# PROGRAMME BOOKLET

## 5-Year Integrated Dual Degree Programme

[B.Tech. (Metallurgical Engineering)
& M.Tech. (Metallurgical Engineering)]

(Applicable to Academic Session 2014-15 and onwards)

**Department Undergraduate Committee (DUGC)**

**DEPARTMENT OF METALLURGICAL ENGINEERING**
**INDIAN INSTITUTE OF TECHNOLOGY**
**(BANARAS HINDU UNIVERSITY)**
**VARANASI-221005**
**INDIA**

**March 2016**

PROGRAMME BOOKLET

# 5-Year Integrated Dual Degree Programme

## [B.Tech. (Metallurgical Engineering) & M.Tech. (Metallurgical Engineering)]

**1.Introduction of Department:** The Department of Metallurgical Engineering at Banaras Hindu University, established in the year 1919, has pioneered metallurgical education and research in this country owing to the noble thoughts and dreams of Mahamana Pandit Madan Mohan Malaviyaji. The undergraduate(UG) programme began soon after in the year 1923 and the first ever undergraduate and doctoral degrees in metallurgy in the country were awarded by this Department in the years 1927 and 1955 respectively. This is one of the first two Departments in the country to confer a postgraduate degree in metallurgy in the year 1959. The foundations of this educational edifice were laid by Professor N.P. Gandhi and nurtured by Professors Daya Swarup and T.R. Anantharaman who were the first three Heads of this Department. Subsequently, fourteen illustrious successive Heads of the Department have continued to do their utmost to enhance the levels of excellence that the Department is known for. The Department celebrated its Golden Jubilee in the year 1973, Diamond Jubilee in 1983 and Platinum Jubilee in the year 1998 in a befitting manner. Currently the Department offers following programmes:

(1) 4-Year B.Tech. programme in Metallurgical Engineering with two streams of Process Metallurgy and Physical Metallurgy, (2) 5-Year Integrated Dual Degree (B.Tech. and M. Tech.) programme in Metallurgical Engineering with two streams of Process Metallurgy and Physical Metallurgy, (3) 2-Year M Tech in Metallurgical Engineering with a specialization of Alloy Technology or Extractive Metallurgy and (4) Ph.D. degree in various specializations of Metallurgical Engineering.

Our graduates excel themselves at the top Universities/research organizations/manufacturing plants and business houses. They are also constantly contributing to the development of the department. The outstanding research contributions of the Department have resulted in its recognition as a Centre of Advanced Study (CAS) in Metallurgy by the UGC in 1980, the first-ever Engineering Department to be so recognized in the country. The Department has a unique distinction of receiving special assistance under CAS for four consecutive phases, under the COSIST programmes of UGC and also has a National Electron Microscopy Facility (NELMIF) from DST since 1982 and FIST level I & II. The Department is also recognized as a Centre for Quality Improvement Programme of MHRD/AICTE from the year 1981. Advanced Research Centre for Iron and Steel under ministry of Steel as well as Malaviya Chair for Railway Technology from Ministry of Railways have been sanctioned in the last couple of years. Members of the staff, research scholars and students have won a very large number of awards and distinctions in recognition of their outstanding contributions. The current research activities span over wide - ranging fields of Microstructural, Structural and Chemical Characterization, Mechanical Behavior, Deformation Processing and Failure Analysis, Phase Equilibria and Phase Transformation, Non-Equilibrium Processing of Advanced Materials, Ultra-Fine Grained and Nano-Structured Material, Metallurgical and E-Waste Utilization, Design and Development of Advanced Steels, Tribology and Surface Engineering, Thermodynamics and Kinetics of Metallurgical Processes, Advanced Structural and Functional Materials etc.

**2. Programme Objectives:** The objectives of 5-Year Integrated Dual Degree [B.Tech. & M.Tech.] programme in Metallurgical Engineering are that the students will learn the concepts and develop skills related to Metallurgical Engineering and have a broad based fundamental knowledge of both science and engineering with analytical and innovative skills. The students will also acquire a wide base of humanities and build their character. The objectives are not only to develop motivation among students for study, knowledge and skills development but also to inculcate stream based research in the area of Process Metallurgy and Physical Metallurgy, innovation aptitude, enhancing creativity with sensitivity towards nature and society. Department of Metallurgical Engineering takes a challenge to meet the above requirements in its curriculum of 5-Year Integrated Dual Degree [B.Tech. & M.Tech.] programme.

## 3. Overview of Curriculum (Including overall Programme, Disciplines, Streams, Research Areas):

The new academic curriculum is effective since academic session 2014-15.. The programme components include courses related to Humanities and Social Science, Science, Engineering Courses from other branches, Engineering Practice Courses, Language and Management, Department Core courses, Exploratory projects, Department Electives, Open Electives from other branches, Projects, Dissertation/Masters Thesis, Industrial training/internship, Practicals, Gymkhana Courses, Creative Practice etc. The department offers the stream based education in the curriculum of 5-Year Integrated Dual Degree [B.Tech. (Metallurgical Engineering) & M.Tech. (Metallurgical Engineering)] Programme. Apart from core Metallurgical Engineering subjects, the department offers stream electives courses for the following two streams:

Non-Stream-0
Stream-1: Process Metallurgy
Stream 2: Physical Metallurgy

## 2. Semesterwise Course Structure for 5-Year Integrated Dual Degree [B.Tech. (Metallurgical Engineering) & M.Tech. (Metallurgical Engineering)]

**For students admitted in Session 2014-15 onwards**

All DC courses (except practicals) are available for options by students of other Departments/Schools subject to (i) a maximum of total 18 students (from all Departments/Schools put together) and (ii) Course Convener, Convener, DUGC and Head/Coordinator of the school are convinced about the eligibility.

### (a) Course Structure for IDD First Semester Programs

| UG-CRC | Course Code | Course Name | L–T–P | | | Credits | Page No |
|---|---|---|---|---|---|---|---|
| IS.PHY101.14 | PHY101 | Physics – I: Classical, Quantum & Relativistic Mechanics | 3 | 1 | 2 | 13 | 12 |
| IS.CY101.14 | CY101 | Chemistry – I | 2 | 1 | 2 | 10 | 13 |
| IS.MA101.14 | MA101 | Engineering Mathematics – I | 3 | 1 | 0 | 11 | 14 |
| IE.ME103.14 | ME103 | Engineering Thermodynamics | 3 | 1 | 0 | 11 | 15 |
| EP.ME105.14 | ME105 | Manufacturing Practices– I | 0 | 0 | 3 | 3 | 17 |
| EP.ME104.14 | ME104 | Engineering Drawing | 1 | 0 | 3 | 6 | 18 |
| IH.H101.14 | H101 | Universal Human Values – I: Self and Family | 1 | 1 | 0 | 5 | 19 |
| | | **Total** | **13** | **5** | **10** | **59** | |
| LM.HL101.14 | HL101 | Basic English* | 2 | 0 | 1 | 7 | 22 |
| | | **Total** | **15** | **5** | **11** | **66** | |
| GY.PE101.14 | PE101 | Elementary Physical Education | 0 | 1 | 3 | 5 | 23 |

### (b) Course Structure for IDD Second Semester Programs

| UG-CRC | Course Code | Course Name | L–T–P | | | Credits | Page No |
|---|---|---|---|---|---|---|---|
| IS.MA102.14 | MA102 | Engineering Mathematics – II | 3 | 1 | 0 | 11 | 24 |
| IE.CSO101.14 | CSO101 | Computer Programming | 3 | 1 | 2 | 13 | 25 |
| DC.MT101.14 | MT101 | Introduction to Metallurgy and Materials Engineering | 2 | 0 | 0 | 6 | 26 |
| DC.MT102.14 | MT102 | Metallurgical Thermodynamics and Kinetics | 3 | 1 | 0 | 11 | 27 |
| EP.ME106.14 | ME106 | Manufacturing Practices – II | 0 | 0 | 3 | 3 | 29 |
| EP.MT103.15 | MT103 | Metallurgical Practices – I | 0 | 0 | 3 | 3 | 29 |
| IH.H103.14 | H103 | Development of Societies | 2 | 1 | 0 | 8 | 30 |
| IH.H104.14 | H104 | History and Civilization | | | | | 31 |
| IH.H105.14 | H105 | Philosophy | | | | | 33 |
| IH.H106.14 | H106 | Education and Self | | | | | 34 |
| | | **Total** | **3** | **4** | **8** | **55** | |
| GY.PE101.14 | PE101 | Elementary Physical Education# | 0 | 1 | 3 | 5 | 23 |
| GY.CPXXX.14 | CPXXX | Creative Practice # | | | | | |

## (c) Course Structure for IDD Third Semester Programs

| UG-CRC | Course Code | Course Name | L–T–P | | | Credits | Page No |
|---|---|---|---|---|---|---|---|
| IS.MA201.14 | MA201 | Numerical Techniques | 3 | 1 | 0 | 11 | 35 |
| IE.EO102.14 | EO102 | Fundamentals of Electronics and Instrumentation Engineering | 3 | 1 | 2 | 13 | 36 |
| DC.MT201.14 | MT201 | Structure of Materials | 3 | 1 | 0 | 11 | 38 |
| DC.MT202.15 | MT202 | Principles of Extractive Metallurgy | 3 | 0 | 0 | 9 | 39 |
| DC.MT203.15 | MT203 | Extractive Metallurgy Practical | 0 | 0 | 3 | 3 | 40 |
| IH.H103.14 | H103 | Development of Societies | 2 | 1 | 0 | 8 | 30 |
| IH.H104.14 | H104 | History and Civilization | | | | | 31 |
| IH.H105.14 | H105 | Philosophy | | | | | 33 |
| IH.H106.14 | H106 | Education and Self | | | | | 34 |
| DP.MT291.15 | MT291 | Exploratory Project | 0 | 0 | 5 | 5 | |
| | | **Total** | **14** | **4** | **13** | **60** | |
| GY.CPXXX.14 | CPXXX | Creative Practice # | 0 | 1 | 3 | 5 | |

*,#The students who pass the Diagnostic Test in English shall take PE101 Elementary Physical Education in the First Semester. All others shall take HL101 Basic English. Those who pass PE101 Elementary Physical Education shall take CPXXX Creative Practice.

## (d) Course Structure for IDD Fourth Semester Programs

| UG-CRC | Course Code | Stream | Course Name | L–T–P | | | Credits | Page No |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| IS. MA203.14 | MA203 | | Mathematical Methods | 3 | 1 | 0 | 11 | 41 |
| IE.MO102.14 | MO102 | | Transport Phenomena | 3 | 1 | 0 | 11 | 42 |
| DC.MT204.15 | MT204 | | Phase Diagrams | 3 | 0 | 0 | 9 | 44 |
| DC.MT205.15 | MT205 | | Transport Phenomena Practical | 0 | 0 | 3 | 3 | 45 |
| DC.MT211.15 | MT211 | 1 | Iron Making Technologies | 3 | 0 | 0 | 9 | 46 |
| DC.MT221.15 | MT221 | 2 | Metallography Techniques | 3 | 0 | 0 | 9 | 48 |
| DC.MT222.15 | MT222 | 2 | Metallography Techniques Practical | 0 | 0 | 3 | 3 | 49 |
| IH.H201.14 | H201 | | Universal Human Values – II: Self, Society and Nature | 1 | 1 | 0 | 5 | 51 |
| | | | **Total** | **16** | **3** | **6** | **60** | |
| DP.MT291.15 | MT291 | | Exploratory Project **(only for 2014 Batch)** | 0 | 0 | 5 | 5 | |
| GY. | | | Hobbies and Club | 0 | 1 | 3 | 5 | |

## (e) Course Structure for IDD Fifth Semester Programs

| UG-CRC | Course Code | Stream | Course Name | L–T–P | | | Credits | Page No |
|---|---|---|---|---|---|---|---|---|
| DC.MT301.15 | MT301 | | Modelling and Simulation in Metallurgy | 2 | 0 | 0 | 6 | 52 |
| DC.MT302.15 | MT302 | | Modelling and Simulation in MetallurgyPractical | 0 | 0 | 3 | 3 | 54 |

| UG-CRC | Course Code | Stream | Course Name | L–T–P | | | Credits | Page No |
|---|---|---|---|---|---|---|---|---|
| DC.MT303.15 | MT303 | | Deformation and Testing of Materials | 3 | 0 | 0 | 9 | 55 |
| DC.MT304.15 | MT304 | | Materials Testing Practical | 0 | 0 | 3 | 3 | 57 |
| DC.MT321.15 | MT321 | 2 | Phase Transformations (for nonstream and stream 2) | 3 | 0 | 0 | 9 | 58 |
| DC.MT411.15 | MT 411 | 1 | Material Processing Technologies (for Stream I, from VII Sem) | | | | | 75 |
| EP.MT413.15 | MT413 | 1 | Metallurgical Practices II: Materials Processing (for stream I, from VII Sem) | 0 | 0 | 2 | 2 | 77 |
| | | | **Department Elective I** | | | | | |
| DE.MT305.15 | MT305 | | Energy and Environment in Metallurgical Industries | 3 | 0 | 0 | 9 | 59 |
| DE.MT311.15 | MT311 | 1 | Fuels & Refractories* | | | | | 61 |
| DE.MT322.15 | MT322 | 2 | Instrumental Analysis * | | | | | 62 |
| OE. | | | **OPEN ELECTIVE – I(preferential)** | 3 | 0 | 0 | 9 | |
| HU/LM | | | **HU/LM-I** | 3 | 0 | 0 | 9 | |
| | | | **Total** | **17** | **0** | **6/8** | **57/59** | |
| DP.MT391.15 | MT391 | | Stream Project (Hons.) | 0 | 0 | 10 | 10 | |
| OE.MT306.15 | MT306 | | Nuclear Metallurgy*** | 3 | 0 | 0 | 9 | 63 |

***Department students are eligible to opt all OE courses as one of the Department Elective

## (f) Course Structure for IDD Sixth Semester Programs

| UG-CRC | Course Code | Stream | Course Name | L–T–P | | | Credits | Page No |
|---|---|---|---|---|---|---|---|---|
| DC.MT.307.15 | MT307 | | Heat Treatment | 2 | 0 | 0 | 6 | 65 |
| DC.MT.308.15 | MT308 | | Heat Treatment Practical | 0 | 0 | 3 | 3 | 66 |
| DC.MT414.15 | MT414 | 1 | Steel Making Technologies (for stream 1, from VIII Sem) | 3 | 0 | 0 | 9 | 86 |
| DC. MT323.15 | MT323 | 2 | Mechanical Behaviour of Materials (for non stream and stream 2) | | | | | 67 |
| EP.MT415.15 | MT415 | 1 | Metallurgical Practices-III: Ferrous Metallurgy (for stream 1, from VIII sem) | 0 | 0 | 3 | 3 | 87 |
| | | | **Department Elective II** | | | | | |
| DE.MT309.15 | MT309 | | Advanced Processing Technologies | 3 | 0 | 0 | 9 | 69 |
| DE.MT312.15 | MT312 | 1 | Alternative Routes of Iron and Steel Making* | | | | | 70 |
| DE.MT324.15 | MT324 | 2 | Electronic and Magnetic Materials* | | | | | 71 |
| OE. | | | **OPEN ELECTIVE - II** | 3 | 0 | 0 | 9 | |
| HU/LM | | | **HU/LM-II** | 3 | 0 | 0 | 9 | |
| DP.MT392.15 | MT392 | | UG Project or Stream Project | 0 | 0 | 10 | 10 | |
| | | | | | | | | |
| | | | **Total** | **14** | **0** | **13/16** | **55/58** | |
| OE.MT361.15 | MT361** | | Composite Materials*** | **3** | **0** | **0** | **9** | **73** |

** middle number 6 has been selected to adjust serial number of the course

## (g) Course Structure for UGD/IDD Summer Term Programs

| UG-CRC | Course Code | Course Name | L–T–P | | | Credits |
|---|---|---|---|---|---|---|
| DP.MT393.15 | MT393 | **Industrial Training/Project/Internship** | 0 | 0 | 5 | 5 |
| | | **Total** | **0** | **0** | **5** | **5** |

## (h) Course Structure for IDD Seventh Semester Programs

| UG-CRC | Course Code | Stream | Course Name | L–T–P | | | Credits | Page No |
|---|---|---|---|---|---|---|---|---|
| DC.MT.401.15 | MT401 | | Non-Ferrous Extractive Metallurgy | 2 | 0 | 0 | 6 | 74 |
| DC.MT.411.15 | MT411 | 1 | Materials Processing Technologies( for non stream and stream 2) | 3 | 0 | 0 | 9 | 75 |
| DC.MT321.15 | MT321 | 2 | Phase Transformations (for Stream 1 from V Sem) | | | | | 58 |
| EP.MT.412.15 | MT412 | 1 | Metallurgical Practices-II: Materials Processing ( for non-stream and stream 2) | 0 | 0 | 2 | 2 | 77 |
| | | | **Department Elective III** | | | | | |
| DE.MT501.15 | MT501 | | Wear, Friction and Lubrication | 3 | 0 | 0 | 9 | 78 |
| DE.MT511.15 | MT511 | 1 | Plasma Technologies for Metallurgical Applications* | | | | | 79 |
| DE.MT521.15 | MT521 | 2 | Solidification Processing * | | | | | 81 |
| OE. | | | **OPEN ELECTIVE III** | | | | | |
| HU/LM | | | HU/LM-III | 3 | 0 | 0 | 9 | |
| DP.MT491.15 | MT491 | | UG Project or Stream Project | 0 | 0 | 10 | 10 | |
| | | | **Total** | **14** | **0** | **12/14** | **52/54** | |
| OE.MT408.15 | MT408 | | Nanostructured Materials *** | **3** | **0** | **0** | **9** | **82** |

## (i) Course Structure for IDD Eighth Semester Programs

Non-stream students can select any course from stream from eight semester onwards

| UG-CRC | Course Code | | Course Name | L–T–P | | | Credits | Page No |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| DC.MT404.15 | MT404 | | Corrosion and Prevention | 2 | 0 | 0 | 6 | 83 |
| DC.MT405.15 | MT405 | | Electrometallurgy and Corrosion Practical | 0 | 0 | 3 | 3 | 84 |
| DC.MT414.15 | MT414 | 1 | Steel Making Technologies (for non stream and stream 2) | 3 | 0 | 0 | 9 | 86 |
| DC. MT323.15 | MT323 | 2 | Mechanical Behaviour of Materials (for Stream 1 from VI sem) | | | | | 67 |
| EP.MT415.15 | MT415 | 1 | Metallurgical Practices-III: Ferrous Metallurgy (for non stream and stream 2) | 0 | 0 | 3 | 3 | 87 |
| | | | **Department Elective IV** | | | | | |
| DE.MT502.15 | MT502 | | Heat Treatment of Advanced Ferrous Alloys | 3 | 0 | 0 | 9 | 88 |
| DE.MT512.15 | MT512 | 1 | Alloy Steel Production Technology* | | | | | 90 |
| DE.MT522.15 | MT522 | 2 | Intermetallics* | | | | | 92 |
| OE. | | | **OPEN ELECTIVE IV** | 3 | 0 | 0 | 9 | |
| DT.MT493.15 | MT493 | | Master Thesis | 0 | 0 | 10 | 10 | |
| HU/LM | | | HU/LM IV | 3 | 1 | 0 | 9 | |
| | | | **Total** | **14** | **1** | **13/16** | **55/58** | |
| DP.MT492.15 | MT492 | | Stream Project (Hons.) | 0 | 0 | 10 | 10 | |
| OE.MT407.15 | MT407 | | Automotive and Aerospace Materials*** | 3 | 0 | 0 | 9 | 93 |

## (j) Course Structure for IDD Ninth Semester Programs

| UG-CRC | Course Code | Stream | Course Name | L–T–P | | | Credits | Page No |
|---|---|---|---|---|---|---|---|---|
| | | | **Department Elective V** | | | | | |
| DE.MT513.15 | MT513 | 1 | Near-Net Shape Processing of Materials* | 3 | 0 | 0 | 9 | 94 |
| DE.MT523.15 | MT523 | 2 | Advanced X-ray and Electron Metallography * | | | | | 96 |
| | | | **Department Elective VI** | | | | | |
| DE.MT514.15 | MT514 | 1 | Surface Engineering | 3 | 0 | 0 | 9 | 98 |
| DE.MT524.15 | MT524 | 2 | Failure Analysis* | | | | | 99 |
| OE. | | | **OPEN ELECTIVE V** | 3 | 0 | 0 | 9 | |
| HU/LM | | | HU/LM-V | 3 | 0 | 0 | 9 | |
| DT.MT591.15 | MT591 | | Master Thesis | 0 | 0 | 20 | 20 | |
| | | | | | | | | |
| | | | **Total** | **14** | **0** | **20** | **56** | |
| OE.MT503.15 | MT503 | | Advanced Materials*** | **3** | **0** | **0** | **9** | **100** |

## (k) Course Structure for IDD Tenth Semester Programs

| UG-CRC | Course Code | Course Code | Course Name | L–T–P | | | Credits | Page No |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| DT.MT592.15 | MT592 | | Master Thesis | 0 | 0 | 50 | 50 | |
| | | | **Total** | **0** | **0** | **50** | **50** | |

## 5. Summary sheet of programme components as attached

Credit Allocation for I SEM to VIII Sem for B Tech (Metallurgical Engineering) and Integrated Dual Degree [B. Tech (Metallurgical Engineering) & M. Tech. (Metallurgical Engineering)] for Students 2015-16- onwards

| S.NO. | Cat. | Programme Components | | | 5-year Programme | |
|---|---|---|---|---|---|---|
| | | | | | %(Min-Max Credits | Number of Courses (9-13 Credits) |
| 1 | HU | Humanities and Social Science | | | 8 (41-46) | 4-5 |
| **Dept allotted** | | | | | **26+** | **4** |
| 2 | IS | Science | | | 12 (62-70) | 6-7 |
| **Dept allotted** | | | | | **67** | **6** |
| 3 | IE | Institute Requirement Engineering/ Pharmacy | | | 8 (41-46) | 4-5 |
| **Dept allotted** | | | | | **(48)** | **4** |
| 4 | EP | Engineering Drawing(Manual and Computer Aided), Manufacturing Practices and Practice course of Department/School* | | | 4 (20-24) | 2 |
| **Dept allotted** | | | | | **(20)** | **6** |
| 5 | LM | Language and Management | | | 5 (27-31) | 2-3 |
| **Dept allotted** | | | | | **(45+** | **5** |
| 6 | DC/MC | Department/Programme Core (Includes Stream Courses) | | | 22-25 (105-155) | 10-13 |
| **Dept allotted** | | | | | **(154)** | **23** |
| 7 | DE/BE | Department/Programme Elective (Includes Stream Courses) | | | 10-12 (60-80) | 6-8 |
| **Dept allotted** | | | | | **(54)** | **6** |

| | | | | | | |
|---|---|---|---|---|---|---|
| 8 | OE | Open Elective (Interdisciplinary Stream Courses from Science/Engineering/Pharmacy) (Room for Minor with some additional credits) | | | 10-15 (55-90) | 5-8 |
| **Dept allotted** | | | | | **(45)** | **5** |
| 9 | DP | Project/Industrial Visit/Training | | | 5-10 (20-50) | 5-10 Units |
| **Dept allotted** | | | | | **(30)** | **4** |
| 10 | DT | Dissertation | | | 13-15 (70-80) | 14-16 Units |
| **Dept allotted** | | | | | **(80)** | **3** |
| **Dept allotted** | | | | | | |
| | | Total (Regular) | | | (540-570) | |
| Dept allotted | | Total (Regular) | | | 569 | 66 |
| | | Total (Hons) | | | (560-590) | |
| Dept allotted | | Total (Hons) | | | 589 | 68 |

+Humanities, Social science, language and management courses put together satisfy Humanities course requirement
Department/Programme Core (**DC**) Courses also include Multi-Departmental Core Courses (**MC**)
Department/Programme Elective (**DE**) Courses also include Bouquet Elective (**BE**) Courses.

## 6. List of Department Electives

| UG-CRC | Course Code | | Course Name | L–T–P | | | Credits | Psge No |
|---|---|---|---|---|---|---|---|---|
| | | | **Department Elective I (Sem V)** | | | | | |
| DE.MT305.15 | MT305 | | Energy and Environment in Metallurgical Industries | 3 | 0 | 0 | 9 | 59 |
| DE.MT311.15 | MT311 | 1 | Fuels & Refractories* | | | | | 61 |
| DE.MT322.15 | MT322 | 2 | Instrumental Analysis* | | | | | 62 |
| | | | **Department Elective II (Sem VI)** | | | | | |
| DE.MT309.15 | MT309 | | Advanced Processing Technologies | 3 | 0 | 0 | 9 | 69 |
| DE.MT312.15 | MT312 | 1 | Alternative Routes of Iron and Steel Making | | | | | 70 |
| DE.MT324.15 | MT324 | 2 | Electronic and Magnetic Materials(for non stream and stream 2)* | | | | | 71 |
| | | | **Department Elective III (Sem VII)** | | | | | |
| DE.MT501.15 | MT501 | | Wear, Friction and Lubrication | 3 | 0 | 0 | 9 | 78 |
| DE.MT511.15 | MT511 | 1 | Plasma Technologies for Metallurgical Applications* | | | | | 79 |
| DE.MT521.15 | MT521 | 2 | Solidification Processing * | | | | | 81 |
| | | | **Department Elective IV (Sem VIII)** | | | | | |
| DE.MT502.15 | MT502 | | Heat Treatment of Advanced Ferrous Alloys | 3 | 0 | 0 | 9 | 88 |
| DE.MT512.15 | MT512 | 1 | Alloy Steel Production Technology* | | | | | 90 |
| DE.MT522.15 | MT522 | 2 | Intermetallics* | | | | | 92 |
| | | | **Department Elective V (Sem IX)** | | | | | |
| DE.MT513.15 | MT513 | 1 | Near-Net Shape Processing of Materials* | 3 | 0 | 0 | 9 | 94 |
| DE.MT523.15 | MT523 | 2 | Advanced X-ray and Electron Metallography * | | | | | 96 |
| | | | **Department Elective VI (Sem IX)** | | | | | |
| DE.MT514.15 | MT514 | 1 | Surface Engineering* | 3 | 0 | 0 | 9 | 98 |
| DE.MT524.15 | MT524 | 2 | Failure Analysis* | | | | | 99 |

## 7. List of Streams

| Streams in Metallurgical Engineering | | | | | | |
|---|---|---|---|---|---|---|
| **Stream** | **Stream Code** | **Stream Title** | | | | |
| PM | X1X | Process Metallurgy | | | | |
| PhM | X2X | Physical Metallurgy | | | | |

## 8. List of Stream Core

| UG-CRC | Course Code | Stream | Course Name | L–T–P | | | Credits | Page No |
|---|---|---|---|---|---|---|---|---|
| | | | Stream-I | 3 | 0 | 0 | 9 | |
| DC.MT211.15 | MT211 | 1 | Iron Making Technologies (Sem IV) | 3 | 0 | 0 | 9 | 46 |
| DC.MT411.15 | MT 411 | 1 | Material Processing Technologies (Sem VII) | 3 | 0 | 0 | 9 | 75 |
| DC.MT412.15 | MT412 | 1 | Metallurgical Practices II: Materials Processing (Sem VII) | 0 | 0 | 2 | 2 | 77 |
| DC.MT414.15 | MT414 | 1 | Steel Making Technologies (Sem VIII) | 3 | 0 | 0 | 9 | 86 |
| EP.MT415.15 | MT415 | 1 | Metallurgical Practices-III: Ferrous Metallurgy (Sem VIII) | 0 | 0 | 3 | 3 | 87 |
| | | | Stream 2 | | | | | |
| DC.MT221.15 | MT221 | 2 | Metallography Techniques (Sem IV) | 3 | 0 | 0 | 9 | 48 |
| DC.MT222.15 | MT222 | 2 | Metallography Techniques Practical (Sem IV) | 0 | 0 | 3 | 3 | 49 |
| DC.MT321.15 | MT321 | 2 | Phase Transformations (Sem V) | 3 | 0 | 0 | 9 | 58 |
| DC. MT323.15 | MT323 | 2 | Mechanical Behaviour of Materials (Sem VI) | 3 | 0 | 0 | 9 | 67 |

*Student can select any Elective course offered by a Department/School of the Institute and which is duly recommended by the Supervisor/Mentor of the student concerned.

## 9. List of Stream Electives

| UG-CRC | Course Code | Stream | Course Name | L–T–P | | | Credits | Page No |
|---|---|---|---|---|---|---|---|---|
| | | | Stream-I | 3 | 0 | 0 | 9 | |
| DE.MT311.15 | MT311 | 1 | Fuels & Refractories * (Sem V) | 3 | 0 | 0 | 9 | 61 |
| DE.MT312.15 | MT312 | 1 | Alternative Routes of Iron and Steel Making (Sem VI) | 3 | 0 | 0 | 9 | 70 |
| DE.MT511.15 | MT511 | 1 | Plasma Technologies for Metallurgical Applications* | | | | | 79 |
| DE.MT512.15 | MT512 | 1 | Alloy Steel Production Technology* | | | | | 90 |
| DE.MT513.15 | MT513 | 1 | Near-Net Shape Processing of Materials* (Sem IX) | 3 | 0 | 0 | 9 | 94 |
| DE.MT514.15 | MT514 | 1 | Surface Engineering* (Sem IX) | 3 | 0 | 0 | 9 | 98 |
| | | | | | | | | |
| | | | Stream 2 | | | | | |
| DE.MT322.15 | MT322 | 2 | Instrumental Analysis* (Sem V) | 3 | 0 | 0 | 9 | 62 |

| UG-CRC | Course Code | Stream | Course Name | L–T–P | | | Credits | Page No |
|---|---|---|---|---|---|---|---|---|
| DE.MT324.15 | MT324 | 2 | Electronic and Magnetic Materials* (Sem VI) | 3 | 0 | 0 | 9 | 71 |
| DE.MT521.15 | MT521 | 2 | Solidification Processing * (Sem VII) | 3 | 0 | 0 | 9 | 81 |
| DE.MT522.15 | MT522 | 2 | Intermetallics* | 3 | 0 | 0 | 9 | 92 |
| DE.MT523.15 | MT523 | 2 | Advanced X-ray and Electron Metallography * (Sem IX) | 3 | 0 | 0 | 9 | 96 |
| DE.MT524.15 | MT524 | 2 | Failure Analysis* (IX) | 3 | 0 | 0 | 9 | 99 |

*Student can select any Elective course offered by a Department/School of the Institute and which is duly recommended by the Supervisor/Mentor of the student concerned.

## 10. List of open electives (to be offered for other departments):

Department students are eligible to take any OE course offered by Department as Department Elective

| UG-CRC | Course Code | | Course Name | L–T–P | | | Credits | Page No |
|---|---|---|---|---|---|---|---|---|
| OE.MT306.15 | MT306 | | Nuclear Metallurgy (Sem V) | 3 | 0 | 0 | 9 | 63 |
| OE.MT361.15 | MT361** | | Composite Materials (Sem VI) | 3 | 0 | 0 | 9 | 73 |
| OE.MT408.15 | MT408 | | Nanostructured Materials (Sem VII) | 3 | 0 | 0 | 9 | 82 |
| OE.MT407.15 | MT407 | | Automotive and Aerospace Materials (Sem VIII) | 3 | 0 | 0 | 9 | 93 |
| OE.MT503.15 | MT503 | | Advanced Materials (Sem IX) | 3 | 0 | 0 | 9 | 100 |

## IS.PHY 101.14 Physics-I (Classical, Quantum & Relativistic Mechanics)

**1. GENERAL**

1.1 TITLE: **Physics-I (Classical, Quantum & Relativistic Mechanics)**
1.2 COURSE NUMBER:IS.**PHY 101**.14
1.3 CREDITS: 3-1-2 - Credit 13
1.4 SEMESTER -OFFERED: Both
1.5 Prerequisite: None
1.6 Syllabus Committee Member: Dr. P. C. Pandey (Convener), Prof. O. N. Singh, Dr. S. Chatterjee, Dr. (Mrs.) S. Upadhyay

**2. OBJECTIVE**

This course is prepared to understand the basic principles and laws of fundamental Physics for macroscopic, microscopic and system of particles. The 1st part of the course is devoted on the understanding of mechanics of a mechanical system in different coordinate system and reference frames. The second part of the syllabus is devoted on the concept of wave-particle duality and need of other formulation to explain the finding which could not be explained by known classical mechanics. The Schrodinger‘s equation and its application in different cases are also kept in the syllabus. As the mechanics of very fast moving object could not be explained by the above laws and principles, some understanding of special theory of relativity is also provided in the syllabus.

**3. COURSE CONTENT**

**UNIT I: Classical Mechanics (15 L)**

Co-ordinate systems, plane polar, cylindrical and spherical polar co-ordinate systems, frame of reference, rotational frame, Coriolis forces. Motion of system of particles, Conservation laws, Constraints and degrees of freedom, Generalized co-ordinates, Lagrange‘s and Hamilton‘s formulations, Poisson‘s brackets.

**UNIT II: Quantum Mechanics (15 L)**

Origin of Quantum Mechanics, Plank‘s black body radiation, Matter waves and concept of wave function, Heisenberg uncertainty principle, Schrodinger‘s equation, Applications of Schrodinger time independent equation; (i) Particle in a box, (ii) Potential step, (iii) Potential barrier, (iv) Harmonic oscillator (one-dimensional) & (v) Periodic potential.

**UNIT III: Relativistic Mechanics (8 L)**

Michelson – Morley experiment, postulates of special relativity, Lorentz transformation, length contraction, time dilation, Doppler effect, addition of velocities, variation of mass with velocity, equivalence of mass & energy, mass less particle.

**4. READINGS**

**4.1 TEXTBOOK:**

1. D. Kleppner and R. J. Kolenkow, An Introduction to Mechanics, Tata McGraw-Hill,
2. D T Greenwood, Classical Dynamics, Prentice Hall of India, Pvt. Ltd., New Delhi
3. A. Beiser, Perspective of Modern Physics, McGraw-Hills Co., Inc., New York.
4. Robert Resnick. Introduction to special relativity

**4.2 REFERENCE BOOKS:**

1. H Goldstein, Classical Mechanics, Reading Mass Adison-Wesley Press, Inc.
2. J L Powell and B Crasemann, Quantum Mechanics, Narosa Publishing House, New Delhi
3. Ghatak and Loknathan, Quantum Mechanics, Macmillan India Ltd.

**5. OUTCOME OF THE COURSE:**

This course is designed in such a way that the students learn the fundamental Physics, which will construct the base for the study of Engineering and Technology.

## IS.CY 101.14 Chemistry- I

**1. GENERAL**

1.1 TITLE:: Chemistry – I
1.2 *COURSE NUMBER::IS**.CY 101.**14
1.3 CREDITS:: 2-1-2 Credits 10
1.4 *SEMESTER -OFFERED:: Odd Semester
1.5 PREREQUISITE: None
1.6SYLLABUS COMMITTEE MEMBERS: Prof. Y. C. Sharma, (Convener), Dr. I. Sinha, Dr. Manisha Malviya

**2. COURSE CONTENT**

**UNIT I: Titrimetric Analysis (4 L)**
Introduction to titrimetric analysis; acid-base, Redox and complexometric titrations.

**UNIT II:Coordination Chemistry (5 L)**
General introduction to ligands and complexes, Crystal field theory as applicable to metal complexes, Crystal field splitting in octahedral and tetrahedral complexes, Factors affecting crystal field parameter, Jahn-Teller distortion, Square planar complexes, Colour of complexes.

**UNIT III: Organic Reaction Mechanisms (5 L)**
Nucleophilic Substitution Reactions: Brief review of nucleophilic substitution reactions at saturated carbon atom, Substitution reactions at allylic substrates, Mechanisms and stereochemistry of SNi and Neighbouring group participation reactions, Factors affecting nucleophilic substitution reactions.

**UNIT IV: Elimination Reactions (4 L)**
Mechanism of E1 and E1cb reactions. Mechanism and stereochemistry of E2 reactions, anti, syn and pyro Elimination reactions, Mechanism and stereochemistry of electrophilic addition reaction.

**UNIT V: Chemical Kinetics (5 L)**
Concepts of rate, rate constant, Order and molecularity of elementary and multi-step reactions, First and second-order reactions, determination of rate law, reversible reactions, concurrent and consecutive reactions first order reactions.

**UNIT VI: Photochemistry (4 L)**
Laws of photochemistry, Quantum yield, experimental determination of quantum yield, Kinetics of photochemical reactions (simple and chain reactions), Photo-physical processes: fluorescence, phosphorescence (with spectroscopic consideration), Photosensitization.

**3. RECOMMENDED BOOKS**

1. F. A. Cotton, G. Wilkinson, C.A. Murillo and M. Bochmann, Advanced Inorganic Chemistry, John Wiley, 6th Ed., 1999.
2. Ellen A Keiter, James E. Huheey, Okhil K. Medhi, Richard L. Keiter, Inorganic Chemistry: principles of structure and reactivity, 4th Ed., Pearson Education, 2012.

3. J.D. Lee, Concise Inorganic Chemistry, 5th Ed., Wiley India Pvt. Ltd.
4. Vogel's text book of Quantitative chemical Analysis, revised by G.H. Jeffery, J. Bassett, J. Mendham and R.C. Denny, Longman, UK.
5. Ira N. Levine, Physical Chemistry, Tata McGraw Hill.
6. R. A. Alberty and R. J. Silbey, Physical Chemistry, John Wiley & Sons.
7. G. W. Castellan, Physical Chemistry, Narosa Publishing House.
8. R.T. Morrison and R. N. Boyd, Text book of Organic Chemistry, Prentice Hall, New Delhi, 6th edition, 1992,
9. P. Sykes, Guide book to Reaction Mechanism in Organic Chemistry, Longman, London, 6th edition, 1996.
10. T.W.G. Solomon, C.B. Fryhle Organic Chemistry, John Wiley & sons, New York. 8th edition, 2004.

## IS.MA 101.14 Engineering Mathematics – I

**1. GENERAL**

1.1 TITLE::Engineering Mathematics - I
1.2 *COURSE NUMBER::IS**.MA 101.**14
1.3 CREDITS:: 3-1-0: Credits 11
1.4 *SEMESTER -OFFERED:: Both
1.5 Prerequisite: None
1.6Syllabus of Committee Member: Prof. T. Som (Convener), Dr. V.K. Singh

**2. COURSE CONTENT**

**UNIT I: 1 Sequences and Continuous Functions (10 L)**

Real number system : Completeness axiom, density of rationals (irrationals) in R, Convergence of a sequence, Sandwich theorem, Monotone sequences.
Limits and Continuity of functions, Intermediate value property, Differentiability, Necessary condition for local maxima, Rolle's theorem and Mean value theorem, Cauchy mean value theorem, L'Hospital rule, Increasing and decreasing functions, Convexity, Second derivative test for max and min, Point of inflection, curve sketching.

**UNIT II: 2 Power Series Expansions (4 L)**

Taylor's theorem with remainder, Convergence of series, Absolute convergence, Comparison test, Ratio test, Root test, Power series, Radius of convergence, Taylor series, Maclaurin series.

**UNIT III: 3 Riemann Integration, Surface Area & Volume (7 L)**

Introduction to Riemann integration, Elementary properties of integral, Fundamental Theorems of calculus, Improper integral of first & second kind, Comparison test, Absolute convergence, Applications of definite integral: Polar coordinates, Graphs in polar coordinates, Area between two curves when their equations are given in polar coordinates, Volumes by slicing, Length of a curve.

**UNIT IV: 4 Multi-variable Calculus (6 L)**

Functions of several variables, Continuity, Partial derivatives, Total derivative, Increment theorem, Chain rule, Gradient, Directional derivatives, Tangent plane and Normal line, Mixed derivative theorem, Necessary and sufficient conditions for Maxima, Minima and Saddle point, The method of Lagrange multipliers.

**UNIT V: Vector Calculus (4 L)**

Review of vector algebra, Equations of lines and planes, Continuity and Differentiability of vector functions, Arc length for space curves, Unit tangent vector, Unit normal and Curvature to plane and space curves,

**UNIT VI: Multiple Integrals** **(8 L)**
Double integral, Fubini's theorem, Volumes and Areas, Change of variable in a double integral, special case: Polar coordinates, Triple integral, Applications, Change of variables in a triple integral, Surface area, Surface area (contd.), Line integrals, Surface integrals, Green's Theorem, Vector fields, Divergence and Curl of a vector field, Stokes' Theorem, The divergence theorem.

**4. READINGS**
**4.1 TEXTBOOK:**
**4.2 REFERENCE BOOKS:** Calculus by Thomas and Finney.

## IE. **ME103**.14 **Engineering Thermodynamics**

**1. GENERAL**
1.1 TITLE:: Engineering Thermodynamics
1.2 *COURSE NUMBER::IE. **ME103**.14
1.3 CREDITS::3-1-0 –Credits 11
1.4 *SEMESTER -OFFERED:: Both
1.5 Prerequisite: None
1.6 Syllabus Committee Member: Prof. P. Ahuja (CH) (Convener), Prof. S.P. Singh (CR), Prof. B.N. Sharma (MT), Prof. M. Prasad (ME), Dr. S.S. Mondal, Dr. J. Sirkar, Dr. B. Eshpuniyani

**2. OBJECTIVE**
The course shall prepare the students to understand the laws of thermodynamics and apply them to various engineering problems and also to understand the thermodynamic property relations and their usage in thermodynamic property estimation.

**3. COURSE CONTENT**
**UNIT I: Introduction**. **(2 L)**
Concept of internal energy, enthalpy, heat and work. State and path functions. Degrees of freedom for saturated and superheated steam and subcooled liquid. Extensive and intensive properties. Work done in an internally reversible non-flow process.T-V, P-V, and P-T diagrams of a pure substance.Standard Molar heat capacity (of pure ideal gas, pure liquid and pure solid) as a function of temperature.Zeroth law of thermodynamics.

**UNIT II: Importance of equations of state**. **(2 L)**
Ideal gas equation of state. van der Waals fluid equation of state.Reduced temperature and reducedpressure.Two-parameter and three-parameter Law of corresponding states.Molar volume of saturated vapour and saturated liquid. Compressibility factor of gases and liquids.

**UNIT III: First law and its applications.** **(6 L)**
Non-flow processes: Energy balance in a non-flow process. Constant pressure process, constant volume process, constant temperature process, adiabatic process, polytropicprocessSteady Flow processes: Energy balance in a steady flow process. Work done in an steady flow process. Nozzles and diffusers, turbines and compressors, multistage

compression with intercoolers.Transient flow processes, uniform flow process, charging process, discharging process.

**UNIT IV: Second law and its applications**. **(6 L)**
Carnot cycle.Clausiusinequality.Limitations of first law.Entropy balance for closed system.Reversible and irreversible expansion at constant temperature.Irreversibility due to heat transfer over temperature difference.Increase of entropy principle.Entropy balance for control volume.Adiabatic efficiency of steady flow devices.Statistical interpretation of entropy.Third law of thermodynamics.

**UNIT V: Exergy (or Availability).** **(4 L)**
Exergy of heat.First and second law efficiency of a heat engine.Reversible useful work of non-flow processes, Exergy of non-flow process.PdV versus reversible work for non-flow process.Irreversibility of non-flow process. Lost work. Reversible work of steady flow process.Comparison of Internally reversible, reversible and irreversible processes.

**UNIT VI: Chemical reactions.** **(3 L)**
Standard enthalpy, entropy and Gibbs energy of formation at 298.15 K.Standard enthalpy change of reaction as a function of temperature. Standard entropy change of reaction as a function of temperature. Standard Gibbs energy change of reaction as a function of temperature.

**UNIT VII: Thermodynamic property relations of pure substances.** **(8 L)**
Introduction to the thermodynamic properties of idealized and real fluids.Thermodynamic Relations for dU, dH, dA, and dG.Maxwellrelations.General equation for dU, dH, dS.Volumeexpansivity and isothermal compressibility.General equation for molar heat capacities.Joule-Thomson coefficient. Clapeyron equation. Antoine equation.Residualproperty.dU, dH, and dS for ideal gases and real gases. Calculations of Joule-Thompson coefficient and residual properties of gases and liquids and molar heat capacity at constant pressure using van der Waals equation of state.dG=RTdlnf, and the importance of fugacity in relation to equilibrium.

**UNIT VIII: Thermodynamic cycles.** **(7 L)**
Rankine cycle. Comparison of Carnot and Rankinecycles.Reheat cycle. Regenerative cycle. Air standard power cycles. Otto cycle. Diesel cycle. Braytoncycle.Coefficient of Performance. Reversed Carnot Cycle. Vapour-compression refrigeration cycle. Ammonia absorption refrigeration cycle. Linde-Hampson liquefaction cycle.

**4. READINGS**

**4.1 TEXTBOOK::**

Nag, P.K., Engineering Thermodynamics, Third Edition, Tata McGraw-Hill, New Delhi, 2005

**4.2 *REFERENCE BOOKS::**

1. Cengel, Y.A. and Boles, M.A., Thermodynamics: An Engineering Approach, McGraw-Hill, New York, 1988
2. Howell, J.R. and Buckius, R.O., Fundamentals of Engineering Thermodynamics, McGraw-Hill, Singapore, 1987
3. Huang, F.F., Engineering Thermodynamics: Fundamentals and Applications, Macmillan Publishing Co., 1976.
4. Jones, J.B. and Hawkins, G.A., Engineering Thermodynamics, Prentice Hall of India, 2000.
5. Moran, M.J. and Shapiro, H.N., Fundamentals of Engineering Thermodynamics, Fourth Edition, John Wiley, 2000

6. Rogers, G. F. C. and Mayhew, Y. R., Engineering Thermodynamics, Work and Heat Transfer, Fourth Edition, Pearson Education, New Delhi, 1992
7. Van Wylen, G.J. and Sonntag, R.E., Fundamentals of Classical Thermodynamics, Third Edition, John Wiley, New York, 1985
8. Wark, K., Thermodynamics, Fourth Edition, McGraw-Hill, New York, 1983
9. Ahuja, P., Chemical Engineering Thermodynamics, PHI Learning, 2009

**5. OUTCOME OF THE COURSE**

The students have learnt to apply first and second laws of thermodynamics to various engineering problems and also learnt the usage of thermodynamic property relations for estimation of thermodynamic properties using steam tables and equations of state.

## EP.ME 105.14Manufacturing Practice I

**1. GENERAL**

1.1 TITLE::Manufacturing Practice I
1.2 *COURSE NUMBER::EP**.ME 105.**14
1.3 CREDITS:: 0-0-3 – Credits 3
1.4 *SEMESTER -OFFERED:: Both
1.5 Syllabus Committee Member: Prof. A. K. Jha (Convener), Prof. Santosh Kumar, Dr. M.Z. Khan Yusufzai, Dr. M. Vashista (ME)

**2. OBJECTIVES**

To make the students familiar with various manufacturing processes and to get an on hand experience on these processes. Impart practical knowledge about the capabilities of manufacturing processes and how these processes could be used to produce various types of components and products.

**3. DELIVERABLES**

To develop skill and confidence among the students to successfully use various manufacturing processes and to understand the difficulties faced by the personnel working on these manufacturing processes

**4. PRACTICE PLAN**

1. **Manufacturing Practice I*(Total hours: 3 hours per week x 10 weeks=30 Hours)***
    a. Foundry ***(1 turn)***
    b. Pattern Making ***(1 turn)***
    c. Material joining and Deposition Processes ***(2 turns)***
    d. Metal forming processes ***(1 turn)***
    e. Demonstration of Videos on Manufacturing Processes ***(1 turn)***
    f. **Project work-I** ***(4 turns)***
    2. **Manufacturing Practice II*(Total hours: 3 hours per week x 10 weeks=30 Hours)***
    a. Centre Lathe ***(1 turns)***
    b. Fitting ***(1 turn)***
    c. Milling ***(1 turn)***
    d. Shaping ***(1 turn)***
    e. CNC ***(1 turn)***
    f. Demonstration of Videos on Manufacturing Processes **(1 turn)**
    g. **Project work-II** ***(4 turns)***

***Note: (i) 1 turn means contact duration of three hours***
***(ii) Project work I & II may be combined into a larger project***

## EP.ME 104.14 Engineering Drawing (Manual and Computer Aided)

**1. GENERAL**
1.1 TITLE::Engineering Drawing (Manual and Computer Aided)
1.2 *COURSE NUMBER::EP**.ME 104.**14
1.3 CREDITS:: 1-0-3 Credits 6
1.4 *SEMESTER -OFFERED:: Both
1.5 Prerequisite: None
1.6 Syllabus Committee Member:**Dr. S. K. Shah(Convener)**, Dr. Amit Tyagi,Dr. D. Khan, Dr. U. S. Rao (ME)

**1. OBJECTIVE : :**

Technical drawing is the language of engineering. The objective of this course is to learn initially the basic principles involved in the projection of points, lines, lamina and solids. As well this course is focused towards the interpenetration of solids, development of surfaces, isometric drawings and some basics of computer aided drafting software. It is expected that a student should learn this subject in a very systematic way to develop the skill to express effectively his/her idea about an object to others through drawings.

**2. COURSE CONTENT : :**

**UNIT I:** **(12 L)**
Instruments used, Lettering, Types of Lines used, Types of Projections in use, Dimensioning of Figures, etc.; Orthographic Projections of Points, Lines & Lamina

**UNIT II:** **(16 L)**
Projection of Solids; Section of Solids & its Projections; Interpenetration of Solids & Curve of Interpenetration; Development of Surfaces.

**UNIT III:** **(12 L)**
Isometric Drawing & Isometric Projection; Free-Hand sketching of Engineering Components

**UNIT IV:** **(12 L)**
Introduction to Drafting Software (AutoCAD) & its Basic Commands,
Solving Problems using AutoCAD.

3. READINGS : :
3.1 TEXT BOOKS : :

1. Title: Engineering Drawing Author: N. D. Bhatt
2. Title: Engineering Graphics With Autocad Author: James D. Bethune

3.2 REFERENCE BOOKS : :

1. Title: Engineering Drawing & Graphics Author: K. Venugopal
2. Title: Engineering Drawing Author R. K. Dhawan
3. Title: Engineering Drawing Author: M. B. Shah & B. C. Rana

7. OUTCOME OF THE COURSE : :

It is anticipated that after completion of the course, a student would be in a position to study/guide basic engineering drawings required in workshop for the fabrication purposes. Also this basic course will help the students to handle effectively the course on machine drawing.

## IH.H101.14 Universal Human Values 1: Self and Family

**1. GENERAL**

1.1 Title : Universal Human Values 1 : Self and Family
1.2 Course Number: IH**.H 101.14**
1.3 Credits : 1-2-0 – Credits 5
1.4 Semester offered : 1st
1.5 Pre-requisites : 4-day Harmony–1 Workshop (co-requisite)

**2. OBJECTIVE**

The objective of the course is four fold:
1. Sensitization of student towards issues in all dimensions of life.
2. Inculcation of self reflection.
3. Understanding (clarity) of relationships, and family.
4. Exposure to issues in society and environment.
**5.** Development of commitment and courage to act.

**2.1. Sensitization of student towards issues in all dimensions of life**

There are a whole range of issues which one faces in life towards which the young students are generally unfamiliar and therefore insensitive. Almost all the concerns - environmental, societal, familial or personal, are result of human action. Sensitization towards them therefore is an important step.

**2.2. Inculcation of Self Reflection.**

Human action is governed by various internal factors primarily the beliefs one holds, and therefore ‗looking-in' becomes essential, to see what beliefs one is holding, whether they are really true or not, if they are not true, then what could be the process to get the "right" belief and then further validate it.

Most of the young people are somehow trained to look only ―outside‖. The motivation and the skill to look inside are missing. Inculcation of self reflection in students will result in them becoming more responsible, honest and trustworthy. Lack of such qualities in individuals is major concern of organizations, institutions and society in general.

**2.3. Understanding (Clarity) of Human Relationships and Family.**

It will try to show that relationships and material prosperity are the basic desire for a human being.

Two global problems which we face today are war (including terrorism) and imbalance in nature (global warming). If we look at reasons for war, the fundamental cause is: Human Being is in opposition to other Human Being. Therefore one is willing (or gets compelled) to exploit others. This is due to lack of understanding of relationships.

**2.4 Exposure to Issues in Society and nature (larger manmade systems and Nature)**

To show that the fundamental reasons for imbalance in nature are: pollution and resource depletion. Both these aspects are result of consumerist model of development.

. To show how harmony can be ensured at following levels of our living: individual, human-human relationships, larger society, Various social systems like education system, economic system, political system and others, and rest of the nature.

**2.5. Development of Commitment and Courage to Act.**
If the understanding is right, then the actions become right. Commitment and courage to act are considered consequences of right understanding in an individual. In the course, an attempt will be made to build right understanding in the individual, and then further plan of actions will also be discussed in order to implement the understanding in various life situations in the right manner.

**3. COURSE TOPICS**
Following are the topics to be covered in broadly the given sequence.

1. **Motivation and Objectives of Human Values Course.**
Introduction to the objectives of the course. Content and process of the course including mode of conduct. Daily life as lab for the course. Activities in the course.

2. **Purpose of Education**
How human being has a need for Knowledge, what should be the content of knowledge, how the content should be discussed in education. Complimentarily of skills and values, how the current education system falls short.

**3.Peers Pressure, Social Pressure**
In various dimensions of life, how do these things work. What is the way out? In the context of education, peer pressure etc. movie ―TaareZameen Par‖ can be used.

**3. Concept of Competition and Excellence**
How competition leads to degradation of self and relationships. How excellence is the basic need of a human being. What is excellence? Movie ―Fearless‖ can be used to discuss the concept.

5. **Time Management**
How does one deal with myriads of activities in college? Focus of the mind.

**4. Concept of Preconditioning.**
How preconditioning affects our thinking, behavior, work, relationships, society and nature. How do we develop pre-conditioning?
What are the various sources of preconditioning? How do we evaluate our Preconditioning? How do we come out of it?

**5. Concept of Natural Acceptance in Human Being**
What is natural acceptance? How can the concept of natural acceptance be used to evaluate our preconditioning. Universal nature of natural acceptance.
Are anger, jealousy, hatred natural? How do we feel when we experience them?
Which feelings are natural for a human being and which are not?

8. **Understanding Relationships.**

a) **Are relationships important?**
What is the role of relationships in our life? If relationships are important then why they are important? If they are important then why it is the case that we are not discussing them? What are the notions/conditions and factors which stop us to explore more into relationships. Relationships in family and extended family. Dealing with anger. Show film ―Right Here, Right Now‖.

b) **Basic expectations in relationships. Seven types of relations.**

c) **Gratitude as a universal value in relationships. Discuss with scenarios. Elicit examples from students' lives.**

d) **Nine universal values in human relationships. Trust as the founding value.**

e) **Concept of acceptance. Unconditional acceptance in relationships.**

f) **Our preconditioning affecting our relationships.**
Our relationships with subordinate staff, with people of opposite gender, caste, class, race. Movie ―Dharm‖ (set in Varanasi) can be used to show the conflict between preconditioning and relationships. How relationships have the power to force a person to change his preconditioning.

9. **Concept of prosperity**
Material goods and knowledge of one's physical needs is essential for feeling of prosperity.
What role others have played in making material goods available to me: Identifying from one's own life.

10. **Idea of Society.** What is a society? What constitutes a society? What systems are needed for a society to work? What is the purpose of society and various systems which are working in it?
How understanding of Human Nature is important in order to understand the purpose of Society and various social systems? And what happens when this understanding is lacking?

11. **Idea of decentralization of politics, economics, education, justice etc. Its comparison with centralized systems. The idea of Swaraj. Various social initiatives by NGOs, social organizations and other people.** (If time permits)

12. **Balance in nature**
**a) Balance which already exists in nature.**
b) **How human beings are disturbing the balance. Resource depletion and pollution.**
Our own role in wastage of electricity, water and in use of plastics. Waste management. (Show episode on city waste from SatyamevaJayate 2.)
c) **Issues like global warming, animal extinction.**
Show ―Story of Stuff‖ documentary film. ―Home‖ film can also be used.

## 4. READINGS

### 4.1 Text Book

1. Human Values and Professional Ethics by R R Gaur, R Sangal, G P Bagaria, Excel Books, New Delhi, 2010.

### 4.2 Reference Books

1. The Story of Stuff (Book).
2. The Story of My Experiments with Truth - by Mohandas Karamchand Gandhi
3. On Education - J Krishnamurthy
4. Siddhartha - Hermann Hesse
5. Old Path White Clouds - ThichNhatHanh
6. On Education - The Mother
7. Diaries of Anne Frank - Anne Frank
8. Life and Philosophy of Swami Vivekananda
9. Swami Vivekananda on Himself

10. Small is Beautiful - E. F Schumacher.
11. Slow is Beautiful - Cecile Andrews
12. JeevanVidya: EkParichaya, ANagaraj, JeevanVidyaPrakashan, Amarkantak, 1999.
13. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi
14. Rediscovering India - by Dharampal
15. Hind Swaraj or Indian Home Rule - by Mohandas K. Gandhi
16. India Wins Freedom - Maulana Abdul Kalam Azad
17. Ramakrishna kijeevani - Romain Rolland (English)
18. Vivekananda - Romain Rolland (English)
19. Gandhi - Romain Rolland (English)
20. Autobiography of a Yogi – by ParamhansaYogananda
21. Gandhi and Question of Science – Sahasrabudhe

**5. OUTCOME OF THE COURSE**

At the end of the course, students are expected to become more aware of their self and their relationships and would have better reflective and discerning ability. They would also become more sensitive to their surroundings including both people and nature, with commitment towards what they believe in (human values). It is hoped that they would be able to apply what they have learnt to their own self in different ordinary day-to-day settings in real life with higher commitment and courage.

## LM.HL 101.14 Basic English

**1. GENERAL**

1.1 TITLE:: REMEDIALENGLISH
1.2 *COURSE NUMBER::LM.**HL 101.**14
1.3 CREDITS:: 2-0-1-- 7
1.4 SEMESTER-OFFERED:: Ist Sem.

**2. OBJECTIVE**

To improve the language skill for the students who are not skilled enough to use English as a language for their academic needs.

**3. COURSE TOPICS**

**1. Vocabulary Building**

1.1. The concept of word formation
1.2. Root words from foreign languages and their use in English
1.3. Acquaintance with prefixes and suffixes from foreign languages in English to form derivatives
1.4. Synonyms, antonyms and standard abbreviations

**2.Basic Writing Skills**

2.1. Sentence structures
2.2. Use of phrases and clauses in sentences
2.3. Importance of proper punctuation
2.4. Creating coherence
2.5. Organizing principles of paragraphs in documents
2.6. Techniques for writing precisely

**3. Identifying Common Errors in writing**

3.1. Subject-verb agreement
3.2. Noun-pronoun agreement

3.3. Misplaced modifiers
3.4. Articles
3.5. Prepositions
3.6. Redundancies
3.7. Clichés

**4 Nature and style of sensible writing**
4.1. Describing
4.2. Defining
4.3. Classifying
4.4. Providing examples or evidence
4.5. Writing introduction and conclusion

**5 Writing practices**
5.1. Comprehension
5.2. Précis writing
5.3. Essay writing

**4. READINGS**
*1. Practical English Usage*. Michael Swan. OUP. 1995.
*2. Remedial English Grammar*. F. T. Wood. Macmillan. 2007.
*3. A course in Academic Writing*. Renu Gupta. Orient Blackswan. 2010.
*4. Study Writing*. Liz Hamp-Lyons and Ben Heasley. Cambridge University Press. 2006.

**5. OUTCOME OF THE COURSE**
To make students aware about the importance of a English for communication needs. Also to equip them for the higher courses such as Academic Writing and Professional Communication in later stages.

## GY.PE 101.14 Elementary Physical Education

**1. GENERAL**
1.1 TITLE:: **Elementry Physical Education**
1.2 *COURSE NUMBER:: GY.**PE 101**.14
1.3 CREDITS::**0-1-3 Credit 5**
1.4 SEMESTER-OFFERED : Both
1.5 PRE-REQUISITES:: None
1.6 SYLLABUS COMMITTEE: Dr. Satish Kanajiya

**2. OBJECTIVE::** All round development of Personality (physical, mental, social & Spiritual development) of students through Physical Activities**.**

**3. COURSE CONTENT ::**

**Unit-I Physical Fitness**
Definition and benefits of Physical Fitness, Components of Physical Fitness, Types of Physical Fitness (Health related & Performance related)

**Unit-II Warming up and Cooling Down**
Warming up and its significance. Types of warming up. Cooling Down

**Unit-III Practical in Sports Field**

Basic Physical Exercises.Basic Skills of Selected Games

**4. READINGS-**

- Bucher C.A., Foundation of Physical Education. St. Louis: The C.V. Mosby Co., 1972.
- Sharman, J.R. Introduction to Physical Education, New York, A. S. Barnes & Co. 1964.
- Marley, William P., Health and Physical Fitness. Taking Charge of your Health. CBSCollege Publishing. Philadelphia, 1982.
- Fox, Edward L. and Mathews, Donald K., The Physiological Basis of Physical
- Education and Athletics. Saunders College Publishing, New York, 3rd Edition, 1981.

**5. ASSESSMENT**Continuous assessment through class test andperformance in the playground.

**7. OUTCOME OF THE COURSE::** Tomake students aware about the importance of Physical Activities and sports in their daily life. Also, to equip them with the knowledge of healthy living and better life.

## IS.MA 102.14 Engineering Mathematics-II

**1. GENERAL**

1.1 TITLE::Engineering Mathematics - II
1.2 *COURSE NUMBER::**IS.MA 102.14**
1.3 CREDITS:: 3-1-0: Credits 11
1.4 *SEMESTER -OFFERED:: Both
1.5 Prerequisite: None
1.6Syllabus of Committee Member: Prof. O.P. Singh (Convener), Prof. S.K. Pandey

**2. COURSE CONTENT**

**Unit 1: Vector spaces (5 L)**

Sets, Relations, equivalence relation, functions, partition of set, Cartesian product of Set, Binary operations, examples. Definition and examples ofGroups (stress on additive and multiplicative), Subgroups, Fields. Vector Spaces over real and complex fields. Subspaces. Some properties of subspaces. Finite linear combinations Dependent and independent vectors. Basis and Dimension of vector space. Basis and dimension (contd.), The infinite dimensional vector spaces Ck[a, b], Lp[a, b], k = 0, 1, 2,… and p >0.

**Unit 2: Linear Transformations (7 L)**

Linear transformations, Kernel and Range of a linear transformation, nullity theorem., Matrix of a linear transformation over finite basis, Matrix of change of basis, Similar matrices, rank of a matrix. Solution of system of linear equations, Eigen values and eigen vectors, eigen space, Caley-Hamilton theorem and its implications. Inner product spaces, Matrix of inner product, norm induced by an inner product, parallelogram law.

**Unit 3: Orthogonal Expansion (5 L)**

Orthogonal and orthonormal vectors and systems, Gram Schmidt orthogonalization process. Orthogonal expansion of function in L2[a, b]. Expansion of function in Fourier series (real and complex form), examples in $0,2\pi$ , $-l,l$ , $0,l$ , Convergence and sum of Fourier series, Even and odd functions, half range expansions, Half range Fourier series , odd and even extensions, Gibbs phenomenon, Trigonometric approximation, Parseval's relation, Bessel inequality, Fourier integrals, Fourier sine and cosine transforms.

**Unit 4: Holomorphic Functions (3 L)**

Planer sets, curves, domains and regions in the complex plane, continuous and differential functions of complex variables, Holomorphic functions, C-R equations, Laplace equation, Harmonic functions and their applications.

**Unit 5: Complex Integration (8 L)**

Line integral, bound for the absolute value of integrals, Cauchy integral theorem, Cauchy integral formula, Derivatives of holomorphic functions, Cauchy inequality, Liouville's theorem (with proof), morra's theorem (statement), fundamental theorem of algebra, Power series, radius of convergence and Taylor's series. Laurent Series, Laurent series (contd.), Singularities and Zeros, behavior of f(z) at infinity, Residues, Residue theorem, residue integration method, Evaluation of real integrals

**Unit 6: Differential Equations (10 L)**

Basic concepts and ideas of first order differential equations, geometrical meaning of y'=f(x, y), direction fields, Exact differential equations, Integrating factors, Linear differential equations. Bernoulli equation, Existence and Uniqueness of solutions, Wronskian, Homogeneous linear equations of second order. Second-order Homogeneous equations with constant coefficients, Cases of complex roots, complex exponential functions Euler –Cauchy equation, Non homogeneous equations, Solution by undetermined coefficients, Solution by variation of parameters, System of differential equations: introductory examples-mixing problem involving two tanks, model of an electrical network, Conversion of an nth order differential equation to a system, linear systems.

**Text Books:**

1. Advanced Engineering Mathematics by Erwin Kreysgic.
2. Linear Algebra by K. Hoffman and Ray Kunz

## IE.CSO 101.14 Computer programming

**1. GENERAL**

1.1 TITLE::Computer Programming
1.2 *COURSE NUMBER::**IE.CSO 101.14**
1.3 CREDITS:: 3-1-2 - Credits 13
1.4 *SEMESTER -OFFERED:: Both
1.5 Prerequisite: None
1.5 Syllabus of Committee Member: Prof. S.K. Pandey (Convener), Dr. Rajeev Srivastava, Dr. Ravi Shankar Singh, Prof. L.P. Singh, Prof. S. Mukhapadhyay, Dr. Subir Das, Prof. B.N. Sharma, Prof. R.K. Mishra, Dr. P. Ghosh

**2.OBJECTIVE**

1. To introduce problem solving methods and algorithm development.
2. To teach programming language C.
3. To teach how to design, code, debug and document programs using techniques of good programming style.

**3. COURSE CONTENT**

**UNIT I: (10 L)**

Programming Language C and programming: Basic Syntax and Semantics, Variables, Types, Expressions, Assignment statements, Conditional and Iterative Control Structures.

**UNITII: (10 L)**

Simple I/O, Functions and parameter passing, Strings and string processing, Pointers and References, Structures, Recursion.

**UNIT III:** **(19 L)**
Algorithm development: Techniques of problem solving, Stepwise Refinement, Simple numerical examples, algorithms for searching and sorting, merging order lists. Examples taken from such areas as business applications involving data manipulation, and simulation involving games.

**4. OUTCOME**
1. Analyze and explain the behaviour of simple programs involving the fundamental programming constructs. 2. Modify and expand short programs that use standard conditional and iterative controls structures and functions.
3. Design, implement, test and debug a program that uses each of fundamental programming constructs.
4. Apply the technique of structured decomposition to break a program into smaller pieces.

## DC.MT 101.14: **Introduction To Metallurgy And Materials Engineering**

1. GENERAL
1.1 TITLE::**Introduction To Metallurgy And Materials Engineering**
1.2 *COURSE NUMBER (if known):: DC.MT 101.14
1.3 CREDITS:: 6 (L-T-P: 2-0-0)
1.4 SEMESTER-OFFERED:: II
1.5 PRE-REQUISITES:: None
1.6 COURSE COMMITTEE MEMBERS:: Prof. S.N. Ojha (Convener), Prof. B.N. Sarma, Prof. N.K. Mukhopadhyay, Prof. A.K. Ghose and Prof. T.R. Mankhand

2. OBJECTIVES:: This course gives broad exposure about Metals and Materials. It begins with historical perspectives and ends by giving latest trends in materials design and development.

3. COURSE TOPICS::
**Historical Perspectives of Metals and Alloys** **(2 L)**
Metals in relation to growth of civilization, Industrial revolution and emergence of value added products.

**Structure-Property Correlation** **(3L)**
Classification of Materials and their typical applications, structures at different length scales and their influence on properties.

**Ore and Minerals for Common Metals** (**4 L)**
An overview of processes of primary metal production, Historical developments-Current status and Future challenges.

**Materials Processing** **(9 L)**

Castings and their homogenization, Secondary processing - Rolling, Forging; Metal Joining, Powder metallurgy, Emerging processing technologies.

**Materials for Automotive, Defence, Aerospace, Power Sectors; Nuclear Programmes and Naval Industries (4 L)**

**Recent trends in materials for future technologies (4 L)**
New and Advanced Materials; Designing Materials for next generation technologies.

4. READINGS

4.1 TEXTBOOKS::

1. H.K.D.H. Bhadesia and R.W. Honeycombe: Steels, Microstructure and Properties, 3rd Edition (2006).
2. G.J. Davies: Solidification and Casting, Applied Science Publishers Ltd., London (1973).
3. Anish Upadhyaya and G.S. Upadhyaya: Powder Metallurgy: Science, Technology and Materials, Universities Press-IIM Series in Metallurgy and Materials Science.

4.2 *REFERENCE BOOKS::

1. P. Rama Rao (Editor): Advances in Materials and their Application, Wiley Eastern Limited, New Delhi (1993).
2. Metals in Service of Man, 10th Edition (Penguin Science), Penguin Books, U.K. (1994).

5. OTHER SESSIONS
5.1 *TUTORIALS::
5.2 *LABORATORY::
5.3 *PROJECT::

6. ASSESSMENT (indicative only)
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE] Nil
6.3 PERIODICAL EXAMS:: [xx% GRADE]
6.4 *PROJECT:: [xx% GRADE] Nil
6.5 FINAL EXAM:: [xx% GRADE]

7. OUTCOME OF THE COURSE:: The students, after undergoing this course, will be able to appreciate length and breadth of Metallurgy and Materials Engineering. They will also know importance of materials in technological advance.

8. *EXPECTED ENROLLMENT FOR THE COURSE:: 89

## DC.MT102.14 Metallurgical Thermodynamics And Kinetics

1. GENERAL
1.1 TITLE:: **Metallurgical Thermodynamics And Kinetics**
1.2 *COURSE NUMBER (if known):: DC.MT102.14
1.3 CREDITS:: 11(L-T-P), (3-1-0)
1.4 SEMESTER-OFFERED:: II Semester
1.5 PRE-REQUISITES:: None

1.6 COURSE COMMITTEE MEMBERS :: Dr. B. N. Sarma (Convener), Dr. C. K. Behera, Dr. J. K. Singh and Dr. V. Jindal

2. OBJECTIVES:: This course aims to make students learn thermodynamic and kinetic approaches to various metallurgical problems and thermodynamic measurement techniques.

3. COURSE TOPICS::

**Revision of Basic Principles** **(6 L)**
Revision of first, second and third law of thermodynamics. Ellingham diagram, Clausius-Clapeyron equation. Statistical concept of entropy.

**Solution Thermodynamics** **(12 L)**
Solution, mixture and compound. Raoult's law: activity, ideal solution, standard state. Partial molar quantities, Gibbs-Duhem equation, chemical potential, fugacity, activity and equilibrium constant. Free energy of mixing, excess and integral quantities. Regular solutions, $\alpha$-function. Dilute solutions: Henry's and Sievert's laws. Alternative standard states. Gibbs-Duhem integration. Short and long range ording and their models.
Elements of Gibbs Phase Rule and its applications. Free energy-composition diagram.

**Experimental Techniques** **(9 L)**
Determination of thermodynamic quantities by different techniques, viz. calorimetry, chemical equilibria, vapour pressure and electrochemical: aqueous, fused and solid electrolytes; formation, concentration and displacement cells.

**Kinetics** **(12 L)**
Arrhenius equation, activation energy, homogeneous and heretogeneous reactions, order and molecularity of reactions, adsorption, chemisorption, collision theory, absolute reaction rate theory,Diffusion: Fick's laws; applications to gas-solid reactions, kinetics of iron ore reduction.

4. READINGS

4.1 TEXTBOOKS::
1. D.R. Gaskell: Introduction to Metallurgical Thermodynamics, McGraw-Hill.
2. L.S. Darken and R.W. Gurry: Physical Chemistry of Metals, McGraw-Hill.
3. G.S. Upadhyaya and R.K. Dube: Problems in Metallurgical Thermodynamics and Kinetics, Pergamon.
4. J. Mekowiak: Physical Chemistry for Metallurgists, George Allen & Unwin.

4.2 *REFERENCE BOOKS::
1. J.J. Moore: Chemical Metallurgy, Butterworths.
2. R.H. Parker: An Introduction to Chemical Metallurgy, Pergamon.
3. K.J. Laidler: Chemical Kinetics, McGraw-Hill.

5. OTHER SESSIONS
5.1 *TUTORIALS::
5.2 *LABORATORY::
5.3 *PROJECT::
6. ASSESSMENT: To be announced by instructor.
6.1 HA:: [xx% GRADE] 20
6.2 QUIZZES-HA:: [xx% GRADE] Nil
6.3 PERIODICAL EXAMS:: [xx% GRADE] 30

6.4 *PROJECT:: [xx% GRADE] Nil
6.5 FINAL EXAM:: [xx% GRADE] 50
7. OUTCOME OF THE COURSE:: Student will be able to do various thermodynamic calculations for solid and liquid metallic solutions. They will be able to make kinetic analysis for various metallurgical processes. They will be able to conduct experiments for the measurement of various thermodynamic properties.
8. *EXPECTED ENROLLMENT FOR THE COURSE:: 89

## EP.ME 106.14 Manufacturing Practice II

**EP.ME 106.14**
a. **Centre Lathe:** Classification and types of lathe, parts and components of a lathe. Demonstration of various turning operation. Practice of a few turning operations on a centre lathe. Cutting tool.
b. **Fitting:** Demonstration of various types of files, saws, marking and clamping tools. Drilling and tapping. Practice of a assembling and fitting a job.
c. **Milling:** Classification and types of milling machines, parts and components of a milling machine. Milling cutter, Indexing and gear cutting.
d. **Shaping:** Parts and components of a shaper and planer. Quick return mechanism. Practice on preparing component using shaper
e. **CNC:** Specifications of a CNC Machine, difference between a conventional machine and CNC Machines. Types of CNC Machine. Basics of CNC Programming. Writing a CNC program and executing it on a CNC Machine.
f. **Demonstration of Videos on Manufacturing Processes**
g. **Project work-II:** Preparation of a real life job using the processes practiced in manufacturing practice II.

**6. BOOKS**
i. Workshop Technology in SI Units (Part - 1) Author: W. A. J. Chapman, Publisher: CBS Publications
ii. Workshop Technology in SI Units (Part - 2) Author: W. A. J. Chapman, Publisher: CBS Publications
Workshop Technology in SI Units (Part - 3) Author: W. A. J. Chapman, Publisher: CBS Publications

## EP.MT103.15 Metallurgical Practices-I

1. GENERAL
1.1 TITLE:: **Metallurgical Practices-I**
1.2 *COURSE NUMBER (if known):: EP.MT103.15
1.3 CREDITS:: 3, (L-T-P: 0-0-3)
1.4 SEMESTER-OFFERED:: II
1.5 PRE-REQUISITES:: None
1.6 COURSE COMMITTEE MEMBERS :: Prof. S. N. Ojha, Prof (Mrs.) N.C.Santhi Srinivas, Dr. I. Chakraborty, Dr. R. Manna and Dr. N. K. Prasad (Convener).

2. OBJECTIVES:: The objective of this course is to get first hand observations on basic metallurgical practices commonly used in industries for metals and alloys.

3. COURSE TOPICS::
**Illustrative List of Experiments (13 classes and each one of 3 h duration)**

1. Primary calibration of thermocouple
2. Secondary calibration of thermocouple
3. Thermal analysis and cooling pattern during freezing of melt
4. Dilatometry of mild steel
5. Cold rolling and observation of deformed microstructure (Copper)
6. Hot rolling of Al-alloy
7. Hot forging of Al-Si alloys
8. Strain hardening
9. Compaction and sintering of metal powders
10. Analysis of fractured surface

4. READINGS
4.1 TEXTBOOKS::


1. GE Dieter: Mechanical Metallurgy, SI Metric Edition, McGraw-Hill Inc, UK, 1988.
2. Thomas H. Courtney: Mechanical Behavior of Materials, Secon Edition, Overseas Press India Pvt. Ltd, 2006.
3. Experimental Techniques in Physical Metallurgy- V. T. Cherepin and A. K. Mallik, Asia Publishing House, Bombay (1967).
4. Principles of Metallographic Laboratory Practice- George L Kehl, McGraw-Hill Companies (1949).
5. Practical Experimental Metallurgy- D. E. Davies, Elsevier, 1966.
6. P.D. Webster (ed), Fundamentals of Foundry Technology, Port Cullis Press.
7. H.F. Taylor, M.C. Flemings and J. Wulff, Foundry Engineering, Wiley.
8. H.B. Carry: Modern Welding Technology, Prentice Hall.
9. V.S. Arunachalam and O.V. Roman (eds.): Powder Metallurgy-Recent Advances, Oxford & IBH.


4.2 *REFERENCE BOOKS::


1. Metals Handbook, Mechanical Testing, Ninth Edition, ASM.


5. OTHER SESSIONS
5.1 *TUTORIALS::
5.2 *LABORATORY:: As per the illustrative list of experiments
5.3 *PROJECT::
6. ASSESSMENT (indicative only) To be announced by the instructor.
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE] Nil
6.3 PERIODICAL EXAMS:: [xx% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [xx% GRADE]
7. OUTCOME OF THE COURSE:: The students will be familiar with several metallurgical processes like casting, deformation, heat treatment and metallography processes. Familiarity with these practical would provide an insight to students in their subsequent study in theory subjects.
8. *EXPECTED ENROLLMENT FOR THE COURSE:: 89

## IH.H 103.14 Development of Societies

**1. GENERAL**
1.1 TITLE:: Development of Societies
1.2 *COURSE NUMBER (if known):: IH.**H 103**.14
1.3 CREDITS:: 2-1-0- Credits 8
1.4 SEMESTER-OFFERED:: Both

1.5 PRE-REQUISITES:: None

**2. OBJECTIVE::** This is one of the foundation courses of Humanities (in Foundation Area 1). It is envisaged that this course will provide a natural link between engineering and humanities with an emphasis that Development is not just materialistic, larger view of all round human development should also be considered. Importance of sustainable development, inter-dependence and co-existence in nature should be realised through this course. It is to gain an understanding of alternative models of development.

3. COURSE TOPICS::

**Unit I: Social Development** (5 hours)

1. Concepts behind the origin of Family, Clan and Society
2. Different Social Systems
3. Relation between Human being and Society
4. Comparative studies on different models of Social Structures and their evolution

**Unit II: Political Development** (3 hours)

1. Ideas of Political Systems as learnt from History
2. Different models of Governing system and their comparative study

**Unit III: Economic Development** (18 hours)

1. Birth of Capitalism, Socialism, Marxism
2. Concept of development in pre-British, British and post British period- Barter, Jajmani
3. Idea of development in current context.
4. E. F. Schumacher's idea of development, Buddhist economics.
5. Gandhian idea of development. Swaraj and Decentralization.

***PROJECT:: Possible projects in this course could be**

a) Interact with local communities and understand their issues.
b) Study local cottage industry and agricultural practices. Role of engineering and specialized knowledge.
c) Evaluation of technology in the context of its application. Social impact of technology. Enviromental impact of technology. Evaluation from a holistic perspective.

## IH.H 104.14 History and Civilization

**1. GENERAL**

1.1 TITLE:: **History and Civilization**
1.2 *COURSE NUMBER :: IH.**H 104.**14
1.3 CREDITS:: 2-1-0-Credit 8
1.4 SEMESTER-OFFERED:: Both 1.5 PRE-REQUISITES:: None

**2. OBJECTIVE**:: This course is one of the foundation courses of Humanities (in Foundation Area 1). Objective of this course is to make students aware of rich legacy of India and introduce history in the context of survival, political and cultural development. The course is to emphasize the role of history in understanding the concepts of civilization and its connection towards the evolution of future societies. It also gives an opportunity to explore the world civilization and understand the contemporary development.

**3. COURSE TOPICS::**

**Unit I: Overview of Indian History** (19 L)

Two threads will be running while covering the topics

a) Study of history as a way to understand contemporary society

b) Study of history as development of ideas of humankind to understand future societies

1. Prehistoric Period (Earliest times to the formation of States) - Origin of technologies (Stone, Bronze & Iron), subsistence (food collection to food production) in context of survival, Development from Rural to Urban societies.

2. Empires of Ancient India – (Maurya, Kushan & Gupta): study of Governance, Culture achievements (epigraphs, Icons and Architecture).

3. Medieval Period – (Early Medieval dynasties: Pala, Chandela, Rshtrakuta, Chola) & The Mughals: Governance, Sculptures, Paintings, Architecture.

*4*. British Raj & Contemporary India as a study of decentralized society and industrial societies (comparative study), colonialism.

**Unit II: Sources of History & History Writing:** (3 L)

These topics will be taught interspersed with unit I

1. Sources of History – Literary (Texts) & Archaeological (material remains): Nature, limitations.

2. Discoveries & Data retrieval – Methods and techniques of Archaeology (exploration, excavation, recording, dating); Scrutiny of textual narrations (contexts, linguistic, dating).

3. Interpretations & Historical Reconstructions – Identification of cultures, Analysis of data, Interpretative models, Ideological bias.

**Unit III: Survey of World Civilizations** (4 L)

(Beginning to 1500 CE): Mesopotamia, Egypt, China.

4. READINGS 4.1 TEXTBOOK::

1. India: A History by John Keay

2. Discovery of India : by Pt. J. L. Nehru

4.2 *REFERENCE BOOKS::

1. An Advanced History of India. By R.C. Majumdar, H.C. Raychaudhuri, and Kalikinkar Datta. 1946. London: Macmillan.

2. Bharat Mein Angreji Raj - Pundit Sunderlal

**5.3 *PROJECT**:: Thematic projects to create larger picture of times and society. The following can be some of the projects:

- Choose one monument -- do in-depth research
- Choose one festival -- connect with communities and mythology
- Choose one inscription -- connect with historical times
- Choose one personality -- study the times, and how the individual copedwith difficulties. Example: Social leaders, scientists, authors, freedom fighters, and visionaries such as Mahamana Madan Mohan Malviya.
- Choose one city -- what makes the city alive
- Choose family histories
- Choose local oral history (e.g. legends, ballads)

**OUTCOME OF THE COURSE::**

It is expected that after taking this course, students will be aware of the different facet of the evolution of societies in the past. It will also give them an opportunity to envisage the future societies and encourage an exploration of the role of technology in social developments

# IH.H105.14 Philosophy

1. **GENERAL**
1.1 Title ::Philosophy
1.2 Course Number (if known) ::IH.H105.14
1.3 Credits :: 2-1-0-8
1.4 Semester offered :: Both
1.5 Prerequisite:: None

**2. OBJECTIVE::**
Even though developments are taking place with greater production of physical facilities, conflict and strife are increasing in the individual and society. Environmental crisis in the form of climate change is putting life itself in danger.
In spite of achieving ones goals, the individual remains dissatisfied with jobs and positions that are intellectually and mentally unfulfilling, and wealth that breeds problems in family, chaos in society, and imbalance in nature. In fact, the nations and civilizations are increasingly at war.
It is believed that ideas in Humanities and Social Sciences can provide a new understanding, based on which one can move to overcome the current problems, both at the individual level as well as at the societal level.
This course is expected to relate philosophy to literature, culture, society and lived experience can be considered. This is in addition to training students in already available philosophical systems. Instead of only theory or only practical courses attempt can be made to combine both theory and practice.
This course is expected to bridge the gap between theory and practice by making the courses interactive. Along with projects, this course will have more illustrations that would invite students into the subject.

3. COURSE TOPICS::

**Unit 1:The difference between knowledge (Vidya) and Ignorance (Avidya)**:
a. Upanishads;
b. Six systems orthodox and Heterodox Schools of Indian Philosophy.
c. Greek Philosophy:

**Unit 2:Origin of the Universe:**
Nasidiya Sukta: "Who really knows?‖
*Brhadaranyaka Upanishad*; *Chandogya Upanishad*: Non-self, Self, real and unreal.
Taittiriya Upanishad: Siksha Valli.
Plato‘s *Symposium*: Lack as the source of desire and knowledge.
Socratic method of knowledge as discovery.
Language: Word as root of knowledge (Bhartrahari‘s Vakyapadiyam)
Fourteen Knowledge basis as a sources of Vidya: Four Vedas; Six auxiliary sciences (Vedangas); Purana, Nyaya, Mimamsa and Dharma Sastras.

**Unit 3:**
Knowledge as Power: Francis Bacon. Knowledge as both power and self-realization in Bagavad Gita.

**Unit 4:**
Knowledge as oppression: M. Foucault. Discrimination between *Rtam* and *Satyam* in Indian Philosophy.

**Unit 5:**
Knowledge as invention: Modern definition of creativity; scientific activity in the claim that science invents new things at least through technology.

**Unit 6:**
Knowledge about the self, transcendental self; knowledge about society, polity and nature.

**Unit 7:**
Knowledge about moral and ethics codes.

**Unit 8:**
Tools of acquiring knowledge: *Tantrayuktis*, an system of inquiry (Caraka, Sushruta, Kautilya, Vyasa)

**4. READINGS**


1. Copleston, Frederick, *History of Philosophy, Vol. 1*.Great Britain: Continuum.
2 Hiriyanna, M. *Outlines of Indian Philosophy,* Motilal Banarsidass Publishers; Fifth Reprint edition (2009)
3 Sathaye, Avinash, *Translation of Nasadiya Sukta*
4. Ralph T. H. Griffith. *The Hymns of the Ṛgveda*. Motilal Banarsidass: Delhi: 1973.
5. Raju, P. T. *Structural Depths ofIndian Thought*, Albany: State University of New York Press.
6. Plato, *Symposium*, Hamilton Press.
7. Kautilya *Artha Sastra*. Penguin Books, New Delhi.
8. Bacon, *Nova Orgum*
9. Arnold, Edwin. *The Song Celestial*.
10. Foucault, *Knowledge/Power.*
11. Wildon, Anthony, *System of Structure*.
12. Lele, W.K. *The Doctrine of Tantrayukti.* Varanasi: Chowkamba Series.
13. Dasgupta, S. N. *History of Indian Philosophy*, Motilal Banasidas, Delhi.
14. Passmore, John, *Hundred Years of Philosophy*, Penguin.


**5. Other Sessions**
5.1 Mode of Conduct
6. **ASSESSMENT (indicative only)** : Ask students to do term papers, for example, writing biographical details of founders, sustainers, transmitters, modifiers, rewriters; translating monographs of less known philosophers such as K. C. Bhattacharys, Daya Krishna, Gopinath Bhattacharya; comparative study of philosophical system such as Madhyastha Darshan.

7**. OUTCOME OF THE COURSE:: -** Students will develop strong natural familiarity with humanities along with right understanding enabling them to eliminate conflict and strife in the individual and society. Students shall be able to relate philosophy to literature, culture, society and lived experience can be considered.

## IH.**H106**.14 **Education and Self**

**1. GENERAL**
1.1 TITLE :: **Education and Self**
1.2 *COURSE NUMBER:: IH.**H106**.14
1.3 CREDITS:: **2-1-0-8**
1.4 SEMESTER-OFFERED:: Both Semester
1.5 PRE-REQUISITES:: None

**2. OBJECTIVE:: In this course** it is emphasized that understanding self is a crucial aspect of education. and this course aims to explicitly highlight concern for relationship between education and society. Assumption is that any concern with the social issues without understanding the self is likely to cause complications that we witness amongst the well meaning activists today. An understanding of one's psycho-physical makeup, underlying motivations and aspirations helps not only an understanding of one self but also creates an understanding of social interactions. On the other hand, sole occupation with self is likely to alienate the social aspects. Thus it is considered necessary to view concerns of education in relation to social environment as well.
Education or _shiksha' is not so much a matter of pedagogy as of a _way of life'. The fabric of interpersonal relations, values, aspirations, language and many other factors mould the nature of knowledge, learning and teaching.

3. **COURSE TOPICS::** Following are the topics to be covered in broadly the given sequence.

**Unit-I: Understanding Education.**

1. Dialogues on education.
- To reflect over meaning and significance of education.
2. History and philosophy of education.
- Search for truth and understanding of cosmos and society.
- Pre industrialization and post industrialization.
3. Modern education, a process of alienation from self and society.
- Critique of education from the Western and Indian perspectives

**Unit - II: Indian Perspectives of Education.**

1. Notions of Vidya, Shiksha, Talim and Education.
2. Upanishads and Raj-Yoga for understanding and educating the Self.
- Spirit of enquiry of the Upanishads and the path of Ashtanga Yoga.
3. Role of education in transforming social consciousness.
- Alternatives in education in 19th-20th century India.

**Unit - III: Present efforts to integrate education, self, and society.**

1. Drawing upon traditions of Gurukuls, Monanstries, and Yogic practices.
2. Shiksha and Samaj
- The process of learning and teaching as an integral part of a society.
- Shiksha/education in relation to socio-environmental concerns.

**4. READINGS**

- Education and the Significance of Life. J. Krishnamurti, Gollancz, London,1955.
-Glimpses of Raja Yoga, Vimala Thakar, Vimal Prakashan Trust, Ahmedabad,India,!998.

## IS.MA 201.14 Numerical Techniques

**1. GENERAL**

1.1 TITLE::Numerical Techniques
1.2 *COURSE NUMBER::IS**.MA 201.**14
1.3 CREDITS:: 3-1-0: Credits 11 or Contact Hours 3-1-2: Credits 13 (With Practicals)
1.4 *SEMESTER -OFFERED:: Both
1.5 Prerequisite:Engg. Mathematics I; Desirable Engg. Mathematics II & Computer Programming
1.6Syllabus of Committee Member: Prof. O.P. Singh (Convener), Prof. L.P. Singh

**2. COURSE CONTENT**

**UNIT I: Errors in Numerical Methods (2 L)**
Approximate numbers and Significant figures; Rouding-off numbers; Errors: Absolute, Relative and Percentage; Error in Arithmetical operations; A General Error Formula; Errors in Numerical Computations; Inverse Problems.

**UNIT II: Solution of equations in one variable (6 L)**
Bisection method; Iteration method; Regula-Falsi method; Convergence of Regula-Falsi method; Secant method; Newton-Raphson method; Generalised Method for multiple roots; Rate of Convergence of Newton‘s square root formula; Newton‘s Inverse formula; Graffe‘s Root-Squaring method; Ramanujan‘s method; Rate of Convergence and. Computer Programmes for the above methods;

**UNIT III: Numerical solution of system of equations (4 L)**
Gauss elimination method; Gauss-Jordan method; Jacobi‘s iteration method; Gauss Sidel method; Ill conditioned problems; Error analysis; Computer programs based for the above methods.

**UNIT IV: Operators and Difference Equations (5 L)**
Forward difference operator, Backward difference operator, Shift operator, Average operator, Central difference operator and their relations; Factorial Notation; Synthetic division; Missing Term Technique; Basic ideas of Difference Equations.

**UNIT V: Interpolation (6 L)**
Newton‘s forward interpolation formula; Newton‘s backward interpolation formula; Stirling‘s Formula; Bessel formula; Lagrange‘s interpolation formula; Divided differences; Newton‘s divided difference formula; Numerical differentiation and applications; Central Difference Interpolation Formulae; Gauss‘ Forward central Difference Formula; Gauss‘ Backward central Difference Formula; Computer Programs for the above formulas.

**UNIT VI: Numerical integration (8 L)**
A general quadrature formula for equidistant nodes; Trapezoidal rule; Simpson‘s one-third rule, Simpson‘s three-eight rule; Wedddle‘s rule; Inherent errors in numerical integrations; Newton-Cotes quadrature formula; Euler-Maclaurin formula; Gaussian quadrature formula; Flow charts, Algorithms and Computer Programs to implement the above techniques.

**UNIT VII: Numerical Methods of Solution of O.D.E (8 L)**
Picard‘s Method of Successive Approximations ; Picard‘s Method for Simultaneous First Order Differential Equations; Euler‘s Method;; Modified Euler‘s Method; Runge-Kutta method; Flow-charts, algorithms and computer programs for the above methods.

## IE**.EO 102.**14**Fundamentals of Electronics and Instrumentation Engineering**

**1. GENERAL**
1.1 TITLE **: :Fundamentals of Electronics and Instrumentation Engineering**
1.2 *COURSE NUMBER**: :**IE**.EO 102.**14
1.3 CREDITS **:** : 3-1-2 –Credits 13
1.4 *SEMESTER – OFFERED:: Both
1.5 Syllabus Committee Member: Prof. S.P. Singh (EC)(Convener), Dr. R.S. Singh(CH)

**2. OBJECTIVE: :**

To introduce the students to the basics of both theoretical and practical aspects of broader area of Electronics and Instrumentation Engineering

**3. COURSE CONTENT**

**UNIT I:** **(2 L)**
Semiconductor diode characteristics and load line.

**UNIT II:** **(3 L)**
Half-wave and Full-wave rectifiers, filters and power supplies.

**UNIT III:** **(5 L)**
Amplifying devices and their characteristics, Single and multi-stage RC coupled voltage amplifiers, High input impedance circuits.

**UNIT IV:** **(4 L)**
Feedback amplifiers and oscillators.

**UNIT V:** **(4 L)**
Operational Amplifiers and their applications [Applications include inverting amplifier, summing amplifier, non-inverting configuration, voltage follower, differential amplifier, integrator and differentiator]

**UNIT VI:** **(3 L)**
Linear and non-linear wave shaping circuits.

**UNIT VII:** **(3 L)**
Multivibrators and counters.

**UNIT VIII:** **(1 L)**
555 Timer and its applications.

**UNIT IX:** **(1 L)**
Phase Locked Loop (PLL).

**UNIT X:** **(2 L)**
Logic gates.

**UNIT XI:** **(10 L)**
Transducers, Data converters, Display devices including CRO, Multimeter, and Data Acquisition System with an example illustrating continuous monitoring of a process variable.

**UNIT XII:** **(2 L)**
Introduction to Microprocessors and Microcontrollers

# DC.MT 201.14 Structure of Materials

1. GENERAL
1.1 TITLE:: **Structure of Materials**
1.2 *COURSE NUMBER (if known):: DC.MT 201.14
1.3 CREDITS:: 11, (L-T-P: 3-1-0)
1.4 SEMESTER-OFFERED:: III
1.5 PRE-REQUISITES:: None
1.6 COURSE COMMITTEE MEMBERS :: Prof. R.K. Mandal (Convener), Prof. G.V.S. Sastry, Prof. N.K. Mukhopadhyay

2. OBJECTIVES::This course will help students in familiarizing relevant aspects of geometrical crystallography and crystal chemistry. They will also get exposure to correlate properties of materials based on structures at various length scales.

3. COURSE TOPICS::
Geometrical Crystallography: (12 L)
Crystal Systems and Bravais Lattices, Indexing of directions and planes, Wiess Zone Law, stereographic projections, Point groups and their representation, space group, Euler's Construction and restriction on rotational symmetry, Matrix representation, Imperfections in crystals.

Crystal Chemistry: (12 L)
CCP and HCP structures, Metallic and Ceramic Crystals, Voids in close packed structures, solid solutions and their classifications, Hume-Rothery rules, Intermetallic compounds, Electron Lave's and Hagg's Phases, Ionic compounds, Non-crystalline and quasicrystalline structures, Exotic crystals: Fullerenes, Nanotube, Graphene.

Electrons in Solids: (15 L)
Schrodinger equation, Free electron theory of metals, Density of states, Fermi energy, Fermi-Dirac statistics, tight binding approximation, Electrons in a periodic potential, band theory of solids, Brillouin Zones, Effective mass of electrons, Temperature dependence of conductivity of metals, Electronic contribution to specific heat of metallic solids, Thermal conductivity, Optical and Magnetic properties of materials.

4. SUGGESTED READING: (Neither a necessary nor a sufficient requirement)
4.1 TEXTBOOKS::
1. L.A. Azaroff: Introduction to solids, Tata-McGraw Hill
2. S.M. Allen and E.L. Thomas: The Structure of Materials, John Wiley & Sons.
3. C.S. Barret and T.B. Massaski: Structure of Metals, Pergamon.
4. R.E. Reed-Hill and R. Abbaschian: Physical Metallurgy Principles, PWS.
5. K.M. Ralls, T.H. Courtney and J. Wulff: Introduction to Materials Science and Engineering, Wiley Eastern.
6. R.E. Hummel: Electronic Properties of Materials, Springer.

4.2 *REFERENCE BOOKS::
Same as above

5. OTHER SESSIONS
5.1 *TUTORIALS:: Based on theory
5.2 *LABORATORY:: Not Applicable
5.3 *PROJECT:: Not Applicable

6. ASSESSMENT (indicative only)
6.1 HA:: [xx% GRADE] to be declared by the concern instructor in the beginning of the classes as per the UG Manual
6.2 QUIZZES-HA:: [xx% GRADE] to be declared by the concern instructor in the beginning of the classes as per the UG Manual
6.3 PERIODICAL EXAMS:: [xx% GRADE] to be declared by the concern instructor in the beginning of the classes as per the UG Manual
6.4 *PROJECT:: [xx% GRADE] to be declared by the concern instructor in the beginning of the classes as per the UG Manual
6.5 FINAL EXAM:: [xx% GRADE] to be declared by the concern instructor in the beginning of the classes as per the UG Manual

7. OUTCOME OF THE COURSE:: The student will learn about fundamentals of crystallography and crystal chemistry. They will also be able to relate properties of materials with their structures at various length scales.

8. *EXPECTED ENROLLMENT FOR THE COURSE:: 89

## DC.MT 202.14 Principles Of Extractive Metallurgy

1. GENERAL
1.1 TITLE:: **Principles Of Extractive Metallurgy**
1.2 *COURSE NUMBER (if known):: DC.MT 202.14
1.3 CREDITS:: 9, (L-T-P: 3-0-0)
1.4 SEMESTER-OFFERED:: III
1.5 PRE-REQUISITES:: None
1.6 COURSE COMMITTEE MEMBERS :: Dr. K. K. Singh (Convener), Prof. T. R. Mankhand, and Dr. O. P. Sinha

2. OBJECTIVES:: This course is prepared to understand the basic principles of extractive metallurgy. The concept of pyrometallurgy, hydrometallurgy and electrometallurgy will be introduced.

3. COURSE TOPICS::

**Introduction :** Scope of extractive metallurgy, occurrence of metals in nature, minerals and ores. Elementary concepts of Mineral processing and extraction of metals **(5 L)**

**Pyrometallurgy:** Drying and calcinations, roasting & derivation of roasting conditions by Kelloss's diagram , relevance of Ellingham diagram in metal extraction, reduction of metal oxides, matte smelting and converting, metal refining processes: fire-refining, liquation and distillation. (**13 L)**

**Hydrometallurgy:** Leaching and its methods, construction & use of Paurbax diagram, bioleaching, solution purification and concentration: solvent extraction and ion exchange. Recovery of metals from leach solutions. **(7 L)**

**Electrometallurgy :** Principles of electrolysis, electrolytic systems, electro-refining, electro-winning and other electro-metallurgical processes. **(4 L)**

**Process Flow Sheets:** Production of iron and steel, aluminium, copper, zinc and lead. (**6 L)**

**Analysis of unit processes:** Reactor kinetics, heat and material balance. **(3 L)**

4. READINGS
4.1 TEXTBOOKS::


1.J. Newton: Extractive Metallurgy, Wiley.
3. W.H. Dennis: Extractive Metallurgy- Principles an Applications, Pitman.
4. J.D. Gilchrist: Extraction Metallurgy, Pergamon.
5. R.D. Pehlke: Unit Processes in Extractive Metallurgy, Elsevier.
6. T. Rosenqvist: Principles of Extractive Metallurgy, McGraw Hill.
7. C.B. Gill: Nonferrous Extractive Metallurgy, Wiley-Interscience.
8. H.S. Ray and A. Ghosh: Principles of Extractive Metallurgy, New Age International Publishers.
9. H.S.Ray, R. Sridhar and K.P. Abraham: Extraction of Non-ferrous Metals, Affiliated East West.
10. F. Habbashi, Principles of Extractive Metallurgy, Vol 1-4, McGraw-Hill


4.2 *REFERENCE BOOKS::

5. OTHER SESSIONS
5.1 *TUTORIALS::
5.2 *LABORATORY:: As per the illustrative list of experiments
5.3 *PROJECT::
6. ASSESSMENT (indicative only)
6.1 HA:: [xx% GRADE] 20
6.2 QUIZZES-HA:: [xx% GRADE] Nil
6.3 PERIODICAL EXAMS:: [xx% GRADE] 30
6.4 *PROJECT:: [xx% GRADE] Nil
6.5 FINAL EXAM:: [xx% GRADE] 50
7. OUTCOME OF THE COURSE:: The student will learn about principles of extractive metallurgy in its entirety.
8. *EXPECTED ENROLLMENT FOR THE COURSE:: 89

## DC.MT 203.15 Extractive Metallurgy Practical

1. GENERAL
1.1 TITLE:: **Extractive Metallurgy Practical**
1.2 *COURSE NUMBER (if known):: DC.MT 203.15
1.3 CREDITS:: 3, (L-T-P: 0-0-3)
1.4 SEMESTER-OFFERED:: III
1.5 PRE-REQUISITES:: None
1.6 COURSE COMMITTEE MEMBERS :: Dr. K. K. Singh (Convener), Prof. T. R. Mankhand, and Dr. O. P. Sinha

2. OBJECTIVES:: This course is prepared to understand the basic principles of extractive metallurgy. The concept of pyrometallurgy, hydrometallurgy and electrometallurgy will be introduced.
3. COURSE TOPICS::

**Illustrative List of Experiments** **(13 classes of 3 Lecture hours duration)**

1. Roasting of sulphides
2. Reduction of oxides
3. Smelting of sulphide/oxide ores
4. Leaching of oxide ores
5. Solvent extraction
6. Electro-winning
7. Cementation

4. READINGS

4.1 TEXTBOOKS::


1. J. Newton: Extractive Metallurgy, Wiley.
2. W.H. Dennis: Extractive Metallurgy- Principles an Applications, Pitman.
3. J.D. Gilchrist: Extraction Metallurgy, Pergamon.
4. R.D. Pehlke: Unit Processes in Extractive Metallurgy, Elsevier.
5. T. Rosenqvist: Principles of Extractive Metallurgy, McGraw Hill.
6. C.B. Gill: Nonferrous Extractive Metallurgy, Wiley-Interscience.
7. H.S. Ray and A. Ghosh: Principles of Extractive Metallurgy, New Age International Publishers.
8. H.S.Ray, R. Sridhar and K.P. Abraham: Extraction of Non-ferrous Metals, Affiliated East West.
9. F. Habbashi, Principles of Extractive Metallurgy, Vol 1-4, McGraw-Hill


4.2 *REFERENCE BOOKS::

5. OTHER SESSIONS
5.1 *TUTORIALS::
5.2 *LABORATORY:: As per the illustrative list of experiments
5.3 *PROJECT::
6. ASSESSMENT (indicative only)
6.1 HA:: [xx% GRADE] 20
6.2 QUIZZES-HA:: [xx% GRADE] Nil
6.3 PERIODICAL EXAMS:: [xx% GRADE] 30
6.4 *PROJECT:: [xx% GRADE] Nil
6.5 FINAL EXAM:: [xx% GRADE] 50

7. OUTCOME OF THE COURSE:: The student will learn about principles of extractive metallurgy in its entirety.

8. *EXPECTED ENROLLMENT FOR THE COURSE:: 89

## IS**.MA 203.**14 **Mathematical Methods**

**1. GENERAL**
1.1 TITLE::Mathematical Methods
1.2 *COURSE NUMBER::IS**.MA 203.**14

1.3 CREDITS:: 3-1-0: Credits 11
1.4 *SEMESTER -OFFERED:: Even
1.5 Prerequisite: Engineering Mathematics I
1.6Syllabus of Committee Member: Dr. Subir Das (Convener), Dr. Rajeev

**2. COURSE CONTENT**

**UNIT I:** **(12 L)**
Fourier transform, Laplace transform, Solution of differential equations by Laplace and Fourier transform methods, Applications of Laplace and Fourier transforms to Boundary value problems arising in Engineering Sciences.

**UNIT II:** **(4 L)**
Hankel transform, Applications.

**UNIT III:** **(4 L)**
Solutions of Laplace, Wave and Heat Conduction Equations.

**UNIT IV:** **(8 L)**
Basic ideas of Discrete Fourier transform (DFT) and Finite Fourier transform (FFT), Z-transform, and Applications.

**UNIT V:** **(7 L)**
Ordinary Differential Equations: Power series and Frobenius methods, Hermite functions, Bessel functions, Modified Bessel functions, Applications. Legendre polynomials, Associated Legendre polynomials, Rodrigues formula, Orthogonality of Legendre polynomials, Hermite functions and Bessel functions, Sturm-Liouville problem.

**UNIT VI:** **(4 L)**
Concept and calculation of Green's function, Approximate Green's function, Green's function method for differential equations.

**3. READINGS**

**4.1 TEXTBOOK:**

1. O. Scherzer (Ed.), Handbook of Mathematical Methods in Imaging, Springer, 2011.
2. G. S. Rao and K. K. Reddy, Mathematical Methods, I.K.International Pvt. Ltd., 2009.
3. W.W.Bell, Special functions for scientists and engineers, D.VanNostrand Company Ltd., London, 1968.
4. G. N. Watson, A Treatise on the Theory of Bessel Functions, Cambridge University Press, 1944.
5. G. F. Roach, Green's Functions, Cambridge University Press, 1995.
6. A. D. Poularikas, The Transforms and Applications Handbook, CRC Press, 1996.

## IE.**MO 102.**14 **Transport Phenomena**

**1. GENERAL**

1.1 TITLE:: Transport Phenomena
1.2 *COURSE NUMBER::IE.**MO 102.**14
1.3 CREDITS::3-1-0 – Credits 11
1.4 *SEMESTER -OFFERED:: Even
1.5 Syllabus Committee Member: Prof. S. Mohan (MT) (Convener), Prof. N.C. Karmakar (MN), Dr. A. Sirkar, Dr. M.K. Mondal (CH)

**2. OBJECTIVE**

Introduction to different modes of transport.

**3. COURSE CONTENT**

**UNIT I: INTRODUCTION (2 Lectures)**
Transport processes, Dimensional analysis.

**UNIT II: MOMENTUM TRANSFER (12 L)**
Steady and Unsteady flows, Equation of continuity, Euler‘s and Bernoulli‘s equation, Newton's law of viscosity, Laminar flow in falling film, flow through conduits. In viscid fluid flow, viscous flow. Laminar and turbulent flow between parallel plates and pipes, Reynolds experiment, boundary layer theory, Friction factor-Darcy Weisbach equation, Moody diagram, Energy losses in pipe lines, Flow past immersed objects, packed and fluidized bed.

**UNIT III: MASS TRANSFER (9 L)**
Steady state mass transfer and diffusion, molecular diffusion in gases, liquids, biological gels and solids. Unsteady state mass transfer under different conditions, mass transfer coefficient, diffusion through porous medium and capillaries. Boundary layer flow and turbulence in mass transfer.

**UNIT IV: HEAT TRANSFERCONDUCTION (6 L)**
Steady State: One Dimensional - Composite wall and cylinder, multi-dimensional ¬differential heat balance, shape factor, graphical and numerical methods.
Unsteady State: Analytical solutions of one dimensional lumped heat capacity system, heat flow in semi-infinite solid, convection boundary conditions, Heisler chart solutions.

**UNIT V: CONVECTION (6 L)**
Natural and forced convection, overall heat transfer coefficient, Fouling factor

**4. READINGS**
**4.1 TEXTBOOK**
1. J.S. Szekely and N.J. Themelis: Rate Phenomena in Process Metallurgy.
2. C.J. Geankoplis, Transport Processes: Momentum, Heat and Mass.
3. J.R.Welty, C.E. Wicks and R.E. Wilson: Fundamentals of Momentum, Heat and Mass Transfer.
4. J.P. Holman: Heat Transfer.
5. R.B. Bird, W.E. Stewart and J.F. Lightfoot: Transport Phenomena.
6. H. Schlichting, Boundary Layer Theory
7. J. Lal, Fluid Mechanics and Hydraulics

5. **OUTCOME OF THE COURSE**
Students will get have a brief overview of the transport processes taking place in various processes in different industries.

# DC.MT204.15 Phase Diagrams

**1. GENERAL**
1.1 TITLE::**Phase Diagrams**
1.2 *COURSE NUMBER (if known)::DC.MT204.15
1.3 CREDITS::9 (L-T-P::3-0-0)
1.4 SEMESTER-OFFERED::IV
1.5 PRE-REQUISITES::None
1.6 COURSE COMMITTEE MEMBERS:: Prof. B. NageswaraSarma (Convener), Prof. R.K. Mandal and Dr. C.K. Behera.

**2. OBJECTIVES**:: This course is intended to elucidate the thermodynamic basis of multi-component multi-phase equilibria and phase diagrams in alloy systems. This course also explicates the constitution of alloys and their representative microstructures under equilibrium conditions.

**3. COURSE TOPICS::**
**Unary Systems**: Thermodynamic conditions of equilibrium in closed and open systems. Gibbs energy-temperature-pressure diagrams and properties of substances. Scientific Group Thermodata Europe (SGTE) database. Condensed phase rule. Allotropy.Degree of transformation. (3 L)

**Binary Systems with Two Phase Equilibria**: Gibbs energy-composition diagrams. Solution models. Isomorphous systems. Calculation of liquidus and solidus in ideal systems.Lever rule. Iso-Gibbs energy curves. Equilibrium diagrams for systems exhibiting moderate departures from ideal behaviour. Congruent minimum and congruent maximum.Equilibrium and quasi-equilibrium solidification in isomorphous systems and corresponding microstructures.Stability of a phase.Stability function.Miscibility gap and chemical spinodal boundaries.Thermodynamic conditions and determination of miscibility gap, spinodal boundaries and consolute point. Decomposition inside and outside spinodal boundary and the microstructural features.Illustrative examples. (9 L)

**Binary Systems exhibitingInvariant Reactions**: Possible invariant reactions and the thermodynamic conditions. Eutectic systems.Primary and eutectic solidification and resulting microstructures. Ag-Cu, Al-Si and Pb-Sn systems. Eutectoid, monotectic and monotectoid systems. Peritectic systems.Solidification in peritectic systems and resulting microstructures. Cu-Zn system. Peritectoid, syntectic and metatectic systems.Ordered phases. Al-Cu and Ti-Al systems. Metastability. Iron-graphite and iron-cementite phase diagrams. Rules for construction of phase diagrams for complex systems.Typical errors and necessary corrections in the construction of phase diagrams. (12 L)

**Ternary Systems**: Graphical representation of ternary phase diagrams. Isothermal and vertical sections.Ternary isomorphous systems. Computation of liquidus and solidus boundaries.Congruent minimum and congruent maximum.Ternary eutectic systems. (6 L)

**Computation of Phase Diagrams**: CALPHAD methods and computation of multi-component multi-phase equilibria and phase diagrams. (3 L)

**Experimental Determination of Phase Diagrams**: Isothermal methods. Microscopy, x-ray diffraction electrical resistivity and magnetic methods.Diffusion multiples.Non-isothermal methods.Thermal analysis anddilatometry. (6 L)

**4. READINGS**

4.1 TEXTBOOKS::

1.P. Gordon: Principles of Phase Diagrams in Materials Systems, McGraw-Hill, 1968.

2. S.P. Gupta, Phase Equilibria in Materials, Allied, 2003.

3. D.R.F. West and N. Saunders: Ternary Phase Diagrams in Materials Science, 3rd ed., Woodhead, 2002.

4. J.-C. Zhao (Ed.): Methods for Phase Diagram Determination, Elsevier, 2007.

4.2 *REFERENCE BOOKS::

1. D.A. Young: Phase Diagrams of Elements, Univ. of California, 1991.

2. H.A.J. Oonk and M.T. Calvet: Equilibrium between Phases of Matter, Springer, 2008.

3. M.H.G. Jacobs and H.A.J. Oonk: Equilibrium between Phases of Matter-Supplement, Springer, 2011.

4.F.N. Rhines: Phase Diagrams in Metallurgy, McGraw-Hill, 1956.

5. A. Prince: Alloy Phase Equilibria, Elsevier, 1966.

6. C.H.P. Lupis: Chemical Thermodynamics of Materials, North Holland, 1983.

7. M. Hillert: Phase Equilibria, Phase Diagrams and Phase Transformations, 2nd ed., Cambridge, 2007.

8.ASM Handbook Vol.3: Alloy Phase Diagrams, ASM International, 1992.

9.T.B.Massalsky (ed.): Binary Alloy Phase Diagrams, 2nd ed. (in 3 volumes), ASM International, 1990.

**5. OTHER SESSIONS**

5.1 *TUTORIALS:: NIL

5.2 *LABORATORY:: NIL

5.3 *PROJECT:: NIL

**6. ASSESSMENT** (indicative only): To be specified by the instructor concerned, at the beginning of the semester.

6.1 HA:: [xx% GRADE]

6.2 QUIZZES-HA:: [xx% GRADE]

6.3 PERIODICAL EXAMS:: [xx% GRADE]

6.4 *PROJECT:: [xx% GRADE]

6.5 FINAL EXAM:: [xx% GRADE]

**7. OUTCOME OF THE COURSE::**By understanding the thermodynamic basis of phase diagrams, students will be able to interpret phase relations in alloys and their equilibrium microstructures. Building on the course on Metallurgical Thermodynamics, this course prepares students to better appreciate the courses on Phase Transformations and Heat Treatment.

**8. *EXPECTED ENROLLMENT FOR THE COURSE::** 89

## DC.MT205.15 Transport Phenomena Practical

1. GENERAL
1.1 TITLE:: **Transport Phenomena Practical**
1.2 *COURSE NUMBER (if known):: DC.MT205.15
1.3 CREDITS:: 9, (L-T-P: 0-0-3)
1.4 SEMESTER-OFFERED:: IV
1.5 PRE-REQUISITES:: None
1.6 COURSE COMMITTEE MEMBERS:: Prof. S.Mohan (Convener) and J.K.Singh

2. OBJECTIVES:: The set of experiments provides an overview of different transport processes and the different conditions of steady and unsteady state of heat and momentum transfer pertaining to metallurgical process industries.
3. COURSE TOPICS::

1. Determination of pressure drop per unit length for increasing and decreasing flow rates in a fluidized bed operation.
2. Determination of characteristics of flow through isothermal packed bed.
3. Determination of terminal velocity of solid particles and the fluid drops.
4. Determination of volumetric flow rate, using the given orifice meter.
5. Determination of the amount of heat loss during cooling of the given ladle.
6. Determination of the response times of the given set of thermocouples.
7. Determination of the value of the convective heat transfer co-efficient during the cooling of the given metallic ingot.
8. Determination of convective heat transfer co-efficient for the case of free convection of given metallic plate.

4. OTHER SESSIONS
4.1 *TUTORIALS:: Nil
4.2 *LABORATORY::
4.3 *PROJECT:: Nil
5. ASSESSMENT (indicative only):: To be declared by the Instructor in the beginning of semester.
5.1 HA:: [xx% GRADE]
5.2 QUIZZES-HA:: [xx% GRADE] Nil
5.3 PERIODICAL EXAMS:: [xx% GRADE]
5.4 *PROJECT:: [xx% GRADE] Nil
5.5 FINAL EXAM:: [xx% GRADE]

6. OUTCOME OF THE COURSE:: It will help the students to understand different transport processes under different conditions.

7. *EXPECTED ENROLLMENT FOR THE COURSE:: 89

## DC.MT.211.15 Iron Making Technologies

1. GENERAL
1.1 TITLE:: **Iron Making Technologies**
1.2 *COURSE NUMBER (if known):: DC.MT.211.15
1.3 CREDITS:: 3-0-0- credits 9
1.4 SEMESTER-OFFERED:: IV
1.5 PRE-REQUISITES:: None

1.6 COURSE COMMITTEE MEMBERS :: Dr.OP Sinha(Convener), Prof AK Ghose, Dr G S Mahobia and Shri Gangeshwar Singh

2. OBJECTIVES:: To provide basic understanding and a feel of blast furnace process of iron making, challenges in raw material preparation, developments in iron making technologies like smelting reduction , DRI processes etc.

3. COURSE TOPICS::

**Historical Development**. **(1 L)**

Introduction to history of iron making in India and World

**Raw Materials** (**10 L)**

Iron ore types and properties: Strength, Reducibility, Swelling and Softening tests etc. Prepared Ore Feed: Pellet, sinter and Briquettes. Reductant types and properties: Role of coal & Coke, Coke reactivity index (CRI) and strength after reaction (CSR). Fluxes: Types, properties and its role.

.

**Reduction Mechanism of iron ore** **(2 L)**

Reduction of iron ore by CO, $H_2$. Thermodynamic and kinetic requirements

**Blast Furnace process of Iron Making** **(18 L)**

Construction, Refractories, charging, burden distribution, thermal and chemical profile. Reactions in shaft, bosh and hearth. Control of hot metal composition and temperature. Modern Practices: High top pressure, fuel injection (coal dust injection), oxygen enrichment, humidification and use of pre-reduced burden. Blast furnace operations, problems with remedies. Gas cleaning. Hot blast stove, Pig casting, Slag granulation Instrumentation and automation.

**Alternative Methods of Iron Making** (**8 L)**

Need and classification, Coal based rotary kiln and Gas based shaft method of DRI production. DRI storage and passivation , Principles of smelting reduction; COREX process, Scope of renewable sources of energy in Iron making and iron making industries in India.

4. READINGS

4.1 TEXTBOOKS::


1. A.K. Biswas: Principles of Blast Furnace Iron Making, SBA.
2. J.H. Straussburger (ed.): Blast Furnace - Theory & Practice. Vols 1&2, Gordon & Breach.
3. R.H. Tupkary: Introduction to Modern Iron Making, Khanna Publishers.
4. S.S. Gupta and Amit Chatterjee: Blast Furnace Iron making, SBA, New Delhi.
5. Amit Chatterjee, R. Singh and B. Pandey: Metallics for Steelmaking-Production and use, Allied Publishers.
6. H. E. McGannon (ed.): The Making, Shaping and Treating of steel, United States Steel.
7. G.R. Bashforth: The Manufacture of Iron and Steel, Vol.1, Chapman and Hall.
8. RC Gupta: Theory and laboratory experiments in ferrous metallurgy, PHI publications 2010.


5. OTHER SESSIONS

5.1 *TUTORIALS::

5.2 *LABORATORY:: As per the illustrative list of experiments

5.3 *PROJECT::

6. ASSESSMENT (indicative only)
6.1 HA:: [xx% GRADE] 10
6.2 QUIZZES-HA:: [xx% GRADE] Nil
6.3 PERIODICAL EXAMS:: [xx% GRADE] 40
6.4 *PROJECT:: [xx% GRADE] Nil
6.5 FINAL EXAM:: [xx% GRADE] 50

7. OUTCOME OF THE COURSE:: The student will learn about fundamentals of iron making technologies which are important in iron making industries. With the acquired knowledge, he/she would be able to apply them suitably in Industrial and Scientific research work.

8. *EXPECTED ENROLLMENT FOR THE COURSE::

## DC.MT221.15 Metallography Techniques

1. GENERAL
1.1 TITLE:: **Metallography Techniques**
1.2 *COURSE NUMBER (if known):: DC.MT221.15
1.3 CREDITS:: 9, (L-T-P: 3-0-0)
1.4 SEMESTER-OFFERED:: IV
1.5 PRE-REQUISITES:: None
1.6 COURSE COMMITTEE MEMBERS:: Prof. N.K. Mukhopadhyay (Convener), Prof. G.V.S. Sastry, Prof. R.K. Mandal, Dr. R. Manna and Dr. N.K. Prasad

2. OBJECTIVES:: This course aims at introducing the fundamental concepts related to optical, electron-optical and and x-ray diffraction techniques. The students are made familiar with various characterization tools and techniques for characterizing the materials in terms of microstructural, structural and chemical characterization of materials.

3. COURSE TOPICS::
**Optical Microscopy:** Resolution and magnification: Abbe's criterion & Raliegh's criterion for resolution, numerical aperture, minimum & empty magnification. Principles of simple & compound microscopes; important lens defects; types of objective & eyepiece lenses, Principles of image formation, Bright Field, Dark Field images, phase contrast & polarized light microscopy. Quantitative Metallography: ASTM grain size and its correlation with average grain diameter, methods for estimation of grain sizes and volume fraction. **(9 L)**

**Scanning Electron Microscopy and Scanning Probe Microscopy:** Construction and working principle of SEM. Resolving power, magnification, depth of field, depth of focus, image contrast, Secondary electron, back scattered mode of imaging and energy dispersive analysis of x-rays, Scanning Tunneling Microscopy (STM) & Atom Force Microscopy (AFM). Sample preparation techniques. **(6 L)**

**Transmission Electron Microscopy:** Resolving power and optimum resolution achievable, electron lenses and their defects, construction and operation of a modern transmission electron microscope, ray diagrams for bright field, dark field and selected area diffraction modes. Ewald's sphere construction, indexing of diffraction patterns, Principles of kinematical theory of image contrast of bends, thickness variations, grain boundaries, stacking faults, dislocations and coherent precipitates. Sample preparation techniques. **(12 L)**

**X-ray Diffraction :** Principles, production, and filtering of characteristic and white x-rays radiation; Bragg law for diffraction, Laue equations for diffraction, Basic principles of various diffraction techniques, Laue and powder diffraction techniques, Determination of crystal structure and indexing of the powder diffraction patterns of cubic systems, calculation of precision lattice parameter, strain and crystallite size; Structure factor calculation of cubic systems including disordered and ordered alloys. Brief discussion on integrated intensity using structure factor, multiplicity factor, Lorentz-polarization, absorption and temperature factors. **(12 L)**

4. READINGS

4.1 TEXTBOOKS::

1. R.C. Gifkins: Optical Microscopy of Metals, Pitman.
2. P.J. Grundy and G.A. Jones: Electron Microscopy in the Study of Materials, Edward Arnold.
3. D.B. Williams and C.B. Carter, Transmission Electron Microscopy, Plenum Press.
4. B.D. Cullity: Elements of x-ray Diffraction, Addison-Wesley publishing Company.
5. C.S. Suryanarayana, and M. Grant Norton, X-ray Diffraction: A Practical Approach, Springer.

4.2 *REFERENCE BOOKS::

Materials Characterization Techniques, (eds.) G. Sridhar, et al. National Metallurgical Laboratory, Jamshedpur.

R.E. Smallman and K.H.G. Ashbee: Modern Metallography, Pergamon.

ASM Handbook on Materials Characterization, Volume 9.

5. OTHER SESSIONS

5.1 *TUTORIALS:: Nil

5.2 *LABORATORY:: Nil

5.3 *PROJECT:: Nil

6. ASSESSMENT (indicative only):: To be declared by the Instructor in the beginning of semester.

6.1 HA:: [xx% GRADE]

6.2 QUIZZES-HA:: [xx% GRADE] Nil

6.3 PERIODICAL EXAMS:: [xx% GRADE] : To be declared by the Instructor in the beginning of semester.

6.4 *PROJECT:: [xx% GRADE] Nil

6.5 FINAL EXAM:: [xx% GRADE] : To be declared by the Instructor in the beginning of semester.

7. OUTCOME OF THE COURSE:: This course will enable the students to understand the various basic techniques using optical, electron and x-ray radiation through various microscopy and diffraction techniques for identification of phases and estimation of their chemical composition, microstructures and crystal structures.

8. *EXPECTED ENROLLMENT FOR THE COURSE:: 89

## DC.MT222.15 Metallography Techniques Practical

1. GENERAL

1.1 TITLE:: Metallography Techniques Practical

1.2 *COURSE NUMBER (if known):: DC.MT222.15

1.3 CREDITS:: 3, (L-T-P: 0-0-3)
1.4 SEMESTER-OFFERED:: IV
1.5 PRE-REQUISITES:: None
1.6 COURSE COMMITTEE MEMBERS :: Prof. N. K. Mukhopadhyay, Dr. R. Manna and Dr. N. K. Prasad (Convener).

2. OBJECTIVES:: This laboratory is intended to provide understanding about the microstructures of various materials produced in different conditions. This will also impart skill of preparation of samples for metallographic examinations.

3. COURSE TOPICS::
Illustrative List of Experiments (13 classes and each one of 3 hours duration)
1. Sample preparation for metallographic observation of ferrous and non-ferrous specimens.
2. Macroscopy and optical microscopy:- i) as-solidified Aluminium, Copper, Steel and Al-Si alloys (unmodified and modified) and ii) as-weld Aluminium and Steel samples.
3. Microstructural observations of various steels ($0 \leq \%C \leq 1.1$) and stainless steel
4. Microstructure of various cast irons (hypoeutectic, hypereutectic, grey, nodular and Ni-hard)
5. Observations of cold worked and hot worked samples [i) hot extruded brass, iii) cold deformed copper, iii) deformed zinc and iv) deformed LiF single crystal].
6. Observations of complex alloys and composites: i) Ti-6Al-4V alloy (Widmanstätten pattern) , ii) Babbit alloys (Pb-Sn-Sb), iii) Copper-graphite, ii) Al-$Al_2O_3$ and iii) Acetal copolymer-bronze.
7. Quantitative metallography: Estimation of i) Grain size and ii) Volume fraction.
8. Indexing and determination of crystal structure as well as lattice parameter from X-ray diffraction patterns.
9. Indexing of a) electron diffraction patterns and determination of zone axis and b) polycrystalline ring patterns.

4. READINGS
4.1 TEXTBOOKS::
1. Materials Characterization Techniques, (eds.) G. Sridhar, et al. National Metallurgical Laboratory, Jamshedpur.
2. B.D. Cullity: Elements of x-ray Diffraction, Addison-wesley.
3. R.E. Smallman and K.H.G. Ashbee: Modern Metallography, Pergamon.
4. Metallography: Principles and Practice Author: George F. Vander Voort, ASM International

4.2 *REFERENCE BOOKS::
1. ASM Handbook Volume 9: Metallography and Microstructures.

5. OTHER SESSIONS
5.1 *TUTORIALS:: Nil.
5.2 *LABORATORY:: As per the illustrative list of experiments.
5.3 *PROJECT::Nil.

6. ASSESSMENT (indicative only): To be announced by the instructor.
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE] Nil
6.3 PERIODICAL EXAMS:: [xx% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [xx% GRADE]

7. OUTCOME OF THE COURSE:: The students will be familiar with the sample preparation technique for metallographic examinations. These will enable them to understand microstructural features of samples obtained under different conditions.

8. *EXPECTED ENROLLMENT FOR THE COURSE:: 89

## IH.H 201.14 Universal Human Values 2: Self, Society and Nature

**1. GENERAL**

1.1 Title : **Universal Human Values 2 : Self, Society and Nature**

1.2 Course Number: IH.H 201.14

1.3 Credits : 1-2-0 – Credits 5

1.4 Semester offered : Even

1.5 Pre-requisites: Universal Human Values 1: Self & Family (desirable); 4-day Harmony-2 Workshop (co-requisite).

**2. OBJECTIVE**

The objective of the course is four fold:

1. Sensitization of student towards issues in society and nature.
2. Understanding (or developing clarity) of nature, society and larger systems, on the basis of human relationships and resolved individuals.
3. Strengthening of self reflection.
4. Development of commitment and courage to act.

(For elaboration on some of the above, consult course description for Universal Human Values 1: Self and Family).

**3. COURSE TOPICS**

In Universal Human Values 2 course, the focus is more on understanding society and nature on the basis of self and human relationships.

 Purpose and motivation for the course.

 Recapitulation (from the previous course) on ideas of self, pre-conditioning, and natural acceptance.

 Harmony in the self. Understanding human being as co-existence of self and body. Identifying needs and satisfying needs of self and body. Self observations. Handling peer pressure.

 Recapitulation on relationships. Nine universal values in relationships. Reflecting on relationships in family. Hostel and institute as extended family. Real life examples.

 Teacher-student relationship. Shraddha. Guidance. Goal of education.

 Harmony in nature. Four orders of nature – material order, plant order, animal order and human order. Salient features of each. Human being as cause of imbalance in nature. (Film **"Home"** can be used.)

 Human being as cause of imbalance in nature. Depletion of resources – water, food, mineral resources. Pollution. Role of technology. Mutual enrichment not just recycling.

 Prosperity arising out of material goods and understanding of self. Separation of needs of the self and needs of the body. Right utilization of resources. lkekU; vkdka{kk ,oaegRokdka{kk. Understanding the purpose they try to fulfil.

Recapitulation on society. Five major dimensions of human society. Fulfilment of the individual as major goal. Justice in society. Equality in human relationships as naturally acceptable. Establishment of society with abhaya (absence of fear).

 Ethical human conduct. Values, character and netikataa.

 Professional ethics. Conduct as an engineer or scientist.

 Holistic human being through holistic education in just order.

**4. READINGS**

**4.1 Text Book**

1. Human Values and Professional Ethics by R R Gaur, R Sangal, G P Bagaria, Excel Books, New Delhi, 2010

**4.2 Reference Books**

2 JeevanVidya: EkParichaya, ANagaraj, JeevanVidyaPrakashan, Amarkantak, 1999.
3 Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
4 The Story of Stuff (Book).
5 The Story of My Experiments with Truth - by Mohandas Karamchand Gandhi
6 On Education - J Krishnamurthy
7 Siddhartha - Hermann Hesse
8 Old Path White Clouds - ThichNhatHanh
9 On Education - The Mother
10 Diaries of Anne Frank - Anne Frank
11 Life and Philosophy of Swami Vivekananda
12 Swami Vivekananda on Himself
13 Small is Beautiful - E. F Schumacher.
14 Slow is Beautiful - Cecile Andrews
15 Economy of Permanence - J C Kumarappa
16 Bharat Mein Angreji Raj - PanditSunderlal
17 Mahatma and the Rose
18 The Poet and the Charkha
19 Rediscovering India - by Dharampal
20 Hind Swaraj or Indian Home Rule - by Mohandas K. Gandhi
21 Swaraj by Arvind Kejriwal
22 India Wins Freedom - Maulana Abdul Kalam Azad
23 Ramakrishna kijeevani - Romain Rolland (English)
24 Vivekananda - Romain Rolland (English)
25 Gandhi - Romain Rolland (English)
26 Autobiography of a Yogi – by ParamhansaYogananda
27 Gandhi and Question of Science – Sahasrabudhe

**5. OUTCOME OF THE COURSE**

At the end of the course, students are expected to become more aware of their surroundings, society, social problems and their sustainable solutions, while keeping human relationships and human nature in mind. They would have better critical ability. They would also become sensitive to their commitment towards what they believe in (humane values. humane relationships and humane society). It is hoped that they would be able to apply what they have learnt to their own self in different day-to-day settings in real life, at least a beginning would be made in this direction.

## DC.MT301.15 Modelling And Simulation In Metallurgy

**1. GENERAL**

1.1 TITLE::**Modelling And Simulation In Metallurgy**
1.2 *COURSE NUMBER (if known)::DC.MT301.15
1.3 CREDITS::6 (L-T-P::2-0-0)

1.4 SEMESTER-OFFERED::V
1.5 PRE-REQUISITES::None
1.6 COURSE COMMITTEE MEMBERS:: Prof. B. Nageswara Sarma (Convener), Prof. R.K. Mandal and Prof. Sunil Mohan.

**2. OBJECTIVES**:: This course introduces the various modelling and simulation techniques used in metallurgical engineering.

**3. COURSE TOPICS::**

**Modelling:**Classification, functions, limitations and interrelationship of different types of models. Types and development of mathematical models. Development of rigorous and semi-rigorous physical models. Multi-scale modelling of materials. Phase-field methods for modelling solidification microstructures of metals and alloys. (9 L)

**Simulation:**Survey of simulation techniques. Molecular dynamics and Monte-Carlo simulations. Fuzzy logic, neural networks and genetic algorithms. (9 L)

**Applications:** Computation of phase diagrams using solution models and Monte-Carlo simulations.Modelling of blast furnace operations, steel making processes and materials processing. (8 L)

**4. READINGS**
4.1 TEXTBOOKS::

1. J.S.Szekely, J.W. Evans and J.K. Brimakombe: The Mathematical and Physical Modelling of Primary Metals Processing Operations, Wiley.
2. D. Mazumdar and J.W. Evans: Modelling of Steel Making Processes, CRC.
3. N. Provatas and K. Elder: Phase-field Methods in Materials Science and Engineering, Wiley-VCH.
4. S. Rajasekaran, G.A.V. Pai: Neural networks, Fuzzy Logic and Genetic Algorithms-Synthesis and Applications, Prentice-Hall of India.

4.2 *REFERENCE BOOKS::
1. R.J. Arsenault, J.R. Beeler, Jr. and D.M. Esterling (Eds.): Computer Simulation in Materials Science, ASM.
2. S.H. Yip: Modelling and Simulation Handbook,
3. W.H. Press, S.A. Teukolsky, W.T. Vetterling and B.P. Flannery: Numerical Recipes - The art of scientific computing, 3rd ed., Cambridge.
4. I.M. Sibol: The Monte-Carlo method, Little Mathematics Library, Mir.

**5. OTHER SESSIONS**
5.1 *TUTORIALS:: NIL
5.2 *LABORATORY:: NIL
5.3 *PROJECT:: NIL

**6. ASSESSMENT** (indicative only): To be specified by the instructor concerned, at the beginning of the semester.
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE]
6.3 PERIODICAL EXAMS:: [xx% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [xx% GRADE]

**7. OUTCOME OF THE COURSE::**Students will appreciate the importance of modelling and simulation methodologies and their potential application in supplementing and complementing experiments for achieving a comprehensive understanding of materials behaviour.

**8. *EXPECTED ENROLLMENT FOR THE COURSE::** 89

## DC.MT302.15 Modelling And Simulation In Metallurgy Practical

**1. GENERAL**

1.1 TITLE::**Modelling And Simulation In Metallurgy Practical**
1.2 *COURSE NUMBER (if known)::DC.MT302.15
1.3 CREDITS::3 (L-T-P::0-0-3)
1.4 SEMESTER-OFFERED::V
1.5 PRE-REQUISITES::None
1.6 COURSE COMMITTEE MEMBERS:: Prof. B. Nageswara Sarma (Convener), Prof. R.K. Mandal and Prof. Sunil Mohan.

**2. OBJECTIVES**:: This course is designed to impart hands-on experience on the various modelling and simulation techniques used in metallurgical engineering.

**3. COURSE TOPICS::**

**List of experiments:**Development and execution of illustrative computer programs pertaining to the following topics.

1. Computation of phase diagrams and property diagrams.
2. Finite difference method for heat conduction and solidification.
3. Finite element method for elasto-plastic deformation.
4. Simulated annealing for finding global minimum of a function.
5. Genetic algorithms for steel making processes and optimization.
6. Artificial Neural networks for steel making processes and optimization.
7. First-principles calculation of enthalpies of elements.
8. Monte Carlo simulations.

**4. READINGS**

4.1 TEXTBOOKS::

1 J.S.Szekely, J.W. Evans and J.K. Brimakombe: The Mathematical and Physical Modelling of Primary
Metals Processing Operations, Wiley.

2 D. Mazumdar and J.W. Evans: Modelling of Steel Making Processes, CRC.

3.S. Rajasekaran, G.A.V. Pai: Neural networks, Fuzzy Logic and Genetic Algorithms-Synthesis and Applications, Prentice-Hall of India.

4.2 *REFERENCE BOOKS::

1. R.J. Arsenault, J.R. Beeler, Jr.and D.M. Esterling (Eds.): Computer Simulation in Materials Science, ASM.
2. S.H. Yip: Modelling and Simulation Handbook,
3. W.H. Press, S.A. Teukolsky, W.T. Vetterling and B.P. Flannery: Numerical Recipes - The art of scientific computing, 3rd ed., Cambridge.
4. I.M. Sibol: The Monte-Carlo method, Little Mathematics Library, Mir.

**5. OTHER SESSIONS**
5.1 *TUTORIALS:: NIL
5.2 *LABORATORY:: As per the list of experiments as above.
5.3 *PROJECT:: NIL

**6. ASSESSMENT** (indicative only): To be specified by the instructor concerned, at the beginning of the semester.
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE]
6.3 PERIODICAL EXAMS:: [xx% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [xx% GRADE]

**7. OUTCOME OF THE COURSE::**Students will acquire a hands-on training on different modelling and simulation techniques. They will realize the importance of modelling and simulation methodologies for supplementing and complementing experiments for achieving a comprehensive understanding of materials behaviour.

**8. *EXPECTED ENROLLMENT FOR THE COURSE::** 89

## DC.MT303.15 Deformation and Testing of Materials

1. GENERAL
1.1 TITLE:: **Deformation and Testing of Materials**
1.2 *COURSE NUMBER (if known):: DC.MT303.15
1.3 CREDITS:: 3-0-0- credits 9
1.4 SEMESTER-OFFERED:: V
1.5 PRE-REQUISITES:: None
1.6 COURSE COMMITTEE MEMBERS :: Prof (Mrs) N.C.Santhi Srinivas (Convener), Prof Vakil Singh, Dr K.Chattopadhyay

2. OBJECTIVES:: The course aims at introducing mechanics of deformation and fracture and their relevance to testing of materials.

3. COURSE TOPICS::
**Deformation of materials**: Introduction to elastic and plastic deformation, stress and strain. **(1 L)**

**Elastic Deformation:** Stress at a point. State of stress in two and three dimensions, principal stresses, Mohr's circle of stress. Stress tensor. Strain at a point, principal strains, Mohr's circle of strain. Hydrostatic and deviator components of stress and strain, Elastic stress-strain relationships. Plane stress and plane strain deformation. Strain energy. Generalised Hooke's law. (**8 L)**

**Plastic deformation:** Flow curves. Von-Mises and Tresca yield criteria, yield locus and yield surface. Invariants of stress and strain. Levy-Mises and Prandtl-Reuss equations. **(4 L)**

**Fracture Mechanics:** Ductile and brittle fracture. Griffith criterion of brittle fracture, Modified Griffith equation for ductile materials. Stress concentration and stress intensity factors, modes of loading. Fracture toughness and design. Plastic zone size Fracture

toughness parameters: Crack extension force G, Plane strain fracture toughness $K_{IC}$, Crack Opening Displacement COD and J integral. Significance of R curve. **(6 L)**

**Testing of Materials :** Introduction about standard testing methods such as ASTM and Indian Standards. (**1 L)**

**Hardness Testing:** Principles, merits and limitations of Brinell, Vickers and Rockwell hardness testing. Micro and nano-indentation techniques.
**(3 L)**

**Tensile Testing :** Specimen geometry. Engineering and true stress-strain curves. Evaluation of properties. Strain hardening and plastic instability. Testing machines, Strain and load measuring devices. Temperature and strain rate effects. **(7 L)**

**Impact Testing and other tests :** Notched bar and instrumented impact. Compression, torsion and bend tests. Creep and fatigue tests. Sheet formability tests. **(5 L)**

**Non-Destructive Testing:** Principles, merits, limitations and applications of dye-penetrant, magnetic particle, ultrasonic, eddy-current, radiography and acoustic emission inspection methods. **(4 L)**

4. READINGS
4.1 TEXTBOOKS::

10. GE Dieter: Mechanical Metallurgy, SI Metric Edition, McGraw-Hill Inc, UK
11. RW Herzberg: Deformation and Fracture Mechanics of Engineering Materials, Fourth Edition, John Wiley & Sons INC, USA,.

4.2 *REFERENCE BOOKS::

1. Metals Handbook, Mechanical Testing, Ninth Edition, Vol 8, ASM
2. Metal Handbook, Non Destructive Evaluation and Control, Ninth Edition, Vol 17, ASM

5. OTHER SESSIONS
5.1 *TUTORIALS::
5.2 *LABORATORY::
5.3 *PROJECT::

6. ASSESSMENT (indicative only): To be announced by the Instructor at the beginning of the semester
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE]
6.3 PERIODICAL EXAMS:: [xx% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [xx% GRADE]

7. OUTCOME OF THE COURSE:: The student will learn about fundamentals of deformation and fracture as well as different destructive and non-destructive testing methods which are important in evaluating different properties of materials . With the acquired knowledge, he/she would be able to apply these methods suitably in quality control, industrial and scientific research.

8. *EXPECTED ENROLLMENT FOR THE COURSE:: 89

# DC.MT304.15 Materials Testing Practical

1. GENERAL
1.1 TITLE:: **Materials Testing Practical**
1.2 *COURSE NUMBER (if known):: DC.MT304.15
1.3 CREDITS:: 0-0-3- credits 3
1.4 SEMESTER-OFFERED:: V
1.5 PRE-REQUISITES:: None
1.6 COURSE COMMITTEE MEMBERS :: Prof (Mrs) N.C.Santhi Srinivas (Convener), Prof Vakil Singh, Dr K.Chattopadhyay

2. OBJECTIVES:: The practical is intended to familiarize the student with different destructive and nondestructive methods of materials testing.
3. COURSE TOPICS:: List of experiments

1. Examine the variation of BHN & MHN with applied load for given samples and determine the Meyer's constants.
2. Study the variation of VHN with applied load for given specimens.
3. Evaluate Rockwell hardness of the given samples using appropriate scales.
4. Perform tensile test of the round sample and determine the following parameters: (i) modulus of elasticity (ii) 0.2% YS (iii) UTS (iv) fracture strength (v) % elongation (vi) % RA and (vii) uniform elongation. Also, draw engineering and true stress-strain curves. Determine work hardening parameters.
5. Perform tensile test of the 'flat' sample and determine the following parameters: (i) modulus of elasticity (ii) 0.2% YS (iii) UTS (iv) fracture strength (v) % elongation and (vi) uniform elongation.
   Also, draw engineering and true stress-strain curves. Determine work hardening parameters.
6. Determine the impact energy of given samples at different temperatures using Charpy impact tester and comment on the DBTT obtained.
7. Determine the impact energy of given sample by Izod testing machine compare the results obtained by direct reading and by calculation.
8. Determine the Erichsen-ductility values of given sheet specimens. Comment on the surface feature of domes.
9. Detect surface flaws and cracks present in the given samples using dye-penetrant Inspection method.
10. Detect surface /subsurface flaws and cracks present in the given samples using magnetic particle Inspection method.
11. Detect and measure depth of flaws in the given samples and determine modulus of elasticity of samples using ultrasonic flaw detection method.
12. Detect flaws and measure coating thickness and conductivity of given samples by eddy-current inspection.
13. Demonstration of (a) compression, tension and shear testing using universal testing machine (b) fatigue testing and (c) creep testing

4. READINGS
4.1 TEXTBOOKS::

12. GE Dieter: Mechanical Metallurgy, SI Metric Edition, McGraw-Hill Inc, UK, 1988
13. RW Herzberg: Deformation and Fracture Mechanics of Engineering Materials, Fourth Edition, John Wiley & Sons INC, USA,1996.

4.2 *REFERENCE BOOKS::

3. Metals Handbook, Mechanical Testing, Ninth Edition, Vol 8, ASM
4. Metal Handbook, Non Destructive Evaluation and Control, Ninth Edition, Vol 17, ASM

5. OTHER SESSIONS
5.1 *TUTORIALS::
5.2 *LABORATORY::
5.3 *PROJECT::

6. ASSESSMENT (indicative only): To be announced by the Instructor at the beginning of the semester
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE]
6.3 PERIODICAL EXAMS:: [xx% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [xx% GRADE]

7. OUTCOME OF THE COURSE:: The student will learn about different destructive and non-destructive testing methods for evaluating different properties of materials .

8. *EXPECTED ENROLLMENT FOR THE COURSE::

## DC.MT 321.15 Phase Transformations

1. GENERAL
1.1 TITLE:: **Phase Transformations**
1.2 *COURSE NUMBER (if known):: DC.MT 321.15
1.3 CREDITS:: 9, (L-T-P: 3-0-0)
1.4 SEMESTER-OFFERED:: V
1.5 PRE-REQUISITES:: None
1.6 COURSE COMMITTEE MEMBERS:: Prof. R.K. Mandal (Convener), Prof. B.N. Sarma and Dr. R. Manna

2. OBJECTIVES:: This course is designed for introducing concepts of diffusion for phase stability and applications of phase diagram for understanding various types of phase transformations that are relevant to metals and alloys.
3. COURSE TOPICS::

**Unit I: Atomic Movements:** Laws and mechanisms of diffusion, Kirkendall effect, concentration and temperature dependence of diffusion coefficient, Darken's equations, Matano method, intrinsic diffusivities, diffusion along dislocations and grain boundaries. **(7 L)**

**Unit II: Nucleation and Growth:**Homogenous and heterogeneous nucleation, Thermodynamic barrier for nucleation, nucleation rate, Structure and energy of interfaces. Strain energy and its effect on nucleation. Diffusion controlled and interface controlled growth mechanisms. (**8 L)**

**Unit III: Solidifications of Alloys:** Redistribution of solute during solidification, constitutional supercooling. Origin of cellular and dendritic structures, solidification at high undercoooling, Rapid solidification, Zone refining, Growth of single crystals. **(6 L)**

**Unit IV: Solid State Transformations:** Classification, KJMA kinetics, Precipitation reactions, Spinodal decomposition, Particle coarsening, Cellular precipitation, Eutectoidal transformation, Order-disorder transformation. Characterstics of diffusionless transformations, Crystallography and thermodynamics of martensitic transformation, Bainitic and Massive transformation. **(18 L)**

4. READINGS
4.1 TEXTBOOKS::


10. J.D. Verhoeven: Fundamentals of Physical Metallurgy, Wiley.
11. D.A. Porter and K.E. Easterling: Phase Transformations in Metals and Alloys, Chapman and Hall.
12. V. Raghavan: Solid State Phase Transformations, Prentice-Hall.
13. R.E. Reed-Hill and R. Abbaschian: Physical Metallurgy Principles, Third Edition, PWS, Boston.
14. G.A. Chadwick: Metallography of Phase Transformations, Butterworths.


4.2 *REFERENCE BOOKS::


1. J.W. Christian: The Theory of Transformations in Metals and Alloys, Part-I & II, Pergamon.
2. R.W. Cahn and P. Hassen: Physical Metallurgy, Part I & II, North-Holland Physics Publishing.


5. OTHER SESSIONS
5.1 *TUTORIALS:: Nil
5.2 *LABORATORY:: Nil
5.3 *PROJECT:: Nil

6. ASSESSMENT (indicative only):: To be declared by the Instructor in the beginning of semester.
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE] Nil
6.3 PERIODICAL EXAMS:: [xx% GRADE]
6.4 *PROJECT:: [xx% GRADE] Nil
6.5 FINAL EXAM:: [xx% GRADE]

7. OUTCOME OF THE COURSE:: The exposure of phase transformation processes will enable students to comprehend evolution of microstructures at various length scales during processing. This course will enable them to design heat-treatment and processing conditions for desired microstructures to obtain a set of properties.

8. *EXPECTED ENROLLMENT FOR THE COURSE:: 89

## DE.MT305.15 Energy and Environment in Metallurgical Industries

1. GENERAL
1.1 TITLE::**Energy and Environment in Metallurgical Industries**
1.2 *COURSE NUMBER (if known)::DE.MT305.15
1.3 CREDITS::9 (L-T-P::3-0-0)
1.4 SEMESTER-OFFERED::V
1.5 PRE-REQUISITES:: Principles of Extractive Metallurgy

1.6 COURSE COMMITTEE MEMBERS:: Prof. T.R.Mankhand (Convenor) , Dr.K.K.Singh, Dr O.P.Sinha, Dr G.S.Mahobia

**2. OBJECTIVES**: This Course Is intended to give concept of effective utilization of energy in metallurgical processes. It also provides knowledge regarding various pollutants and their methods of control in metallurgical industries.

**3. COURSE TOPICS:**

**Energy:** Energy resources: non-renewable and renewable, Indian energy resources. Use of energy in metal production, process fuel equivalent. Conservation of energy in metallurgical industries with examples of aluminium, iron & steel making. Hydrogen energy: characteristics, production, storage and utilization in metal industries.
Biomass: types of biomass, wood char as reductant in iron making. **(14 L)**

.

**Environment:** Sources and types of pollutants (wastes) from metal / minerals industries. Gaseous emissions: control of SPM, hazardous gases*, viz.* sulphur dioxide, fluorides, nitrogen oxides. Greenhouse gases: Greenhouse effect, global warming potential, Kyoto protocol, carbon trading. Emission and control from, iron & steelmaking and aluminium smelting. Liquid effluents: treatment of waste water, with examples from metal industries. Solid wastes: types, disposal and utilization of red mud and spent pot lining, iron and steel slags. Impact of pollutants on human health, management of radioactive wastes,e-waste, noise pollution, thermal pollution. **(25 L)**

**4. READINGS**

4.1 TEXTBOOKS:


1. R.C.Gupta: Energy and Environmental Managemant in Metallurgical Industries, PHI Learning
2. H.S.Ray. B.P.Singh, S.Bhattcharya, V.N.Misra,. Energy in Mineral and Metallurgical Industries, Allied Publisher
3. C.S.Rao: Environmental Pollution Control Engineering, Wiley Eastern Ltd.
4. J.A.Nathanson: Basic Environmental Technology, prentice-Hall India


*REFERENCE BOOKS:


1 R.C.Gupta(ed.): Proc. Environmental Management in Metallurgical Industries(EMMI-2000),Allied Publishers
2 R.C.Gupta(ed.): Proc. Environmental Management in Metallurgical Industries(EMMI-2010),Allied Publishers
3 FathiHabashi: Pollution Problems in Mineral and Metallurgical Industries,Metallurgie Extractive Quebec.
4 H.S.Peavy et al.: Environmental Engineering, McGraw Hill


**5. OTHER SESSIONS**

5.1 *TUTORIALS:: NIL
5.2 *LABORATORY:: NIL
5.3 *PROJECT:: NIL

**6. ASSESSMENT** (indicative only): To be specified by the instructor concerned, at the beginning of the semester.

6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE]
6.3 PERIODICAL EXAMS:: [xx% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [xx% GRADE]

**7. OUTCOME OF THE COURSE:** By studying the subject, the student will have understanding to make better use of the energy and minimisation of pollution from metallurgical processes. He can utilise this knowledge not only to make cost effective metal production processes but also save our planet from the hazards of pollution.

**8. *EXPECTED ENROLLMENT FOR THE COURSE::** 10-25

## DE.MT 311.15 Fuels and Refractories

**1. GENERAL**

1.1 TITLE:: **Fuels and Refractories**
1.2 *COURSE NUMBER (if known):: DE.MT 311.15
1.3 CREDITS::9 (L-T-P::3-0-0)
1.4 SEMESTER-OFFERED::V
1.5 PRE-REQUISITES: Iron and steel making
1.6 COURSE COMMITTEE MEMBERS:: Dr.I Chakravarty (Convener), Dr.OP Sinha, Dr.KK Singh, and Dr.JK Singh.

**2. OBJECTIVES**:: This course is intended to elucidate the use of fuels and refractories in the field of metallurgy.

**3. COURSE TOPICS::**

**Fuels :** Classification of fuels, their merits and limitations. (2 L)

**Solid Fuels:** Origin of coal, types, properties, proximate and ultimate analysis, storage and reserves in India. Coal washing, preparation and blending methods. Applications of coal. Coke making by beehive and by-product ovens. Modern practices of coke making. Principles of graphitisation and reactivity. Characterization of coal and coke. (9 L)

Selection of reductant /fuel for Blast Furnace, DRI, COREX, Cupola and Pit Furnace. **(**15 L)

**Liquid and Gaseous Fuels:** Types and uses of liquid and gaseous fuels. Flame characteristics. Burners for liquid, gas and pulverized coal. Synthesis and reformation of gas for direct reduction, Producer gas and Water gas. (6 L)

**Refractories:** Classification of refractories. Properties and applications of Fireclay, Silica, Chromite, Carbon/Graphite, Magnesite, Dolomite, Zirconia, Silicon Carbide, Sillimanite, Kyanite refractories. (6 L)

**Selection of Refractories**: Blast Furnace, LD Converter, Electric Arc Furnace. (1 L)

**4. READINGS**

4.1 TEXTBOOKS::

1. O.P. Gupta: Elements of Fuels, Furnaces and Refractories, Khanna Publishers (Delhi).
2. Efficient Use of Fuel, HMSO (London).
3. J.D. Gilchrist: Fuels, Furnaces and Refractories, Pergamon.
4. RC Gupta : Theory and laboratory experiments in ferrous metallurgy,PHI, New Delhi,2010

4.2 *REFERENCE BOOKS::

1. D.N. Nandi: Handbook of Refractories, Tata McGraw-Hill.
2. J.H. Chestors: Steel Plant Refractories; United Steel Companies, Sheffield.
3. F.H. Norton: Refractories, McGraw-Hill.

**5. OTHER SESSIONS**
5.1 *TUTORIALS:: NIL
5.2 *LABORATORY:: NIL
5.3 *PROJECT:: NIL

**6. ASSESSMENT** (indicative only): To be specified by the instructor concerned, at the beginning of the semester.
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE]
6.3 PERIODICAL EXAMS:: [xx% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [xx% GRADE]

**7. OUTCOME OF THE COURSE::**By understanding the fuels and refractories, students will be able to apply them suitably in the field of iron and steel making.

**8. *EXPECTED ENROLLMENT FOR THE COURSE::** 89

## DE.MT322.15 Instrumental Analysis

**1. GENERAL**
1.1 TITLE::**Instrumental Analysis**
1.2 *COURSE NUMBER (if known)::DE.MT322.15
1.3 CREDITS::9 (L-T-P::3-0-0)
1.4 SEMESTER-OFFERED::V
1.5 PRE-REQUISITES::None
1.6 COURSE COMMITTEE MEMBERS:: **Dr. I.Chakrabarty (Convener)**, Prof. N.K. Mukhopadhyay, Dr.C.K. Behera, Prof. T.R. Mankhand, Dr. K.K. Singh, Dr. O.P. Sinha.

**2. OBJECTIVES**:: To impart knowledge of qualitative and quantitative instrumental methods of chemical analysis of metallic and mineral substances.

**3. COURSE TOPICS::**

**X-ray and Electron Analytical Methods (19 L)**
X-ray fluorescence analysis (XRF), X-ray absorption analysis (XAS), Electron probe microanalysis (EPMA), Energy dispersive spectroscopy (EDS), Wavelength dispersive spectroscopy (WDS), Electron energy loss spectroscopy (EELS), Secondary ion mass spectroscopy (SIMS), Auger electron spectroscopy (AES), X-ray photoelectron spectroscopy, Raman spectroscopy.

**Physico-chemical Methods (20 L)**
Spectrochemical Analysis: Atomic emission spectrography. Atomic absorption spectrography. Spectrophotometers and colorimeters.
Electro-analytical Techniques: Polarography, Electrogravimetry, Conductometry and Potentiometry.
Chromatographic Analysis: Gas chromatography.

Determination of non-metals by combustion and vacuum fusion analysis.

**4. READINGS**

4.1 TEXTBOOKS::

1. L.E. Murr: Electron and Ion Microscopy and Microanalysis - Principles and Applications, Marcel Dekker.
2. C.R. Brundle and A.D. Baker: Electron Spectroscopy, Vol.l-3, Academic.
3. D.A.Skoog et al.: Principles of Instrumental Analysis, Brooks Cole
4. H.H. Willard et.al.: Instrumental Methods of Analysis, CBS.

4.2 *REFERENCE BOOKS::

1. B.K.Sharma: Instrumental Methods of Chemical Analysis, Goel.
2. Materials Characterization Techniques, (eds.) G. Sridhar et.al. NML, Jamshedpur.
3. A.I. Vogel: Text book of Quantitative Inorganic Analysis, ELBS Longman.

**5. OTHER SESSIONS**

5.1 *TUTORIALS:: NIL
5.2 *LABORATORY:: NIL
5.3 *PROJECT:: NIL

**6. ASSESSMENT** (indicative only): To be specified by the instructor concerned, at the beginning of the semester.

6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE]
6.3 PERIODICAL EXAMS:: [xx% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [xx% GRADE]

**7. OUTCOME OF THE COURSE::**Students will learn about the common methods of bulk and surface analysis and how to select the best instrumental method given a particular measurement need.

**8. *EXPECTED ENROLLMENT FOR THE COURSE::** 89

## OE.MT306.15 Nuclear Metallurgy

**1. GENERAL**

1.1 TITLE::**Nuclear Metallurgy**
1.2 *COURSE NUMBER (if known)::OE.MT306.15
1.3 CREDITS::9 (L-T-P::3-0-0)
1.4 SEMESTER-OFFERED::V
1.5 PRE-REQUISITES::Principles of Extractive Metallurgy
1.6 COURSE COMMITTEE MEMBERS::Prof. T.R.Mankhand (Convenor) and Prof. R.K.Mandal.

**2. OBJECTIVES**: This course is intended to give the concept of nuclear physics, nuclear reactor and its materials. It will also help to understand the effect of radiation on materials, safe disposal of nuclear waste and extraction of nuclear fuel and related materials.

**3. COURSE TOPICS:**

**Nuclear Structure** **(**7 L)

Structure of the nucleus, binding energy, fission reactions, neutron cross sections, moderation of neutrons, multiplication factor.Fusion reactions.

**Reactors and Materials** **(**11 L)
Classification of nuclear reactors.Materials for nuclear reactors viz., fuels, moderators, control rods, coolants, reflectors and structural materials.Fabrication of fuel and cladding materials.

**Radiation Effects** **(**6 L)
Interaction of radiation with materials. Radiation hazards, safety and shielding. Uses of radioactive isotopes.Disposal of radioactive wastes.

**Production of Nuclear Grade Materials** **(**12 L)
Atomic minerals, their occurrence in India, general methods of their processing.Production metallurgy of nuclear grade uranium, thorium, beryllium and zirconium.Production of enriched uranium.Processing of spent fuel and extraction of plutonium.

**Indian Reactors and Nuclear Energy Programme in India** **(**3 L)

**4. READINGS**
4.1 TEXTBOOKS:

2. R. Stephenson: Introduction to Nuclear Engineering, McGraw-Hill.
3. S. Glasstone and A. Sesonke: Nuclear Reactor Engineering, Van Nostrand.
3. A.N. Zelikman, O.E. Krein and G.W. Samsonov: Metallurgy of Rare Metals, Israel Programme of Scientific Translation.
4. H.S.Ray, R.Sridhar and K.P.Abraham: Extraction of Non-Ferrous Metals, Affiliated East-West Press.

*REFERENCE BOOKS:

5 C.D. Harrington and A.E. Ruehle (eds.): Uranium Production Technology, Van Nostrand.
6 A.R. Cooper: Chemical Processing in the Atomic Energy Industry, Iliffe.
7 K.LingaMurty and IndrajitCharit, Introduction to Nuclear Materials: Fundamentals and Applications.
8T.J. Connolly: Foundation of Nuclear Engineering, Wiley

**5. OTHER SESSIONS**
5.1 *TUTORIALS:: NIL
5.2 *LABORATORY:: NIL
5.3 *PROJECT:: NIL
**6. ASSESSMENT** (indicative only): To be specified by the instructor concerned, at the beginning of the semester.
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE]
6.3 PERIODICAL EXAMS:: [xx% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [xx% GRADE]
**7. OUTCOME OF THE COURSE:** By gaining knowledge of nuclear physics, nuclear materials, its materials and their extraction processes, the students will have better have prospects of working under the nuclear science and technology programme of India.
**8. *EXPECTED ENROLLMENT FOR THE COURSE::**10-25

# DC.MT 307.15 Heat Treatment

1. GENERAL
1.1 TITLE:: **Heat Treatment**
1.2 *COURSE NUMBER (if known):: DC.MT 307.15
1.3 CREDITS:: 6, (L-T-P: 2-0-0)
1.4 SEMESTER-OFFERED:: VI
1.5 PRE-REQUISITES:: None
1.6 COURSE COMMITTEE MEMBERS :: Prof S. N. Ojha, Dr. R. Manna (Convener), Dr. N. K. Prasad

2. OBJECTIVES:: Metals and alloys are subjected to different kinds of heat treatment processes to develop appropriate microstructure with desired set of properties. Hence a thorough understanding of fundamentals of microstructural developments by different heat treatment processes is necessary for structure-property correlations. The syllabus is designed to meet both the requirements.

3. COURSE TOPICS::

**Fundamentals**. **(7 L)**

Iron-carbon equilibrium diagram, Isothermal transformation diagrams, continuous cooling transformation diagram. Austenisation and austenite grain size. Hardenability, its measurement and control.

**Heat Treatment of ferrous alloys** (**12 L)**

Homogenisation, quenching and quenching media, annealing, normalizing, hardening and tempering of steels. Case hardening treatments-case carburizing and post carburizing heat treatment, nitriding, carbonitriding, boronising, chromising, Toyota diffusion processes.Surface hardening treatments-induction hardening, flame hardening, laser hardening and electron beam hardening processes.

**Heat treatment of nonferrous alloys** **(7 L)**

Recrystallisation annealing of cold worked metals, age hardening. Temper designations for aluminum and magnesium alloys. Heat treatment of aluminium, copper, magnesium, titanium and nickel alloys.

4. READINGS
4.1 TEXTBOOKS::


1. R.E. Reed-Hill and R. Abbaschian: Physical Metallurgy Principles, PWS Publishing Company, Boston, Third Edition.
2. Vijendra Singh: Heat treatment of Metals, Standard Publishers Distributors, Delhi.
3. R.C. Sharma: Principles of Heat Treatment of Steels, New Age International (P) Ltd. Publisher.
4. G. Krauss.: Principles of Heat Treatment of steel, ASM, 1980
5. Yu. M. Lakhtin: Engineering Physical Metallurgy and Heat Treatment, Mir publisher, 1979.


4.2 *REFERENCE BOOKS::


5. Anil Kumar Sinha: Physical Metallurgy Handbook, McGraw-Hill Publication, 2003
6. R.W.K. Honeycomb and H.K.D.H. Bhadeshia, Steels: Microstructure and Properties, 3rd Edition, Butterworth-Heinemann, 2006.

7. Metals Handbook, Heat Treatment, Ninth Edition, Vol 4, ASM

5. OTHER SESSIONS
5.1 *TUTORIALS::
5.2 *LABORATORY::
5.3 *PROJECT::

6. ASSESSMENT (will be announced by instructor)
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE] Nil
6.3 PERIODICAL EXAMS:: [xx% GRADE]
6.4 *PROJECT:: [xx% GRADE] Nil
6.5 FINAL EXAM:: [xx% GRADE]

7. OUTCOME OF THE COURSE:: The student will learn about the fundamentals of microstructural modification of metals and alloys through heat treatment processes. Students would be able to correlate heat treatment processes to microstructure and properties and apply them suitably in industrial practice and scientific research.

8. *EXPECTED ENROLLMENT FOR THE COURSE:: 89

## DC.MT308.15 Heat Treatment Practical

1. GENERAL
1.1 TITLE:: **Heat Treatment Practical**
1.2 *COURSE NUMBER (if known):: DC.MT308.15
1.3 CREDITS:: 3, (L-T-P: 0-0-3)
1.4 SEMESTER-OFFERED:: VI
1.5 PRE-REQUISITES:: None
1.6 COURSE COMMITTEE MEMBERS :: Prof S. N. Ojha, Dr. R. Manna (Convener), Dr. N. K. Prasad

2. OBJECTIVES:: Metals and alloys are subjected to different kinds of heat treatment processes to develop appropriate microstructure to get desired set of properties. The syllabus is designed to get hand on experience of heat treatment processes in laboratory.
3. COURSE TOPICS::

. **Illustrative list of experiments (13 classes of 3 hours duration)**

1. Influence of cooling rate on the microstructure and hardness of plain carbon steels.
2. Effect of temperature on austenite grain size.
3. Tempering characteristics of plain carbon steels.
4. Jominy end-quench test to determine hardenability.
5. Surface hardening of plain carbon steel.
6. Isothermal transformation characteristics of an alloy steel.
7. Recrystallisation annealing of cold worked metal
8. Heat treatment of high speed steels.
9. Heat treatment of cast irons.
10. Age hardening of aluminium alloys.
11. Heat treatment of copper alloys.
12. Heat treatment of titanium alloys.

4. READINGS
4.1 TEXTBOOKS::

1. Vijendra Singh: Heat treatment of Metals, Standard Publishers Distributors, Delhi.
2. A. R. Bailey and L E Samuels, Annotated Metallographic Specimens, Foundry Metallography, Metallurgical Services Laboratory Ltd, 1976
3. A. R. Bailey , Annotated Metallographic Specimens, The Structure and Strength of Metals, Foundry Metallography, Metallurgical Services Laboratory Ltd, 1967

4.2 *REFERENCE BOOKS::

8. M Atkins: Atlas of continuous cooling transformation diagram, ASM international, 1980
9. Metals Handbook, Heat Treatment, Ninth Edition, Vol 4, ASM
10. Metals Handbook, Metallography and Microstructures, Ninth Edition, Vol 9, ASM

5. OTHER SESSIONS
5.1 *TUTORIALS::
5.2 *LABORATORY:: As per the illustrative list of experiments
5.3 *PROJECT::
6. ASSESSMENT (will be announced by instructor)
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE] Nil
6.3 PERIODICAL EXAMS:: [xx% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [xx% GRADE]

7. OUTCOME OF THE COURSE:: The student will learn about the fundamentals of microstructural modification of metals and alloys through heat treatment practices. With the acquired knowledge, he/she would be able to correlate heat treatment processes to microstructure and properties and apply them suitably.

8. *EXPECTED ENROLLMENT FOR THE COURSE:: 89

## DC.MT323.15 Mechanical Behaviour of Materials

1. GENERAL
1.1 TITLE:: **Mechanical Behaviour of Materials**
1.2 *COURSE NUMBER (if known):: DC.MT323.15
1.3 CREDITS:: 3-0-0- credits 9
1.4 SEMESTER-OFFERED:: VI
1.5 PRE-REQUISITES:: None
1.6 COURSE COMMITTEE MEMBERS :: Prof (Mrs) N.C.Santhi Srinivas (Convener), Prof Vakil Singh, Dr K. Chattopadhyay,

2. OBJECTIVES::. The subject aims at explaining response of materials to different kinds of stresses, temperature and environment. The syllabus is focussed on explaining the theory of dislocations and different strengthening mechanisms of materials based on dislocation theory.

3. COURSE TOPICS::
**Modes of Plastic Deformation** **(5 L)**

Mechanisms of slip and twinning, Concept of critical resolved shear stress. Deformation of single crystals and poly crystals.

**Dislocation Theory** **(6 L)**

Types of dislocations, their elastic propertis. Observation, movement and multiplication of dislocations. Dislocation intersection and reactions. Partial dislocations. Glide and climb.

**Strengthening Mechanisms** **(10 L)**

Grain boundary, solid solution and martensite strengthening, Precipitation and dispersion hardening. Yield point, strain ageing and work hardening.

**Creep** **(9 L)**

Generation and analysis of creep and creep-rupture data. Dislocation and diffusion mechanisms of creep. Grain boundary sliding and migration. Deformation mechanism maps. Effect of metallurgical and test variables on creep and fracture. Super plasticity. Parametric methods for prediction of long time properties. Creep fracture.

**Fatigue** **(9 L)**

Stress cycles, Effect of mean stress on fatigue. High cycle and low cycle fatigue. Analysis of cyclic stress-strain data. Mechanisms of fatigue crack nucleation and propagation. Effect of metallurgical variables on fatigue. Corrosion fatigue. Fatigue fracture.

4. READINGS

4.1 TEXTBOOKS::


14. GE Dieter: Mechanical Metallurgy, SI Metric Edition, McGraw-Hill Inc, UK,
15. M.N Shetty: Dislocations and Mechanical Behaviour of Materials, PHI, India
16. Thomas H. Courtney : Mechanical Behaviour of Materials, Second edition, Press India Pvt.ltd.


4.2 *REFERENCE BOOKS::


11. RW Herzberg: Deformation and Fracture Mechanics of Engineering Materials, Fourth Edition, John Wiley & Sons INC, USA
12. R.W.K. Honeycombe: The Plastic Deformation of Metals, Edward Arnold
13. D.Hull: Introduction to Dislocations, Pergamon.
14. F. Garofalo: Fundamentals of Creep and Creep Rupture in Metals, MacMillan.
15. M.A. Meyers and K.K. Chawla: Mechanical Behaviour of Materials, Prentice Hall.


5. OTHER SESSIONS

5.1 *TUTORIALS::

5.2 *LABORATORY::

5.3 *PROJECT::

6. ASSESSMENT (indicative only) : To be announced by the Instructor at the beginning of the semester

6.1 HA:: [xx% GRADE]

6.2 QUIZZES-HA:: [xx% GRADE]

6.3 PERIODICAL EXAMS:: [xx% GRADE]

6.4 *PROJECT:: [xx% GRADE]

6.5 FINAL EXAM:: [xx% GRADE]

7. OUTCOME OF THE COURSE:: The students will understand the behavior of materials under different types of loading and apply the knowledge forn selection of materials for intended applications.

8. *EXPECTED ENROLLMENT FOR THE COURSE:: 89

## DE.MT309.15 Advanced Processing Technologies

**1. GENERAL**

1.1 TITLE::**Advanced Processing Technologies**
1.2 *COURSE NUMBER (if known):: DE.MT309.15
1.3 CREDITS::9 (L-T-P::3-0-0)
1.4 SEMESTER-OFFERED::VI
1.5 PRE-REQUISITES::None
1.6 COURSE COMMITTEE MEMBERS:: Dr. N. K. Prasad (Convener), Prof. R.K. Mandal and Prof. S. N. Ojha

**2. OBJECTIVES**:: This course is intended to explain principles and technologies for the processing techniques for the materials which are used for advanced applications.

**3. COURSE TOPICS::**

**Principles** (8 L)
Synthesis of novel microstructures. Solidification under local equilibrium, metastable phase selection, departures from local interfacial equilibrium. Thermal history and solute redistribution. Directional solidification. Metal foaming.

**Rapid Solidification** (16 L)
Splat quenching, melt spinning and planar flow casting techniques. Ideal and Newtonian cooling, estimation of cooling rate. Atomization and spray forming, undercooling techniques of materials synthesis. Stability of metastable microstructures. Consolidation of rapidly solidified materials: Hot pressing, hot extrusion and hot isostatic pressing. Structure, properties and applications of thermoplastics and thermosets. Conducting and biopolymers.

**Nanomaterials Processing** (15 L)
Vapour condensation, sol-gel, mechanical alloying, chemical processing, biomimetic processing, laser cladding, thermal and plasma spray coating techniques. Processes involving severe plastic deformation.

**4. READINGS**

4.1 TEXTBOOKS::

1. M.C. Flemings: Solidification Processing, McGraw-Hill.
2. T.R. Anantharaman and C. Suryanarayana (eds.): Rapid Solidification: Technology, Trans Tech.
3. V.S. Arunachalam and O.V. Raman (eds.): Powder Metallurgy- Recent Advances, Oxford and IBM.
4. P. Rama Rao: Advances in Materials and Their Applications, Wiley Eastern.

4.2 *REFERENCE BOOKS::

1. M. Cohen, B.H. Kear and R. Mehrabian (eds.): Rapid solidification Processing-Principles and Technologies, Vols 1 &2, Claitors.

**5. OTHER SESSIONS**
5.1 *TUTORIALS:: NIL
5.2 *LABORATORY:: NIL
5.3 *PROJECT:: NIL

**6. ASSESSMENT** (indicative only): To be specified by the instructor concerned, at the beginning of the semester.
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE]
6.3 PERIODICAL EXAMS:: [xx% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [xx% GRADE]

**7. OUTCOME OF THE COURSE::**The understanding of the principles and processing techniques will help the students to analyze the behaviour of such materials.

**8. *EXPECTED ENROLLMENT FOR THE COURSE::** 50

## DE.MT 312.15 Alternative routes of iron and steel making

1. GENERAL
1.1 TITLE::**Alternative routes of iron and steel making**
1.2 *COURSE NUMBER (if known)::DE.MT 312.15
1.3 CREDITS::9 (L-T-P::3-0-0)
1.4 SEMESTER-OFFERED::VI
1.5 PRE-REQUISITES:Iron and steel Making
1.6 COURSE COMMITTEE MEMBERS:: Dr OP Sinha (Convener), Shri G Singh, Dr KK Singh, and Dr.I Chakravarty.

**2. OBJECTIVES**:: This course is intended to elucidate the alternative routes of iron and steel making.

**3. COURSE TOPICS::**

**Introduction:** Need for the development of alternative routes, approaches towards new techniques. Classification of processes. (2 L)

**Principles:** Thermodynamic and kinetic aspects of iron ore reduction in solid and liquid state using solid/gaseous reductants. (4 L)

**Methods :** Sponge iron production using shaft, kiln, retort and rotary hearth reactors. Raw materials preparation. Selection of reductants. Heat and mass transfer. Energy consumption and operating problems. Storage, transportation and utilization of sponge iron in India. (17 L)

**Pre-Reduced Pellets and Powders:** Pre-reduced iron ore pellets for blast furnace applications, concept of composite pellets and its feasibility. Iron powder and iron carbide preparation from fluidised bed reactor and other processes. Operating/storage problems. (8 L)

**Smelting-Reduction Processes :** Principles, classification, merits and limitations. COREX process and electric smelting processes. (4 L)

**Steel Making :** Continuous and direct steel making. (4 L)

**4. READINGS**

4.1 TEXTBOOKS::

1. L.Von Bogdandy and H.J. Engell: Reduction of Iron Ores, Springer.
2. R.R. Rogers (ed.): Proc. of Symp. Iron Ore Reduction, Pergamon.
3. A Chatterjee: Sponge iron production by direct reduction of iron oxide,PHI,New Delhi,2010
4. A Chatterjee:hot metal production by smelting reduction of iron oxide, PHI,New Delhi,2010
5. RH Tupkary : Modern iron making,Khanna publishers, New delhi

4.2 *REFERENCE BOOKS::

1. Proc. of Int. Conf. on Alternative Routes to Iron & Steel under Indian Conditions, IIM Jamshedpur 1988.
2. A. Chatterjee, R. Singh and B. Pandey: Metallics for Steelmaking-Production and Use, Allied Publisher.

**5. OTHER SESSIONS**

5.1 *TUTORIALS:: NIL
5.2 *LABORATORY:: NIL
5.3 *PROJECT:: NIL

**6. ASSESSMENT** (indicative only): To be specified by the instructor concerned, at the beginning of the semester.

6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE]
6.3 PERIODICAL EXAMS:: [xx% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [xx% GRADE]

**7. OUTCOME OF THE COURSE::**By understanding the alternative routes of iron and steel making, students will be able to learn and apply them suitably.

**8. *EXPECTED ENROLLMENT FOR THE COURSE::** 89

## DE.MT 324.15 Electronic And Magnetic Materials

1. GENERAL

1.1 TITLE:: **Electronic And Magnetic Materials**
1.2 *COURSE NUMBER (if known):: DE.MT 324.15
1.3 CREDITS:: 9, (L-T-P: 3-0-0)
1.4 SEMESTER-OFFERED:: VI
1.5 PRE-REQUISITES:: None
1.6 COURSE COMMITTEE MEMBERS:: Prof. N.K. Mukhopadhyay (Convener), Prof. R.K. Mandal and Dr. N.K. Prasad

2. OBJECTIVES:: The objective of the course is to familiarize the students with various concepts related to electronic and magnetic properties and their exploitation to develop the useful materials based on the structure, chemistry and the processing techniques.

3. COURSE TOPICS::

**Electronic Materials :** Review of electron conduction in solids. Conductors, semiconductors and insulators. Hall effect. Temperature dependence of electrical conductivity. Thermal conductivity. Thermoelectric properties. **(6 L)**

Semiconductor materials, direct and indirect band gap semiconductors. Semiconductor devices. Amorphous semiconductors and their applications. Opto-electronic and photonic materials. **(6 L)**

Ionic conductivity, superconductivity, superconducting materials and their applications. Dielectric, piezoelectric and ferroelectric materials: Applications in transducers and sensors. **(6 L)**

**Magnetic Materials**
Introduction of magnetic properties and their origin based on Hund's rule. Classification of magnetic materials. Magnetic moments and domains. Concept of Hysterisis loop. **(6 L)**

Soft magnetic materials: Fe-Si alloys with reference to transformer core, CRGO steel, permalloy, uperpermalloy and amorphous magnetic alloys, ferrites (inverse spinel), maghemites, garnets, and superparamagnetic aterials. Various applications soft magnetic materials. **(6 L)**

Hard magnetic materials: Magnetic anisotropy, ALNI and ALNICO, barium hexaferrites and other hard magnetic materials. Applications hard magnetic materials. **(6 L)**

Magnetic bubbles, rectangular loop ferrites, magnetostriction. giant and colossal magneto resistance materials. **(3 L)**

4. READINGS (Neither a necessary nor a sufficient requirement)

4.1 TEXTBOOKS::

1. L.I. Azaroff: Magnetic Materials
2. R.E. Hummel: Electronic Properties of Materials, Springer

4.2 *REFERENCE BOOKS::

1. L. Solymar and D. Walsh: Lectures in the Electronic Properties of Materials, Oxford University Press
2. V. Raghavan: Materials Science and Engineering, Prentice-Hall of India.
3. M.C. Lovell, A.J. Avery and M.W. Vernon: Physical Properties of Materials, ELBS.
4. S.O. Kasap: Principles of Electronic Materials and Devices, Tata McGraw-Hill

5. OTHER SESSIONS
5.1 *TUTORIALS:: Nil
5.2 *LABORATORY:: Nil
5.3 *PROJECT:: Nil

6. ASSESSMENT (indicative only):: To be declared by the Instructor in the beginning of semester.
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE] Nil
6.3 PERIODICAL EXAMS:: [xx% GRADE]
6.4 *PROJECT:: [xx% GRADE] Nil
6.5 FINAL EXAM:: [xx% GRADE]

7. OUTCOME OF THE COURSE:: The students will learn related concepts on electronic and Magnetic behavior of materials. They will develop understanding on the various materials that are being used and also in developing stage.

8. *EXPECTED ENROLLMENT FOR THE COURSE:: 89

## OE.MT361.15 Composite Materials

1. General
1.1 TITLE:: **Composite Materials**
1.2 *COURSE NUMBER::OE.MT361.15
1.3 CREDITS:: 9 (L-T-P::3-0-0)
1.4 *SEMESTER -OFFERED:: VI
1.5 PRE-REQUISITES::
1.6 COURSE COMMITTEE MEMBERS:: Prof. S.Mohan (Convener), Dr.J.K.Singh

2. OBJECTIVE::This course has been designed to cater to the need for understanding of new materials.

3. COURSE CONTANT [GIVE TOPICS WITH NUMBER OF LECTURES FOR EACH TOPIC]

Introduction (2 L)
Constituent for composites; reinforcements and matrices; strengthening mechanisms.

Reinforcements (5 L)
Types of reinforcements; production techniques of reinforcements and properties.

Matrices (2 L)
Types of matrices; properties; general considerations for use.

Organic-Matrix Composites (6 L)
Matrices and reinforcements; processing routes: Hand lay-up, spray forming, stir casting, filament winding, pultrusion, resin transfer moulding, injection moulding, sheet moulding compound; mechanical and tribological properties.

Metal-Matrix Composites (10 L)
Matrices and reinforcements; processing routes: Liquid state processing, solid state processing, insitu routes such as direct melt reaction; mechanical and tribological properties.

Ceramic-Matrix Composites (6 L)
Matrices and reinforcements; processing routes: cold pressing and sintering, hot pressing, reaction bonding, infiltration, lanxide, insitu method, sol-gel; mechanical and tribological properties.

Applications (8 L)
Automotive, space, aerospace, sports, thermal management, electronics packaging, high temperature, marine and structural

4. READINGS
4.1 TEXTBOOK::K.K. Chawla,: Composite Materials, Springer.

4.2 *REFERENCE BOOKS::
P.K. Mallick,: Fiber-Reinforced Composites, Marcel Dekker, Inc., New York.
K.K. Chawla,: Ceramic Matrix Composites, Chapman & Hall, London, 2003.
M.M. Schwartz: Composite Materials Handbook, McGraw-Hill Book company, New York.

5. OTHER SESSION
5.1 *TUTORIALS::
5.2 *LABORATORY::
5.3 *PROJECT::

6. *ASSESSEMENT:: [DO NOT FILL NOW]
6.1 HA::
6.2 QUIZZES-HA::
6.3 PERIODICAL EXAMINATION::
6.4 PROJECT/LAB::
6.5 FINAL EXAM::

7. OUTCOME OF THE COURSE::

8. *EXPECTED ENROLLEMENT IN THE COURSE::

## DC.MT401.15 Nonferrous Extractive Metallurgy

1. GENERAL
1.1 TITLE:: **Nonferrous Extractive Metallurgy**
1.2 *COURSE NUMBER (if known):: DC.MT401.15
1.3 CREDITS:: 6, (L-T-P), (2-0-0)
1.4 SEMESTER-OFFERED:: VII
1.5 PRE-REQUISITES:: None
1.6 COURSE COMMITTEE MEMBERS :: Dr. K. K. Singh (Convener), Dr. C. K. Behera, and Prof. T. R. Mankhand,

2. OBJECTIVES:: To elucidate the concepts of production of some of common non-ferrous metals by conventional routes to bring about the challenges associated with production of metals in an energy efficient and environment friendly manner.

3. COURSE TOPICS::
**Aluminium:** Bayer process, its chemistry and practice. Hall-Heroult process: carbon anodes, theoretical principles, factors influencing the process, current and energy efficiencies. (6 L)

**Copper:** Roasting, matte smelting, converting, fire-refining and electro-refining, .Ausmelt / Isasmelt process, Hydrometallurgy of copper. **Zinc:** Pyrometallurgy, sinter-roasting and Imperial smelting process. Hydrometallurgical extraction: roasting, leaching and electro-winning. **Lead:** Blast furnace smelting, refining of lead bullion.

(10 **L)**

**Titanium:U**p-gradation of ilmenite and Kroll process. **Uranium:** Acid and alkali processes for digestion of uranium ores. Production of reactor grade uranium and $UO_2$. **Gold:** Cyanidation process. Carbon-in pulp process.
Other important metals such as nickel and magnesium, major non-ferrous metal production in India**.** **(**10 L)

4. READINGS
4.1 TEXTBOOKS::
1. K. Grjortheim and B.J. Welch: Aluminium Smelter Technology, Aluminium-Verlag.
2. A.K.Biswas and W.G. Davenport: Extractive Metallurgy of Copper, Pergamon.
3. S.W.K Morgaon: Zinc and its Alloy, Mac Donald and Evans.
4. H.S.Ray, R. Sridhar and K.P. Abraham: Extraction of Non-Ferrous Metals, Affiliated East – West.

4.2 *REFERENCE BOOKS::
1. A.R. Burkin (ed.) : Production of Aluminium and Alumina Wiley.
2. A.R. Burkin (ed.): Extractive Metallurgy of Nickel, Wiley.
3. C.D.Harrington and AE. Reuhle: Uranium Production Technology, Van Naostrand.
4. N. Sevryukov, B. Kuzumin and Y. Chelishchev: General Metallurgy, Mir.
5. Fathi Habashi; Principles of Extractive metallurgy, vol 1, 2, 3 and 4; Gordon and Breach

5. OTHER SESSIONS
5.1 *TUTORIALS::
5.2 *LABORATORY::
5.3 *PROJECT::
6. ASSESSMENT: To be announce by instructor.
6.1 HA:: [xx% GRADE] 20
6.2 QUIZZES-HA:: [xx% GRADE] Nil
6.3 PERIODICAL EXAMS:: [xx% GRADE] 30
6.4 *PROJECT:: [xx% GRADE] Nil
6.5 FINAL EXAM:: [xx% GRADE] 50
7. OUTCOME OF THE COURSE:: Students will be able to understand fundamentals of production of non-ferrous metals.

8. *EXPECTED ENROLLMENT FOR THE COURSE:: 89

## DC.MT411.15 Materials Processing Technologies

1. GENERAL
1.1 TITLE:: Materials Processing Technologies
1.2 *COURSE NUMBER (if known):: DC.MT411.15
1.3 CREDITS:: 9, (L-T-P:3-0-0)
1.4 SEMESTER-OFFERED:: VII
1.5 PRE-REQUISITES:: None
1.6 COURSE COMMITTEE MEMBERS :: Prof. S.N.Ojha, Prof. N.C.ShanthiSrinivas, Sri J.K.Singh and Dr. I.Chakrabarty(Convener).

2. OBJECTIVES::To impart knowledge of fundamentals of common fabrication processes, mechanical and metallurgical design aspects and defect controlling measures for production of useful metal shapes.

3. COURSE TOPICS::
**Metal Casting Processes** **(9 L)**
Conventional, modern and emerging casting processes.Macro- and microstructural features of cast products.Limitations of cast products.Casting practices of ferrous and non-ferrous alloys.

**Mechanical Working** **(12 L)**

Hot, warm and cold working.Role of temperature, strain rate and friction in metal working.Effect of working on structure and properties of metals and alloys. Workability Equipment,Principles and governing equations: Rolling, forging, extrusion, wire drawing and tube making. Manufacturing methods of sheet metal forming, hot stamping and hydro-forming.Defects.

**Powder Metallurgy** **(9 L)**

Methods of powder production: Chemical reaction and decomposition, atomization, electrolytic decomposition, mechanical methods. Characterization of powders. Methods of compaction: Die, isostatic and continuous, hot and warm pressing.Types of sintering, mechanisms and variables.Applications of powder metallurgical components.

**Metal Joining** **(9 L)**

Principles of welding, brazing and soldering.Welding processes: fusion and solid state, consumable and non-consumable. Types of joints.Positions of welding. Types and role of fluxes and gases.
Heat-affected-zone, Weldability, Defects and testing of welds.

4. READINGS
4.1 TEXTBOOKS::
1.G.E. Dieter: Mechanical Metallurgy, McGraw-Hill.
2. S. Kalpakjian and S.R. Schmid, Manufacturing Processes for Engineering Materials, Pearson.
3.. A. Upadhyaya and G.S. Upadhyaya: Powder Metallurgy- Science, Technology and Materials, Universities Press-IIM.
4. Principles of Metal Casting; R.W. Heine, C.R. Lopper, P.C.Rosenthal, Tata-McGraw-Hill.
5. Solidification and casting; G.J.Davies, Applied Science.
6. A.C.Davies; Science and Practice of welding, Cambridge.
7. R.S. Parmar; Welding engineering and technology, Khanna Publishers.

4.2 *REFERENCE BOOKS::
1. The Making, Shaping and Treating of Steel, U.S., H E. McGannon (ed.).
2. ASM Metals Handbook, 9th. Ed., Vo1.l4, Forming and Forging,.
3. ASM Metals Handbook, 9th. Ed., Vol.15, Castings,
4. ASM Metals Handbook, 9th. Ed., Vol.6, Welding & Brazing.
5.1 *TUTORIALS::
5.2 *LABORATORY::
5.3 *PROJECT::

6. ASSESSMENT (indicative only) To be announced by the course instructor.
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE] Nil
6.3 PERIODICAL EXAMS:: [xx% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [xx% GRADE]

7. OUTCOME OF THE COURSE::
Students will be able to evaluate specific methods and materials in order to select most suitable process for production of a particular component for a specific application. They will also be able to apply knowledge of fundamental techniques to design process parameters for desired property requirements.

8. *EXPECTED ENROLLMENT FOR THE COURSE::89

# EP.MT412.15 Metallurgical Practices-II

1. GENERAL
1.1 TITLE::**Metallurgical Practices-II**
1.2 *COURSE NUMBER (if known)::EP.MT412.15
1.3 CREDITS:: 2, (L-T-P: 0-0-2)
1.4 SEMESTER-OFFERED::VII
1.5 PRE-REQUISITES:: None
1.6 COURSE COMMITTEE MEMBERS :: Prof. N.C.Shanthi Srinivas, Dr. J.K.Singh and Dr. I. Chakrabarty (Convener).

2. OBJECTIVES:: To be familiar with practical aspects of some of the most common fabrication methods such as casting, rolling, forging, powder metallurgy and welding and important controlling parameters in these processes for production of defect free metal shapes.

3. COURSE TOPICS::
**List of Experiments:**

1. Analysis of grain size and grain size distribution of sands.
2. Effects of clay content on green compression strength and green permeability of molding sands.
3. Effects of moisture content on green compression strength and green permeability of molding sands.
4. Melting, Casting in green sand moldand defect analysis of metals/alloys.
5. Centrifugal casting of non-ferrous metals.
6. Investment casting of metals/alloys.
7. To determine apparent density and flow rate of metal powders.
8. To compact at different pressures and find green densities and green compression strengths.
9. Sintering of compacts at suitable temperature and determine sintered density.
10. Welding of mild steel plates and microstructural observation of heat affected zone.
11. Strain ageing.

4. READINGS
4.1 TEXTBOOKS::
1. Principles of Metal Casting; R.W. Heine, C.R. Lopper, P.C.Rosenthal, Tata-McGraw-Hill.
2. A. Upadhyaya and G.S. Upadhyaya: Powder Metallurgy- Science, Technology and Materials,
Universities Press-IIM.
3. R.S. Parmar; Welding engineering and technology, Khanna Publishers.
4. J.N. Harris: Mechanical working of Metals - Theory and Practice, Pergamon.
5.G.E.Dieter; Mechanical Metallurgy, McGraw-Hill Inc, UK.

4.2 *REFERENCE BOOKS::
1. ASM Metals Handbook, 9th. Ed., Vol.15, Castings.
2. ASM Metals Handbook, 9th. Ed., Vol.6, Welding & Brazing.
3. ASM Metals Handbook, 9th. Ed., Vol.8, Mechanical Testing.
5.1 *TUTORIALS::Nil.
5.2 *LABORATORY::As per list of experiments
5.3 *PROJECT:: Nil.

6. ASSESSMENT (indicative only) To be announced by the Instructor at the beginning of the
semester.
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE] Nil
6.3 PERIODICAL EXAMS:: [xx% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [xx% GRADE]

7. OUTCOME OF THE COURSE:: Practical understanding of fundamentals of some most common fabrication processes, different parameters associated with the processes and their influence on the end product.

8. *EXPECTED ENROLLMENT FOR THE COURSE:: 89

## DE.MT501.15 Wear, Friction & Lubrication

1. General
1.1 TITLE:: **Wear, Friction & Lubrication**
1.2 *COURSE NUMBER:: DE.MT501.15
1.3 CREDITS:: 9, (L-T-P::3-0-0)
1.4 *SEMESTER -OFFERED:: VII
1.5 PRE-REQUISITES::
1.6 COURSE COMMITTEE MEMBERS:: Prof. S.Mohan (Convener), Dr.J.K.Singh

2. OBJECTIVE:: To develop basic understanding of tribology

3. COURSE CONTANT [GIVE TOPICS WITH NUMBER OF LECTURES FOR EACH TOPIC]

Introduction (2 L)
Importance of wear, friction & Lubrication

Friction (8 L)
Solid friction; Fundamentals, basic theories and mechanism; types of friction: sliding and rolling; friction in metals, alloys and composites; effect of parameters affecting friction; measurement of friction; frictional heating and calculations.

Wear (10 L)
Introduction to wear; surface damage; types of wear: solid-solid, solid-liquid and solid gas such as adhesion, abrasion, slurry erosion, cavitation erosion, liquid impingement erosion, fretting, erosion-corrosion, types of contacts: sliding, rolling; worn surface topography, debris analysis and wear mechanism mechanisms; parameters affecting wear.

Lubrication (3 L)
Lubricants & additives, mechanism of solid, liquid and gaseous lubricants.

Friction and wear of different components (8 L)
Solid and rolling contact bearings, gears, seals, dynamic pistons, cylinders, connecting rods, push rods, drive shafts, brakes, IC engine parts, drive chains, cutting tools, dies and electrical contacts.

Materials for friction and wear applications (8 L)
Cast irons, carbon and alloy steels, stainless steels, bearing steels, tool steels, hardfacing alloys, aluminium alloys, intermetallics, and composites.

4. READING
4.1 TEXTBOOK::
1. Wear of metals by A.D.Sarkar, Pergamon Press, Oxford
2. Engineering Tribology by Prasanta Sahoo, PHI Learning Pvt Ltd, New Delhi
3. Principles and Applications of Trobology by Bhushan B, John wiley and Sons, New York
4.2 *REFERENCE BOOKS::
1. Friction and Wear of Materials by Rabinowicz.E,Jphn Wiley nd Sons, New York
2.Engineering Tribology by Williams. J.A, Oxford University Ptress, New York.

5. OTHER SESSION
5.1 *TUTORIALS::
5.2 *LABORATORY::
5.3 *PROJECT::

6. *ASSESSEMENT:: [DO NOT FILL NOW]
6.1 HA::
6.2 QUIZZES-HA::
6.3 PERIODICAL EXAMINATION::
6.4 PROJECT/LAB::
6.5 FINAL EXAM::

7. OUTCOME OF THE COURSE:: It will cater the basic knowledge of tribology and help students undergoing to related projects.

8. *EXPECTED ENROLLEMENT IN THE COURSE::

## DE.MT 511.15 Plasma Technologies for Metallurgical Applications

**1. GENERAL**
1.1 TITLE::**Plasma Technologies for Metallurgical Applications**
1.2 *COURSE NUMBER (if known)::DE.MT 511.15
1.3 CREDITS::9 (L-T-P::3-0-0)
1.4 SEMESTER-OFFERED::VII
1.5 PRE-REQUISITES::Iron and Steel Making
1.6 COURSE COMMITTEE MEMBERS:: Dr. OP Sinha (Convener), Dr.GS mahobia, Dr G Singh and Dr.I Chakravarty.

**2. OBJECTIVES**:: This course is intended to elucidate the applications of plasma technology in metallurgical industries.

**3. COURSE TOPICS::**
**Historical Review** **(**1 L)
**Fundamentals**: Plasma metallurgy-Basic principles, types of arcs, arc characteristics. (3 L)

**Plasma Generation**: Electrical and mechanical components, types of plasma torches, comparison of AC and DC plasma, evaluation of plasma techniques as compared to conventional in the light of energy, environment and economy. (9 L)

**Applications:**
Iron Making: Plasmasmelt, plasmared, plasmacan, Elred, expanded precisive plasma (EPP), sustained shockwave plasma (SSP). (6 L)

Steel making: Inmetco process, SKF plasma dust process. (2 L)

Steel melting and Alloy Technology: Plasma arc scrap melting unit, plasma induction furnace, plasma progressive casting furnace (PPCF). (3 L)

Plasma in Ferro-Alloy Technology: Plasma carbo-thermic smelting reduction (Fe-Cr, Fe-Mn,Fe-Si,Fe-V). (2 L)

Plasma in Nonferrous Metals: Processing of sulphide ores ( Mo and Cu ) and oxide ore ( Ti ). (1 L)

Plasma Technology in Ceramic Material Coating and metal nitriding. (1 L)

Plasma Arc Remelting: Techniques and applications. (1 L)

Assesment, Development and Future Prospects. (1 L)

**4. READINGS**
4.1 TEXTBOOKS::

1.V.Dembovsky:Plasma metallurgy-The Principle (Elsevier) 1985.
2. Jerome Feinman:Plasma Technology in metallurgical processesing,Iron and steel society,USA,1987.

4.2 *REFERENCE BOOKS::
1. Mintek Review no.6 1987.
2. FP Edernal:electrometallrgy offerro alloys,01,MIR publishers 1979.

.**5. OTHER SESSIONS**
5.1 *TUTORIALS:: NIL
5.2 *LABORATORY:: NIL
5.3 *PROJECT:: NIL

**6. ASSESSMENT** (indicative only): To be specified by the instructor concerned, at the beginning of the semester.
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE]
6.3 PERIODICAL EXAMS:: [xx% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [xx% GRADE]

**7. OUTCOME OF THE COURSE::** By understanding the applications of plasma technology, students will be able to learn and apply them suitably in metallurgical field.

**8. *EXPECTED ENROLLMENT FOR THE COURSE::** 89

# DE.MT521.15 Solidification Processing

**1. GENERAL**

1.1 TITLE:: **Solidification Processing**

1.2 *COURSE NUMBER (if known):: DE.MT521.15

1.3 CREDITS::9 (L-T-P::3-0-0)

1.4 SEMESTER-OFFERED::VII

1.5 PRE-REQUISITES::Phase Transformations

1.6 COURSE COMMITTEE MEMBERS:: ,Prof. S. N. Ojha (Convenor), Dr I. Chakravorty, Dr. J. K. Singh

.

2. OBJECTIVES: This course is intended to impart knowledge about freezing characteristics of liquid metals and evolution of various cast structures

**Course description**

**Solidification of single and polyphase alloy**

Homogeneous and heterogeneous nucleation and growth processes, solidification under various conditions of diffusion in the solid and liquid phases, growth of single crystals, cellular and dendritic solidification, thermal and constitutional supercooling. Eutectic, peritectic and monotectic solidification.Ditectional solidification of binaryalloys**. (10 L)**

**Heat and fluid flow during solidification**

Heat flow in castings of different moulds, modeling of solidification, nature of metal flow and laws governing rates of metal flow, interdendritic fluid flow, movement of liquid plus solid, micro and macrosegregation in castings**. (7 L)**

**Cast structures and processing**

Macrostructures of castings and fusion welds, factors affecting columnar-to-equiaxed zone transition, theories of equiaxed zone formation. Control of cast structures, grain refinement and modification.Mechanisms of formation of shrinkage and gas porosity on solidification.Production of aligned composites.Rapid solidification processing. Squeeze casting. Rheo- and Compo-casting**. (10 L)**

**Reading**

4.1 Text books

1. M.C. Flemings, Solidification Processing, McGraw-Hills, NY.
2. W.Kurz and D.J. Fisher, Fundamentals of Solidification, Tran.Tech. Publication.
3. G.J. Davis, Solidification and Casting, Applied Science Publishers Ltd.
4. B. Chalmers, Principle or Solidification, Robert E. Krieger Publishing Company, NY.

4.2 Reference book

1.Transport Phenomena in Metallurgy by Geigerand Poirier, Addison-Wesley Publishing Company

**5. OTHER SESSIONS**

5.1 *TUTORIALS:: NIL

5.2 *LABORATORY:: NIL

5.3 *PROJECT:: NIL

**6. ASSESSMENT** (indicative only): To be specified by the instructor concerned, at the beginning of the semester.
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE]
6.3 PERIODICAL EXAMS:: [xx% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [xx% GRADE]

7. OUTCOME OF THE COURSE::

8. *EXPECTED ENROLLMENT FOR THE COURSE:: 20-89

## OE.MT408.15 Nanostructured Materials

**1. GENERAL**
1.1 TITLE:: **Nanostructured Materials**
1.2 *COURSE NUMBER (if known):: OE.MT408.15
1.3 CREDITS::9 (L-T-P::3-0-0)
1.4 SEMESTER-OFFERED::VII
1.5 PRE-REQUISITES::None
1.6 COURSE COMMITTEE MEMBERS:: Dr. N. K. Prasad (Convener), Prof. R.K. Mandal and Prof. N. K. Mukhopadhyay

**2. OBJECTIVES**:: This course will illustrate about the reasons for changing the properties of materials when their size reduces to nano-dimension. It will further discuss about the processing, characterization and application of wide range of nanostructutred materials.

**3. COURSE TOPICS::**

**Introduction**
Micro- and Nano-structures, properties and length scales of microstructures, nano-materials and nano-composites. Manipulation of surfaces at nanoscales. (5 L)

**Processing of nano structured materials**
Top-down and bottom-up approaches (wet chemical, ball milling, self assembly, biomimetic, micro-machining, lithography processing). (13 L)

**Characterization**
Nano-diffraction and HREM, Scanning probe microscopy: Scanning tunneling microscopy and spectroscopy, Atomic-, Magnetic-, Friction- and Electrical Force Microscopy. Evaluation of surface characteristics. Electric and magnetic properties. Mechanical behaviour using Dynamic Ultra- microhardness and nanohardness tests. **(**16 L)

**Applications**
Data storage, optoelctronic, environmentally sensitive coatings, diagnostic, drug delivery, imaging and therapy. Future potential. (5 L)

**4. READINGS**
4.1 TEXTBOOKS::

1. Charles P. Poole Jr., Frank J. Owenes, Introduction to nano-technology, Wiley Interscience.
2. Bhusan (Ed.) Nanotechnology, Springer.
3. H. Fujita (Ed.), Micromechanics as tools for nanotechnology, Springer International Edition.

4.2 *REFERENCE BOOKS::
1. M.V. Gandhi and B.S. Thompson, Smart Materials and Structures, Chapman and Hall.
2. Gabor L. Hornyak, H.F. Tibbals, Joydeep Dutta, John J. Moore, Introduction to Nanoscience and Nanotechnology, CRC Press

**5. OTHER SESSIONS**
5.1 *TUTORIALS:: NIL
5.2 *LABORATORY:: NIL
5.3 *PROJECT:: NIL

**6. ASSESSMENT** (indicative only): To be specified by the instructor concerned, at the beginning of the semester.
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE]
6.3 PERIODICAL EXAMS:: [xx% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [xx% GRADE]

**7. OUTCOME OF THE COURSE::**
Students will be able to impart knowledge on nanostructured materials.

**8. *EXPECTED ENROLLMENT FOR THE COURSE::**50

## DC.MT404.15 Corrosion And Prevention

1. GENERAL
1.1 TITLE:: **Corrosion And Prevention**
1.2 *COURSE NUMBER (if known):: DC.MT404.15
1.3 CREDITS:: 6, (L-T-P), (2-0-0)
1.4 SEMESTER-OFFERED:: VIII
1.5 PRE-REQUISITES:: None
1.6 COURSE COMMITTEE MEMBERS :: Dr. K. K. Singh (Convener), Dr. C. K. Behera, Prof. T. R. Mankhand, and Dr. B. mukherjee

2. OBJECTIVES:: To elucidate the principles of corrosion and its prevention to the students.

3. COURSE TOPICS::
**Unit I: Fundamentals of electrochemistry and corrosion: (8 L)**
Scope of electrochemical processes, Concept of Electrode potential, Polarization, Exchange current density, Tafel equation, Electrochemical principles of corrosion, Mixed potential theory, Passivity.

**Unit II: Forms of corrosion:** **(8 L)**
Uniform corrosion, crevice corrosion, galvanic corrosion, pitting corrosion, intergranular corrosion. erosion corrosion. stress corrosion cracking. hydrogen embrittlment. corrosion fatigue.Ooxidation of metals, Pilling-Bedworth ratio, high temperature corrosion, kinetics and mechanisms, hot corrosion.

**Unit III: Prevention of corrosion:** **(10 L)**
Materials selection, alteration of environment: media and inhibitor, design of materials. metallic coatings: electroplating, galvanizing, chromatizing. Anodic protection and anodizing. Cathodic protection: sacrificial anode cathodic protection, impressed current cathodic protection.

4. READINGS

4.1 TEXTBOOKS::

1. M.C. Fontana: Corrosion Engineering, McGraw-Hill
2. J.C. Scully: the Fundamentals of Corrosion, Pergamon.
3. S. Glasstone: An Introduction to Electrochemistry, Van Nostrand

4.1 *REFERENCE BOOKS::

1. F.A.Lovenheim: Electroplating, McGraw-Hill.
2. SatyaNarain and R. Saran: An Introducton to Electrometallurgy, Standard Publishers.
3. C C.L. Mantell: Electrochemical Engineering, McGraw-Hill.

5. OTHER SESSIONS
5.1 *TUTORIALS:: NIL
5.2 *LABORATORY:: NIL
5.3 *PROJECT::NIL

6. ASSESSMENT (indicative only) : To be announced by instructor.
6.1 HA:: [xx% GRADE] 20
6.2 QUIZZES-HA:: [xx% GRADE] Nil
6.3 PERIODICAL EXAMS:: [xx% GRADE] 30
6.4 *PROJECT:: [xx% GRADE] Nil
6.5 FINAL EXAM:: [xx% GRADE] 50

7. OUTCOME OF THE COURSE:: The course will enable the students to understand the corrosion losses, possible failure in service and necessary remedial measures. It will also be helpful in design and selection of material.
8. *EXPECTED ENROLLMENT FOR THE COURSE:: 89

## DC.MT405.15 Electrometallurgy And Corrosion Practical

1. GENERAL
1.1 TITLE:: **Electrometallurgy And Corrosion Practical**

1.2 *COURSE NUMBER (if known):: DC.MT405.15
1.3 CREDITS:: 3, (L-T-P), (0-0-3)
1.4 SEMESTER-OFFERED:: VIII
1.5 PRE-REQUISITES:: None
1.6 COURSE COMMITTEE MEMBERS :: Dr. K. K. Singh (Convener), Dr. C. K. Behera, Prof. T. R. Mankhand, and Dr. B. mukherjee

2. OBJECTIVES:: To understand the principles of electrometallurgy and corrosion by practical

3. ILLUSTRATIVE LIST OF EXPERIMENT::

1. Study of electrode potential of metals.
2. Study of galvanic and oxygen concentration cells
3. Study of oxidation of metals
4. Electropolishing
5. Throwing power of electrolytic bath
6. Anodizing of Aluminium
7. Chromium and nickel plating on steel
8. Effect of current density on current efficiency
9. Cementation of copper by iron

4. READINGS

4.1 TEXTBOOKS::

5. M.C. Fontana: Corrosion Engineering, McGraw-Hill
6. J.C. Scully: the Fundamentals of Corrosion, Pergamon.
7. S. Glasstone: An Introduction to Electrochemistry, Van Nostrand

4.2 *REFERENCE BOOKS::

6. F.A.Lovenheim: Electroplating, McGraw-Hill.
7. SatyaNarain and R. Saran: An Introducton to Electrometallurgy, Standard Publishers.
8. C C.L. Mantell: Electrochemical Engineering, McGraw-Hill.

5. OTHER SESSIONS
5.1 *TUTORIALS:: NIL
5.2 *LABORATORY:: 39 L
5.3 *PROJECT::NIL
6. ASSESSMENT (indicative only) : To be announced by instructor.
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE] Nil
6.3 PERIODICAL EXAMS:: [xx% GRADE] 50
6.4 *PROJECT:: [xx% GRADE] Nil
6.5 FINAL EXAM:: [xx% GRADE] 50
7. OUTCOME OF THE COURSE:: The course will enable the students to understand the principles of electrometallurgy and corrosion
8. *EXPECTED ENROLLMENT FOR THE COURSE:: 89

# DC.MT404.15 Steel Making Technologies

1. GENERAL
1.1 TITLE:: **Steel Making Technologies**
1.2 *COURSE NUMBER (if known):: DC.MT404.15
1.3 CREDITS:: 3-0-0- credits 9
1.4 SEMESTER-OFFERED:: VIII
1.5 PRE-REQUISITES:: None
1.6 COURSE COMMITTEE MEMBERS :: Prof SN Ojha (Convener), Dr.OP Sinha, Dr G S Mahobia and Shri Gangeshwar Singh

2. OBJECTIVES:: This course will provide the knowledge of production of steel through various technologies, current challenges in the steel industry and help the students in understanding the importance of steel making.

3. COURSE TOPICS::

**Unit I: Historical Development**. **(1 L)**
Introduction to history of steel making in India and World, Indian and world steel production scenario

**Unit II: Basic Principles** (**6 L)**
Physical chemistry of carbon, silicon, manganese, phosphorus and sulphur reactions. Control of nitrogen and hydrogen in steel. Deoxidation practice, desulphurization techniques

**Unit III: Basic oxygen steel making (BOF) (10 L)**
Principle, vessel design, and refractory lining. Lancing nozzles and jet-bath interaction. Raw materials and operating practices: charging, blowing, turndown, corrective practices and tapping.

**Unit IV: Electric steel Making (10 L)**
Arc and Induction furnace: merits and limitations. Electric Arc furnace (EAF): mechanical and electrical components, transformer rating and furnace capacity, refractory practices. Raw material selection and melting practice. Induction furnace (IF): principle, type, construction, refractory lining and melting practice.

**Unit V: Alloy steel and ferro alloy production** (**4 L)**
High carbon steels. Stainless steel, Tool steel. by EAF and IF.Ferro alloys: Fe-Si, Fe-Cr, Fe-Mn

**Unit VI: Secondary steel making** (**6 L)**
Clean steel, Stirring techniques- ladle metallurgy, Vacuum treatments & Decarburizing techniques: Argon oxygen decarburization (AOD), Vacuum oxygen decarburization (VOD), degassing processes (RH & REDA process),Vacuum Induction Melting (VIM), Post solidification treatments: Vacuum Arc Re-melting (VAR), Electro slag Re-melting (ESR), Injection metallurgy, Secondary refining furnaces (Ladle and SKF furnaces).

**Unit VI: Continuous casting of steel (2 L)**
Principles, Methods, conventional and thin slab casting processes, function of mould flux, recent advances, Defects and remedies

4. READINGS
4.1 TEXTBOOKS::
1. J.M. Gaines (ed.): BOF Steelmaking, Vols. 1&2, The Iron and Steel Society.

2. G.R. Bashforth: The Manufacture of Iron and Steel, Vol 2, Chapman & Hall.
3. H.F. Schrewe: Continuous Casting of Steel, Stahl-eisen.
4. F.P. Edneral: Electrometallurgy of Steel and Ferro-alloys, Vols. 1&2, Mir.
5. R.H. Tupkary: An Introduction to Modem Steel Making, Khanna Publishers.
6. H E. McGannon (ed.): The Making, Shaping and Treating of Steel, U.S.

5. OTHER SESSIONS
5.1 *TUTORIALS::
5.2 *LABORATORY:: As per the illustrative list of experiments
5.3 *PROJECT::

6. ASSESSMENT (indicative only)
6.1 HA:: [xx% GRADE] 10
6.2 QUIZZES-HA:: [xx% GRADE] Nil
6.3 PERIODICAL EXAMS:: [xx% GRADE] 40
6.4 *PROJECT:: [xx% GRADE] Nil
6.5 FINAL EXAM:: [xx% GRADE] 50

7. OUTCOME OF THE COURSE:: The student will learn about fundamentals of steel making technologies both by theory and practice which are important in production of steel . With the acquired knowledge, he/she would be able to apply them suitably in Industrial and Scientific research.

8. *EXPECTED ENROLLMENT FOR THE COURSE::

## EP.MT415.15 Metallurgical Practices-III

1. GENERAL
1.1 TITLE:: **Metallurgical Practices-III**
1.2 *COURSE NUMBER (if known):: EP.MT415.15
1.3 CREDITS:: 0-0-3- credits 3
1.4 SEMESTER-OFFERED:: VIII
1.5 PRE-REQUISITES:: None
1.6 COURSE COMMITTEE MEMBERS:: Dr GS Mahobia (Convener) and Dr. OP Sinha

2. OBJECTIVES:: Steel is the most important engineering material known to mankind. ferrous metallurgy has been the dominant branch of metallurgical engineering, in terms of scale of production, size of the industry, manpower employed and so on. It is also worth noting that iron making and steel making technologies have made tremendous advances in the last forty years so it is the need to provide up to date information to the all metallurgical engineering students. Iron and steel industry demands very stringent quality control on the raw materials. The experiments in this practical class will provide a fundamental understanding of various types of raw materials used in iron and steel industry along with exposure of different tests conducted to check these properties. It also demonstrates various technologies of iron and steel making like pelletization, sintering, DRI making, hot rolling and melting through plasma and induction furnace etc.

3. COURSE TOPICS::

**Illustrative List of Experiments**

1. Identification of Raw materials used in iron and steel industry

2. Study on apparent porosity, true porosity and voidage of the given raw materials
3. Crushing and drop strength of green iron ore pellets by varying % of water addition and bentonite
4. Effect of particle size and shape on the bulk density of the given raw materials
5. Effect of temperature on the viscosity of given oil sample and determine the flash point of the given sample
6. Reduction and swelling behavior of iron ore pellets in the bed of reductant like coke and coal
7. Effect of particle size, shape, surface condition and moisture content on angle of repose of raw materials
8. Shatter strength and tumbler strength of given raw material
9. Proximate analysis of given reductant (coal/coke/charcoal) and its utility for DRI production
10. Hot rolling studies
11. Jet-bath interaction in BOF vessel
12. Pelletization in disk pelletizer and Sintering in pot sinter machine (demonstration)

4. READINGS
4.1 TEXTBOOKS::
1. RC Gupta: Theory and laboratory experiments in ferrous metallurgy, PHI publications 2010.

5. OTHER SESSIONS
5.1 *TUTORIALS::
5.2 *LABORATORY:: As per the illustrative list of experiments
5.3 *PROJECT::

6. ASSESSMENT (indicative only)
6.1 HA:: [xx% GRADE] Nil
6.2 QUIZZES-HA:: [xx% GRADE] 10
6.3 PERIODICAL EXAMS:: [xx% GRADE] 40
6.4 *PROJECT:: [xx% GRADE] Nil
6.5 FINAL EXAM:: [xx% GRADE] 50

7. OUTCOME OF THE COURSE:: The student will learn about fundamentals of iron and steel making technologies by conducting experiments which are important in iron and steel making industries . With the acquired knowledge, he/she would be able to apply them suitably in Industrial and Scientific research work.

8. *EXPECTED ENROLLMENT FOR THE COURSE::

## DE.MT 502.15 Heat Treatment of Advanced Ferrous Alloys

1. GENERAL
1.1 TITLE:: **Heat Treatment of Advanced Ferrous Alloys**
1.2 *COURSE NUMBER (if known):: DE.MT 502.15
1.3 CREDITS:: 9, (L-T-P: 3-0-0)
1.4 SEMESTER-OFFERED:: VIII
1.5 PRE-REQUISITES:: None
1.6 COURSE COMMITTEE MEMBERS :: Prof S. N. Ojha, Dr. R. Manna (Convener), Dr. O. P. Sinha, Dr. G. S. Mahobia

2. OBJECTIVES:: Advanced ferrous alloys are subjected to different kinds of heat treatment processes to develop appropriate microstructure with desired set of properties. Hence a thorough understanding of fundamentals of microstructural developments by different heat treatment processes is necessary for structure-property correlations. The syllabus is designed to meet both the requirements.

3. COURSE TOPICS::

**Fundamentals**. **(12 L)**

Phase diagrams: Fe-C phase diagrams and effects of alloying elements, Austenisation-continuous heating transformation diagram, effect of alloying elements on austenite grain size. Isothermal transformation diagrams: determination, types, effect of variable; continuous cooling transformation diagram for alloy steels: determination, types, effect of variables, Conversion of TTT diagrams to CCT and vice versa. Hardenability, its measurement and control for alloy steels: variables, methods, severity of quench (H), determination of H, Dc, DI, calculation of Jominy curves, hardenability band, hardenability of deep hardenable steels, Boron hardenability.

**Processes to alloy steels** (**17 L)**

Homogenisation of alloy steels, Annealing-diffusion annealing, full annealing, spheroidising annealing, recrystallisation annealing, stress relieving annealing, normalizing, hardening and tempering of alloy steels. Embrittlements. Case hardening treatments-case carburizing-solid, liquid, gas carburizing, homogeneous carburizing, plasma carburizing and post carburizing heat treatments, nitriding- Fe-N diagram, gas nitriding, ion nitriding, carbonitriding, cyaniding, boronising-Fe-B phase diagram, chromising-Fe-Cr phase diagram, Toyota diffusion processes.

**Specific ferrous alloys** (**10 L)**

Stainless steels-Schaeffler diagram, heat treatments to ferritic, martensitic, austenitic, duplex stainless steels, Precipitation hardenable stainless steels-martensitic, semiaustenitic, austenitic grade; High speed tool steels-property requirements, effect of alloying elements, types, typical heat treatments of specific tool steel, Maraging steels-types, effect of alloying elements, maraging heat treatment; HSLA steels-composition, property requirements, types of ferrous thermomechanical treatments, typical heat treat to HSLA steels, cast irons: types, heat treatments to white, gray, malleable S.G. irons and alloy cast irons.

Numerical problems: quantification of phases, homogenization, calculation of TTT/CCT diagrams, hardenability, case hardening.

4. READINGS

4.1 TEXTBOOKS::


2. R.E. Reed-Hill and R. Abbaschian: Physical Metallurgy Principles, PWS Publishing Company, Boston, Third Edition.
6. Vijendra Singh: Heat treatment of Metals, Standard Publishers Distributors, Delhi.
7. R.C. Sharma: Principles of Heat Treatment of Steels, New Age International (P) Ltd. Publisher.
8. G. Krauss.: Principles of Heat Treatment of steel, ASM, 1980
9. Yu. M. Lakhtin: Engineering Physical Metallurgy and Heat Treatment, Mir publisher, 1979.


4.2 *REFERENCE BOOKS::


16. Anil Kumar Sinha: Physical Metallurgy Handbook, McGraw-Hill Publication, 2003

17. R.W.K. Honeycomb and H.K.D.H. Bhadeshia, Steels: Microstructure and Properties, 3rd Edition, Butterworth-Heinemann, 2006.
18. Metals Handbook, Heat Treatment, Ninth Edition, Vol 4, ASM
19. **Website:** www.msm.cam.ac.uk/phase-trans, http://www.iitbhu.ac.in/met/index.php/people/faculty/35.html, http://www.tra-erf.org/tm.html

5. OTHER SESSIONS
5.1 *TUTORIALS::
5.2 *LABORATORY::
5.3 *PROJECT::

6. ASSESSMENT (will be announced by instructor)
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE] Nil
6.3 PERIODICAL EXAMS:: [xx% GRADE]
6.4 *PROJECT:: [xx% GRADE] Nil
6.5 FINAL EXAM:: [xx% GRADE]

7. OUTCOME OF THE COURSE:: The student will learn about the fundamentals of microstructural modification of advanced ferrous alloys through heat treatment processes. Students would be able to correlate heat treatment processes to microstructure and properties and apply them suitably in industrial practice and scientific research.

8. *EXPECTED ENROLLMENT FOR THE COURSE::

## DE MT 512.15 Alloy Steels Production Technology

1. General
   - **1.1** Title:: Alloy Steels Production Technology
   - **1.2** Course No:: DE MT 512.15
   - **1.3** Credits:: 9 (L-T-P : 3-0-0)
   - **1.4** Semester Offered:: VIII
   - **1.5** Pre-requisites::
   - **1.6** Course Committee Members::Dr. OP Sinha, Dr. GS Mahobia, Sri G. Singh, Dr. SN Ojha

2. Objectives:: The course will provide the students an insight into importance of different melting technologies used for producing quality steels.

**3. COURSE TOPICS::**

**Introduction:** Historical & Technological changes in steel making processes with reference to Indian condition. (2 L)

**Electric Arc Furnace:** Construction and operation of furnace; Reactions involve including deoxidation and slags; Refractory Lining; Raw materials selection and melting practice for production of low alloy steels and stainless steels; Role of gases and inclusions in steel. (10 L)

**Recent developments in the EAF:** UHP transformer for rapid melting; Water cooled furnace panels; Electrode Technology; Scrape preheater; Emission control; powder injection; Slag free tapping and hot heel practice;

DC arc furnaces; Plasma Furnaces. (15 L)

**Induction Melting Furnace:** Principles, classification, construction, refractory lining, operation and manufacture of alloys. (4 L)

**Secondary Steel Making Technology:** Vacuum Degassing; AOD; VOD;VPAD (3 L)

**Special Melting processes:** VIM; VAR; ESR; Electron beam Remelting. (3 L)

**Ingot Making and Continuous Casting:** Pencil ingots; Special ingots; Continuous casting; Casting defects & remedies; (3 L)

**Plant Practice:**Status of mini steel mills in India & Future Prospects. (1 L)

4. Readings::
   **4.1** Text Books
      1. S K Goel and etal; Production of quality steels in mini steel plants;
      2. K F Bansal; Vacuum Metallurgy;
      3. H F Schrewe; Continuos casting of steel; Stahl eisen
      4. F P Edneral; Electrometallurgy of steel and ferro-alloys; Vol. 1,2; Mir Publ.
      5. R H Tupkary; An Introduction to Modern steel Making; Khanna Publ.
   **4.2** Reference Books
      1. HE Mc Gannon(ed);The making, shaping& Treating of steel; United states steels.
      2. CE Sims(ed);Electric furnacesteel making; Vol.2; Interscience.

5. Other Sessions::
   **5.1** * Tutorials:: NIL
   **5.2** *Laboratory::NIL
   **5.3** *Projects::NIL

6. Assessment ( indicative only):: To be specified by the instructor concerned, at the beginning of the semester.
   **6.1** HA::[xx% GRADE]
   **6.2** Quizzes-HA:: [xx% GRADE]
   **6.3** Periodical Exams:: [xx% GRADE]
   **6.4** *Project :: [xx% GRADE]
   **6.5** Final Exam :: [xx% GRADE]

7. OUT COMES OF THE COURSE:: The students will learn about different melting processes and utilized the knowledge for producing quality alloy steels in plants.

8. *Expected Enrollment for the course ::89

# DE.MT 522.15 Intermetallics

1. GENERAL
1.1 TITLE:: **Intermetallics**
1.2 *COURSE NUMBER (if known):: DE.MT 522.15
1.3 CREDITS:: 9, (L-T-P: 3-0-0)
1.4 SEMESTER-OFFERED:: VIII
1.5 PRE-REQUISITES:: None
1.6 COURSE COMMITTEE MEMBERS:: Prof. N.K. Mukhopadhyay (Convener) and Prof. R.K. Mandal

2. OBJECTIVES:: The complex intermetallic alloys will be discussed with reference to their structural complexities, stability and possible applications. The attempts will be made to link simple to complex intermetallics including incommensurate crystals and quasicrystals.
3. COURSE TOPICS::

**Basic Concepts** **(3 L)**
Definition, nomenclature and characteristics. Thermodynamic factors for formation. Role of intermetallics as reinforcing phases for strengthening and toughening mechanisms. Complex Metallic Alloys (CMAs).

**Criteria for formation** **(12 L)**
(i) Geometrical Principles: Packing based on space, symmetry & connectivity. (ii) Electronic effects: Electron/atom ratio (iii) Eelctrochemical factors. Illustrative Phases conforming to the above principles: Frank Kasper phase, Laves phase; Hume-Rothery phase; Zintl phase.
Structural examples: Intermetallics of transition metals: Commonly known Topologicaly close packed (TCP) Structures. Examples and their structures.
Aperiodic intermetallics : Structurally complex phases, quasiperiodic phases, incommensurately modulated superstructures.

**Superstructures and Interstitial compounds** **(12 L)**
Ordered intermetallics, solid state order-disorder transformation (e.g. β brass & B2) $L1_2$ or $Cu_3Au$ I type, B2, $L1_0$ or CuAu I type, $DO_3$ and $L2_1$ type, $D0_{19}$ or $Mg_3Cd$ type, B19, Long period superllatices, silicides, Carbides, borides, nitrides.

**Processing and prospects of some selected Intermetallics** **(12 L)**
Mechanical Characteristics of strucutural intermetallics. Nickel alumindes, Titanium aluminides, Iron aluminides. Modification by alloying addition. Magnetic intermetallics and Electronic intermetallics. Intermetallic composites, Nanocrystalline intermetallics. Disordered intermetallics.

4. READINGS (Neither a necessary nor a sufficient requirement)

4.1 TEXTBOOKS::
1. 1 G. Sauthoff, Intermetallics, VCH, Germany
2. C. Barrett and T.E. Massalski, Structure of Metals, Pergamon Press.

4.2 *REFERENCE BOOKS::
3. L. Pauling, The nature of chemical bond, Oxford & IBH Publishing Co.
4. P.E.A. Turchi, R.D. Shull and A. Genis, The Science of Alloys for the 21st Century: A Hume-Rothery Symposium Colebration, TMS Publication.

5. OTHER SESSIONS
5.1 *TUTORIALS:: Nil
5.2 *LABORATORY:: Nil
5.3 *PROJECT:: Nil

6. ASSESSMENT (indicative only):: To be declared by the Instructor in the beginning of semester.
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE] Nil
6.3 PERIODICAL EXAMS:: [xx% GRADE]
6.4 *PROJECT:: [xx% GRADE] Nil
6.5 FINAL EXAM:: [xx% GRADE]

7. OUTCOME OF THE COURSE::

8. *EXPECTED ENROLLMENT FOR THE COURSE:: The students will develop an insight into the structural complexities and their stabilities as well as various properties and applications.

## OE.MT407.15 Automotive and Aerospace Materials

1. GENERAL
1.1 TITLE:: **Automotive and Aerospace Materials**
1.2 *COURSE NUMBER (if known):: OE.MT407.15
1.3 CREDITS:: 3-0-0- credits 9
1.4 SEMESTER-OFFERED:: VIII
1.5 PRE-REQUISITES:: Heat Treatment
1.6 COURSE COMMITTEE MEMBERS :: Prof (Mrs) N.C.Santhi Srinivas (Convener), Prof Vakil Singh, Prof S N Ojha, Dr K.Chattopadhyay

2. OBJECTIVES:: The course is intended to familiarize the student with different automotive and aerospace materials and the recent developments.

3. COURSE SYLLABUS::
**Introduction:** Brief outline of the essential requirements of materials for automotive and aerospace applications. (3 L)

**Light Metals and Alloys:** Processing, properties and applications: Aluminium alloys e.g. Al-Cu, Al-Si, Al-Cu-Mg, Al-Zn- Mg-Cu, Al-Li; titanium alloys e.g. alpha, near alpha, alpha beta and titanium aluminides; magnesium alloys with Cu, Zn, Zr and rare earth elements. (12 L)

**Superalloys:** Classification and development of superalloys. Physical and mechanical properties; heat treatment, microstructures and strengthening mechanisms. Creep resistance. Oxidation and hot corrosion. Coatings. Processing developments and applications. (6 L)

**Steels:**Heat treatment, microstructure, mechanical properties and typical applications of HSLA, dual phase, ultra low carbon, interstitial free, ultra high strength, cryogenic and maraging steels. (9 L)

**Composites and Metal Foams:** Typical composites and their applications: Metal-matrix, fibre reinforced plastic and carbon- carbon composites. Metal foams and their applications. (6 L)

**Recent developments** (3 L)

4. READINGS
4.1 TEXTBOOKS::

1. I.J. Polmear: Light Alloys-Metallurgy of the Light Metals, Edward Arnold.
2. C.T. Sims and W.C. Hagel: The Superalloys, Wiley-Interscience.
3. F.B. Pickering: Physical Metallurgy and Design of Steels, Applied Science.

4.2 REFERENCE BOOKS::

1. L.J. Broutman and R.H. Krock (eds.): Composite Materials, Academic press.

5. OTHER SESSIONS
5.1 *TUTORIALS::
5.2 *LABORATORY::
5.3 *PROJECT::

6. ASSESSMENT (indicative only): To be announced by the Instructor at the beginning of the semester
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE]
6.3 PERIODICAL EXAMS:: [xx% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [xx% GRADE]

7. OUTCOME OF THE COURSE:: The student will learn about different materials used in automotive and aerospace applications.

8. *EXPECTED ENROLLMENT FOR THE COURSE::

## DE.MT513.15 Near- net Shape Processing

**1. GENERAL**
1.1 TITLE:: **Near- net Shape Processing**
1.2 *COURSE NUMBER (if known)::DE.MT513.15
1.3 CREDITS::9 (L-T-P::3-0-0)
1.4 SEMESTER-OFFERED::IX
1.5 PRE-REQUISITES::Solidification Processing
1.6 COURSE COMMITTEE MEMBERS:: ,Prof.S.N.Ojha (Convenor), Dr I. Chakravorty, Dr.J.K.Singh
.
2. OBJECTIVES: This course is intended to impart knowledge about processing methodology of materials into specific shape of the component. The course also provides a valuable insight into manufacturing processes

**Course description**

**Introduction**

Major benefits of near-net shape processing: Fundamentals of manufacturing of preforms with citations from steel technology. (5 L)

**Castings methodology** Rheo-casting, thixo-casting and squeeze-casting processes. rheological behavior and microstructural evolution during semi-solid processing, component shape control. (8 L)

**Powder Metallurgy techniques** Special consolidation processes, hot pressing and hot isostatic pressing, mechanisms of sintering. Injection molding and liquid infiltration processes. (6 L)

**Spray forming** Gas-melt interaction during melt atomization, droplet dynamics and their non-equilibrium solidification processes. Control of component shape by substrate maneuvering. Industrial applications of spray formed components.· (10 L)

**Sheet metal forming processes** A brief review of high precision forming, superplastic forming, shaping induced materials properties.Isoforming,ausforming,hot stamping and hydroforming processes. (10 L)

4. READINGS

4.1 TEXTBOOKS::

1. M.C. Flemings, Solidification Processing, McGraw-Hills, NY
2. Y. Wu and E.J. Laverina, Spray Atomization and Deposition, John Wiley and Sons, NY
3. V.S. Arunnachalam and O.V. Raman (eds.): Powder Metallurgy; Recent Advances; Oxford and IBM Publis.

4.2 REFERENCE BOOKS

1. Thermo-mechanical simulation and processing of steels, Viva Books Private Ltd, Delhi
2. Powder Metallurgy: Science, Technology andApplication by Angelo and Subramanian, PHI Publishers, New Delhi.
3.C.E. Sims (ed.): Electric Furnace Steel Making, vol.2, Interscience.
4.F.P. Edward: Electrometallurgy of Steel and Ferroalloys, vol.1 and 2, Mir.
5.C.K. Gupta and A.K. Suri: Ferroalloy Technology in India, Milind.

**5. OTHER SESSIONS**

5.1 *TUTORIALS:: NIL
5.2 *LABORATORY:: NIL
5.3 *PROJECT:: NIL

**6. ASSESSMENT** (indicative only): To be specified by the instructor concerned, at the beginning of the semester.

6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE]
6.3 PERIODICAL EXAMS:: [xx% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [xx% GRADE]

**7. OUTCOME OF THE COURSE::**The students will learn about the alloying behavior of iron, role of processing parameters on the characteristics of some widely used alloy and special steels and also the selection of a particular steel for a specific application.

**8. *EXPECTED ENROLLMENT FOR THE COURSE::** 89

# DE.MT523.15 Advanced X-Ray and Electron Metallography

**1. GENERAL**
1.1 TITLE:: **Advanced X-Ray and Electron Metallography**
1.2 *COURSE NUMBER (if known)::DE.MT523.15
1.3 CREDITS::9 (L-T-P::3-0-0)
1.4 SEMESTER-OFFERED::IX
1.5 PRE-REQUISITES::Metallography Techniques or Equivalent
1.6 COURSE COMMITTEE MEMBERS:: Prof. G.V.S. Sastry (Convener), Prof. R.K. Mandal and Prof. N.K.Mukhopadhyay

**2. OBJECTIVES**:: This course is designed to deeper knowledge in advanced techniques of materials characterisation such as x-ray line profile analysis, imaging under dynamical conditions, phase contrast imaging in TEM, micro and macro texture analysis and CBED. This course also explicates the constitution of alloys and their representative microstructures under equilibrium conditions.

**3. COURSE TOPICS::**

**X-ray Metallography**
**Diffraction Methods**
Diffractometer (general features, counters for measurement of line position and intensity, use of mono chromators). Texture goniometers. Synchrotron radiation. (4 L)

**Applications**
Pole figures for determination of texture (wire, rod and sheet). Line profile analysis, effects due to chemical ordering, particle size and residual stress estimate. (7 L)

**Electron Metallography**
**Theories of Image Contrast**
Basic concepts of Fourier analysis and Fourier transformation, relevance to diffraction analysis. Dynamical theory of image contrast. Comparison of kinematical and dynamical theories, Expression for intensity of a diffracted beam. (5 L)

**Imaging of Perfect and Imperfect Crystals**
Interpretation of image contrast due to perfect flat crystals, thickness and flatness variations, grain boundaries, stacking faults, twins, dislocations, vacancy and interstitial loops under dynamical conditions. 6 L)

**High Resolution Electron Microscopy**
Theory of image formation under phase contrast conditions. Contrast transfer function, role of spherical aberration. Definition of point resolution and line resolution. Concept of passbands. (5 L)

**Electron Diffraction**
Interpretation of shape and size effects on the diffraction spots using Fourier transformation. Reciprocal lattice. Kikuchi lines and maps. Diffraction from single particles and nanotubes. Orientation relationships and trace analysis using electron diffraction, weak beam techniques. Introduction to convergent beam electron diffraction. Electron Back Scattered Diffraction and microtexture. (12 L)

**4. READINGS**

4.1 TEXTBOOKS::

1. B.E. Warren: X-ray Diffraction, Addison-Wesley
2. B.D. Cullity: Elements of X-ray Diffraction, Addison-Wesley
3. L.E. Murr: Electron Optical Applications, McGraw-Hill
4. Marc de Graef, Introduction to Conventional Transmission Electron Microscopy, Cambridge
5. J.C.H. Spence and J.M. Zuo, Electron Microdiffraction, Plenum Press

4.2 *REFERENCE BOOKS::

1. S.G. Lipson and H. Lipson, Optical Physics, Cambridge
2. D.B. Williams and C.B. Carter, Transmission Electron microscopy, vol. 2&3, Plenum
3. S. Amelinckx, R. Gevers and J. Van Landuyt (eds.): Diffraction and Imaging Techniques in Materials Science, North Holland.
4. J.W. Edington, Practical Electron Microscopy, vols. 1-4, Philips, Holland.

**5. OTHER SESSIONS**

5.1 *TUTORIALS:: NIL
5.2 *LABORATORY:: NIL
5.3 *PROJECT:: NIL

**6. ASSESSMENT** (indicative only): To be specified by the instructor concerned, at the beginning of the semester.

6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE]
6.3 PERIODICAL EXAMS:: [xx% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [xx% GRADE]

**7. OUTCOME OF THE COURSE::T**his course prepares students to choose and adopt the advanced materials characterisation techniques appropriate for their research topics during Thesis work.

**8. *EXPECTED ENROLLMENT FOR THE COURSE::** 20

# DE.MT514.15 Surface Engineering

1. General
1.1 TITLE:: **Surface Engineering**
1.2 *COURSE NUMBER::
1.3 CREDITS:: 3
1.4 *SEMESTER -OFFERED:: IX
1.5 PRE-REQUISITES::

1.6 COURSE COMMITTEE MEMBERS:: Prof. Sunil Mohan (Convener), Dr. C. K. Behera

2. OBJECTIVE:: Understanding of tribology

3. COURSE CONTENT [GIVE TOPICS WITH NUMBER OF LECTURES FOR EACH TOPIC]

Introduction (2 L)
Material surfaces and their importance in tribology.

Friction (8 L)
Fundamentals, types and measurement of solid, liquid and gaseous friction. Frictional heat and its estimation.

Wear (8 L)
Modes of adhesive, abrasive, erosive, fretting, corrosive, erosive-corrosive, sliding, rolling, impact and lamination wear. Worn surface topography, debris analysis and wear mechanism maps.
.
Friction and wear Applications (8 L)
Bearings, pistons, cylinders, brakes, cutting tools, dies and electrical contacts.
Materials: Al-Si, Ti-alloys, Cemented carbides and metal -polymer and ceramic-matrix composites

Materials for Friction & Wear Applications (8 L)
Cast irons, carbon and alloy steels, stainless steels, bearing steels, tool steels, hardfacing alloys, aluminium alloys, intermetallics, and composites.

Brief introduction of surface modification processes (5 L)
Case-hardening, shot peening, chemical vapour deposition (CVD), physical vapour deposition (PVD), thermal barrier coatings, plasma deposition, sputter coating, laser processing, ion implantation, electro-and electroless-plating processes.

4. READINGS
4.1 TEXTBOOK::
1. Wear of metals by A.D.Sarkar, Pergamon Press, Oxford
2. Principles and Applications of Trobology by Bhushan B, John wiley and Sons, New York
3. Properties of Metallic Surfaces: Institute of Metals.
4. Surface treatments for protection. The Institute of Metallurgists Series 3, No.10.

4.2 *REFERENCE BOOKS::
1. Friction and Wear of Materials by Rabinowicz.E,Jphn Wiley nd Sons, New York
2. Engineering Tribology by Williams. J.A, Oxford University Ptress, New York.
3. Friction, Lubrication and Wear Technology, Vol. 18, ASM, Handbook.

5. OTHER SESSION
5.1 *TUTORIALS::
5.2 *LABORATORY::
5.3 *PROJECT::

6. *ASSESSEMENT:: [DO NOT FILL NOW]
6.1 HA::
6.2 QUIZZES-HA::
6.3 PERIODICAL EXAMINATION::
6.4 PROJECT/LAB::
6.5 FINAL EXAM::

7. OUTCOME OF THE COURSE:: Student will be exposed to tribology and related problems that will help them in their dissertation work.

8. *EXPECTED ENROLLEMENT IN THE COURSE::

## DE.MT524.15 Failure Analysis

1. GENERAL
1.1 TITLE:: **Failure Analysis**
1.2 *COURSE NUMBER (if known):: DE.MT524.15
1.3 CREDITS:: 9(L-T-P:: 3-0-0)
1.4 SEMESTER-OFFERED:: IX
1.5 PRE-REQUISITES:: Deformation and Testing of Materials
1.6 COURSE COMMITTEE MEMBERS :: Prof (Mrs) N.C.Santhi Srinivas (Convener), Prof Vakil Singh, Dr K.Chattopadhyay

2. OBJECTIVES:: The course aims at familiarizing students about different types, causes and mechanisms of failures of engineering components and methodology of failure analysis and remedial measures to prevent failures.

3. COURSE TOPICS::
**Introduction** **(1 L)**
Fracture / Failure of engineering components.

**Types of Fracture** **(6 L)**
Ductile and brittle fractures, fatigue, stress corrosion cracking, corrosion fatigue and creep.

**Types of Failures** **(6 L)**
Distortion , wear, erosion, corrosion. Embrittlement by solid-metal environment, liquid metal, hydrogen.

**Importance of fracture mechanics. Fracture mechanism maps of important materials.** **(4 L)**

**Common causes of Failures** **(6 L)**
Deficiency in Design, Failures due to materials, Failures due to manufacturing processes, Failures of manufactured components and assemblies, Inspection and maintenance, Environmental effects, Sabotage.

**Methodology of Failure Analysis** **(6 L)**
Background Information, Location of the Failed Component, Specimen Collection, Preliminary Examination,
Macro fractography and Microfractography, Chemical Analysis , Mechanical Properties, Nondestructive Examination: Conventional Nondestructive Evaluation Techniques , Special Techniques, Simulation Studies, Analysis of Data, Preparation of the Report

**Remedial Measures after Failure Analysis** **(1 L)**

**Advanced Techniques of Failure Analysis** **(3 L)**

**Illustrative case studies in Failure Analysis** **(6 L)**

4. READINGS
4.1 TEXTBOOKS::

4. Failure Analysis of Engineering Structures: Methodology and Case Histories V. Ramachandran, A.C. Raghuram, R.V. Krishnan, and S.K. Bhaumik, ASM International, Materials Park, Ohio
5. RW Herzberg: Deformation and Fracture Mechanics of Engineering Materials, Fourth Edition, John Wiley & Sons INC, USA

4.2 *REFERENCE BOOKS::

20. Failure Analysis and Prevention: Metals Handbook, 9th edition, Vol.11, ASM.
21. Mechanical Testing : Metals Handbook, 9th Edition, Vol 8, ASM
22. Non Destructive Evaluation and Control : Metal Handbook, 9th Edition, Vol 17, ASM

5. OTHER SESSIONS
5.1 *TUTORIALS::
5.2 *LABORATORY::
5.3 *PROJECT::

6. ASSESSMENT (indicative only): To be announced by the Instructor at the beginning of the semester
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE]
6.3 PERIODICAL EXAMS:: [xx% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [xx% GRADE]

7. OUTCOME OF THE COURSE:: The student will learn about principles of failure analysis and apply them suitably to analyse different failures of engineering components.

8. *EXPECTED ENROLLMENT FOR THE COURSE:: 89

## OE.MT503.15 Advanced Materials

**1. GENERAL**
1.1 TITLE:: **Advanced Materials**
1.2 *COURSE NUMBER (if known)::OE.MT503.15
1.3 CREDITS::9 (L-T-P::3-0-0)
1.4 SEMESTER-OFFERED::IX

1.5 PRE-REQUISITES::None
1.6 COURSE COMMITTEE MEMBERS:: Dr. N. K. Prasad (Convener), Prof. R.K. Mandal, Prof. N. K. Mukhopadhyay, Prof. V. Singh and Prof. S. N. Ojha

**2. OBJECTIVES**::
The course is intended to explain about synthesis, characterization of various materials for advanced applications.

**3. COURSE TOPICS::**

**Introduction**
Demand and Design Principles (5 L)

**Structural Materials**
Cellular materials, Metallic foam, Porous oxides, Porous-matrix ceramic composites. Mechanically alloyed oxide dispersion strengthened superalloys, high strength and ductile bulk quasicrystalline alloys and their composites. Synthesis and properties of Bulk Metallic glasses. Thermal barrier coating for aeroengines and gas turbine. Processing of Ni base superalloys for turbine engine discs. (20 L)

**Functional Materials**
Dielectric materials, optoelectronic materials. Soft and hard magnetic materials. Shape Memory alloys, Energy materials, Multiferroic materials, Functionally Gradient Material (FGM). (14 L)

**4. READINGS**
4.1 TEXTBOOKS::

1. Charles P. Poole Jr., Frank J. Owenes, Introduction to nano-technology, Wiley Interscience.
2. B. Bhusan, Nano-technology (ed.) Springer.
3. Micromechanics as tools for nanotechnology, Springer International Edition.
4. P. Rama Rao, (ed.) Advances in Materials & their Application, Wiley Eastern Ltd.


4.2 *REFERENCE BOOKS::

1. A.K. Ray (eds.) L.C. Pathak, K. Venkateswarlu, A. Bandopadhyay & Advanced materials, Allied Publishers Pvt. Ltd.
2. M.V. Gandhi and B.S. Thompson, Smart Materials and Structures, Chapman and Hall


**5. OTHER SESSIONS**
5.1 *TUTORIALS:: NIL
5.2 *LABORATORY:: NIL
5.3 *PROJECT:: NIL

**6. ASSESSMENT** (indicative only): To be specified by the instructor concerned, at the beginning of the semester.
6.1 HA:: [xx% GRADE]
6.2 QUIZZES-HA:: [xx% GRADE]
6.3 PERIODICAL EXAMS:: [xx% GRADE]
6.4 *PROJECT:: [xx% GRADE]
6.5 FINAL EXAM:: [xx% GRADE]

**7. OUTCOME OF THE COURSE::**

The students will obtain knowledge about processing and characterization of various advanced materials.

**8. *EXPECTED ENROLLMENT FOR THE COURSE::89**

## Department Undergraduate Committee (DUGC)

| | | Signature |
|---|---|---|
| **Prof. R. K. Mandal** | **HOD and Member** | R. K. Mandal |
| **Dr. R. Manna** | **Convener** | 2/3/2016 |
| **Prof. B. N. Sarma** | **Member** | 02/03/16 |
| **Dr. O. P. Sinha** | **Member** | |
| **Dr. I. Chakrabarty** | **Member** | out station |
| **Dr. J. K. Singh** | **Member** | |
| **Dr. K. Chattopadhyay** | **Member** | |
| **Shri Ashwini Kumar Sahay** | **Student Member** | Ashwini |
| **Shri Mayank Jha** | **Student Member** | Mayank Jha |

Indian Institute of Technology (B.H.U.), Varanasi-221005
Convener
DUGC