Name of Institute: IITE
Name of Faculty: Dr. S.K. Chaudhury

Course code: **MME0705**
Course name: **Advanced Ferrous Metallurgy**
Pre-requisites: Mineral Processing, Introduction to Process Metallurgy, Iron Making, Steel Making
Credit points: 03
Offered Semester: 07

Course Coordinator

Full Name: Dr. S.K. Chaudhury
Department with siting location: Metallurgical Engineering, Met. Lab 3, Groud Floor, Bhanwar Building
Telephone: 8469943117
Email: sujoychaudhury.mt@indusuni.ac.in
Consultation times: 4:10-5:00 PM

Course Lecturer

Full Name: Dr. S.K. Chaudhury
Department with siting location: Metallurgical Engineering, Met. Lab 3, Groud Floor, Bhanwar Building
Telephone: 8469943117
Email: sujoychaudhury.mt@indusuni.ac.in
Consultation times: 4:10-5:00 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 impart the overall idea of how Steel is produced the history of Steel making.
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 and post treatment to make steel.

Course Outcomes (CO)

CO 1: Able to define all terms and derive equations in Advanced Ferrous Metallurgy. (BT-1)

CO 2: Able to explain theories, represent mathematical equations to reality and understand their limitations. (BT-2)
CO 3: Apply the knowledge to determine optimum condition of different metallurgical processes in iron and steel making. (BT-3)
CO 4: Analyze results of numerical pertinent to thermodynamics and kinetics of iron and steel making. (BT-4)

CO 5: Evaluate technical problems related to iron and steel industries and ways to mitigate them. (BT-5)
CO 6: Develop understanding of mechanisms of various techniques for steel making and learn about their advantages, limitations, and their recent advances. (BT-6)

Course Outline

Proposed course mainly deal with nuances of Iron Making and Steel Making in advanced technologies and deals with the majority of process pertaining to making iron and steel and exploring alternative routes for the production of the same, along with this, the subject deals with reaction mechanisms for production of high quality ferrous materials.

Method of delivery

Face to face lectures, Experiments in Laboratory, Model Making, Online class

Study time

4 Lectures

CO-PO Mapping (PO: Program Outcomes)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
C0 1	2	3	1									1
C0 2	3	3	1			1	1					1
C0 3	2	2	1	1			1					1
C0 4	3	1								2		
C0 5		1	2	1		1				1		3
C0 6	1		1	3						1		2
MT0706	2.2	2	1.2	1.7		1	1			1.3		1.6

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

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

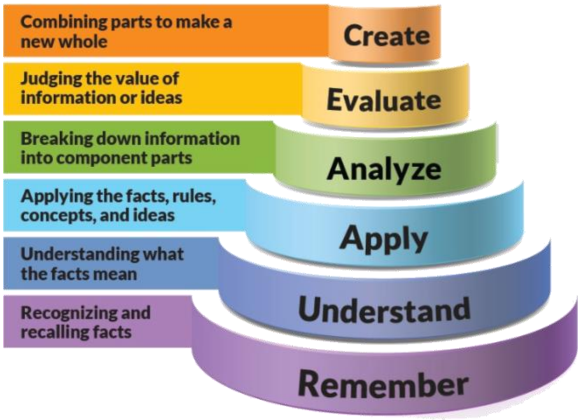


Figure 1: Blooms Taxonomy

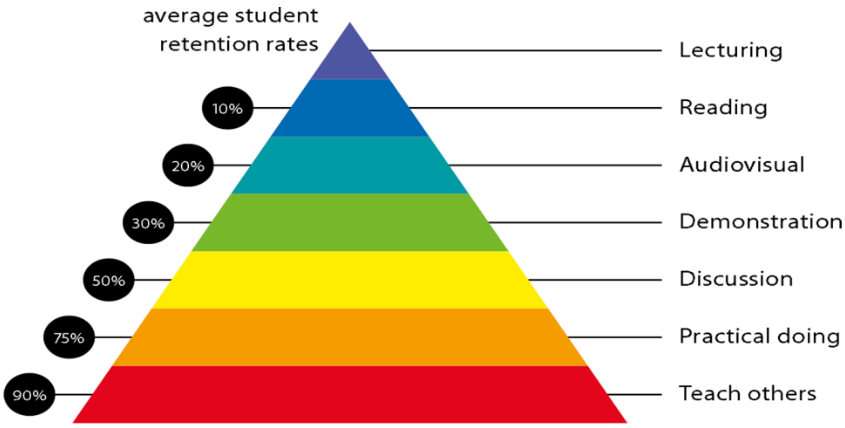


Figure 2: Knowledge retention

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. 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:

(NA)

Lecture/tutorial times

Lecture	Monday	09.00 -10:00 am	Room LH 3
Lecture	Tuesday	09:00 -10:00 am	Room LH 3
Lecture	Thursday	10:00 -11:00 am	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. 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.

Text books

1. A. Ghosh, "Principles of Secondary Processing and Casting of Liquid Steel", South Asia Books, 1st Edition, 1990, ISBN: 9788120405585.
2. F.P.Edneral, "Electrometallurgy of Steel and Ferro-alloys, Vol. I & II", Mir Publishers, 1st Edition, 1979, ISBN: 9780828515184.

Additional Materials

1. NPTEL MOOC Course on "Steel Quality: Role of Secondary Refining & Continuous Casting" (https://onlinecourses.nptel.ac.in/noc17_mm10/preview)
2. 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:

CIE 60 marks :(40 marks mid semester examination + 20 marks internal evaluation)
Breakup of 20 Marks: (05 marks as attendance bonus for all students having attendance > 80%) + (05 marks for presentation)+(10 marks for assignment or case studies)
ESE: 40 Marks of End Semester Examination

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, For remedial and repeater remedial - CIE 60 marks (40 marks remedial mid semester examination + 20 marks for assignments or case studies, limited to minimum 04 assignments per course), and end semester repeater and remedial examination would be carried out centrally according to University Policy

Practical Work Report/Laboratory Report:

Upon completion of each experiment, the student has to complete the journal and get it evaluated within a weeks' time before the next experiment is started.

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	**Thermodynamics of oxides and their reduction:**	1,2	BB, PPT, OL
	Weeks 2	Thermodynamics and kinetics of iron oxide reduction	1,2,4	BB, PPT, OL
	Week 3	. Kinetics of solid- solid and solid-gas reactions.	1,2,4	BB, PPT, OL
	Week 4	**General Problems related to Indian Steel plants**	3	BB, PPT, OL
	Week 5	Problems of Indian Steel Plants. High temperature properties of iron bearing materials	5	BB, PPT, OL
	Week 6	Advances in Charging Mechanisms and Blast Modifications.	1,2	BB, PPT, OL
	Week 7	**Pre-treatment Techniques:** Pre-treatment of hot metal. Physico-chemical aspects of pre-treatment processes. Status of hot metal treatment in India.	5, 6	BB, PPT, OL
	Week 8	**Electric Arc Furnace (EAF) steel making:** Design of EAF-AC, DC electric arc. Latest trends in EAF design and operation.	5, 6	BB, PPT, OL
	Week 9	**Secondary steel making processes:** Alloy steel making in EAF using secondary refining. Continuous casting	5, 6	BB, PPT, OL
	Week 10	**Secondary steel making processes:** Continuous casting	5,6	BB, PPT, OL
	Week 11	**Secondary steel making processes:** ESR	5,6	BB, PPT, OL
	Week 12	Quality Assessment of sound steel making	3	BB, PPT, OL

	Week 13	Concast Technique	5,6	BB, PPT, OL
	Week 14	Role of synthetic slags. Electro-slag refining.	5,6	BB, PPT, OL
	Week 15	Slag-metal reaction in iron and steel making.	6	BB, PPT, OL
	Week 16	Ferro-alloy production. Application of plasma technology.	6	BB, PPT, OL

Program Mapping for Metallurgy 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-I; Physical Metallurgy
4th	Iron Making; Transport Phenomena; Metal Casting and Solidification (OE); Recycled Materials (OE); Heat Treatment Principles and Practices; Soft Skill and Interpersonal Comm.; Personality Credit-1
5th	Foundry Technology; Steel Making; Fuel Furnace and Refractories (EL); Environmental Pollution and its Control in Met. Ind. (EL); Non Ferrous Extractive Metallurgy; Plastic Deformation of Metals; Energy Economy and Waste Management- (OE); Internship-2
6th	Metal Forming; Phase Transformation; Powder Metallurgy (Elective-1); Modelling of Metallurgical Processes (Elective-1); Electrometallurgy and Corrosion; Ind. Ceramics and Polymers (El-2); Nano Technology (OE); Metal Joining Processes; Composite Materials (EL-2); Personality Credit-2
7th	Metal Testing and Characterization; Alloy Design (EL); Advanced Ferrous Metallurgy (EL); Surface (EL); Internship-3; Non Destructive Testing (EL) and (OE); Material Testing and Standards; Selection of Material & Failure analysis (EL) & (OE); Advanced Foundry Technology (EL)
8th	Project

Subject: Advanced Ferrous Metallurgy (EL–5)								
Program: **B. Tech in Metallurgical Engineering**				Subject Code: **MME0705**			Semester: **VII**	
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 impart the overall idea of how Steel is produced the history of Steel making.
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 and post treatment to make steel.

CONTENTS

UNIT-I

[10 hours]

Thermodynamics of oxides and their reduction:
Thermodynamics and kinetics of iron oxide reduction. Kinetics of solid- solid and solid-gas reactions.

UNIT-II

[10 hours]

General Problems related to Indian Steel plants: Problems of Indian Steel Plants. High temperature properties of iron bearing materials.

UNIT-III

[10 hours]

Pre-treatment Techniques:
Pre-treatment of hot metal. Physico-chemical aspects of pre-treatment processes. Status of hot metal treatment in India.
Electric Arc Furnace (EAF) steel making:
Design of EAF-AC, DC electric arc. Latest trends in EAF design and operation.
Induction furnace steel making:
Secondary steel making processes:
Alloy steel making in EAF using secondary refining. Continuous casting.

UNIT-IV

[10 hours]

Roll of synthetic slags. Electro-slag refining. Slag-metal reaction in iron and steel making. Ferro-alloy production. Application of plasma technology.

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. A. Ghosh, “Principles of Secondary Processing and Casting of Liquid Steel”, South Asia Books, 1st Edition, 1990, ISBN: 9788120405585.
2. F.P.Edneral, “Electrometallurgy of Steel and Ferro-alloys, Vol. I & II”, Mir Publishers, 1st Edition, 1979, ISBN: 9780828515184.

Reference Books

1. A. W. Cramb, “Making, Shaping and Treating of Steels”, Association of Iron and Steel Engineers, 11thEdition, 1985, ISBN: 9780930767020.
2. J. G. Peacey and W. G. Davenport, “Blast Furnace: Theory and Practice”, Pergamon Press, Oxford, 1stEdition, 1979, ISBN: 9780080232584.

Web Resources

1. NPTEL MOOC Course on “Steel Quality: Role of Secondary Refining & Continuous Casting” (https://onlinecourses.nptel.ac.in/noc17_mm10/preview)
2. NPTEL Course on “Materials and Heat Balance in Metallurgical Processes” (http://nptel.ac.in/courses/113104060/26)

Name of Institute: Indus Institute of Technology & Engineering
Name of Faculty: Sujoy K. Chaudhury

Course Code: MME0701
Course Name: Material Testing and Characterizations
Pre-requisites: Students must be aware about the basic concept of destructive and non-destructive testing.
Credit points: 04
Offered Semester: VII

Course Coordinator (weeks 01–16)
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 01–16)
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 personally via e-mail with important information relating to this course.

Course Objectives

1. To understand different types of Mechanical testing (i.e. destructive testing and non-destructive testing).
2. To understand different types of standards related to different mechanical testing.
3. To understand standard procedure for mechanical testing.

Course Outcomes (CO)

CO1. To develop the capability to analyze and select the various testing techniques for materials.
CO2. Identify the requirements of testing criteria as per material composition.
CO3. To understand the concept of destructive testing.
CO4. To understand the various Standard Test Methods for Metallic Material
CO5. To understand the working principle of various characterizations techniques
CO6. To analyze data measured using various characterizations techniques.

Course Outline

The aim is to introduce students the overview of the standard testing methods of materials. The course covers non-destructive destructive testing. It gives an idea about selection of the testing criteria.

Method of delivery

Online lectures

Study time

3 Hour Lecture per week

CO-PO Mapping (PO: Program Outcomes)

Mapping CO's with PO's

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

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

Blooms Taxonomy and Knowledge retention (For reference)

(Blooms taxonomy has been given for reference)

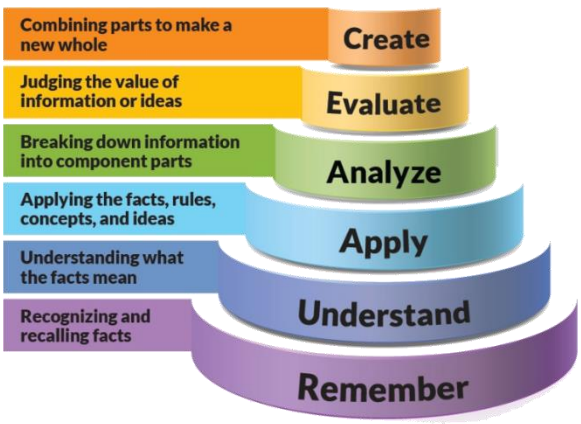


Figure 1: Blooms Taxonomy

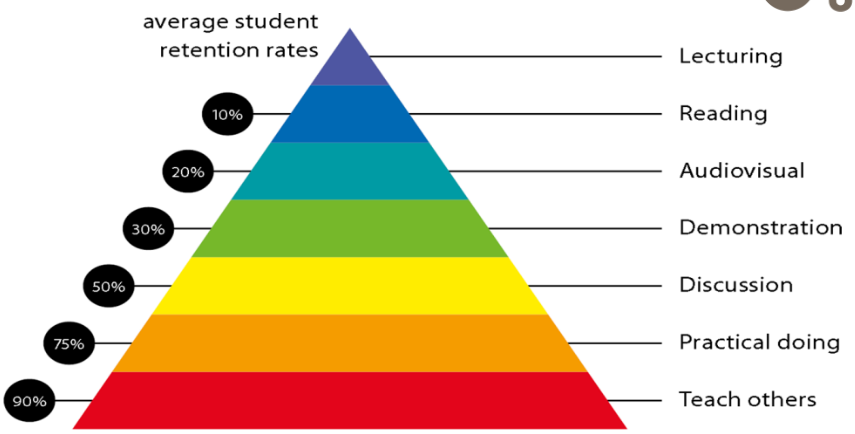


Figure 2: Knowledge retention

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. Find and evaluate information, using a variety of sources and technologies. Acknowledge the work and ideas of others.	**2 Information literacy, gathering & processing**
Problem solvers Take on challenges and opportunities. Apply creative, logical and critical thinking skills to respond effectively. Make and implement decisions. Be flexible, thorough, innovative and aim for high standards.	**4 Problem solving skills**
Effective communicators Articulate ideas and convey them effectively using a range of media. Work collaboratively and engage with people in different settings. Recognize how culture can shape communication.	**5 Written communication** **6 Oral communication** **7 Teamwork**

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

Practical work:
(Mention what practical work this Course involves)

NA

Lecture/tutorial times

Example:		
Monday	12:00 – 01.00 PM	Online
Tuesday	11.00 – 12.00 PM	Online
Wednesday	11.00 – 12.00 PM	Online
Friday	9.00-11.00 AM	Online

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. G. E. Dieter, "Mechanical Metallurgy", McGraw Hill, 3rd Edition, 2013, ISBN: 9781259064791.
2. A. V. K. Suryanarayana, "Testing of Metallic Materials", B. S. Publications, 2nd Edition, 2007, ISBN: 9788178001340.

Additional Materials

Reference Books

1. R. Abbaschian, L. Abbaschian and R. E. Reed-Hill, "Physical Metallurgy Principles", Wadsworth Publishing Co Inc, 4th Edition, 2008, ISBN: 9780495082545.
2. R. W. Hertzberg, R. P. Vinci and J. L. Hertzberg, "Deformation and Fracture Mechanics of Engineering Materials", John Wiley & Sons, 5th Edition, 2012, ISBN: 9780470527801.
3. T. H. Courtney, "Mechanical Behavior of Materials", McGraw-Hill Education, 2nd Edition, 2017, ISBN: 9781259027512.
4. ASM International, "ASM Handbook: Nondestructive Evaluation and Quality Control", ASM International, 9th Edition, 1989, ISBN: 9780871700230.
5. H. E. Davis, G. E. Troxell and C. T. Wiscosil, "Testing and Inspection of Engineering Materials", Mcgraw-Hill Book Company, 2nd Edition, 1954, ASIN: B000I1C8DI.
6. R. A. Beaumont, "Mechanical Testing of Metallic Materials", Sir Isaac Pitman & Sons, 1st Edition, 1945, ASIN: B0010XYLO2.
7. C. W. Richards and E. A. Trabant, "Engineering Materials Science", Literary Licensing, 1st Edition, 2012, ISBN: 9781258243067.

8. W. J. McGonnagle, “Non Destructive Testing”, Routledge, 1st Edition, 1971, ISBN: 9780677005003.

Web Resources

1. NPTEL MOOC Course on “Theory and Practice of Non Destructive Testing” (https://onlinecourses.nptel.ac.in/noc16_mm07/preview)

ASSESSMENT GUIDELINES

Your final course mark will be calculated from the following:

CIE	60 Mark		
		Quiz	10%
		Attendance	5%
		Assignment	5%
		Mid semester examination	40%
End semester exam	40 Mark	As per IU format	

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.

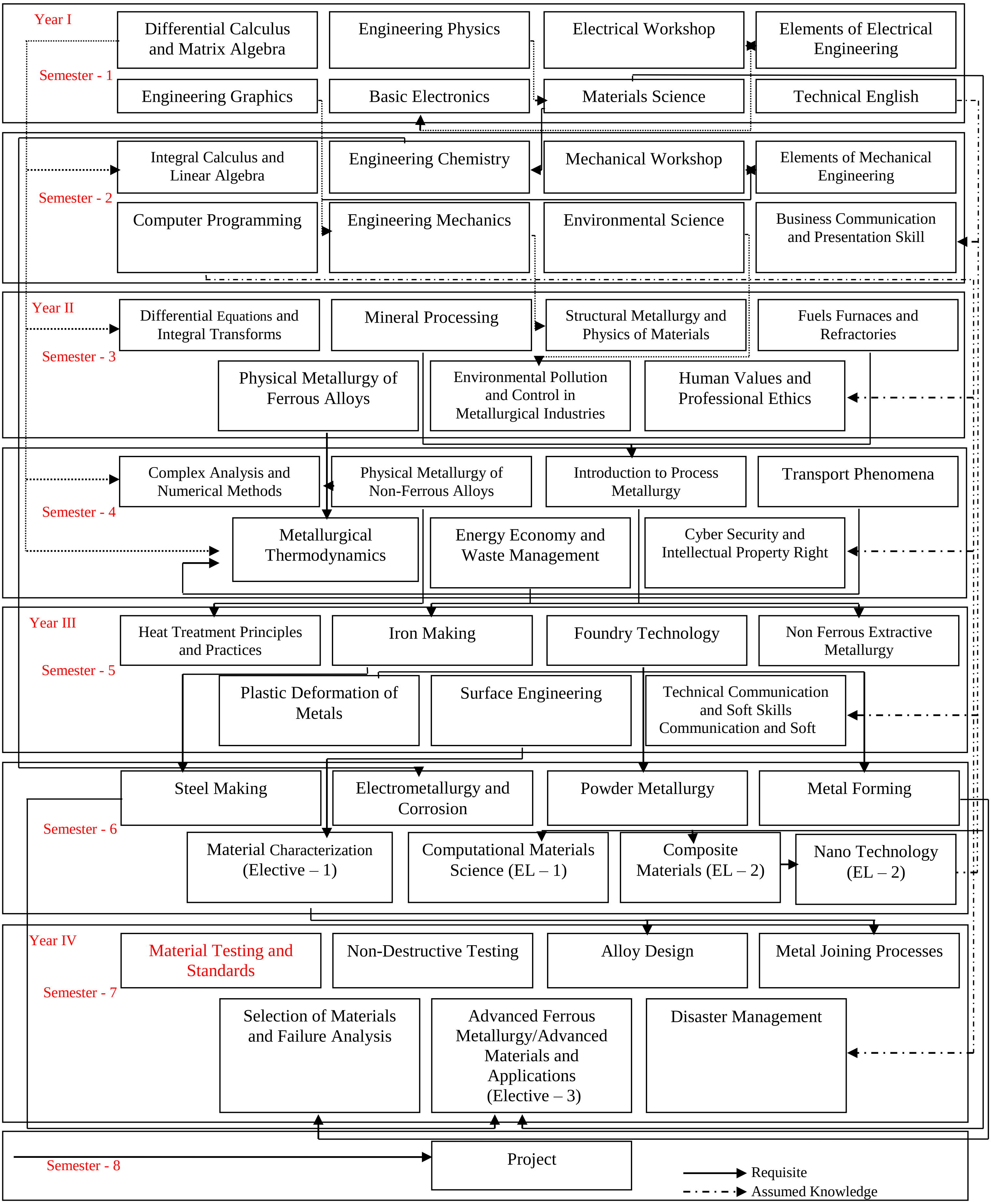
Do not copy the work of other students.
Do not share your work with other students (except where required for a group activity or assessment).

Course schedule

Weeks	Topic & contents	CO Addressed	Teaching Learning Activity (TLA)
Week01	**Introduction**: Importance of Material Testing. Classification of various types of testing methods.	CO1	BB/PPT
Week02	Selection of testing methods. Importance of calibration of testing instruments. Calibration methods and standards for various tests. Problem Solving	CO1	BB/PPT
Week 03	**Tensile test**: Engineering stress –strain curve, true stress –strain curve, Instability in tension, Stress distribution at neck, principle of stress and strain measurement, bend test measurement of ductility and formability, High temperature tensile test	CO1, CO3, CO4,	BB/PPT
Week 04	**Hardness test**: Introduction, Brinell, Vickers and Rockwell hardness tests, Meyer hardness test, Analysis of indentation by an indenter, Relationship between hardness and the flow curve, Micro-hardness tests, Hardness conversion, Hardness at elevated temperature.		BB/PPT
Week 05	Relationship between hardness and the flow curve, Micro-hardness tests, Hardness conversion, Hardness at elevated temperature.	CO1, CO3, CO4	BB/PPT

Week 06	**Torsion test:** Introduction, Mechanical properties in torsion, Torsional stresses for large plastic strains, Types of torsion failures, Torsion test vs. tension test, Hot torsion test.	CO1, CO3, CO4	BB/PPT
Week 07	**Fatigue and Creep Testing:** Elementary treatment of fatigue phenomenon, S – N curve and corrosion fatigue, Fatigue testing principle, Signification of Creep testing procedure, creep curve and its interpretation, stress-rupture test.	CO1, CO3, CO4	BB/PPT
Week 08	Metallurgical and mechanical factors affecting, creep and fatigue failures. Problem Solving	CO1, CO3, CO4	BB/PPT
Week 09	Introduction to various standards for mechanical testing: Standard Test Methods for Metallic Material	CO1, CO3, CO4	BB/PPT
Week 10	Importance of Material characterization, Classification of techniques for characterization. Image formation, resolving power, numerical aperture, empty magnification, depth of focus, components of microscopes, important lens defects and their correction, principles of phase contrast, interference and polarized light microscopy, Image analyzer	CO5, CO6	BB/PPT
Week 11	Thermal Analysis techniques: Basic Principles, Working and applications of DTA, TGA, TMA, and DSC.	CO5, CO6	BB/PPT
Week 12	Studies by electron microscopes: Principle, Construction and Working of TEM,	CO5, CO6	BB/PPT
Week 13	SEM, STEM with their merits, demerit and applications, techniques of replica preparation.	CO5, CO6	BB/PPT
Week 14	X-Ray diffraction and their applications: Working principles of diffractometer. Indexing of XRD patterns, Determination of crystal structure, lattice parameter, and crystallite size by diffraction techniques. Numerical based on XRD.	CO5, CO6	BB/PPT
Week 15	Spectroscopic and Chemical analysis Techniques: IR & Raman spectroscopy, Energy Dispersive Spectroscopy (EDS) & Wavelength Dispersive Spectroscopy (WDS), XRF.	CO5, CO6	BB/PPT
Week 16	Revision	CO1, CO2, CO3, CO4, CO5, CO6	BB/PPT

PROGRAM MAP FOR BACHELOR OF ENGINEERING (MME)



Subject: **Material Testing and Characterization**								
Program: **B. Tech in Metallurgical Engineering**					Subject Code: **MME0701**		Semester: **VII**	
Teaching Scheme (Hours per week)				**Examination Evaluation Scheme (Marks)**				
Lecture	**Tutorial**	**Practical**	**Credits**	**University Theory Examination**	**University Practical Examination**	**Continuous Internal Evaluation (CIE)-Theory**	**Continuous Internal Evaluation (CIE)-Practical**	**Total**
3	0	2	4	16/40	16/40	24/60	24/60	200

Course Objectives

1. To understand different types of Mechanical testing (i.e. destructive testing and non-destructive testing).
2. To understand different types of standards related to different mechanical testing.
3. To understand standard procedure for mechanical testing.
4. To provide knowledge about the basic concepts of behind material characterization.
5. To understand different methods of characterization in order to understand different properties.

CONTENTS

UNIT-I

[10 hours]

Introduction:
Importance of Material Testing. Classification of various types of testing methods – destructive and non-destructive testing. Selection of testing methods. Importance of calibration of testing instruments. Calibration methods and standards for various tests.

Tensile and Hardness test:
Engineering and true stress –strain curve, principle of stress and strain measurement, bend test measurement of ductility and formability, compression test, yield stress and proof stress, universal tensile testing machine and tensometer, Numericals of Tensile test.

Brinell, Vickers and Rockwell hardness tests, Meyer hardness test, Analysis of indentation by an indenter, Relationship between hardness and the flow curve, Micro-hardness tests.

UNIT-II

[10 hours]

Impact and Torsion test:
Types of impact tests and their relative merits and demerits. Ductile-brittle transitions behavior and its significance.

Mechanical properties in torsion, Torsional stresses for large plastic strains, Types of torsion failures, Torsion test vs. tension test, Hot torsion test.

Fatigue and Creep Testing:
Elementary treatment of fatigue phenomenon, S – N curve and corrosion fatigue, fatigue testing principle, Signification of Creep testing procedure, creep curve and its interpretation, stress-rupture test. Metallurgical and mechanical factors affecting, creep and fatigue failures.

UNIT-III

[10 hours]

Importance of Material characterization, Classification of techniques for characterization. Image formation, resolving power, numerical aperture, empty magnification, depth of focus, components of microscopes, important lens defects and their correction, principles of phase contrast, interference and polarized light microscopy, Image analyzer.
Thermal Analysis techniques: Basic Principles, Working and applications of DTA, TGA, TMA and DSC.

UNIT-IV

[10 hours]

Studies by electron microscopes: Principle, Construction and Working of TEM, SEM, STEM with their merits, demerit and applications, techniques of replica preparation.
X-Ray diffraction and their applications: Working principles of diffractometer. Indexing of XRD patterns, determination of crystal structure, lattice parameter, and crystallite size by diffraction techniques. Numerical based on XRD.
Spectroscopic and Chemical analysis Techniques: IR & Raman spectroscopy, Energy Dispersive Spectroscopy (EDS) & Wavelength Dispersive Spectroscopy (WDS), XRF.

Material Testing and Standards Lab (List of Experiments)

Experiment No.	Title
1	To study the Brinell hardness testing machine & perform the Brinell hardness test.
2	To study the Rockwell hardness testing machine & perform the Rockwell hardness test.
3	To study the Vickers hardness testing machine & perform the Vickers hardness test.
4	To determine the impact toughness of a given specimen by Izod test and Charpy test.
5	To determine the tensile strength of specimen.
6	To study room temperature creep strength of specimen.
7	To study room temperature fatigue strength of specimen.
8	To perform compression & bending tests on UTM.
9	Visual Inspection of fractured surfaces.
10	To perform Dye Penetration Test for given sample.
11	To study of Magnetic particle tester.
12	To study Ultrasonic Flaw Detector
13	To study Eddy Current Tester.
14	Detailed study of Radiographic Testing Method.
15	To study In situ Metallographic using replica technique

Course Outcomes

1. To develop the capability to analyze and select the various testing techniques for materials.
2. To understand various standards available to perform specific tests on different materials.

3. To solve different numerical pertaining to optical microscopy and X-ray diffraction.
4. To understand the basic elements of electron microscopy.
5. To understand the basic aspects of optical characterization methods including Raman and infrared spectroscopy.

Text Books

1. G. E. Dieter, "Mechanical Metallurgy", McGraw Hill, 3rd Edition, 2013, ISBN: 9781259064791.
2. A.V.K. Suryanarayana, "Testing of Metallic Materials", B. S.Publications, 2nd Edition, 2007, ISBN: 9788178001340.
3. J. M. Walls, "Methods of Surface Analysis: Techniques & Applications", Cambridge University Press, 1stEdition, 1989, ISBN: 9780521305648.
4. J. P. Sibilia, "A Guide to Materials Characterization and Chemical Analysis", Wiley-Blackwell, 2nd Edition, 1996, ISBN: 9780471186335.
5. P. R. Khangaonkar, "An Introduction to Materials Characterization", Penram International Publishing, 1st Edition, 2010, ISBN: 9788187972808.

Reference Books

1. R. Abbaschian, L. Abbaschian and R.E. Reed-Hill, "Physical Metallurgy Principles", Wadsworth Publishing Co Inc, 4th Edition, 2008, ISBN: 9780495082545.
2. R. W. Hertzberg, R. P. Vinci and J. L. Hertzberg, "Deformation and Fracture Mechanics of Engineering Materials", John Wiley & Sons, 5th Edition, 2012, ISBN: 9780470527801.
3. T. H. Courtney, "Mechanical Behavior of Materials", McGraw-Hill Education, 2nd Edition, 2017,ISBN: 9781259027512.
4. M. Spencer, "Fundamentals of Light Microscopy",Cambridge University Press, 1stEdition, 1982, ISBN: 9780521289672.
5. D. B. Williams and C. B. Carter, "Transmission Electron Microscopy: A Textbook for aterials Science",Springer, 2ndEdition, 2009, ISBN: 9780387765020.
6. C. R. Brundle, C. A. Evans Jr. and S. Wilson, "Encyclopedia of Materials Characterization", Butterworth-Heinemann, Braille Edition, 1992, ISBN: 9780750691680.
7. B. D. Cullity and S. R. Stock, "Elements of X-Ray Diffraction", Pearson, 3rd Edition, 2001, ISBN: 9780201610918.

Web Resources

1. NPTEL MOOC Course on "Theory and Practice of Non Destructive Testing" (https://onlinecourses.nptel.ac.in/noc16_mm07/preview)
2. NPTEL MOOC Course on "Fundamentals of Optical and Scanning Electron Microscopy" (https://swayam.gov.in/course/1399-fundamentals-of-optical-and-scanning-electron-microscopy)
3. NPTEL MOOC Course on "X-ray Crystallography & Diffraction" (https://onlinecourses.nptel.ac.in/noc17_mm11/preview)
4. NPTEL MOOC Course on "Fundamentals of X-ray Diffraction & Transmission Electron Microscopy" (https://onlinecourses.nptel.ac.in/noc16_mm06/preview)
5. NPTEL MOOC Course on "Electron Diffraction and Imaging" (https://onlinecourses.nptel.ac.in/noc17_me30/preview)

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

Course code: MME0708
Course name: Non-Destructive Testing
Pre-requisites: Materials Science
Credit points: 3
Offered Semester: 7

Course Coordinator
Full Name: Mr. Monil Salot
Department with siting location: Ground Floor Met Lab 4
Telephone: +91-9428600336
Email: monilsalot.mt@indusuni.ac.in
Consultation times: 4:15 – 5:00

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

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

1) To understand the principle and application of visual testing methods
2) To understand principle of liquid penetration testing and magnetic particle testing technique.
3) To understand principle of ultrasonic and radiographic testing technique and its applications.

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CO 6: Develop test method and/or standard that would replicate the actual condition. (BT-6)

Course Outline

The proposed course deals with visual, liquid penetrant, magnetic particle, ultrasonic, radiographic, eddy current, acoustic emission testing.

Method of delivery

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

Study time

3 lectures per week

CO-PO Mapping (PO: Program Outcomes)

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

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

Blooms Taxonomy and Knowledge retention

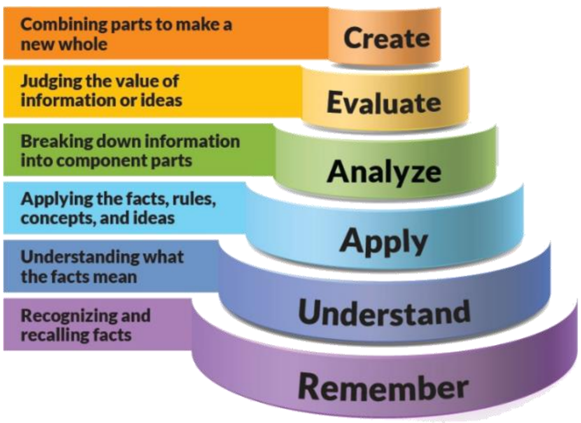

Figure 1: Blooms Taxonomy

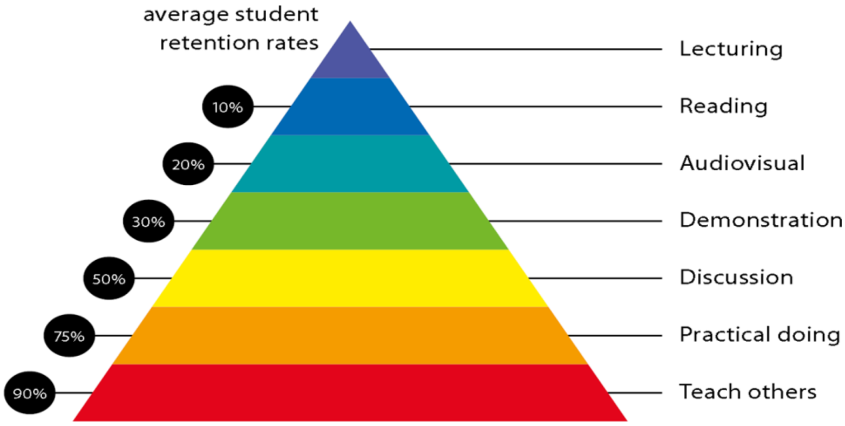

Figure 2: Knowledge retention

Graduate Qualities and Capabilities covered

(Qualities graduates harness crediting this Course)

General Graduate Qualities	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:

NA

Lecture/tutorial times

Lecture	Monday	10:00 – 11:00 AM	Room LH 3
Lecture	Tuesday	10:00 – 11:00 AM	Room LH 3
Lecture	Wednesday	10:00 – 11:00 AM	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

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2) Non-destructive testing, Warren J. McGonnagle, Gordon Breach, Science

Reference Books

1) Ultrasonic Testing of Materials,J.Krautkramer
2) Treaties on Non-destructive testing,by Dr.E.G.Krishnadas Nair, Non-destructive testing, R. Hatmshaw.
3) Ultrasonic Methods of Testing Materials, Leszek Filipezynski, Zdzislaw Pawlowski

Digital Learning Resources

www.nptel.ac.in

ASSESSMENT GUIDELINES

Your final course mark will be calculated from the following:

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

Breakup of 20 Marks: (05 marks as attendance bonus for all students having attendance > 80%) + (05 marks for presentation)+(10 marks for assignment or case studies)

ESE: 40 Marks of End Semester Examination

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. , For remedial and repeater remedial - CIE 60 marks (40 marks remedial mid semester examination + 20 marks for assignments or case studies, limited to minimum 04 assignments per course), and end semester repeater and remedial examination would be carried out centrally according to University Policy

Practical Work Report/Laboratory Report:

NA

Late Work

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

Format

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

Retention of Written Work

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

University and Faculty Policies

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

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

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

Course schedule (subject to change)

Week #	Topic & contents	CO Addressed	Teaching Learning Activity (TLA)
Weeks 1	Fundamentals and introduction to non-destructive testing. Scope and limitationsof NDT	1,2,3	BB, PPT, OL
Weeks 2	Visual examination methods. Different visual examination aids.	1,2,3	BB, PPT, OL
Week 3	Leak and pressure testing of industrial components. Various methods of pressure and leak testing underlying principles of these testing systems.	1,2,3	BB, PPT, OL
Week 4	Dye penetrant Methods, Basic Principles, Capillary Action, Wetting and Non-Wetting	1,2,3	BB, PPT, OL
Week 5	Characteristics, Different Types of Penetrants, Detailed Procedure and Recent Developments in DPT.	1,2,3	BB, PPT, OL
Week 6	Magnetic Particle Testing methods, Basic Principles of MPT, magnetizationmethods demagnetization methods.	1,2,3	BB, PPT, OL
Week 7	MPT equipment & instruments, sensitivity calibration of MPT equipment.	1,2,3	BB, PPT, OL
Week 8	Ultrasonic methods of NDT-Basic principles of wave propagation, types of waves	1,2,3	BB, PPT, OL
Week 9	Transducers and transducer materials, advantages and limitations of UT. Pulse Echo and Through Transmission techniques of UT	1,2,3	BB, PPT, OL
Week 10	Calibration methods, use of standard blocks, Thickness determination by ultrasonic method. Study of A, B and C scan presentations.	1,2,3	BB, PPT, OL
Week 11	Radiographic testing of metallic components. X-ray and Gamma-Ray radiography. Their principles, methods of generation.	1,2,3	BB, PPT, OL
Week 12	Industrial radiography techniques. Types of films, screens and penetrameters. Interpretation of radiographs. Film Processing. Radiography Contrast.	1,2,3	BB, PPT, OL

	Week 13	Eddy current testing: Basic principles and applications such as detection of defects and characterization, sorting of materials, determination of film/coating thickness, measurement of electrical conductivity and magnetic permeability of materials.	1,2,3	BB, PPT, OL
	Week 14	Eddy current testing equipments and its block diagram, different types of test coils and their applications.	1,2,3	BB, PPT, OL
	Week 15	Acoustic Emission Technique. Conductivity & resistivity methods and their applications. Thermal methods of NDT.	1,2,3	BB, PPT, OL
	Week 16	Selection Criteria for various NDT techniques. Revision	1,2,3	BB, PPT, OL

Program Mapping (Metallurgy Engineering Department)

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

Subject: Non Destructive Testing (EL–6)								
Program: **B. Tech in Metallurgical Engineering**					Subject Code: **MME0708**		Semester: **VII**	
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 understand the significance of testing of metallic and non-metallic materials and components without destroying them.
2. To study the application of these methods in assessing reliability of components & plants.
3. To study the life time assessment of components.

CONTENTS

UNIT-I

[10 hours]

Fundamentals and introduction to non-destructive testing. Scope and limitationsof NDT
Visual examination methods. Different visual examination aids.
Leak and pressure testing of industrial components. Various methods of pressure and leak testing underlying principles of these testing systems.

UNIT-II

[10 hours]

Dye penetrant Methods, Basic Principles, Capillary Action, Wetting and Non-Wetting Characteristics, Different Types of Penetrants, Detailed Procedure and Recent Developments in DPT.
Magnetic Particle Testing methods, Basic Principles of MPT, magnetization methods demagnetization methods, MPT equipment & instruments, sensitivity calibration of MPT equipment.
Ultrasonic methods of NDT-Basic principles of wave propagation, types of waves, transducers and transducer materials, advantages and limitations of UT.

UNIT-III

[10 hours]

Pulse Echo and Through Transmission techniques of UT, Calibration methods, use of standard blocks, Thickness determination by ultrasonic method. Study of A, B and C scan presentations.
Radiographic testing of metallic components. X-ray and Gamma-Ray radiography. Their principles, methods of generation. Industrial radiography techniques. Types of films, screens and penetrameters. Interpretation of radiographs. Film Processing. Radiography Contrast.

UNIT-IV

[10 hours]

Eddy current testing: Basic principles and applications such as detection of defects and characterization, sorting of materials, determination of film/coating thickness, measurement of

electrical conductivity and magnetic permeability of materials. Eddy current testing equipment and its block diagram, different types of test coils and their applications.
Acoustic Emission Technique. Conductivity & resistivity methods and their applications. Thermal methods of NDT.
Selection Criteria for various NDT techniques.

Course Outcomes

1. To understand the principle and application of visual testing methods.
2. To understand principle of liquid penetration testing technique.
3. To understand the principle of magnetic particle testing and its applications.

Text Books

1. B. Raj,T. Jayakumar and M. Thavasimuthu, "Practical Non-Destructive Testing",Norosa Publishing House, 3rd Edition, 2014, ISBN: 9788173197970.
2. W. J. McGonnagle, "Non Destructive Testing", Routledge, 1stEdition, 1971, ISBN: 9780677005003.

Reference Books

1. J. Krautkramer, "Ultrasonic Testing of Materials", Allen & Unwin, 2nd Edition, 1969, ISBN: 9780046200015.
2. J. Prasad and C. G. K. Nair, "Non-Destructive Test and Evaluation of Materials",McGraw Hill Education, 2nd Edition, 2011, ISBN: 9781259061615.
3. R. Halmshaw, "Non-Destructive Testing (Metallurgy and Materials Science)", Butterworth-Heinemann, 2nd Edition, 1991, ISBN: 9780340545218.
4. L. Filipczynski, Z. Pawłowski and J. Wehr, "Ultrasonic Methods of Testing Materials", Butterworth, 1st Edition, 1966, ASIN: B00MJ3OOIU.

Web Resources

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

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Course Outline

The proposed course deals with visual, liquid penetrant, magnetic particle, ultrasonic, radiographic, eddy current, acoustic emission testing.

Method of delivery

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

Study time

3 lectures per week

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
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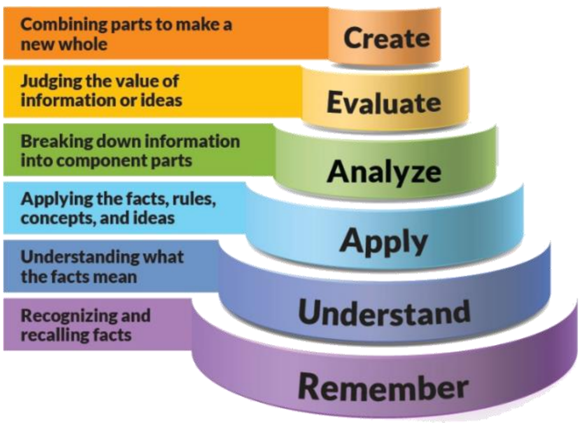

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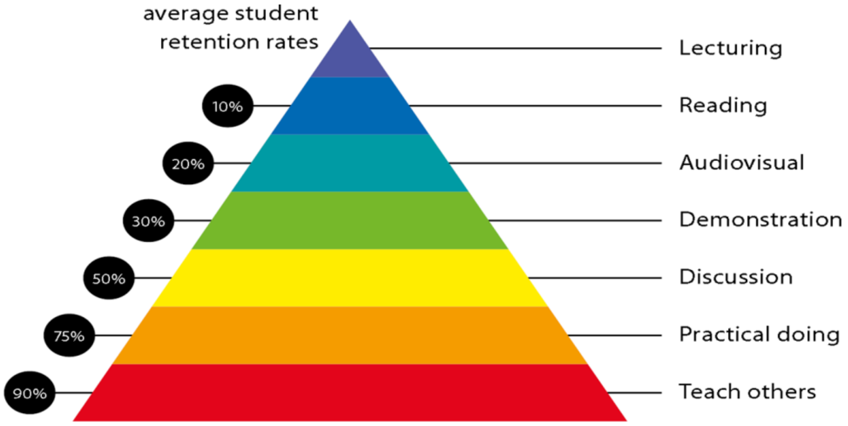

Figure 2: Knowledge retention

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	Week 11	Radiographic testing of metallic components. X-ray and Gamma-Ray radiography. Their principles, methods of generation.	1,2,3	BB, PPT, OL
	Week 12	Industrial radiography techniques. Types of films, screens and penetrameters. Interpretation of radiographs. Film Processing. Radiography Contrast.	1,2,3	BB, PPT, OL

	Week 13	Eddy current testing: Basic principles and applications such as detection of defects and characterization, sorting of materials, determination of film/coating thickness, measurement of electrical conductivity and magnetic permeability of materials.	1,2,3	BB, PPT, OL
	Week 14	Eddy current testing equipments and its block diagram, different types of test coils and their applications.	1,2,3	BB, PPT, OL
	Week 15	Acoustic Emission Technique. Conductivity & resistivity methods and their applications. Thermal methods of NDT.	1,2,3	BB, PPT, OL
	Week 16	Selection Criteria for various NDT techniques. Revision	1,2,3	BB, PPT, OL

Program Mapping (Metallurgy Engineering Department)

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

<table>
<tr><th colspan="9">Subject: Non Destructive Testing (EL–6)</th></tr>
<tr><td colspan="4">Program: B. Tech in Metallurgical Engineering</td><td colspan="3">Subject Code: MME0708</td><td colspan="2">Semester: VII</td></tr>
<tr><td colspan="4">Teaching Scheme (Hours per week)</td><td colspan="4">Examination Evaluation Scheme (Marks)</td><td></td></tr>
<tr><td>Lecture</td><td>Tutorial</td><td>Practical</td><td>Credits</td><td>University Theory Examination</td><td>University Practical Examination</td><td>Continuous Internal Evaluation (CIE)-Theory</td><td>Continuous Internal Evaluation (CIE)-Practical</td><td>Total</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td><td>16/40</td><td>0</td><td>24/60</td><td>0</td><td>100</td></tr>
</table>

Course Objectives

1. To understand the significance of testing of metallic and non-metallic materials and components without destroying them.
2. To study the application of these methods in assessing reliability of components & plants.
3. To study the life time assessment of components.

CONTENTS

UNIT-I

[10 hours]

Fundamentals and introduction to non-destructive testing. Scope and limitationsof NDT
Visual examination methods. Different visual examination aids.
Leak and pressure testing of industrial components. Various methods of pressure and leak testing underlying principles of these testing systems.

UNIT-II

[10 hours]

Dye penetrant Methods, Basic Principles, Capillary Action, Wetting and Non-Wetting Characteristics, Different Types of Penetrants, Detailed Procedure and Recent Developments in DPT.
Magnetic Particle Testing methods, Basic Principles of MPT, magnetization methods demagnetization methods, MPT equipment & instruments, sensitivity calibration of MPT equipment.
Ultrasonic methods of NDT-Basic principles of wave propagation, types of waves, transducers and transducer materials, advantages and limitations of UT.

UNIT-III

[10 hours]

Pulse Echo and Through Transmission techniques of UT, Calibration methods, use of standard blocks, Thickness determination by ultrasonic method. Study of A, B and C scan presentations.
Radiographic testing of metallic components. X-ray and Gamma-Ray radiography. Their principles, methods of generation. Industrial radiography techniques. Types of films, screens and penetrameters. Interpretation of radiographs. Film Processing. Radiography Contrast.

UNIT-IV

[10 hours]

Eddy current testing: Basic principles and applications such as detection of defects and characterization, sorting of materials, determination of film/coating thickness, measurement of

electrical conductivity and magnetic permeability of materials. Eddy current testing equipment and its block diagram, different types of test coils and their applications.
Acoustic Emission Technique. Conductivity & resistivity methods and their applications. Thermal methods of NDT.
Selection Criteria for various NDT techniques.

Course Outcomes

1. To understand the principle and application of visual testing methods.
2. To understand principle of liquid penetration testing technique.
3. To understand the principle of magnetic particle testing and its applications.

Text Books

1. B. Raj,T. Jayakumar and M. Thavasimuthu, "Practical Non-Destructive Testing",Norosa Publishing House, 3rd Edition, 2014, ISBN: 9788173197970.
2. W. J. McGonnagle, "Non Destructive Testing", Routledge, 1stEdition, 1971, ISBN: 9780677005003.

Reference Books

1. J. Krautkramer, "Ultrasonic Testing of Materials", Allen & Unwin, 2nd Edition, 1969, ISBN: 9780046200015.
2. J. Prasad and C. G. K. Nair, "Non-Destructive Test and Evaluation of Materials",McGraw Hill Education, 2nd Edition, 2011, ISBN: 9781259061615.
3. R. Halmshaw, "Non-Destructive Testing (Metallurgy and Materials Science)", Butterworth-Heinemann, 2nd Edition, 1991, ISBN: 9780340545218.
4. L. Filipczynski, Z. Pawłowski and J. Wehr, "Ultrasonic Methods of Testing Materials", Butterworth, 1st Edition, 1966, ASIN: B00MJ3OOIU.

Web Resources

1. NPTEL MOOC Course on "Theory and Practice of Non Destructive Testing"
(https://onlinecourses.nptel.ac.in/noc16_mm07/preview)