX)
Full Name: Gaurav Awasthi
Department with sitting location: Third Floor staff room
Telephone:9909709727
Email: gauravavasthi.mt@indusuni.ac.in
Consultation times: 4:15 – 5:00PM

Students will be contacted throughout the Session via Mail with important information relating to this Course.

Course Objectives

By participating in and understanding all facets of this Course a student will:

1. To describe and explain Nanotechnology.
2. To describe Nanomaterials based on their dimensionality.
3. To explain the importance of reduction in materials dimensionality, and its relationship with materials properties.

Course Outcomes (CO)

CO 1: Students will be able to define basic terms used in Nano Technology. [BT-1]
CO 2: Students will be able to design experiments of synthesis, purification and applications of carbon nanotubes [BT-6]
CO 3: Students will be able to learn characterization tools to analyses nanomaterials. [BT-4]
CO 4: Students will be able to classify different types of Nano Materials. [BT-2]
CO 5: Students will be able to explain the effect of particles or grains size on mechanical, thermal, optical and electrical properties of nanomaterials. [BT-5]
CO 6: Students will able to experiment to synthesis the nanomaterials by top-down and bottom up approaches. [BT-3]

Course Outline

The proposed course deals with nano material and their properties.

Method of delivery

(Face to face lectures, self study material, Active Learning Techniques)

Study time

3 lectures

CO-PO Mapping (PO: Program Outcomes)

Nanotechnology (MME0607)												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	1	1	-	1	-	-	-	-	-	-	-
CO2	2	2	2	2	2	-	-	-	-	-	-	1
CO3	1	2	3	3	3	-	-	-	-	-	2	-
CO4	2	3	2	1	3	-	-	-	-	-	-	2
CO5	3	2	3	2	2	-	-	-	-	-	1	-
CO6	2	3	2	3	3	-	-	-	-	-	-	-
MT0607	**2.16**	**2.16**	**2.16**	**1.83**	**2.33**	-	-	-	-	-	**1.5**	**1.5**

1-Lightly Mapped 2- Moderately Mapped 3- Highly Mapped

Blooms Taxonomyand Knowledge retention(For reference)

(Blooms taxonomy has been given for reference)

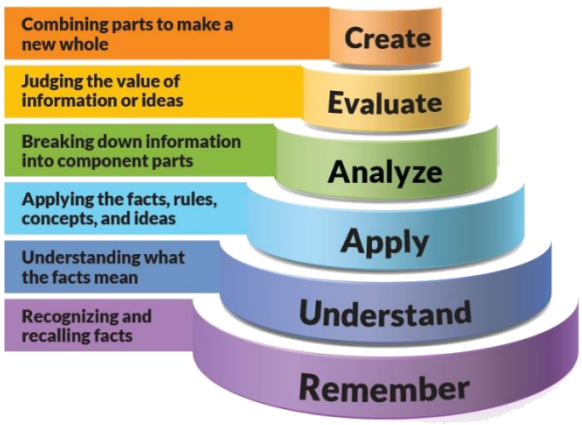

Figure 1: Blooms Taxonomy

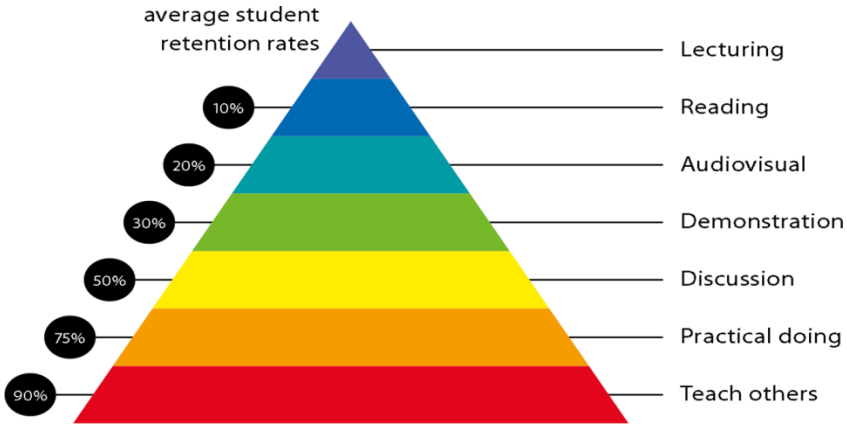

Figure 2: Knowledge retention

Graduate Qualities and Capabilities covered

(Qualities graduates harness crediting this Course)

General Graduate Qualities	Specific Department of _____Graduate Capabilities
Informed Have a sound knowledge of an area of study or profession and understand its current issues, locally and internationally. Know how to apply this knowledge. Understand how an area of study has developed and how it relates to other areas.	**1 Professional knowledge, grounding & awareness**
Independent learners Engage with new ideas and ways of thinking and critically analyze issues. Seek to extend knowledge through ongoing research, enquiry and reflection. Find and evaluate information, using a variety of sources and technologies. Acknowledge the work and ideas of others.	**2 Information literacy, gathering & processing**
Problem solvers Take on challenges and opportunities. Apply creative, logical and critical thinking skills to respond effectively.	**4 Problem solving skills**

Make and implement decisions. Be flexible, thorough, innovative and aim for high standards.	
Effective communicators Articulate ideas and convey them effectively using a range of media. Work collaboratively and engage with people in different settings. Recognize how culture can shape communication.	**5 Written communication** **6 Oral communication** **7 Teamwork**
Responsible Understand how decisions can affect others and make ethically informed choices. Appreciate and respect diversity. Act with integrity as part of local, national, global and professional communities.	**10 Sustainability, societal & environmental impact**

Practical work:

Corrosion rate measurement, Study of Pitting corrosion, Electroplating, Effect of current density on Anodizing

Lecture/tutorial times

(Give lecture times in the format below)

Example:

Lecture	Monday	09:55 – 10:50 am	Lab 4
Lecture	Tuesday	09:00 – 09:55 am	Lab 4
Lecture	Thursday	02:25– 03:2 pm	Lab 4

Attendance Requirements

The University norms states that it is the responsibility of students to attend all lectures, tutorials, seminars and practical work as stipulated in the Course outline. Minimum

attendance requirement as per university norms is compulsory for being eligible for mid and end semester examinations.

Details of referencing system to be used in written work

Text Books

1. A. K. Bandopadhyay, "Nano Materials", New Age International Publishers, 1st Edition, 2009, ISBN: 9781906574277.

2. K. K. Chattopadhyay and A. N. Banerjee "Introduction to Nanoscience and Nanotechnology", PHI Learning, 1st Edition, 2009, ISBN: 9788120336087

3. C. C. Koch, "Nanostructured Materials: Professing, Properties and Applications", William Andrew Publishing, 2nd Edition, 2006, ISBN: 9780815518426.

Reference Books

1. G. Timp, "Nanotechnology", Springer, 1999th Edition, 1999, ISBN: 9780387983349.

2. J. H. Fendler, "Nanoparticles and Nanostructured Films: Preparation, Characterization and Applications", Wiley-VCH, 1st Edition, 1998, ISBN: 9783527294435.

3. Z. L. Wang, Z. Zhang and Y. Lim, "Handbook of Nanophase and Nanostructured Materials", Springer, 1st Edition, 2002, ISBN: 9780306472497.

4. H. S. Nalwa, "Handbook of Nanostructured Materials and Nanotechnology", Academic Press, 5 Volume Set Edition, 1999, ISBN: 9780471958932.

5. M. Meyyappan, "Carbon Nanotubes: Science and Applications", CRC Press, 1st Edition, 2004, ISBN: 9780203494936.

6. L. L. Shaw, C. Suryanarayana and Rajiv S. Mishra, "Processing and Properties of Structural Nanomaterials", Wiley-TMS, 1st Edition, 2003, ISBN: 9780873395588.

7. A. S. Edelstein and R.C. Cammarata, "Nanomaterials: Synthesis, Properties & Applications", Taylor and Francis, 1st Edition, 1996, ISBN: 9780750303583.

Web Resources

1. NPTEL MOOC Course on "Soft Nano Technology"

(https://onlinecourses.nptel.ac.in/noc16_ch06/preview)

2. EdX Online Course on "Nanotechnology: Fundamentals of Nanotransistors"

(https://www.edx.org/course/nanotechnology-fundamentals-purduex-nano530x)

ASSESSMENT GUIDELINES

Your final course mark will be calculated from the following:

Example:

MSE	40%
Assignment	10%
Attendance	**05%**
Class Participation	**05%**
Final exam (*closed book*)	40%

SUPPLEMENTARY ASSESSMENT

Students who receive an overall mark less than 40% in mid semester or end semester will be considered for supplementary assessment in the respective components (i.e mid semester or end semester) of semester concerned. Students must make themselves available during the supplementary examination period to take up the respective components (mid semester or end semester) and need to obtain the required minimum 40% marks to clear the concerned components.

Practical Work Report/Laboratory Report: (NA)

Late Work

Late assignments will not be accepted without supporting documentation. Late submission of the reports will result in a deduction of -1% of the maximum mark per calendar day

Format

All assignments must be presented in a neat, legible format with all information sources correctly referenced. **Assignment material handed in throughout the session that is not neat and legible will not be marked and will be returned to the student.**

Retention of Written Work

Written assessment work will be retained by the Course coordinator/lecturer for two weeks after marking to be collected by the students.

University and Faculty Policies

Students should make themselves aware of the University and/or Faculty Policies regarding plagiarism, special consideration, supplementary examinations and other educational issues and student matters.

Plagiarism - Plagiarism is not acceptable and may result in the imposition of severe penalties. Plagiarism is the use of another person's work, or idea, as if it is his or her own - if you have any doubts at all on what constitutes plagiarism, please consult your Course coordinator or lecturer. Plagiarism will be penalized severely.

Do not copy the work of other students.

Do not share your work with other students (except where required for a group activity or assessment)

.

Course schedule (subject to change)

	Week #	Topic & contents	CO Addressed	Teaching Learning Activity (TLA)
	Weeks 1	Introduction to Nanomaterials and nanotechnology,		BB, PPT
	Weeks 2	historical developments. An overview of scope & applications of nanotechnology,		BB, PPT
	Week 3	classifications and types of Nanomaterials. Basic understanding of various phenomena at nanoscale namely size confinement, interfacial surface phenomena.		BB, PPT
	Week 4	Introduction to basic building blocks namely atoms, molecules, self-assembly,		BB, PPT
	Week 5	carbon nanotubes, nanocrystals, fullerenes		BB, PPT
	Week 6	quantum dots, and quantum wires.		BB, PPT
	Week 7	Functional properties of nanomaterials such as physical, mechanical, electrical, magnetic, chemical and optical properties. Size dependence of material at nano scale. Bulk vs. nano properties of materials.		BB, PPT
	Week 8	Functional properties of nanomaterials such as physical, mechanical, electrical, magnetic, chemical and optical properties. Size dependence of material at nano scale. Bulk vs. nano properties of materials.		BB, PPT
	Week 9	Synthesis & fabrication techniques 'Top down' vs. 'Bottom-up' approach of synthesis.		BB, PPT

	Week 10	Review of synthesis methods namely sol-gel method, chemical vapour deposition, physical vapour deposition, sputtering, etc..		BB, PPT
	Week 11	Consolidation methods for nanopowders such as cold isostatic pressing (CIP), hot isostatic pressing (HIP),		BB, PPT
	Week 12	Dynamic compaction, Conventional and Microwave sintering		BB, PPT
	Week 13	Characterization of nanomaterials by using transmission electron microscopy (TEM, atomicforce microscopy (AFM).		BB, PPT
	Week 14	Applications of nanomaterials namely nanograined structural materials		BB, PPT
	Week 15	nanocomposites, nanomagnetic materials, chemical applications etc.		BB, PPT

Program Mapping (Metallurgy Engineering Department)

Sem	Subjects
1st	Calculus; Engineering Physics; Workshop; Material Science; Enviornmental Science; Material Science (OE); Technical Communication; Engineering Graphics
2nd	Engineering; Differential Equations and Linear Algebra; Engineering Chemistry; Metallurgy for Non Metallurgists (OE); Structural Properties and Physics of Materials; Engineering Graphics; Advanced Material and Application (OE); Business Communication and Presentation Skills
3rd	Probability, Statistics and Numerical Methods; Management for Engineers; Human Values and Professional Ethics; Mineral Processing; Metallurgical Thermodynamics; Internship-I; Physical Metallurgy
4th	& Refractories; Iron Making; Transport Phenomena; Metal Casting and Solidification (OE); Recycled Materials (OE); Differential Calculus and; Heat Treatment Principles and Practices; Soft Skill and Interpersonal Comm.; Personality Credit-1
5th	Foundry Technology; Steel Making; Fuel Furnace and Refractories (EL); Enviornmental Pollution and its Control in Met. Ind. (EL); Differential Calculus and; Non Ferrous Extractive Metallurgy; Plastic Deformation of Metals; Energy Economy and Waste Management- (OE); Internship-2
6th	Metal Forming; Phase Transformation; Powder Metallurgy (Elective-1); Engineering Graphics; Modelling of Metallurgical Processes (Elective-1); Electrometallurgy and Corrosion; Ind. Ceramics and Polymers (El-2); Nano Technology (OE); Metal Joining Processes; Composite Materials (EL-2); Personality Credit-2
7th	Differential Calculus and; Metal Testing and Charachterization; Alloy Design (EL); Advanced Ferrous Metallurgy (EL); Surface (EL); Internship-3; Non Destructive Testing (EL) and (OE); Material Testing and Standards; Selection of Material & Failure analysis (EL) & (OE); Advanced Foundry Technology (EL)
8th	Project; ngineering Graphics

Subject: Nano Technology (EL–2)								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0607**			Semester: **VI**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. To describe and explain Nanotechnology.
2. To describe Nanomaterials based on their dimensionality.
3. To explain the importance of reduction in materials dimensionality, and its relationship with materials properties.

CONTENTS

UNIT-I

[10 hours]

Introduction to Nanomaterials and nanotechnology, historical developments. An overview of scope & applications of nanotechnology, classifications and types of Nanomaterials. Basic understanding of various phenomena at nanoscale namely size confinement, interfacial surface phenomena.

UNIT-II

[10 hours]

Introduction to basic building blocks namely atoms, molecules, self-assembly, carbon nanotubes, nanocrystals, fullerenes, quantum dots, and quantum wires. Functional properties of nanomaterials such as physical, mechanical, electrical, magnetic, chemical and optical properties. Size dependence of material at nano scale. Bulk vs. nano properties of materials.

UNIT-III

[10 hours]

Synthesis & fabrication techniques 'Top down' vs. 'Bottom-up' approach of synthesis.
Review of synthesis methods namely sol-gel method, chemical vapour deposition, physical vapour deposition, sputtering, milling etc. Consolidation methods for nano powders such as coldisostatic pressing (CIP), hot isostatic pressing (HIP), Dynamic compaction, Conventional and Micro wave sintering.

UNIT-IV

[10 hours]

Characterization of nano materials by using transmission electron microscopy (TEM, atomic force microscopy (AFM) and Dynamic Light Scattering (DLS) measurement techniques. Applications of

nano materials namely nano grained structural materials & nano composites, nano magnetic materials, chemical applications etc.

Course Outcomes

1. To explain top-down approaches for Nano material fabrication, and give some examples.
2. To perform a literature survey on a chosen topic in the scientific literature.
3. To write a scientific report with appropriate references and citations.

Text Books

1. A.K.Bandopadhyay, "Nano Materials", New Age International Publishers, 1st Edition, 2009, ISBN: 9781906574277.
2. K. K. Chattopadhyay and A. N. Banerjee "Introduction to Nanoscience and Nanotechnology", PHI Learning, 1st Edition, 2009, ISBN: 9788120336087
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2. J.H. Fendler, "Nanoparticles and Nanostructured Films: Preparation, Characterization and Applications", Wiley-VCH, 1st Edition, 1998, ISBN: 9783527294435.
3. Z.L. Wang, Z. Zhang and Y. Lim, "Handbook of Nanophase and Nanostructured Materials", Springer, 1st Edition, 2002, ISBN: 9780306472497.
4. H.S. Nalwa, "Handbook of Nanostructured Materials and Nanotechnology", Academic Press, 5 Volume Set Edition, 1999, ISBN: 9780471958932.
5. M. Meyyappan, "Carbon Nanotubes: Science and Applications", CRC Press, 1st Edition, 2004, ISBN:9780203494936.
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7. A. S. Edelstein and R.C. Cammarata, "Nanomaterials: Synthesis, Properties & Applications", Taylor and Francis, 1st Edition, 1996, ISBN: 9780750303583.

Web Resources

1. NPTEL MOOC Course on "Soft Nano Technology"
(https://onlinecourses.nptel.ac.in/noc16_ch06/preview)
2. EdX Online Course on "Nanotechnology: Fundamentals of Nanotransistors"
(https://www.edx.org/course/nanotechnology-fundamentals-purduex-nano530x)

Name of Institute: Institute of Technology and Engineering
Name of Faculty: Dr.K. Santhy

Course code: MME0602
Course name: **Phase Transformation**
Pre-requisites: Thermodynamics, Physical Metallurgy
Credit points: 3
Offered Semester: 6th Semester

Course Coordinator (weeks XX - XX)
Full name:Dr.K. Santhy
Department with siting location: Third Floor (Staff Room)
Telephone:9787710922
Email: santhyk.mt@indusuni.ac.in
Consultation times: 4.15-5.00PM

Course Lecturer (weeks xx - XX)
Full name:Dr.K. Santhy
Department with siting location: Third Floor (Staff Room)
Telephone:9787710922
Email: santhyk.mt@indusuni.ac.in
Consultation times: 4.15-5.00PM

Students will be contacted throughout the Session via Mail with important information relating to this Course.

Course Objectives

By participating in and understanding all facets of this Course a student will:

1) To provide the student with an understanding of the basic principles and mechanisms underlying both solid-solid and liquid-solid phase transformations with an emphasis on metallic materials.
2) To apply the concepts of thermodynamics, diffusion and kinetics, and crystallography (crystal structure and symmetry in materials) to develop a clear understanding of the free energy changes and kinetics associated with various types of phase transformations

Course Outcomes (CO)

CO 1: List the types of diffusional transformation [BT-1]
CO 2: Describe the various diffusional transformation occurs in metals and alloys [BT-2]
CO 3: Determine the mechanism involved in diffusionless transformation [BT-3]
CO 4: Schematically illustrate the Gibbs energy diagram for binary system [BT-4]
CO 5: Justify most of the solidifications are heterogeneous in nature [BT-5]
CO 6: Integrate the heat treatment and phase transformation to get required microstructure [BT-6].

Course Outline

(Key in topics to be dealt)
Basics of thermodynamics and diffusion
Diffusional transformation
Diffusionless transformation

Method of delivery

Interactive lectures, Power point presentation

Study time

3 classes per week

CO-PO Mapping (PO: Program Outcomes)

Phase Transformations (MME0602)												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	1	1	1	-	-	-	-	-	-	-	-
CO2	3	2	1	1	-	-	-	-	-	-	-	-
CO3	3	2	1	1	-	-	-	-	-	-	-	-
CO4	3	3	2	1	-	-	-	-	-	-	-	1
CO5	3	2	1	1	-	-	-	-	-	-	-	-
CO6	2	3	3	2	-	-	-	-	-	-	-	1
MME0602	**2.8**	**2.2**	**1.5**	**1.2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**

Blooms Taxonomy and Knowledge retention (For reference)

(Blooms taxonomy has been given for reference)

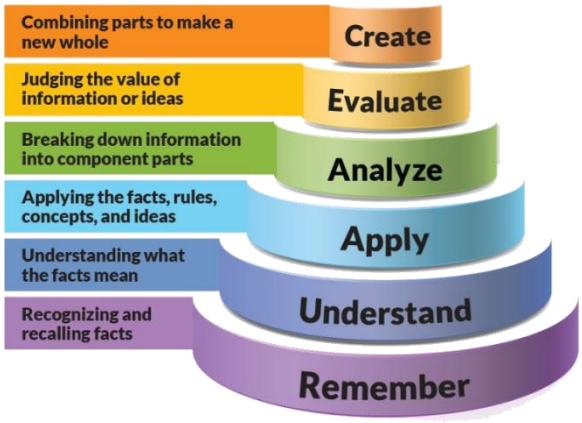


Figure 1: Blooms Taxonomy

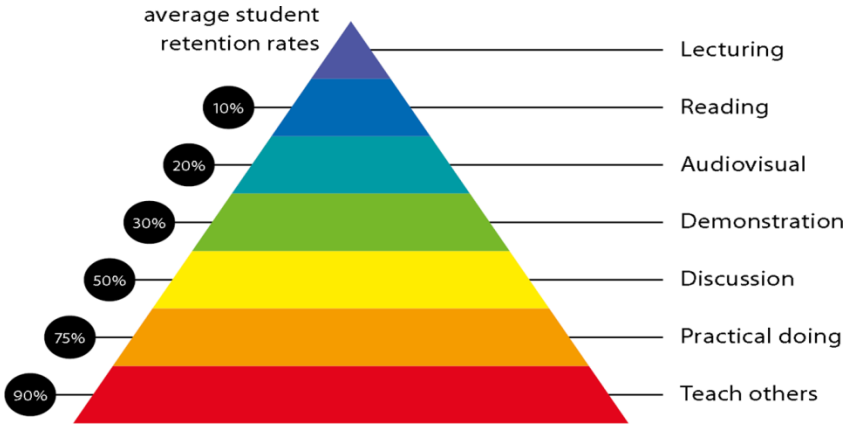


Figure 2: Knowledge retention

Graduate Qualities and Capabilities covered

(Qualities graduates harness crediting this Course)

General Graduate Qualities	Specific Department of _____Graduate Capabilities
Informed Have a sound knowledge of an area of study or profession and understand its current issues, locally and internationally. Know how to apply this knowledge. Understand how an area of study has developed and how it relates to other areas.	**1 Professional knowledge, grounding & awareness**
Independent learners Engage with new ideas and ways of thinking and critically analyze issues. Seek to extend knowledge through ongoing research, enquiry and reflection. Find and evaluate information, using a variety of sources and technologies. Acknowledge the work and ideas of others.	**2 Information literacy, gathering & processing**
Problem solvers Take on challenges and opportunities. Apply creative, logical and critical thinking skills to respond effectively. Make and implement decisions. Be flexible, thorough, innovative and aim for high standards.	**4 Problem solving skills**
Effective communicators Articulate ideas and convey them effectively using a range of media. Work collaboratively and engage with people in different settings. Recognize how culture can shape communication.	**5 Written communication** **6 Oral communication** **7 Teamwork**
Responsible Understand how decisions can affect others and make ethically informed choices. Appreciate and respect diversity. Act with integrity as part of local, national, global and professional communities.	**10 Sustainability, societal & environmental impact**

Practical work:

(Mention what practical work this Course involves)

Lecture/tutorial times

(Give lecture times in the format below)

Example:			
Lecture	Monday	9.55 – 10.50 am	Room LH 30
Lecture	Tuesday	9.55 – 10.50 am	Room LH 30
Lecture	Wednesday	9.55 – 10.50 am	Room LH 30

Attendance Requirements

The University norms states that it is the responsibility of students to attend all lectures, tutorials, seminars and practical work as stipulated in the Course outline. Minimum attendance requirement as per university norms is compulsory for being eligible for mid and end semester examinations.

Details of referencing system to be used in written work

Text books

1. D. A. Porter, K. E. Easterling and M. Sherif "Phase Transformations in Metals and Alloys", CRC Press, 3rd Edition, 2009, ISBN: 9781420062106.

Additional Materials

1. P.G. Shewmon, "Transformations in Metals", Indo American Books, 1st Edition, 2007, ISBN: 9788189617189.
2. M. Hillert, "Phase Equilibria, Phase Diagrams and Phase Transformations: Their Thermodynamic Basis", Cambridge University Press, 2nd Edition, 2007, ISBN: 9780521853514.
3. V. Raghavan, "Solid State Phase Transformations", Prentice Hall India Learning Private Limited, 1st Edition, 1987, ISBN: 9788120304604.
4. SWAYAMMOOC Course on "Phase Transformation in Materials" (https://swayam.gov.in/course/3796-phase-transformation-in-materials)

ASSESSMENT GUIDELINES

Your final course mark will be calculated from the following:

Example:	
Mid Semester	40% (week 4) Objective (1-3)
Presentation	**10%**
Participation of program	**5%**
Attendance	5%
Final exam (*closed book*)	40% Objectives (1-5)

SUPPLEMENTARY ASSESSMENT

Students who receive an overall mark less than 40% in mid semester or end semester will be considered for supplementary assessment in the respective components (i.e mid semester or end semester) of semester concerned. Students must make themselves available during the supplementary examination period to take up the respective components (mid semester or end semester) and need to obtain the required minimum 40% marks to clear the concerned components.

Practical Work Report/Laboratory Report:

A report on the practical work is due the subsequent week after completion of the class by each group.

Late Work

Late assignments will not be accepted without supporting documentation. Late submission of the reports will result in a deduction of 10% of the maximum mark per calendar day

Format

All assignments must be presented in a neat, legible format with all information sources correctly referenced. **Assignment material handed in throughout the session that is not neat and legible will not be marked and will be returned to the student.**

Retention of Written Work

Written assessment work will be retained by the Course coordinator/lecturer for two weeks after marking to be collected by the students.

University and Faculty Policies

Students should make themselves aware of the University and/or Faculty Policies regarding plagiarism, special consideration, supplementary examinations and other educational issues and student matters.

Plagiarism - Plagiarism is not acceptable and may result in the imposition of severe penalties. Plagiarism is the use of another person's work, or idea, as if it is his or her own - if you have any doubts at all on what constitutes plagiarism, please consult your Course coordinator or lecturer. Plagiarism will be penalized severely.

Do not copy the work of other students. Do not share your work with other students (except where required for a group activity or assessment)

Course schedule (subject to change)

(Mention quiz, assignment submission, breaks etc as well in the table under the Teaching Learning Activity Column)

	Week #	Topic & contents	CO Addressed	Teaching Learning Activity (TLA)
	Weeks 1	Equilibrium, Single Component Systems, Binary Solutions	1,2,4	Interactive teaching using PPT
	Weeks 2	Equilibrium in Heterogeneous Systems, Binary Phase Diagrams, Kinetics of Phase Transformations	1,2,4	Interactive teaching using PPT
	Week 3	Atomics Mechanisms of Diffusion, Interstitial diffusion, Self-Diffusion, Vacancy Diffusion, Diffusion in Substitutional Alloys.	1,2,4	Interactive teaching using PPT
	Week 4	Nucleation in pure metals, Growth of a pure Solid	1,3,4	Interactive teaching using PPT
	Week 5	Growth of a pure Solid, Alloy Solidification	1,3,4	Interactive teaching using PPT
	Week 6	Solidification during Quenching from Melt.	1,3,4	Interactive teaching using PPT
	Week 7	Nucleation in solids - Homogeneous and Heterogeneous	5	Interactive teaching using PPT
	Week 8	Overall Transformation Kinetics – TTT Diagrams, Precipitation in Age Hardening Alloys	3,5	Interactive teaching using PPT
	Week 9	Cellular Precipitation, Eutectoid Decomposition,	1,3,5,6	Interactive teaching using PPT
	Week 10	Massive Transformations, Ordering Transformations	5,6	Interactive teaching using PPT
	Week 11	Characteristics of Martensitic Transformations, Martensite Crystallography	5,6	Interactive teaching using PPT
	Week 12	Martensite Nucleation, Martensite Growth	5,6	Interactive teaching using PPT
	Week 13	Tempering of Ferrous Martensite, Strain induced transformation	5	Interactive teaching using PPT

Mapping for B.Tech Metallurgy

Sem	Subjects
1st	Calculus; Engineering Physics; Workshop; Technical Communication; Material Science; Environmental Science; Material Science (OE); Matrix Algebra; Engineering Graphics
2nd	Differential Equations and Linear Algebra; Engineering Chemistry; Metallurgy for Non-Metallurgists (OE); Structural Metallurgy and Physics of Materials; Engineering Graphics; Advanced Material and Applications (OE); Business Communication and Presentation Skills; Matrix Algebra
3rd	Probability, Statistics and Numerical Methods; Management for Engineers; Human Values and Professional Ethics; Engineering Graphics; Mineral Processing; Metallurgical Thermodynamics; Internship-I; Physical Metallurgy; Differential Calculus and Matrix Algebr
4th	Introduction to Process Metallurgy; Transport Phenomena; Metal Casting and Solidification (OE); Recycling of Materials (OE); Heat Treatment Principles and Practices; Soft Skill and Interpersonal Comm.; Iron Making; Personality Credit-1; Matrix Algebra; Differential Calculus and
5th	Foundry Technology; Steel Making; Fuel Furnace & Refractories (EL); Environmental Pollution & its Control in Met. Ind. (EL); Graphics; Non Ferrous Extractive Metallurgy; Plastic Deformation of Metals; Energy Economy & Waste Management- (OE); Internship-2; Graphics
6th	Metal Forming; Phase Transformations; Powder Metallurgy (Elective-1); Modelling of Metallurgical Processes (Elective-1); Engineering Graphics; Electrometallurgy & Corrosion; Nano Technology (OE); Ind. Ceramics and Polymers (El-2); Metal Joining Processes; Composite Materials (EL-2); Personality Credit-2; Nano Techn
7th	Metal Testing & Cha; Alloy Design (EL); Advanced Ferrous Metallurgy (EL); Surface Engg. (EL); Internship-3; Differential Calculus and Matrix Algebra; Non Destructive Testing; Material Testing and Standards; Selection of Material & Failure analysis (EL) & (OE); Advanced Foundry Technology (EL)
8th	Project

Pre-requisite
Co-requisite

Engineering Graphics

Subject: **Phase Transformations (EL–3)**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0602**				Semester: **VI**
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. To provide the student with an understanding of the basic principles and mechanisms underlying both solid-solid and liquid-solid phase transformations with an emphasis on metallic materials.
2. To apply the concepts of thermodynamics, diffusion and kinetics, and crystallography (crystal structure and symmetry in materials) to develop a clear understanding of the free energy changes and kinetics associated with various types of phase transformations.

CONTENTS

UNIT-I

[10 hours]

Review of Thermodynamics:
Equilibrium, Single Component Systems, Binary Solutions, Equilibrium in Heterogeneous Systems, Binary Phase Diagrams, Kinetics of Phase Transformations.

Review of Diffusion:
Atomics Mechanisms of Diffusion, Interstitial diffusion, Self-Diffusion, Vacancy Diffusion, Diffusion in Substitutional Alloys.

UNIT-II

[10 hours]

Solidification:
Nucleation in pure metals, Growth of a pure Solid, Alloy Solidification, Solidification during Quenching from Melt.

UNIT-III

[10 hours]

Diffusional Transformations in Solids:
Nucleation in solids - Homogeneous and Heterogeneous, Overall Transformation Kinetics – TTT Diagrams, Precipitation in Age Hardening Alloys, Cellular Precipitation, Eutectoid Decomposition, Massive Transformations, Ordering Transformations.

UNIT-IV

[10 hours]

Diffusionless Transformations:
Characteristics of Martensitic Transformations, Martensite Crystallography, Martensite Nucleation, Martensite Growth, Tempering of Ferrous Martensite, Strain induced transformation.

Course Outcomes

1. To apply and couple the basic concepts of thermodynamics, diffusion, and crystallography.
2. To apply the concepts of phase transformations in order to design new materials/alloy systems for advancement of technologies.

Text Books

1. D. A. Porter, K. E. Easterling and M. Sherif "Phase Transformations in Metals and Alloys", CRC Press, 3rd Edition, 2009, ISBN: 9781420062106.

Reference Books

1. P.G. Shewmon, "Transformations in Metals", Indo American Books, 1st Edition, 2007, ISBN: 9788189617189.
2. M. Hillert, "Phase Equilibria, Phase Diagrams and Phase Transformations: Their Thermodynamic Basis", Cambridge University Press, 2nd Edition, 2007, ISBN: 9780521853514.
3. V. Raghavan, "Solid State Phase Transformations", Prentice Hall India Learning Private Limited, 1st Edition, 1987, ISBN: 9788120304604.

Web Resources

1. SWAYAMMOOC Course on "Phase Transformation in Materials" (https://swayam.gov.in/course/3796-phase-transformation-in-materials)

Name of Institute: IITE
Name of Faculty: Gaurav Awasthi

Course code: MME0608
Course name: Powder Metallurgy
Pre-requisites: Physics, Chemistry and Material Science and Heat treatment
Credit points: 5
Offered Semester: 6

Course Coordinator (weeks XX - XX)
Full Name: Gaurav Awasthi
Department with sitting location: Third Floor staff room
Telephone:9909709727
Email: gauravavasthi.mt@indusuni.ac.in
Consultation times: 4:15 – 5:00

Course Lecturer (weeks xx - XX)
Full Name: Gaurav Awasthi
Department with sitting location: Third Floor staff room
Telephone:9909709727
Email: gauravavasthi.mt@indusuni.ac.in
Consultation times: 4:15 – 5:00

Students will be contacted throughout the Session via Mail with important information relating to this Course.

Course Objectives
By participating in and understanding all facets of this Course a student will:
1. To define and explain basic conditions of successful application of powder metallurgy technology for production of materials and components.
2. To formulate advantages and disadvantages of powder metallurgy.
3. To classify typical representatives of individual powder metallurgy technologies.

Course Outcomes (CO)
1. CO 1: Students will be able to evaluate and propose for optimum technology for the preparation of powder materials. [BT-5]
CO 2: Students will be able to explain various powder manufacturing processes. [BT-2]
CO 3: Students will be able to estimate the effect of particle size and shape on compressibility of powders, consolidation of powder, secondary operations. [BT-6]
CO 4 Students will be able to select appropriate method of sintering for required applications. [BT-3]
CO 5: Students will be able to know characterization techniques for analyzing phase transformation and properties. [BT-4]

CO 6: Students will be able to select various densifying and non-densifying mechanisms to control density. [BT-1]

Course Outline

The proposed course deals with Powder Metallurgy and its applications.

Method of delivery

(Face to face lectures, self study material, Active Learning Techniques)

Study time

3 lecture

CO-PO Mapping (PO: Program Outcomes)

Powder Metallurgy (MME0608)												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	1	1	-	1	-	-	-	-	1	2
CO2	3	2	3	2	1	1	1	-	-	-	2	2
CO3	2	1	2	2	1	1	1	-	-	-	2	2
CO4	1	3	3	2	-	-	-	-	-	-	1	1
CO5	1	3	2	3	1	1	-	-	-	-	-	1
CO6	1	2	3	2	1	1	-	-	-	-	-	1
MT0603	**1.8**	**2.3**	**2.3**	**2**	**1**	**1**	**1**	-	-	-	**1.4**	**1.5**

1 -Lightly Mapped 2- Moderately Mapped 3- Highly Mapped

Blooms Taxonomyand Knowledge retention(For reference)

(Blooms taxonomy has been given for reference)

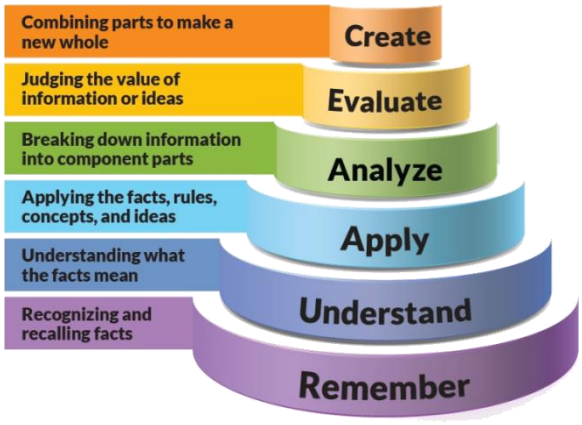


Figure 1: Blooms Taxonomy

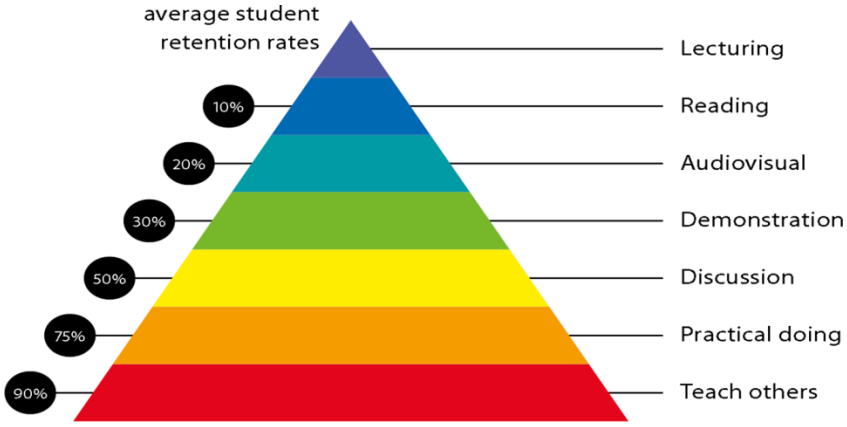


Figure 2: Knowledge retention

Graduate Qualities and Capabilities covered

(Qualities graduates harness crediting this Course)

General Graduate Qualities	Specific Department of _____Graduate Capabilities
Informed Have a sound knowledge of an area of study or profession and understand its current issues, locally and internationally. Know how to apply this knowledge. Understand how an area of study has developed and how it relates to other areas.	**1 Professional knowledge, grounding & awareness**

Independent learners Engage with new ideas and ways of thinking and critically analyze issues. Seek to extend knowledge through ongoing research, enquiry and reflection. Find and evaluate information, using a variety of sources and technologies. Acknowledge the work and ideas of others.	**2 Information literacy, gathering & processing**
Problem solvers Take on challenges and opportunities. Apply creative, logical and critical thinking skills to respond effectively. Make and implement decisions. Be flexible, thorough, innovative and aim for high standards.	**4 Problem solving skills**
Effective communicators Articulate ideas and convey them effectively using a range of media. Work collaboratively and engage with people in different settings. Recognize how culture can shape communication.	**5 Written communication** **6 Oral communication** **7 Teamwork**
Responsible Understand how decisions can affect others and make ethically informed choices. Appreciate and respect diversity. Act with integrity as part of local, national, global and professional communities.	**10 Sustainability, societal & environmental impact**

Practical work:

Corrosion rate measurement, Study of Pitting corrosion, Electroplating, Effect of current density on Anodizing

Lecture/tutorial times

(Give lecture times in the format below)

Example:			
Lecture	Monday	11:00 – 11:55 am	Room 1
Lecture	Tuesday	02:25 – 03:20 pm	Room 1
Lecture	Wednesday	09:00– 09:55 am	Room 1

Attendance Requirements

The University norms states that it is the responsibility of students to attend all lectures, tutorials, seminars and practical work as stipulated in the Course outline. Minimum attendance requirement as per university norms is compulsory for being eligible for mid and end semester examinations.

Details of referencing system to be used in written work

Text Books

1. A. K. Sinha, "Powder Metallurgy", Dhanpat Rai Publications, 2nd Edition, 2006, ISBN: 9788189928513.
2. W. D. Jones, "Fundamental Principles of Powder Metallurgy", E. Arnold, 1st Edition, 1960, ASIN: B0007IXN18.

Reference Books

1. H. H. Hausner, "Handbook of Powder Metallurgy", Chemical Publishing Co Inc, 1st Edition, 1973, ISBN: 9780820602196.
2. G. S. Upadhyaya, "Powder Metallurgy Technology", Cambridge International Science Publishing, 1st Edition, 1998, ISBN: 9781898326403.

Web Resources

1. NPTEL MOOC Course on "Fundamentals of Material Processing - I" (https://onlinecourses.nptel.ac.in/noc17_mm09/preview)
2. NPTEL MOOC Course on "Fundamentals of Material Processing - I" (https://onlinecourses.nptel.ac.in/noc16_mm11/preview)
3. EdX Online Course on "Fundamentals of Manufacturing Processes" (https://www.edx.org/course/fundamentals-manufacturing-processes-mitx-2-008x)

ASSESSMENT GUIDELINES

Your final course mark will be calculated from the following:

Example:	
MSE	40%
Assignment	5%
Project	**10%**
Attendance	**5%**
Final exam (*closed book*)	40%

SUPPLEMENTARY ASSESSMENT

Students who receive an overall mark less than 40% in mid semester or end semester will be considered for supplementary assessment in the respective components (i.e mid semester or end semester) of semester concerned. Students must make themselves available during the supplementary examination period to take up the respective components (mid semester or end semester) and need to obtain the required minimum 40% marks to clear the concerned components.

Practical Work Report/Laboratory Report: (NA)

Late Work

Late assignments will not be accepted without supporting documentation. Late submission of the reports will result in a deduction of -1% of the maximum mark per calendar day

Format

All assignments must be presented in a neat, legible format with all information sources correctly referenced. **Assignment material handed in throughout the session that is not neat and legible will not be marked and will be returned to the student.**

Retention of Written Work

Written assessment work will be retained by the Course coordinator/lecturer for two weeks after marking to be collected by the students.

University and Faculty Policies

Students should make themselves aware of the University and/or Faculty Policies regarding plagiarism, special consideration, supplementary examinations and other educational issues and student matters.

Plagiarism - Plagiarism is not acceptable and may result in the imposition of severe penalties. Plagiarism is the use of another person's work, or idea, as if it is his or her own - if you have any doubts at all on what constitutes plagiarism, please consult your Course coordinator or lecturer. Plagiarism will be penalized severely.

Do not copy the work of other students.

Do not share your work with other students (except where required for a group activity or assessment)

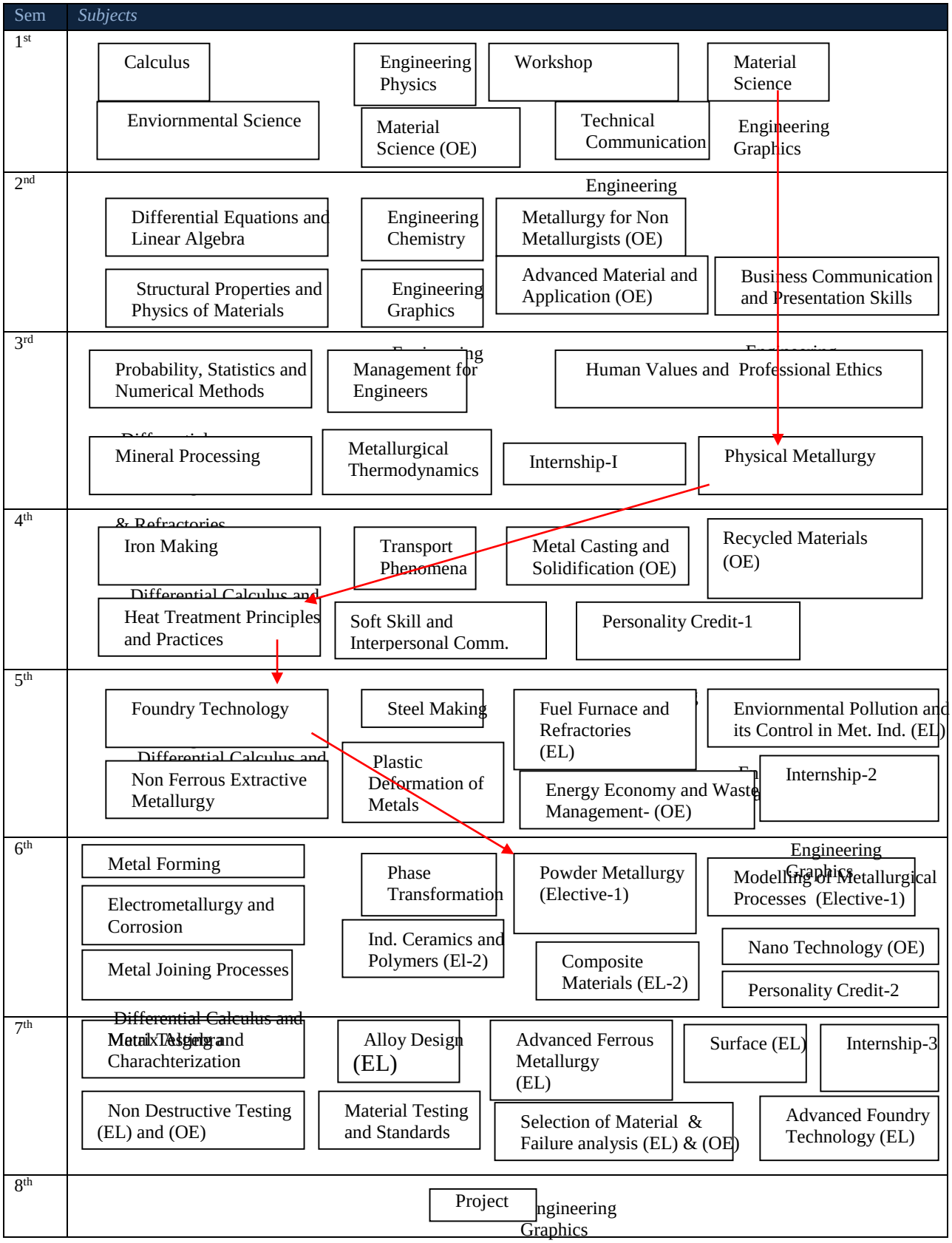
Course schedule(subject to change)

(Mention quiz, assignment submission, breaksetcas well in the table under the Teaching Learning Activity Column)

	Week #	Topic & contents	CO Addressed	Teaching Learning Activity (TLA)
	Weeks 1	Introduction: Historical and modern developments in P/M. Advantages limitations and applications of Powder Metallurgy.		BB, PPT
	Weeks 2	Characteristics of metal powder in terms of particle size , shape and size distribution		BB, PPT
	Week 3	Characteristics of powder mass such as apparent density, tap density, flow rate, friction conditions..		BB, PPT
	Week 4	Properties of green compacts and sintered compacts		BB, PPT
	Week 5	Important methods of metal powder manufacturing like machining, milling, atomization.		BB, PPT
	Week 6	electrodeposition, reduction from oxide, carbonyl process, production of alloy powders, new development.		BB, PPT
	Week 7	Powder conditioning, fundamentals of powder compaction, density distribution in green compacts, types of compaction presses.		BB, PPT
	Week 8	compaction tooling and role of lubricants. Single and double die compaction.		BB, PPT
	Week 9	isostatic pressing, hot pressing, effect of variables on sintering, sintering atmospheres and sintering furnaces		BB, PPT

	Week 10	Powder rolling, powder forging		BB, PPT
	Week 11	powder extrusion and explosive forming technique		BB, PPT
	Week 12	Definition of sintering, stages of sintering		BB, PPT
	Week 13	Mechanism of sintering, liquid-phase sintering		BB, PPT
	Week 14	infiltration process. Study of sintered bearings, cutting tools, and metallic filters..		BB, PPT
	Week 15	Study of friction and antifriction parts and electrical contact materials		BB, PPT

Program Mapping (Metallurgy Engineering Department)



Subject: **Powder Metallurgy**								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME00608**			Semester: **VI**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)- Theory**	**Continuous Internal Evaluation (CIE)- Practical**	**Total**
3	0	0	3	16/40	0	24/60	0	100

Course Objectives

1. To define and explain basic conditions of successful application of powder metallurgy technology for production of materials and components.
2. To formulate advantages and disadvantages of powder metallurgy.
3. To classify typical representatives of individual powder metallurgy technologies.

CONTENTS

UNIT-I

[10 hours]

Introduction: Historical and modern developments in P/M. Advantages limitations and applications of Powder Metallurgy.

Characteristics of metal powder in terms of particle size, shape and size distribution, Characteristics of powder mass such as apparent density, tap density, flow rate, friction conditions. Properties of green compacts and sintered compacts.

UNIT-II

[10 hours]

Important methods of metal powder manufacturing like machining, milling, atomization, electrodeposition, reduction from oxide, carbonyl process, production of alloy powders, new development.

Powder conditioning, fundamentals of powder compaction, density distribution in green compacts, types of compaction presses, compaction tooling and role of lubricants. Single and double die compaction, isostatic pressing, hot pressing, effect of variables on sintering, sintering atmospheres and sintering furnaces.

UNIT-III

[10 hours]

Powder rolling, powder forging, powder extrusion and explosive forming technique Definition of sintering, stages of sintering

UNIT-IV

[10 hours]

Mechanism of sintering, liquid-phase sintering, infiltration process. Study of sintered bearings, cutting tools, and metallic filters. Study of friction and antifriction parts and electrical contact materials.

Course Outcomes

1. To evaluate and propose optimum technology for preparation of powder materials.
2. To evaluate and evaluate influence of individual technological parameters on basic powder metallurgy operations.
3. To optimize material and technological parameters of production.

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1. A. K. Sinha, "Powder Metallurgy", Dhanpat Rai Publications, 2nd Edition, 2006, ISBN: 9788189928513.
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