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

Course code: **MME0404**
Course name: **Heat Treatment Principles and Practices**
Pre-requisites: Physical Metallurgy, Structural Metallurgy and Physics of Materials
Credit points: 4
Offered Semester: 4th

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: 4.15-5.00 PM

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: 4.15-5.00 PM

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 introduce the engineering science principles and applications associated with heat treatments.
2) To study the basic heat treatment processes.
3) To study the structure of metals and its influence on material properties and performance based on different heat treatments.

Course Outcomes (CO)

CO 1: List the different types of furnaces [BT-1]
CO 2: Differentiate thermal, thermo-chemical and thermo-mechanical treatment processes [BT-2]
CO 3: Illustrate the phase transformations in steels [BT-3].
CO 4: Schematically illustrate the TTT and CCT diagram [BT-4]
CO 5: Experimentally determine the microstructure and hardness of the various thermal and thermo-chemical treated metals. [BF-5]
CO 6: Design the proper heat treatment technique to obtain the required microstructure in ferrous and nonferrous materials [BT-6]

Course Outline
(Key in topics to be dealt)

Types of Heat treatment
Heat treatment of ferrous materials (Steel & Cast iron)
Hardening and hardenability
Surface hardening techniques
Case depth measurements
Heat treatment of nonferrous materials
Types of furnace
Root cause analysis of various heat treatment defects

Method of delivery
(self study material, Active Learning Techniques)
Lecture, videos, interactive learning method

Study time
(How many hours per week including class attendance)
3 hours

CO-PO Mapping (PO: Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1	2	-	-	-	-	-	-	-	1
CO2	2	3	2	1	-	1	-	-	-	-	-	1
CO3	3	3	2	2	-	-	-	-	-	-	-	1
CO4	3	3	2	2	-	-	1	-	-	-	-	1
CO5	2	2	2	2	3	-	-	-	-	-	1	2
CO6	3	2	2	2	-	1	-	-	-	-	1	2

Blooms Taxonomy and Knowledge retention (For reference)
(Blooms taxonomy has been given for reference)

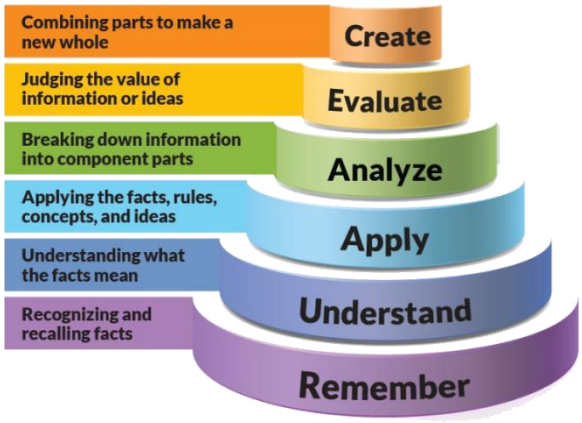


Figure 1: Blooms Taxonomy

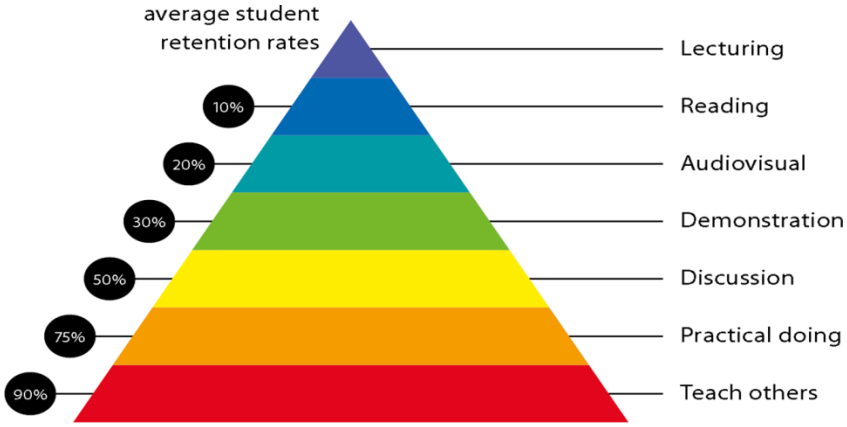


Figure 2: Knowledge retention

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.	**2 Information literacy, gathering & processing**

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:

(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 Lab 1
Lecture	Tuesday	11.55 – 12.50 am	Room Lab 1
Lecture	Thursday	11.55 – 12.50 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. D. S. Clark and W. R. Varney, "Physical Metallurgy for Engineers", Van Nostrand Reinhold Company, 2nd Edition, 1962, ISBN: 9780442015701.
2. T. V. Rajan, C. P. Sharma and A. Sharma, "Heat Treatment (Principles and Techniques)", Prentice Hall India, 2nd Edition, 2011, ISBN: 9788120340954.

Additional Materials

1. S. H. Avner, "Physical Metallurgy", Tata Mcgraw –Hill, 2nd Edition, 2008, ISBN: 9780074630068.
2. Y. Lakhtin, "Engineering Physical Metallurgy", CBS Publishers & Distributors, 1st Edition, 2005, ISBN: 9788123906027.
3. S. H. Avner, "Physical Metallurgy", Tata Mcgraw –Hill, 2nd Edition, 2008, ISBN: 9780074630068.
4. V. D. Kodgire and S. V. Kodgire, "Material Science and Metallurgy for Engineers", Everest Publishing House, 31st Edition, 2011, ISBN: 9788186314005.
5. V. Singh, "Heat Treatment of Metals", Standard Publishers Distribution, 2nd Edition, 2011, ISBN: 9788180140389.
6. V. Raghvan, "Physical Metallurgy (Principles and Practice)", Prentice Hall India, 2nd Edition, 2006, ISBN: 9788120330122.
7. B. Zakharov, "Heat Treatment of Metals", University Press of the Pacific, 2nd Edition, 2002, ISBN: 9781410203052.
8. ASM International, "ASM Handbook on Heat Treating Vol. 4", 11th edition, 1991, ISBN: 9780871703798.
9. K. H. Prabhudev, "Handbook of Heat Treatment", Tata Mc-Graw Hill, 4th Reprint, 2011, ISBN: 9780074518311.

1. NPTEL Course on "Principles of Physical Metallurgy"
(http://nptel.ac.in/courses/113105024/)
2. NPTEL MOOC Course on "Heat Treatment and Surface Hardening-I"
(https://onlinecourses.nptel.ac.in/noc16_mm12/preview)
3. NPTEL MOOC Course on "Heat Treatment and Surface Hardening-Part II"
(https://onlinecourses.nptel.ac.in/noc17_me19/preview)

ASSESSMENT GUIDELINES

Your final course mark will be calculated from the following:

Example:	
Mid semester	40%
MCQ/Assignment	5%
MCQ/Assignment	**5%**
Program participation	**5%**
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. **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 -% 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)

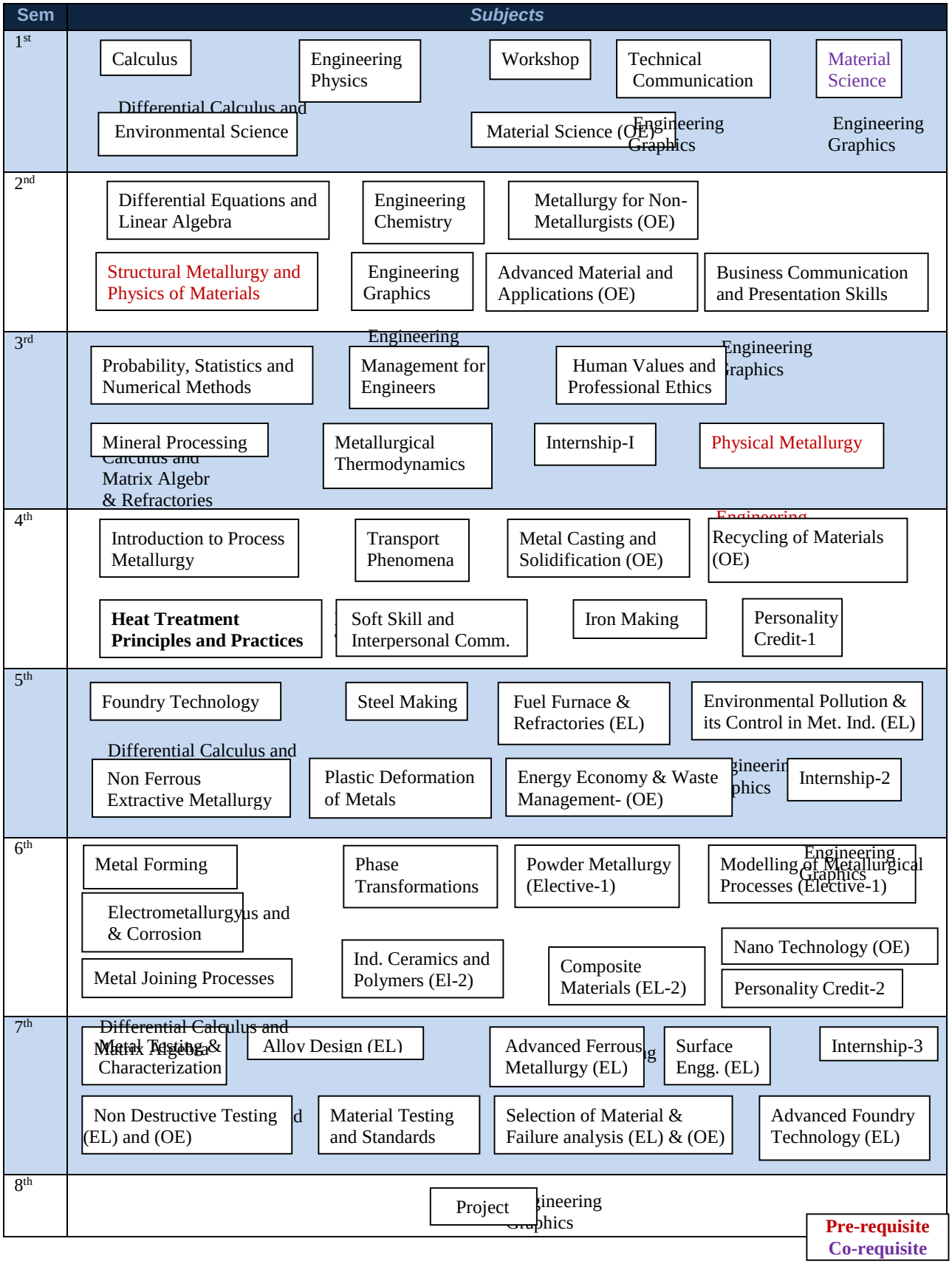
.

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 Fe-C diagram, Phase Transformation on heating, Forming of austenite, Kinetics of formation of austenite.	1,4	Interactive teaching using PPT
	Weeks 2	Nucleation sites in eutectoid steels, Austenitic grain size, Grain growth, Determination of austenitic grain size, Importance of austenitic grain size	1,2,3	Interactive teaching using PPT
	Week 3	Method of plotting, Types of TTT diagram, Critical cooling rate, Effect of alloying elements on TTT diagram, Applications, Continuous cooling transformation diagram, Limitations of Iron-Iron Carbide Diagram, Effect of Alloying elements on CCT diagram.	*2,3,4*	Interactive teaching using PPT
	Week 4	**Pearlitic transformation:** Mechanism of transformation, Kinetics of transformation, Hull-Mehl model of pearlitic transformation, Effect of alloying elements on transformation, Interlameller spacing	*3*	Interactive teaching using PPT
	Week 5	**Bainitic transformation:** Characteristics, Mechanism of transformation, Bainitic structure. **Martensitic transformation:** Diffusionless transformation, Mechanism of transformation, Kinetics of transformation, M_s - M_f temperatures, Athermal and isothermal martensites, Effect of applied stress on transformation, Habit planes, Bain distortion model / crystallographic theory of martensitic transformation, Tempered Martensite, Retained austenite, Martensitic transformation in non-ferrous systems such as Fe-Ni and Cu-Al systems	3	Interactive teaching using PPT
	Week 6	Stress relieving, Annealing – full annealing, partial annealing, bright annealing, diffusion annealing,	*1,5*	Interactive teaching using PPT

		recrystallization annealing, Spheroidizing, Normalizing.		
	Week 7	Hardening and Tempering, Hardening of typical steels, cast irons and non-ferrous alloys.	3,5	Interactive teaching using PPT
	Week 8	Principles involved in induction and flame hardening methods and application of selective hardening, Laser hardening.	2	Interactive teaching using PPT
	Week 9	Case carburizing (solid, liquid and gaseous), Cyaniding, Carbonitriding, Nitriding, Plasma nitriding etc., Depth of penetration - its measurement and relation with time and temperature, Hardening & Hardenability of steels.	*5,6*	Interactive teaching using PPT
	Week10	Austempering, Martempering, Ausforming, Patenting, Sub-zero treatment etc., Thermo Mechanical treatments.	2,5	Interactive teaching using PPT
	Week 11	Heat treatment of carbon steels, alloy steels, tools and dies steels, stainless steels (with reference to carbide precipitation and sigma phase formation) and cast irons.	5	Interactive teaching using PPT
	Week 12	Heat treatment of Aluminum alloys, titanium alloys and copper alloys, Concept of age-hardening. Design for heat treatment, Heat treatment furnaces- their temperature and atmosphere control, Defects in heat treated parts, Causes for the defects in heat-treated parts and remedies.	1,6	Interactive teaching using PPT


Sem
Subjects
1st
Calculus
Engineering Physics
Workshop
Technical Communication
Material Science
Differential Calculus and
Environmental Science
Material Science (OE)
Engineering Graphics
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
3rd
Engineering
Probability, Statistics and Numerical Methods
Management for Engineers
Human Values and Professional Ethics
Engineering
Mineral Processing
Metallurgical Thermodynamics
Internship-I
Physical Metallurgy
Matrix Algebr
& Refractories
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
5th
Foundry Technology
Steel Making
Fuel Furnace & Refractories (EL)
Environmental Pollution & its Control in Met. Ind. (EL)
Differential Calculus and
Non Ferrous Extractive Metallurgy
Plastic Deformation of Metals
Energy Economy & Waste Management- (OE)
Internship-2
6th
Metal Forming
Phase Transformations
Powder Metallurgy (Elective-1)
Modelling of Metallurgical Processes (Elective-1)
Engineering Graphics
Electrometallurgyus and & Corrosion
Nano Technology (OE)
Metal Joining Processes
Ind. Ceramics and Polymers (El-2)
Composite Materials (EL-2)
Personality Credit-2
Nano Techn
7th
Differential Calculus and
Matrix Algebra &
Characterization
Alloy Design (EL)
Advanced Ferrous Metallurgy (EL)
Surface Engg. (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
Pre-requisite
Co-requisite

Subject: Heat Treatment Principles and Practices								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0404**			Semester: **IV**	
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 introduce the engineering science principles and applications associated with heat treatments.
2. To study the basic heat treatment processes.
3. To study the structure of metals and its influence on material properties and performance based on different heat treatments.

CONTENTS

UNIT-I

[10 hours]

Principles of heat treatment of steels:
Phase Transformation on heating, Forming of austenite, Kinetics of formation of austenite, Nucleation sites in eutectoid steels, Austenitic grain size, Grain growth, Determination of austenitic grain size, Importance of austenitic grain size

TTT (Time Temperature Transformation) and CCT (Continuous Cooling Transformation) diagrams:
Method of plotting, Types of TTT diagram, Critical cooling rate, Effect of alloying elements on TTT diagram, Applications, Continuous cooling transformation diagram, Limitations of Iron-Iron Carbide Diagram, Effect of Alloying elements on CCT diagram.

UNIT-II

[10 hours]

Pearlitic transformation: Mechanism of transformation, Kinetics of transformation, Hull-Mehl model of pearlitic transformation, Effect of alloying elements on transformation, Interlameller spacing,

Bainitic transformation: Characteristics, Mechanism of transformation, Bainitic structure.

Martensitic transformation:
Diffusionless transformation, Mechanism of transformation, Kinetics of transformation, M_s - M_f temperatures, Athermal and isothermal martensites, Effect of applied stress on transformation, Habit planes, Bain distortion model / crystallographic theory of martensitic transformation, Tempered Martensite, Retained austenite, Martensitic transformation in non-ferrous systems such as Fe-Ni and Cu-Al systems.

UNIT-III

[10 hours]

Heat treatment processes:
Stress relieving, Annealing – full annealing, partial annealing, bright annealing, diffusion annealing, recrystallization annealing, Spheroidizing, Normalizing, Hardening and Tempering, Hardening of typical steels, cast irons and non-ferrous alloys.

Surface hardening of metals:
Principles involved in induction and flame hardening methods and application of selective hardening,

Laser hardening, Case carburizing (solid, liquid and gaseous), Cyaniding, Carbonitriding, Nitriding, Plasma nitriding etc., Depth of penetration - its measurement and relation with time and temperature, Hardening & Hardenability of steels.

UNIT-IV

[10 hours]

Special methods of heat treatment:
Austempering, Martempering, Ausforming, Patenting, Sub-zero treatment etc., Thermo Mechanical treatments. Heat treatment of carbon steels, alloy steels, tools and dies steels, stainless steels (with reference to carbide precipitation and sigma phase formation) and cast irons – specific examples, Heat treatment of Aluminum alloys, titanium alloys and copper alloys, Concept of age-hardening. Design for heat treatment, Heat treatment furnaces- their temperature and atmosphere control, Defects in heat treated parts, Causes for the defects in heat-treated parts and remedies.

Heat Treatment Principles and Practices Lab (List of Experiments)

Experiment No.	Title
1	Annealing of Medium / High carbon steels
2	Characterization of annealed steel
3	Normalizing of Medium / High carbon steels
4	Characterization of normalized steel
5	Spheroidizing of High carbon steel
6	Characterization of spheroidized steel
7	Hardening of medium/ high carbon steels
8	Characterization of hardened steel
9	Tempering of medium/ high carbon steels
10	Characterization of tempered steel
11	To examine the effect of quenching media on hardening of steel
12	To measure the hardenability of steel using Jominy End-Quench test
13	To study the case hardening processes
14	Carburizing of low carbon steels
15	Case depth measurement and characterization of carburized steels

Course Outcomes

1. To apply the knowledge of various types of heat treatments to design the heat treatment cycles for different components of many areas of mechanical, manufacturing, civil, and materials engineering in the aerospace, automobile, transportation, energy, environmental, biomedical, and electronics industries.
2. To predict the mechanical properties based on the changes in heat treatment variables.
3. To apply their knowledge in the field of alloy design and microstructural engineering.

Text Books

1. D. S. Clark and W. R. Varney, “Physical Metallurgy for Engineers”, Van Nostrand Reinhold Company, 2nd Edition, 1962, ISBN: 9780442015701.

2. T. V. Rajan, C. P. Sharma and A. Sharma, "Heat Treatment (Principles and Techniques)", Prentice Hall India, 2nd Edition, 2011, ISBN: 9788120340954.

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3. S. H. Avner, "Physical Metallurgy", Tata Mcgraw –Hill, 2nd Edition, 2008, ISBN: 9780074630068.
4. V. D. Kodgire and S. V. Kodgire, "Material Science and Metallurgy for Engineers", Everest Publishing House, 31st Edition, 2011, ISBN: 9788186314005.
5. V. Singh, "Heat Treatment of Metals", Standard Publishers Distribution, 2nd Edition, 2011, ISBN: 9788180140389.
6. V. Raghvan, "Physical Metallurgy (Principles and Practice)", Prentice Hall India, 2nd Edition, 2006, ISBN: 9788120330122.
7. B. Zakharov, "Heat Treatment of Metals", University Press of the Pacific, 2nd Edition, 2002, ISBN: 9781410203052.
8. ASM International, "ASM Handbook on Heat Treating Vol. 4", 11th edition, 1991, ISBN: 9780871703798.
9. K. H. Prabhudev, "Handbook of Heat Treatment", Tata Mc-Graw Hill, 4th Reprint, 2011, ISBN: 9780074518311.

Web Resources

1. NPTEL Course on "Principles of Physical Metallurgy"
(http://nptel.ac.in/courses/113105024/)
2. NPTEL MOOC Course on "Heat Treatment and Surface Hardening-I"
(https://onlinecourses.nptel.ac.in/noc16_mm12/preview)
3. NPTEL MOOC Course on "Heat Treatment and Surface Hardening-Part II"
(https://onlinecourses.nptel.ac.in/noc17_me19/preview)

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

Course code: MME0401
Course name: Introduction to Process Metallurgy
Pre-requisites: Mineral Processing
Credit points: 04
Offered Semester: 04

Course Coordinator
Full Name: Mr. Monil Salot
Department with siting location: Metallurgical Engineering, Bhanwar Building, Lab-004 (GF)
Telephone: 9428600336
Email: monilsalot.mt@indusuni.ac.in
Consultation times: 3:45-4:20 PM

Course Lecturer
Full Name: Mr. Monil Salot
Department with siting location: Metallurgical Engineering, Bhanwar Building, Lab-004 (GF)
Telephone: 9428600336
Email: monilsalot.mt@indusuni.ac.in
Consultation times: 3:45-4:20 PM

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 gain knowledge about the basic mechanism affecting the different extraction techniques such as Pyrometallurgical, Hydrometallurgical & Electro metallurgical extraction processes.
2. To gain knowledge about the concept of reaction kinetics & its role in understanding the extraction processes.

Course Outcomes (CO)

CO1: To be able to list and define glossary and terminology associated with extractive metallurgy. (BT-1)
CO2: To understand pyro metallurgy, hydrometallurgy and electrometallurgy and its significance. (BT-2)
CO3: To apply principles of extractive metallurgy for economical extraction of metals. (BT-3)
CO4: To analyse and categorise various techniques for extraction. (BT-4)
CO5: To evaluate reaction mechanism and kinetics for efficient extraction. (BT-5)
CO6: To innovate techniques (Reaction, Process and Factor based) for effective and efficient metal extraction. (BT-6)

Course Outline

Proposed course mainly deal with Reaction Mechanisms, Pyrometallurgical techniques, Hydro Metallurgical techniques and Electrometallurgical techniques for beneficiation and extraction of metallic ores.

Method of delivery

Face to face lectures, Simulations in Tutorials, Model Making

Study time

3 Lectures and 1 Hr. Tutorials

CO-PO Mapping (PO: Program Outcomes)

Introduction to Process Metallurgy (MME0401)												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	1	2	1	1	-	-	-	-	-	1	3
CO2	2	1	2	2	1	1	2	-	-	-	1	2
CO3	1	2	2	1	-	1	-	-	-	-	3	2
CO4	1	2	3	2	1	-	-	-	-	-	1	1
CO5	3	1	1	2	-	-	-	-	-	-	-	2
CO6	2	2	3	2	1	-	-	-	-	-	-	2
MME0401	**2**	1.5	2.1	**1.6**	**1**	**1**	**2**	**-**	**-**	**-**	**1.5**	**2**

Blooms Taxonomyand Knowledge retention(For reference)

(Blooms taxonomy has been given for reference)

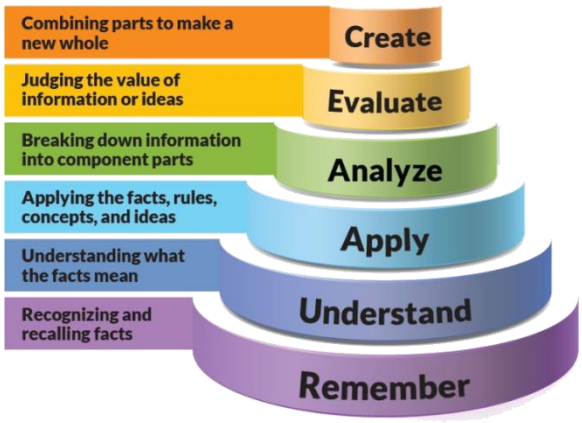


Figure 1: Blooms Taxonomy

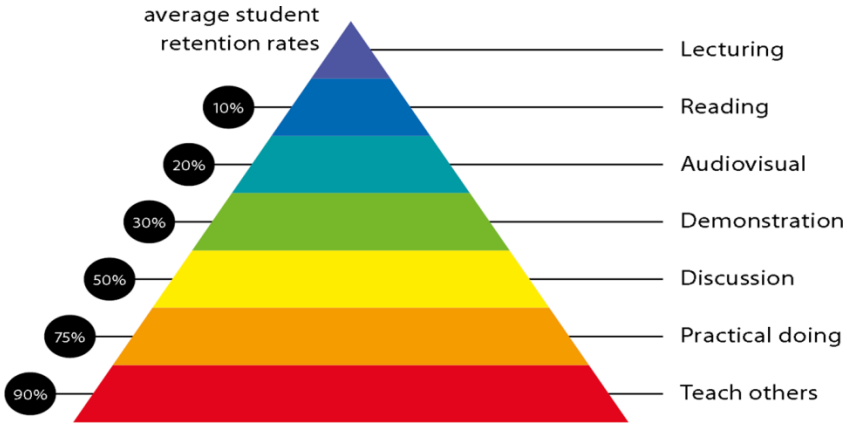


Figure 2: Knowledge retention

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**

Lecture/tutorial times

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

Lecture	Room LH 4
Lecture	Room LH 4
Lecture	Room LH 4
Tutorial	Lab -04 (Ground Floor)

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

Reference Books

1. W. H. Dennis, "Extractive Metallurgy", Pitman Publishing, 1st Edition, 1965, ISBN: 9780273404729.
2. F. Habashi, "Principles of Extractive Metallurgy", Gordon & Breach, 1st Edition, 1970, ISBN: 9780677017808.
3. T. Rosenqvist, "Principles of Extractive Metallurgy", McGraw Hill, 1st Edition, 1974, ISBN: 9780070538474.
4. J. L. Bray, "Nonferrous Production Metallurgy", John Wiley and Sons, 2nd Edition, 1947, ASIN: B0007E2TW6.
5. R. D. Pehlke, "Unit Processed in Extractive Metallurgy", Elsevier, 1st Edition, 1973, ISBN: 9780444001306.
6. H. S. Ray, "Introduction to Melts: Molten Salts, Slags and Glasses", Allied Publishers Pvt Ltd 1st Edition, 2006, ISBN: 9788177648751.
7. H.S. Ray, B.P Singh, S. Bhattacharjee and V. N. Misra, "Energy in Minerals and Metallurgical Industries", Allied Publishers Pvt Ltd, 1st Edition, 2005, ISBN: 8177648748.

Text books

1. H. S. Ray and A. Ghosh, "Principles of Extractive Metallurgy", New Age Publishers, 2nd Edition, 1991, ISBN: 9788122403220.
2. H.S. Ray, R. Sridhar and K.P. Abraham, "Extraction of Nonferrous Metals", Affiliated East West Press Pvt Ltd, 1st Edition, 2008, ISBN: 9788185095639.
3. S. K. Dutta and A. B. Lele, "Metallurgical Thermodynamics Kinetics & Numericals", S. Chand Publications, 2nd Edition, 2014, ISBN: 9788121939645.

Additional Materials

1. NPTEL Course on "Non-Ferrous Extractive Metallurgy"
(http://nptel.ac.in/courses/113105021/)

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.

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 -% 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.

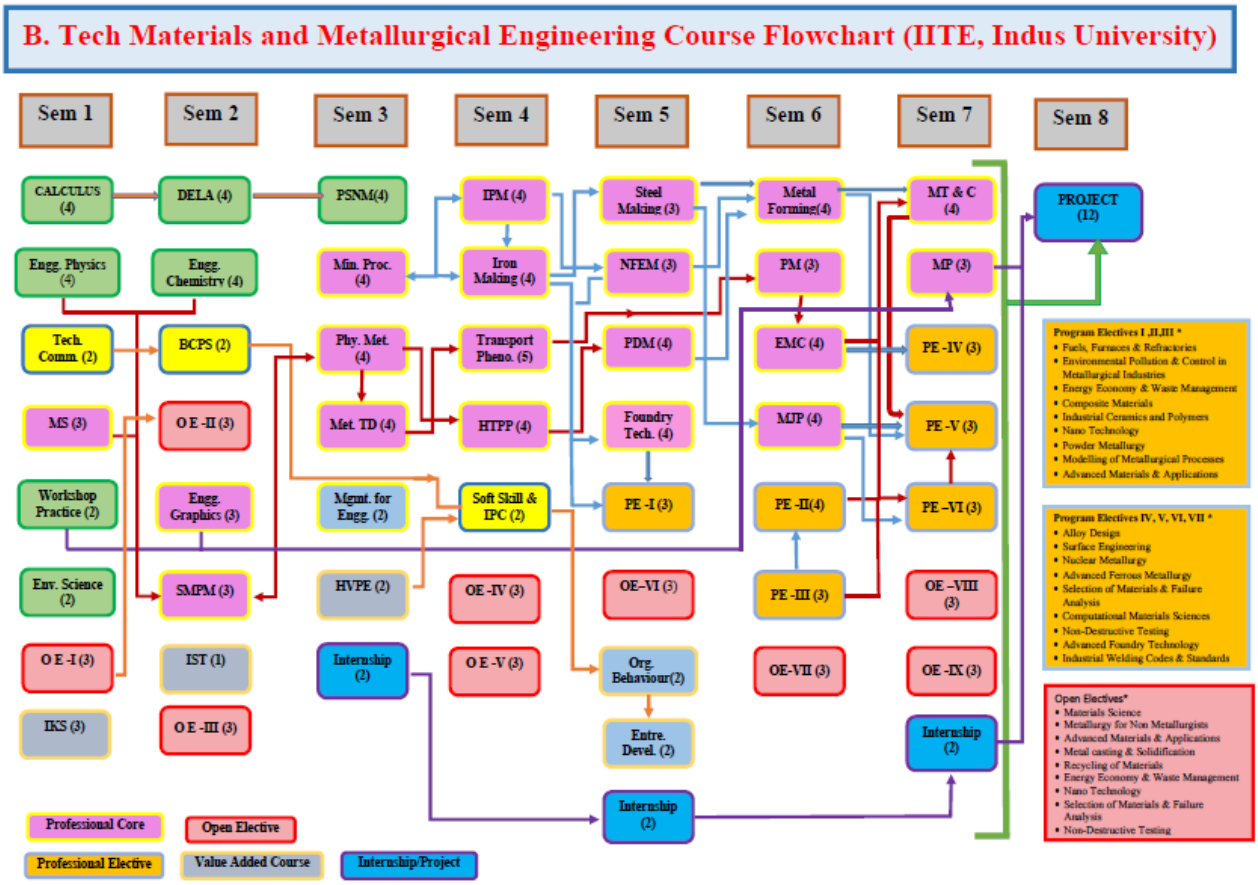
Do not copy the work of other students.
Do not share your work with other students (except where required for a group activity or assessment)

.

Course schedule (subject to change)

	Week #	Topic & contents	CO Addressed	Teaching Learning Activity (TLA)
	Weeks 1	Introduction to Pyrometallurgy	CO1-CO6	BB PPT
	Weeks 2	Drying Roasting Calcination	CO1-CO6	BB PPT
	Week 3	Sintering, Pelletization, converting, smelting	CO1-CO6	BB PPT
	Week 4	Introduction to Hydrometallurgy	CO1-CO6	BB PPT
	Week 5	Unit Processes and Unit Operation	CO1-CO6	BB PPT
	Week 6	Techniques used in metal extraction via hydrometallurgy	CO1-CO6	BB PPT
	Week 7	Introduction to electrometallurgy	CO1-CO6	BB PPT
	Week 8	Reactions of electrometallurgy	CO1-CO6	BB PPT
	Week 9	Processes of electrometallurgy	CO1-CO6	BB PPT
	Week 10	Reactions of electrometallurgy	CO1-CO6	BB PPT
	Week 11	Processes of electrometallurgy	CO1-CO6	BB PPT
	Week 12	Reaction Mechanics	CO1-CO6	BB PPT
	Week 13	Reaction Mechanics-Rate Processes	CO1-CO6	BB PPT
	Week 14	Reaction Mechanics- Chemical Rates	CO1-CO6	BB PPT
	Week 15	Reaction Mechanics- Chemical Rates	CO1-CO6	BB PPT
	Week 16	Revision and Numerical Solution	CO1-CO6	BB PPT

Program Map for Metallurgical Engineering Department



Subject: Introduction to Process Metallurgy (EL)								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0401**				Semester: **IV**
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 gain knowledge about the basic mechanism affecting the different extraction techniques such as Pyro-metallurgical, Hydrometallurgical & Electro metallurgical extraction processes.
2. To gain knowledge about the concept of reaction kinetics & its role in understanding the extraction processes.

CONTENTS

UNIT-I

[10 hours]

Pyro-metallurgical Processes

Basics of Pyro-metallurgical Processes, Drying, Calcination, Agglomeration, Sintering, Roasting, Smelting. Converting, Refining processes with examples for metals like Aluminum, Copper, Zinc, and Lead.

UNIT-II

[10 hours]

Hydrometallurgical Processes

Basics of Hydrometallurgical processes, Fundamentals of Unit processes and Unit operations, Principles and types of Leaching, Kinetics of leaching, and Refining of leached solution, Solvent extraction and ion-exchange processes, Cementation, Gaseous reduction of metals.

UNIT-III

[10 hours]

Electrometallurgical Processes

Basics of Electrometallurgical processes: Electrowinning and Electrorefining, Aqueous/Fused salt electrolysis. Flow-sheets of Extraction of Important Metals, Simplified Flowsheets for the production of Iron, Steel, Aluminum, Copper, Zinc and Lead.

UNIT-IV

[10 hours]

Reaction Kinetics

Kinetics of metallurgical processes and material, velocity/rate of reaction, factors affecting rate of reaction, Order of Reaction and molecularity, zero, first, second order and order of reaction,half-life period, determination of order of reaction, integration method, half period method, rate constants, Arrhenius equation, collision theory, Activation Energy, activation energy profile of an exothermic reaction, activation energy barrier, theory of absolute reaction rate.

Course Outcomes

1. To understand about the requirement of various devices required for carrying out different extraction processes.
2. To analyze and apply various factors affecting these extraction processes.

Text Books

1. H. S. Ray and A. Ghosh, "Principles of Extractive Metallurgy", New Age Publishers, 2nd Edition, 1991, ISBN: 9788122403220.
2. H.S. Ray, R. Sridhar and K.P. Abraham, "Extraction of Nonferrous Metals", Affiliated East West Press Pvt Ltd, 1st Edition, 2008, ISBN: 9788185095639.
3. S. K. Dutta and A. B. Lele, "Metallurgical Thermodynamics Kinetics & Numericals", S. Chand Publications, 2nd Edition, 2014, ISBN: 9788121939645.

Reference Books

1. W. H. Dennis, "Extractive Metallurgy", Pitman Publishing, 1st Edition, 1965, ISBN: 9780273404729.
2. F. Habashi, "Principles of Extractive Metallurgy", Gordon & Breach, 1st Edition, 1970, ISBN: 9780677017808.
3. T. Rosenqvist, "Principles of Extractive Metallurgy", McGraw Hill, 1st Edition, 1974, ISBN: 9780070538474.
4. J. L. Bray, "Nonferrous Production Metallurgy", John Wiley and Sons, 2nd Edition, 1947, ASIN: B0007E2TW6.
5. R. D. Pehlke, "Unit Processed in Extractive Metallurgy", Elsevier, 1st Edition, 1973, ISBN: 9780444001306.
6. H. S. Ray, "Introduction to Melts: Molten Salts, Slags and Glasses", Allied Publishers Pvt Ltd 1st Edition, 2006, ISBN: 9788177648751.
7. H.S. Ray, B.P Singh, S. Bhattacharjee and V. N. Misra, "Energy in Minerals and Metallurgical Industries", Allied Publishers Pvt Ltd, 1st Edition, 2005, ISBN: 8177648748.

Web Resources

1. NPTEL Course on "Non-Ferrous Extractive Metallurgy" (http://nptel.ac.in/courses/113105021/)

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

Course code: MME0402
Course name: Iron Making
Pre-requisites: Material Science, Engineering Chemistry, Mineral Processing, Introduction to Process Metallurgy
Credit points: 04
Offered Semester: 04

Course Coordinator
Full Name: Mr. Monil Salot
Department with sitting location: Metallurgical Engineering, Bhanwar Building, Lab-004 (GF)
Telephone: 9428600336
Email: monilsalot.mt@indusuni.ac.in
Consultation times: 3:45-4:20 PM

Course Lecturer
Full Name: Mr. Monil Salot
Department with sitting location: Metallurgical Engineering, Bhanwar Building, Lab-004 (GF)
Telephone: 9428600336
Email: monilsalot.mt@indusuni.ac.in
Consultation times: 3:45-4:20 PM

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 impart the overall idea of how Iron is produced, the history of Iron making and availability of raw materials for iron production.
2. To know about various techniques of raw material preparation for charging in iron making furnace, construction and operation of iron making furnace and reactions occurring in the furnace, reaction mechanism inside the blast furnace.

Course Outcomes (CO)

CO1: Able to identify the raw materials involved in iron making processes. (BT-1)
CO2: To explain agglomeration processes and be able to differentiate processes of sintering, nodulising, pelletization etc. (BT-2)
CO3: Ability to solve mass balance equations for blast furnace operations. (BT-3)
CO4: To analyse and infer operational parameters with Blast furnace irregularities and implement remedial measures. (BT-4)
CO5: To evaluate and choose the best possible alternative methods of Iron Making with respect to variables and factors involved. (BT-5)
CO6: To design and develop slag metal reactions in favour of Blast Furnace operation desires for tailor made chemistry. (BT-6)

Course Outline

Proposed course mainly deal with history of iron making and its importance, ore and raw material requirement and beneficiation, reaction mechanics, understanding blast furnace proper and related equipments , how to control blast furnace irregularities, maintenance and alternatives routes to iron making.

Method of delivery

- Face to face lectures,
- Numerical and Simulations in Tutorials,
- Model Making
- Video Lectures When and as necessary

Study time

3 Lectures and 2 Hrs. Lab

CO-PO Mapping (PO: Program Outcomes)

Iron Making (MME0402)												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	1	1	1	2	-	-	-	-	-	1	2
CO2	2	2	3	1	1	-	1	-	-	-	-	1
CO3	3	2	3	2	-	-	-	-	-	-	1	2
CO4	2	3	3	3	-	-	-	-	-	-	-	2
CO5	2	1	3	2	2	-	-	-	-	-	2	2
CO6	3	2	1	2	-	-	-	-	-	-	-	2
MME0402	**2.3**	**1.83**	**2.3**	**1.83**	**1.6**	**-**	**1**	**-**	**-**	**-**	**1.3**	**1.83**

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

Blooms Taxonomy and Knowledge retention(For reference)
(Blooms taxonomy has been given for reference)

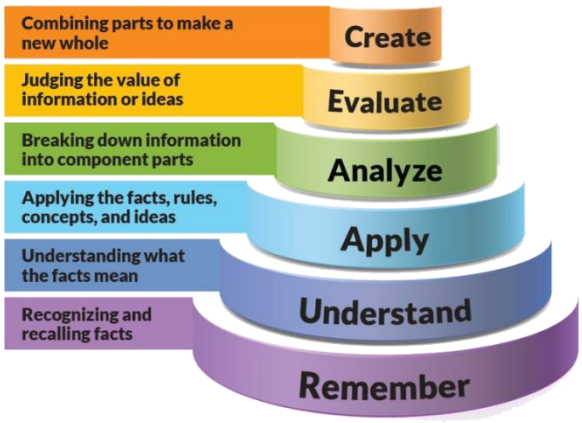


Figure 1: Blooms Taxonomy

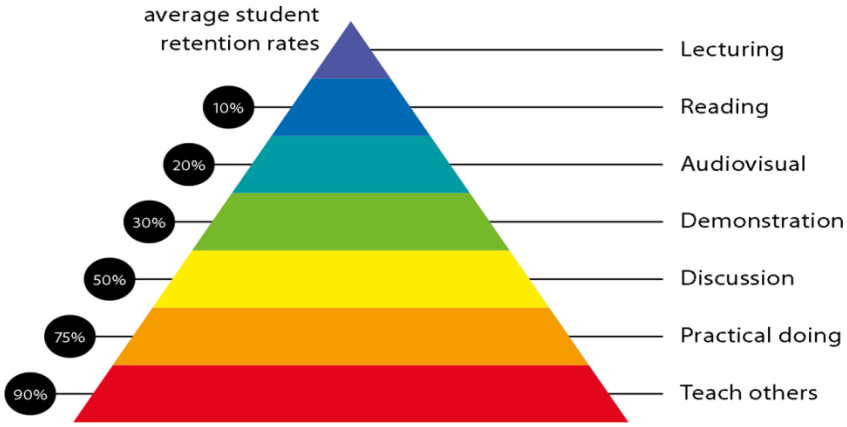


Figure 2: Knowledge retention

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.	**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:

Experiment No	Title
1	Identification of raw material for iron making
2	Bulk density Measurement
3	Determination of Angle of Repose
4	Sintering of iron ore fines
5	Pelletization of iron ore fines
6	Induration behavior of pellets
7	Box compression test of hardened or indurated pellets
8	Tumbling/Drum test of green and indurated pellets
9	Shatter Test of agglomerated products
10	Drop Test of agglomerated products
11	Study of ISP layout
12	Charge calculations for raw materials in Blast Furnace

13	Study of different parts of Blast Furnace
14	Chemical analysis of Iron based products
15	Study of Briquetting Process

Lecture/tutorial times

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

Lecture	Room LH 3
Lecture	Room LH 3
Lecture	Room LH 3
Lab	Lab -04 (Ground Floor)
Lab	Lab -04 (Ground Floor)

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

Reference Books

1. A. W. Cramb, "Making, Shaping and Treating of Steels", Association of Iron and Steel Engineers, 11th Edition, 1985, ISBN: 9780930767020.
2. J. G. Peacey and W. G. Davenport, "Blast Furnace: Theory and Practice", Pergamon Press, Oxford, 1st Edition, 1979, ISBN: 9780080232584.
3. J. J. Gupta and Amit Chatterjee, "Blast Furnace Iron Making", SBA Publications, 1st Edition, 1995, ISBN: 9788185164106.

Text books

Text Books

1. R. H. Tupkary, "Introduction to Modern Iron Making", Khanna Publications, 1st Edition, 2004, ISBN: 9788174090218.
2. A. Ghosh and A. Chatterjee, "Iron Making and Steel Making: Theory and Practice", Prentice Hall, 1st Edition, 2008, ISBN: 9788120332898.
3. A. K. Biswas, "Principles of Blast Furnace Iron Making", SBA Publications, 1st Edition, 1999, ISBN: 9780949917089Edition, 1964, ISBN: 9781295841929.

Additional Materials

1. NPTEL Course on "Materials and Heat Balance in Metallurgical Processes" (http://nptel.ac.in/courses/113104060/26)

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.

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.

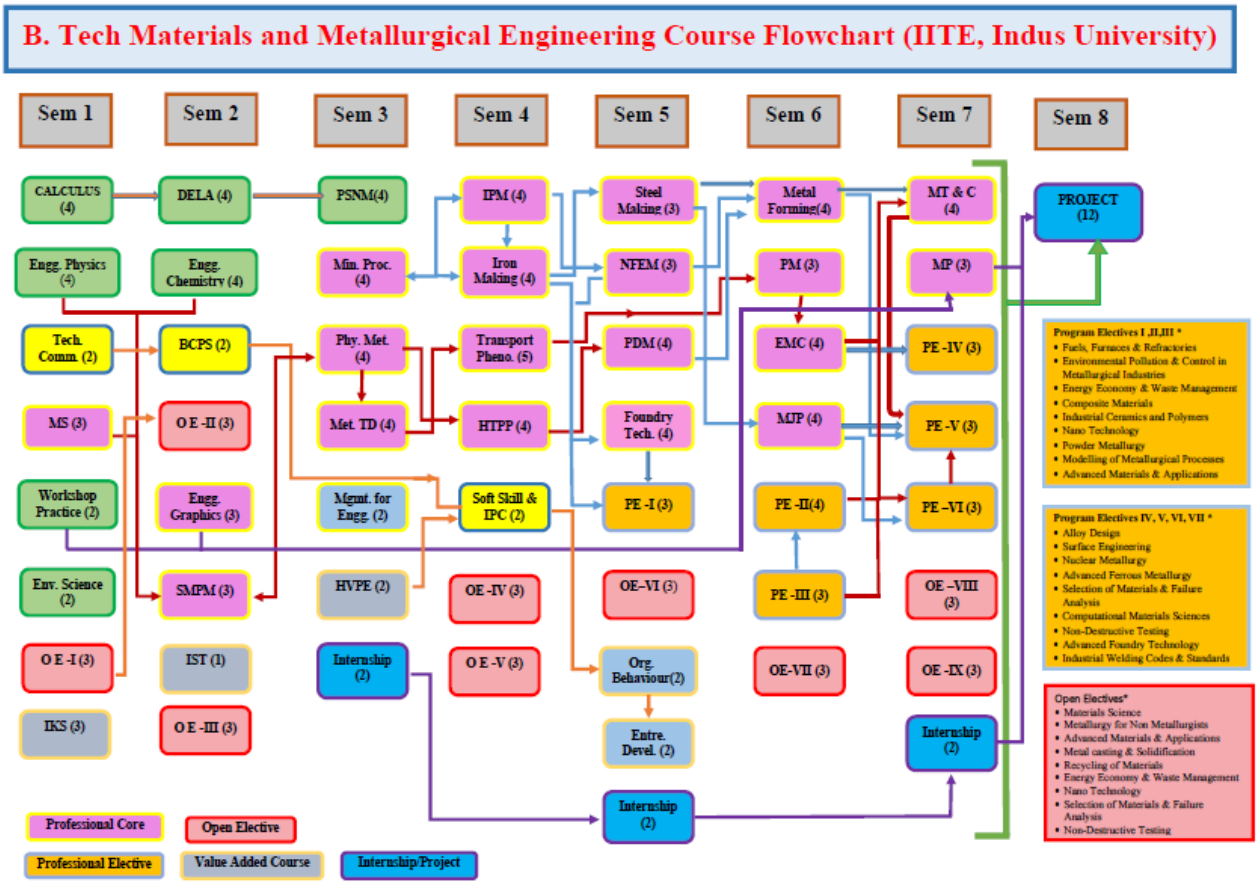
Do not copy the work of other students.
Do not share your work with other students (except where required for a group activity or assessment)

.

Course schedule (subject to change)

	Week #	Topic & contents	CO Addressed	Teaching Learning Activity (TLA)
	Weeks 1	General and History of Iron Making, Beneficiation of Raw Materials: Coke	CO1-CO6	BB PPT
	Weeks 2	Beneficiation of Raw Materials :Sinter,	CO1-CO6	BB PPT
	Week 3	Beneficiation of Raw Materials: Pellets	CO1-CO6	BB PPT
	Week 4	Reaction Mechanics	CO1-CO6	BB PPT
	Week 5	BF Proper	CO1-CO6	BB PPT
	Week 6	BF Accessories	CO1-CO6	BB PPT
	Week 7	Starting and Shutting down a BF	CO1-CO6	BB PPT
	Week 8	BF Irregularities	CO1-CO6	BB PPT
	Week 9	BF Maintenance	CO1-CO6	BB PPT
	Week 10	Alternative Routes of Iron Making: Need and Importacne	CO1-CO6	BB PPT
	Week 11	Alternative Routes of Iron Making: Need and Importacne	CO1-CO6	BB PPT
	Week 12	Alternative Routes of Iron Making: SR Processes	CO1-CO6	BB PPT
	Week 13	Alternative Routes of Iron Making: DR Processes	CO1-CO6	BB PPT
	Week 14	Alternative Routes of Iron Making: DR Processes	CO1-CO6	BB PPT
	Week 15	Alternative Routes of Iron Making: SR Processes	CO1-CO6	BB PPT
	Week 16	Alternative Routes of Iron Making: SR Processes	CO1-CO6	BB PPT

Program Map for Metallurgical Engineering Department (Mapped For Iron Making)



Subject: Iron Making								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0402**				Semester: **IV**
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 impart the overall idea of how Iron is produced, the history of Iron making and availability of raw materials for iron production.
2. To know about various techniques of raw material preparation for charging in iron making furnace, construction and operation of iron making furnace and reactions occurring in the furnace, reaction mechanism inside the blast furnace.

CONTENTS

UNIT-I

[10 hours]

General: History of iron making. Occurrence, distribution and evaluation of raw materials (iron ore, coal and flux) for iron making. Burden materials and burden preparation: Burden preparation, Burden qualities. Agglomeration- Sintering-process, variables and machines. Pelletization process, Theory of bonding. Mechanism of ball formation, Disc and drum pelletizer, Induration of pellets, cold bonding technique and testing of pellets.

UNIT-II

[10 hours]

Blast Furnace (B.F.) Constructional features: Profile, Refractories, Accessories, Charging mechanism, Bell and bell-less charging systems. B.F. – Reactions: Physico-chemical principles of blast furnace. Blast furnace reactions. Reaction in stack, tuyere zone, bosh and hearth. Thermodynamics equilibria, Direct and indirect reduction. Kinetics of iron-oxide reduction, Slag-metal reactions, Desiliconization, Desulphurization.

UNIT-III

[10 hours]

B.F. – Operations: Operational steps, Blast furnace irregularities and remedial measures, Blast furnace gas, properties, cleaning and utilization.

UNIT-IV

[10 hours]

Alternative Methods of Iron Making: Reduction smelting, Direct reduction processes, Fluidized bed process, Electro thermal process and mini blast furnace.

Iron Making Lab (List of Experiments)

Experiment No	Title

1	Identification of raw material for iron making
2	Bulk density Measurement
3	Determination of Angle of Repose
4	Sintering of iron ore fines
5	Pelletization of iron ore fines
6	Induration behavior of pellets
7	Box compression test of hardened or indurated pellets
8	Tumbling/Drum test of green and indurated pellets
9	Shatter Test of agglomerated products
10	Drop Test of agglomerated products
11	Study of ISP layout
12	Charge calculations for raw materials in Blast Furnace
13	Study of different parts of Blast Furnace
14	Chemical analysis of Iron based products
15	Study of Briquetting Process

Course Outcomes

1. To apply the knowledge of various types of routes of iron making to practical scenarios.
2. To innovate the existing ideas and ways of making Iron and developing the technology to make this process energy intensive and cost effective.

Text Books

1. R. H. Tupkary, "Introduction to Modern Iron Making", Khanna Publications, 1st Edition, 2004, ISBN: 9788174090218.
2. A. Ghosh and A. Chatterjee, "Iron Making and Steel Making: Theory and Practice", Prentice Hall, 1st Edition, 2008, ISBN: 9788120332898.
3. A. K. Biswas, "Principles of Blast Furnace Iron Making", SBA Publications, 1st Edition, 1999, ISBN: 9780949917089.

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3. J. J. Gupta and Amit Chatterjee, "Blast Furnace Iron Making", SBA Publications, 1st Edition, 1995, ISBN: 9788185164106.

Web Resources

1. NPTEL Course on "Materials and Heat Balance in Metallurgical Processes" (http://nptel.ac.in/courses/113104060/26)

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

Course code: MME0405
Course name: Metal Casting and Solidification
Pre-requisites: None
Credit points: 03
Offered Semester: 04

Course Coordinator
Full Name: Mr. Monil Salot
Department with sitting location: Metallurgical Engineering, Bhanwar Building, Lab-004 (GF)
Telephone: 9428600336
Email: monilsalot.mt@indusuni.ac.in
Consultation times: 3:45-4:20 PM

Course Lecturer
Full Name: Mr. Monil Salot
Department with sitting location: Metallurgical Engineering, Bhanwar Building, Lab-004 (GF)
Telephone: 9428600336
Email: monilsalot.mt@indusuni.ac.in
Consultation times: 3:45-4:20 PM

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 acquire the knowledge about the fundamentals of the casting, basic terminology related to casting process.
2. To make students aware about the alternative method for the manufacturing of component for engineering applications.

Course Outcomes (CO)

1. To apply knowledge about how to manufacture the intricate casting what should be the process parameter, design of pattern, mould, etc.
2. To apply the theory about the melting practice of different cast alloy.
3. To apply the knowledge to overcome defects generated during casting.

Course Outline

Proposed course mainly deal with fundamentals of metal casting and solidification, its basics, terminologies, importance, processes fro manufacturing and operation of rproducing defect free castings

Method of delivery

- Face to face lectures,
- Numerical and Simulations in Tutorials,
- Model Making
- Video Lectures When and as necessary

Study time

2 Lectures and 2 Hrs. Lab

CO-PO Mapping (PO: Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	-	2	-	1	1	3	1	-	-	2	-
CO2	3	3	2	1	2	2	2	-	-	-	3	1
CO3	3	3	3	3	-	1	1	-	-	2	2	2

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

Blooms Taxonomyand Knowledge retention(For reference)

(Blooms taxonomy has been given for reference)

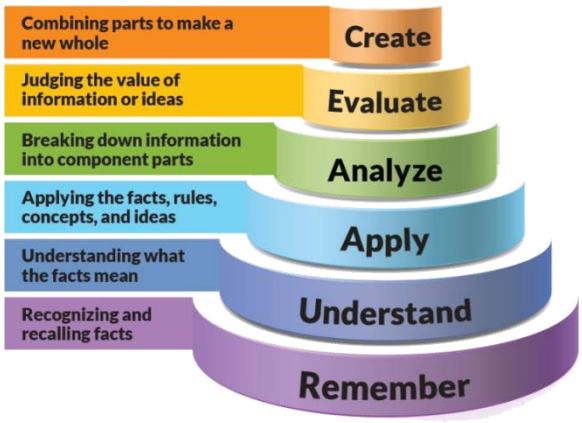

Figure 1: Blooms Taxonomy

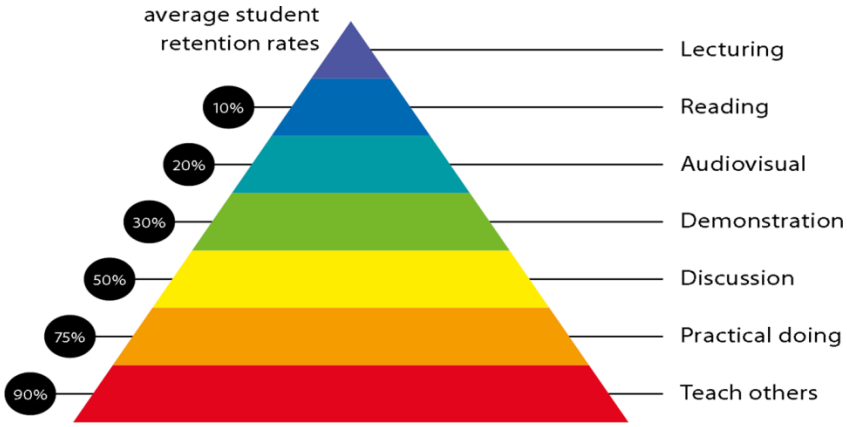

Figure 2: Knowledge retention

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.	**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:

Experiment No.	Title
1	Introduction to foundry laboratory.
2	To detrmine AFS fineness number and distribution coefficient of agiven sand sample
3	To demonstrate the working of sand muller
4	To determine the clay content of given sand sample
5	To prepare standard samples under identical condition for checking important physical properties of foundry sand
6	To determine compression strength of foundry sand
7	To determine permeability number of green sand,core sand and raw sand
8	To find out the green mould hardness of the sand mould
9	To determine shatter index of the sand sample.
10	To determine moisture content of the prepared sand
11	To prepare core sand
12	To findout the hardness of dried cores made out of core sands

13	To perform peelback test on core sand
14	To perform hot distortion and tensile tests on core sand
15	To study the aluminum melting and casting

Lecture/tutorial times

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

Lecture	Room LH 3
Lecture	Room LH 3
Lecture	Room LH 3

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

Reference Books

1. P. C. Mukherjee, "Fundamentals of Metal Casting Technology", Oxford & IBH, 1st Edition, 1988, ISBN: 9788120403635.
2. P. R. Beeley, "Foundry Technology", Butterworth-Heinemann, 2nd Edition, 2001, ISBN: 9780750645676.
3. H. F. Taylor and M. C. Flemings, "Foundry Engineering", Wiley Eastern, 1st Edition, 1959, ISBN: 9780471848431.
4. D. Kumar and S. K. Jain, "Foundry Technology", CBS Publications, 1st Edition, 2007, ISBN: 9788123902906.

Text books

Text Books

1. R. W. Heine, C. R. Loper and P. C. Rosenthal, "Principles of Metal Casting", Tata McGraw Hill, 2nd Edition, 2017, ISBN: 9780070993488.
2. P. L. Jain, "Principles of Foundry Technology", Tata McGraw Hill, 2nd Edition, 1987, ISBN: 9780074516980.

Additional Materials

1. NPTEL MOOC Course on "Principles of Casting Technology" (https://onlinecourses.nptel.ac.in/noc17_me11/preview)

ASSESSMENT GUIDELINES

Your final course mark will be calculated from the following:

Example:

MSE	40% (week 4)	Objective (1-3)
Assignments and Problems	05% (week 8)	Objective (1-4)
Mini Project	10% (due week 10)	Objectives (2-5)
Class Temperament and Innovative Thinking	05%(due week 10)	Objectives (1-5)
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. ***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 -% 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	**Moulding materials: Properties, preparation & testing**	C01, C02	BB PPT
	Weeks 2	**Moulding materials: Properties, preparation & testing**	C01, C02	BB PPT
	Week 3	**Moulding materials: Properties, preparation & testing**	C01, C02	BB PPT
	Week 4	**Production techniques**	C01, C02,CO3	BB PPT
	Week 5	**Production techniques**	C01, C02,C03	BB PPT
	Week 6	**Production techniques**	C01, C02,C03	BB PPT
	Week 7	**Liquid metals and gating & feeding of castings**	C01, C02, C03	BB PPT
	Week 8	**Liquid metals and gating & feeding of castings**	C01, C02, C03	BB PPT
	Week 9	**Liquid metals and gating & feeding of castings**	C01, C03	BB PPT
	Week 10	**Casting design and analysis of casting defects**	C01, C03	BB PPT
	Week 11	**Casting design and analysis of casting defects**	C03, C02	BB PPT
	Week 12	**Casting design and analysis of casting defects**	C03, C02	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); Composite Materials (EL-2); Nano Technology (OE); Metal Joining Processes; 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 Casting and Solidification (OE – 4)								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0405**				Semester: **IV**
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	200

Course Objectives

1. To acquire the knowledge about the fundamentals of the casting, basic terminology related to casting process.
2. To make students aware about the alternative method for the manufacturing of component for engineering applications.

CONTENTS

UNIT-I

[10 hours]

Moulding materials: Properties, preparation & testing:
Functional requirements of moulding materials, moulding practice & special requirements of core sands, foundry sands & binders, sand preparation & systems, silica programme.

UNIT-II

[10 hours]

Production techniques:
Manufacture of sand castings, mould production, moulding techniques, cores & core making, melting & casting, finishing operation. Shell, investment and die casting process, centrifugal casting, other special techniques.

UNIT-III

[10 hours]

Liquid metals and gating & feeding of castings:
Fluidity of liquid metals, mould factors in metal flow, the gating of casting. The feeding characteristics of alloys, methods for feeding of castings; design modifications, padding chills & insulation, the feeding of cast irons, solidification modeling.

UNIT-III

[10 hours]

Casting design and analysis of casting defects:
Preliminary stages & production stages, process & alloy selection, physical design features, quality assessment & control. Categories of defects, gas defects, shrinkage defects, contraction defects, compositional errors & segregation, inclusions & sand defects, shaping faults.

Course Outcomes

1. To apply knowledge about how to manufacture the intricate casting what should be the process parameter, design of pattern, mould, etc.
2. To apply the theory about the melting practice of different cast alloy.
3. To apply the knowledge to overcome defects generated during casting.

Text Books

1. R. W. Heine, C. R. Loper and P. C. Rosenthal, "Principles of Metal Casting", Tata McGraw Hill, 2nd Edition, 2017, ISBN: 9780070993488.
2. P. L. Jain, "Principles of Foundry Technology", Tata McGraw Hill, 2nd Edition, 1987, ISBN: 9780074516980.

Reference Books

1. P. C. Mukherjee, "Fundamentals of Metal Casting Technology", Oxford & IBH, 1st Edition, 1988, ISBN: 9788120403635.
2. P. R. Beeley, "Foundry Technology", Butterworth-Heinemann, 2nd Edition, 2001, ISBN: 9780750645676.
3. H. F. Taylor and M. C. Flemings, "Foundry Engineering", Wiley Eastern, 1st Edition, 1959, ISBN: 9780471848431.
4. D. Kumar and S. K. Jain, "Foundry Technology", CBS Publications, 1st Edition, 2007, ISBN: 9788123902906.

Web Resources

1. NPTEL MOOC Course on "Principles of Casting Technology" (https://onlinecourses.nptel.ac.in/noc17_me11/preview)

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

Course code: MME0406
Course name: Recycling of Materials
Pre-requisites: Physics, Chemistry
Credit points: 3
Offered Semester: 4th 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 make the students aware about the serious issue and how to combat the problem.
2. Classifications of the waste materials, recycling methods, recycling symbol and the technology of recycling within the economic barriers will be dealt with in this course.
3. Students will learn how to make public conscious of recycling of wastes and economic consideration.

Course Outcomes (CO)

CO 1: List the types of waste materials [BT-1]
CO 2: Distinguish reduce, reuse and recycle in waste management. [BT-2]
CO 3: Comprehend the recycling symbols [BT-3]
CO 4: Schematically illustrate the process flow of recycling of solid waste. [BT-4]
CO 5: Criticize advantage and limitation in recycling. [BT-5]
CO 6: Innovate a way for collection and separation of solid waste. [BT-6].

Course Outline

(Key in topics to be dealt)
Solid waste management
Recycling process
Collection and segregation of different waste materials
Symbols for various recycling materials
Disposals of harmful waste

Method of delivery

Interactive lectures, Power point presentation

Study time

3 classes per week

CO-PO Mapping (PO: Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	1	1	-	-	-	-	1
CO2	3	2	1	-	-	-	1	1	-	-	-	1
CO3	3	2		-	-	-	1	1	-	2	-	1
CO4	2	3	1	-	-	-	1	-	-	-	1	1
CO5	2	3	1	-	-	-	1	-	-	-	2	1
CO6	1	3	-	1	-	-	1	1	-	2	1	1

Blooms Taxonomy and Knowledge retention (For reference)

(Blooms taxonomy has been given for reference)

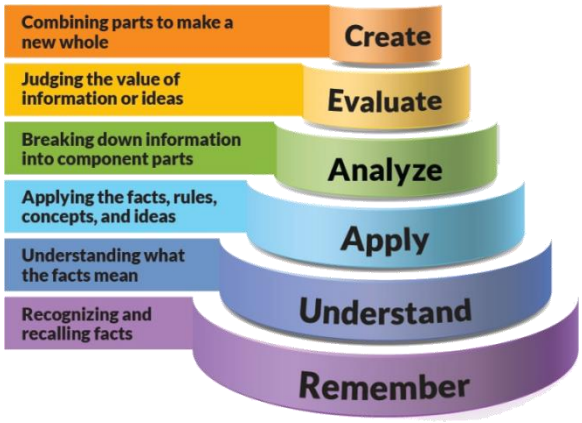

Figure 1: Blooms Taxonomy

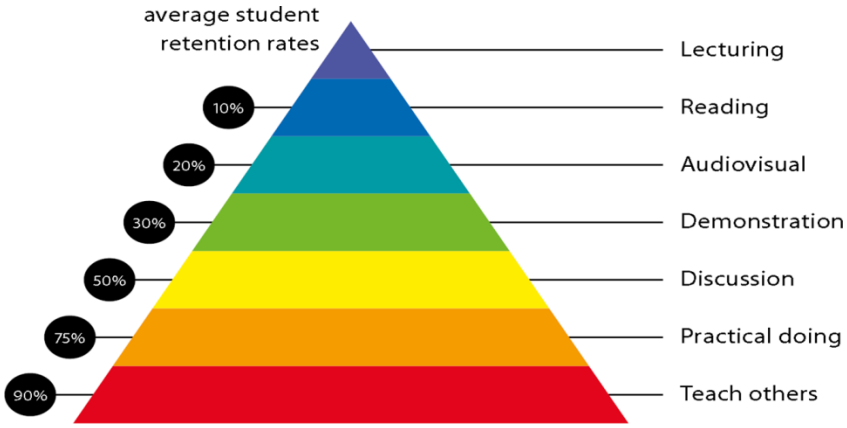

Figure 2: Knowledge retention

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	**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	2.00 – 3.00 pm	Google classroom
Lecture	Wednesday	10.00 – 11.00 am	Google classroom
Lecture	Tuesday	12.20-1.20 pm	Google classroom

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

Reference Materials

1. Material Recycling – Trends and perspectives, Edited by Dimitris S. Achilias, InTech, 2012.
2. Solid Waste Recycling and Processing. Planning of solid waste recycling facilities and programs. Marc J. Rogooff, second edition, Elsevier, 2014.
3. Aluminum Recycling, Mark E. Schelesinger, 2nd edidtion, CRC Press. 2014.
4. Plastic waste Management – NPTEL course.

ASSESSMENT GUIDELINES

Your final course mark will be calculated from the following:

Example:

Mid Semester	40% (week 4) Objective (1-3)
Presentation/Project	**10%**
Assignement	**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

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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.**

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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	Importance, purpose of recycling	1,5	Interactive teaching using PPT
	Weeks 2	Contribution of economy and human and environmental health of recycling	1,5	Interactive teaching using PPT
	Week 3	Reduce, reuse and recycling. Recycling statistics in India and World	2	Interactive teaching using PPT
	Week 4	Recycling processes. Collection, separation and recycling stages of metals (steel)	2,4	Interactive teaching using PPT
	Week 5	Collection, separation, and recycling stages of metals (Aluminum and copper).	2,4	Interactive teaching using PPT
	Week 6	Collection, separation, and recycling stages of Plastics. Recyling symbols.	2,3,4	Interactive teaching using PPT
	Week 7	Collection, Separation and recycling stages of composite wastes	2,3,4	Interactive teaching using PPT
	Week 8	Collection, Separation and recycling stages of glass wastes.	2,3,4	Interactive teaching using PPT
	Week 9	Collection, Separation and recycling stages of building wastes.	2,3,4	Interactive teaching using PPT
	Week 10	Collection, Separation and recycling stages of accumulator and battery wastes	2,3,4	Interactive teaching using PPT
	Week 11	Collection, Separation and recycling stages of electronic wastes	2,3,4	Interactive teaching using PPT
	Week 12	Collection, transportation and disposal of harmful wastes.	2,3,4	Interactive teaching using PPT
	Week 13	Revision	5,6	Interactive teaching using PPT

Subject: Recycling of Materials (OE – 5)								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0406**				Semester: **IV**
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 make the students aware about the serious issue and how to combat the problem.
2. Classifications of the waste materials, recycling methods, recycling symbol and the technology of recycling within the economic barriers will be dealt with in this course.
3. Students will learn how to make public conscious of recycling of wastes and economic consideration.

CONTENT

UNIT-I

[10 hours]

Definition of terms, recycling and recovery.
Importance, purpose, and contribution of economy and human and environmental health of recycling.
Recycling symbols, Recyclable wastes. Recycling statistics in India and World.

UNIT-II

[10 hours]

Defining the stages of recycling processes.
Collection, Separation and recycling stages of plastic wastes, steel/stainless steel, aluminum, and copper wastes, and recycling symbols.

UNIT-III

[10 hours]

Collection, Separation and recycling stages of composite wastes, glass wastes, building wastes, and recycling symbols.

UNIT-IV

[10 hours]

Collection, Separation and recycling stages of accumulator and battery wastes, electronic wastes, and recycling symbols.
Collection, transportation and disposal of harmful wastes.

Course Outcomes

1. The students will be made familiar with different types of waste materials and their disposal problems. Thus, necessitating the knowledge on recycling of the waste materials.
2. Distinguish the recycling, recovery, reuse, reduce and disposal of wastes.
3. Comprehend the recycling symbols.
4. The students will be able to know about the collection and separation systems of wastes.
5. The students will be able to analyses awareness studies to public.

Reference Books

1. Material Recycling – Trends and perspectives, Edited by Dimitris S. Achilias, InTech, 2012.

Name of Institute: IITE
Name of Faculty: Dr.Sujoy Chaudhury

Course code: MME0403
Course name: Transport Phenomena
Pre-requisites: Physics
Credit points: 4
Offered Semester: 4

Course Coordinator (weeks XX - XX)
Full Name: Sujoy K. Chaudhury
Department with sitting location: Materials and Metallurgical Engineering Department, Ground floor, Met. Lab. 3, Bhanwar Building
Telephone: 8469943117
Email: sujoychaudhury.mt@indusuni.ac.in
Consultation times: 3:30 PM – 4:30 PM

Course Lecturer (weeks xx - XX)
Full Name: Sujoy K. Chaudhury
Department with sitting location: Materials and Metallurgical Engineering Department, Ground floor, Met. Lab. 3, Bhanwar Building
Telephone: 8469943117
Email: sujoychaudhury.mt@indusuni.ac.in
Consultation times: 3:30 PM – 4:30 PM

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

Course Objectives

1. To provide knowledge about the basic concept of heat transfer and its different modes.
2. To analyze different modes of heat transfer with examples in day to day life.
3. To demonstrate the application of various factors & mathematical equations governing the heat transfer in the system.

Course Outcomes (CO)

CO 1: Students will able to define constitutive laws as to apply to fluid flow, heat and mass transfer. [BT-1]
CO 2: Students will able to apply Navier-Stoke equation and Bernoulli's equation for solving fluid problems. [BT-3]
CO 3: Students will able design energy efficient systems. [BT-6]
CO 4: Students will be able to demonstrate shell balances for heat, momentum and mass transfer to obtain differential equation describing the velocity, temperature and concentration gradient. [BT-2]

CO 5: Students will able to determine the concentration profile and mass conduction equation analogous to heat conduction equation. [BT-5]
CO 6: Students will able to analyze and quantify the kinetics of the processes.

Course Outline

The proposed course deals Transfer of Heat, Mass and Fluid .

Method of delivery

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

Study time

3 lectures + 1 hours Tutorial+ 2 hours Laboratory per week

CO-PO Mapping (PO: Program Outcomes)

Transport Phenomena (MME0403)												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	2	2	1	2	-	-	-	-	-	2
CO2	2	2	3	2	-	-	-	-	-	-	-	-
CO3	-	-	2	-	-	-	-	-	-	-	-	-
CO4	2	-	3	2	-	-	-	-	-	-	-	1
CO5	2	3	2	2	-	-	-	-	-	-	-	-
CO6	2	2	1	2	-	-	-	-	-	-	-	
MME0403	2.2	2.25	2.16	2	1	2	-	-	-	-	-	1.5

Blooms Taxonomyand Knowledge retention(For reference)

(Blooms taxonomy has been given for reference)

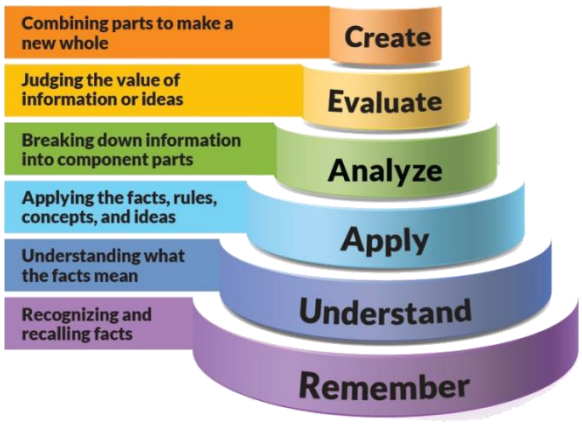

Figure 1: Blooms Taxonomy

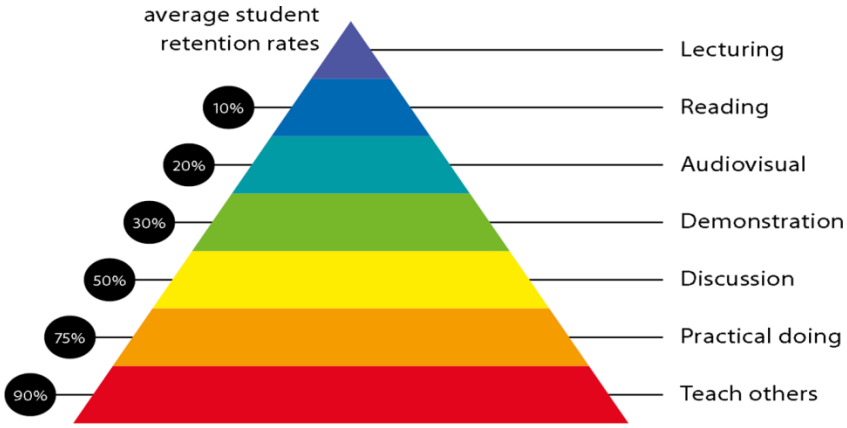

Figure 2: Knowledge retention

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:

Heat And Fluid Transfer modes and their calculations

Lecture/tutorial times

(Give lecture times in the format below)

Example:

Lecture	Monday	11:25 am –12:25 pm	Room LH 4
Lecture	Thursday	1:00 –1:55 am	Room LH 4
Lecture	Friday	1:00 –1:55 am	Room LH 4
Tutorial	Monday	1:55am – 3:45 pm	Room Lab 1
Practicals	Wednesday	10:30am - 12:20pm	Room Lab 3
Practicals	Friday	10:30am - 12:20pm	Room Lab 3

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. Mohanty, “Rate Processes in Metallurgy”, Prentice Hall India Learning Private Limited, 3rd Edition, 2009, ISBN: 9788120335912.
2. V. Gupta, “Elements of Heat and Mass Transfer”, New Age International Publishers, 1st Edition, 1995, ISBN: 9788122408003.
3. J. H. Szekely and N. J. Themelis, “Rate Phenomena in Process Metallurgy”, John Wiley & Sons, 1st Edition, 1971, ISBN: 9780471843030.
4. D. R. Poirier and G. H. Geiger, “Transport Phenomena in Materials Processing”, John Wiley & Sons, 1st Edition, 1998, ISBN: 9780873392723.

Additional Materials

1. R. B. Bird, W. E. Stewart and E. N. Lightfoot, “Transport Phenomena”, Wiley, 2nd Edition, 2006, ISBN: 9788126508082.
2. M. Iguchi and O. J. Ilegbusi, “Basic Transport Phenomena in Materials Engineering”, Springer Nature, 1st Edition, 2014, ISBN: 9784431540199.
3. D. R. Gaskell, “An Introduction to Transport Phenomena in Materials Engineering”, Momentum Press, 2nd Edition, 2012, ISBN: 9781606503553.
4. J. Welty, C.E. Wicks, G.L. Rorrer and R.E. Wilson, “Fundamentals of Momentum, Heat and Mass Transfer”, John Wiley & Sons, 5th Edition, 2012, ISBN: 9780470128688.

Web Resources

. NPTEL MOOC Course on “Transport Phenomena”
(https://onlinecourses.nptel.ac.in/noc17_ch11/preview)
2. SWAYAM MOOC Course on “Transport Phenomena”

(https://swayam.gov.in/course/3719-transport-phenomena)
3. EdX Online Course on "The Basics of Transport Phenomena"
(https://courses.edx.org/courses/course-v1:DelftX+TP101x+1T2017/info)

ASSESSMENT GUIDELINES

Your final course mark will be calculated from the following:

Example:	
Class Activities	05%
Assignment	**10%**
Attendance	**05%**
Mid semester	40%
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:

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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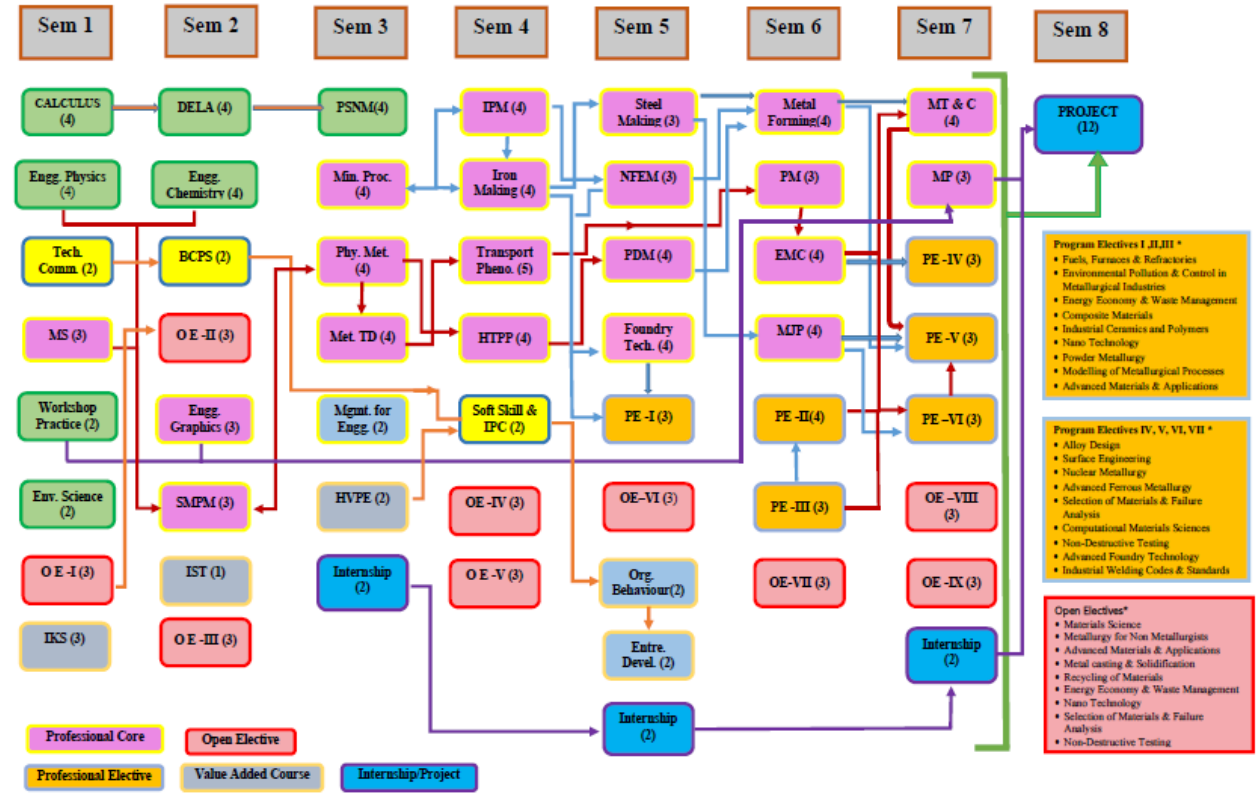
Course schedule (subject to change)

(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	Fluid flow and its relevance to mass transfer. General mass transport equation. Modes of mass transfer. Film and boundary layer theories.		BB, PPT
	Weeks 2	Diffusion, Generalized diffusion equation. Diffusivity in gases, liquids and solids. Steady, diffusion. Pseudo-steady diffusion.		BB, PPT
	Week 3	Diffusion through porous solids. Convective mass transfer- Mass transfer in fluid at solid-fluid interface.		BB, PPT
	Week 4	Mass transfer between two fluids. Mass transfer v/s chemical control, enhancement of process rates. Applications in metallurgical system		BB, PPT
	Week 5	Definition and classification of fluids. Viscosity, Newtonian and non-Newtonian fluids.		BB, PPT
	Week 6	Viscous and non-viscous fluids. General features of fluid flow		BB, PPT
	Week 7	Laminar and turbulent flow, Newton's law of viscosity, Pascal's law.		BB, PPT
	Week 8	Differential mass balance (continuity equation). Differential momentum balance (equation of motion).		BB, PPT
	Week 9	Navier Stokes Equation. Application of Differential Balance Equation. Overall mass balance and momentum balance.		BB, PPT
	Week 10	Euler's equation, Bernoulli's equation. Bernoulli's Equation,		BB, PPT
	Week 11	Applications of Bernoulli's Equation, Flow through porous media.		BB, PPT
	Week 12	Modes of heat transfer. Conduction of heat through solid. Steady and unsteady state.		BB, PPT

	Week 13	Fourier law of heat conduction. General equation of heat conduction in Cartesian co-ordinate, spherical and cylindrical systems.		BB, PPT
	Week 14	Convective heat transfer. Free and forced convection. Application dimensional analysis of effective boundary layer.		BB, PPT
	Week 15	Aspects of Radiative Heat Transfer. Reflection, absorption and transmission of radiation. Black body radiation. Planck's Law. Wein's distribution Law. Heat transfer between two bodies by radiation. Lambert's Law		BB, PPT

B. Tech Materials and Metallurgical Engineering Course Flowchart (IITE, Indus University)



Subject: Transport Phenomena								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0403**			Semester: **IV**	
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	2	5	16/40	16/40	24/60	24/60	200

Course Objectives

1. To provide knowledge about the basic concept of heat transfer and its different modes.
2. To analyze different modes of heat transfer with examples in day to day life.
3. To demonstrate the application of various factors & mathematical equations governing the heat transfer in the system.

CONTENTS

UNIT-I

[10 hours]

Fluid flow and its relevance to mass transfer. General mass transport equation. Modes of mass transfer. Film and boundary layer theories. Diffusion, Generalized diffusion equation. Diffusivity in gases, liquids and solids. Steady, diffusion. Pseudo-steady diffusion. Diffusion through porous solids. Convective mass transfer- Mass transfer in fluid at solid-fluid interface. Mass transfer between two fluids. Mass transfer v/s chemical control, enhancement of process rates. Applications in metallurgical system

UNIT-II

[10 hours]

Definition and classification of fluids. Viscosity, Newtonian and non- Newtonian fluids. Viscous and non-viscous fluids. General features of fluid flow. Laminar and turbulent flow, Newton's law of viscosity, Pascal's law.

UNIT-III

[10 hours]

Differential mass balance (continuity equation). Differential momentum balance (equation of motion). Navier Stokes Equation. Application of Differential Balance Equation. Overall mass balance and momentum balance. Euler's equation, Bernoulli's equation. Bernoulli's Equation, Applications of Bernoulli's Equation, Flow through porous media.

UNIT-IV

[10 hours]

Modes of heat transfer. Conduction of heat through solid. Steady and unsteady state. Fourier law of heat conduction. General equation of heat conduction in Cartesian co-ordinate, spherical and cylindrical systems.

Convective heat transfer. Free and forced convection. Application dimensional analysis of effective boundary layer.

Aspects of Radiative Heat Transfer. Reflection, absorption and transmission of radiation. Black body radiation. Planck's Law. Wein's distribution Law. Heat transfer between two bodies by radiation. Lambert's Law.

Transport Phenomena Lab (List of Experiments)

Experiment No.	Title
1	To study about various fluid properties and fluid flows.
2	To determine Reynold's number for fluid flow
3	Measurement of pressure difference using manometers
4	To verify Bernoulli's theorem.
5	To apply Bernoulli's equation to Venturimeter
6	To apply Bernoulli's equation to Orificemeter
7	To study the fundamentals of heat transfer
8	To determine thermal conductivity of insulating powder using sphere in sphere method.
9	To measure overall heat transfer coefficient for given composite wall with help of composite wall apparatus.
10	To determine temperature distribution and the effectiveness of fin.
11	To determine the surface heat transfer coefficient for a vertical tube losing heat by natural convection.
12	To determine convective heat transfer coefficient in force convection
13	To determine Stefan-Boltzmann constant
14	To determine emissivity for the given surface
15	Study of mass transfer

Course Outcomes

1. To solve different numerical pertaining to all three modes of heat transfer for different systems.
2. To demonstrate the phenomena of conduction, convection & Radiation by conducting laboratory scale experiments.
3. To make the students understand the concept of fluid behavior & its relevance for different modes of mass transfer.
4. To analyze the mass & momentum balance equations to understand the diffusion phenomenon in metallurgical systems.

Text Books

1. A. K. Mohanty, "Rate Processes in Metallurgy", Prentice Hall India Learning Private Limited, 3rd Edition, 2009, ISBN: 9788120335912.
2. V. Gupta, "Elements of Heat and Mass Transfer", New Age International Publishers, 1st Edition, 1995, ISBN: 9788122408003.
3. J. H. Szekely and N. J. Themelis, "Rate Phenomena in Process Metallurgy", John Wiley & Sons, 1st Edition, 1971, ISBN: 9780471843030.
4. D. R. Poirier and G. H. Geiger, "Transport Phenomena in Materials Processing", John Wiley & Sons, 1st Edition, 1998, ISBN: 9780873392723.

Reference Books

1. R. B. Bird, W. E. Stewart and E. N. Lightfoot, "Transport Phenomena", Wiley, 2nd Edition, 2006, ISBN: 9788126508082.
2. M. Iguchi and O. J. Ilegbusi, "Basic Transport Phenomena in Materials Engineering", Springer Nature, 1st Edition, 2014, ISBN: 9784431540199.
3. D. R. Gaskell, "An Introduction to Transport Phenomena in Materials Engineering", Momentum Press, 2nd Edition, 2012, ISBN: 9781606503553.
4. J. Welty, C.E. Wicks, G.L. Rorrer and R.E. Wilson, "Fundamentals of Momentum, Heat and Mass Transfer", John Wiley & Sons, 5th Edition, 2012, ISBN: 9780470128688.
5. F. P. Incropera, D. P. Dewitt and T. L. Bergman, "Fundamentals of Heat and Mass Transfer".
6. Y. A. Cengel and A. J. Ghajar, "Heat and Mass Transfer".

Web Resources

1. NPTEL MOOC Course on "Transport Phenomena"
(https://onlinecourses.nptel.ac.in/noc17_ch11/preview)
2. SWAYAM MOOC Course on "Transport Phenomena"
(https://swayam.gov.in/course/3719-transport-phenomena)
3. EdX Online Course on "The Basics of Transport Phenomena"
(https://courses.edx.org/courses/course-v1:DelftX+TP101x+1T2017/info)
4. EdX Online Course on "Advanced Transport Phenomena"
(https://courses.edx.org/courses/course-v1:DelftX+TP102x+3T2016/info)