### ME – INDUSTRIAL METALLURGY

#### ME Industrial Metallurgy (IM) 2007-08

### I Semester

<table>
<thead>
<tr>
<th>S No</th>
<th>Code</th>
<th>Subject</th>
<th>Marks</th>
<th>Total</th>
<th>Credits</th>
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<tbody>
<tr>
<td>1.</td>
<td>IM11</td>
<td>Material Science</td>
<td>30 70</td>
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<td>2.</td>
<td>IM12</td>
<td>Advances in Casting</td>
<td>30 70</td>
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<td>3.</td>
<td>IM13</td>
<td>Advances in Forming</td>
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<td>6.</td>
<td>IM16P</td>
<td>Casting Lab</td>
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<td>7.</td>
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<td>Materials Testing Lab</td>
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### II Semester

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<td>1.</td>
<td>IM21</td>
<td>Failure Analysis</td>
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<td>IM22</td>
<td>Strengthening Mechanisms</td>
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<td>IM23</td>
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<td>IM25</td>
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<td>IM26P</td>
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### III Semester

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<tr>
<td>1.</td>
<td>IM31</td>
<td>Advances in Iron &amp; Steel Making (Seminar Course)</td>
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### IV Semester

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ME – INDUSTRIAL METALLURGY
(with effect from 2007-08)

I - SEMESTER

IM11 - MATERIALS SCIENCE

Periods / week: 4  Credits: 4  Sessionals: 30  Exam: 70

Introduction, classification of materials, dislocations, types, Burgers’ Vector, Dislocation movement by climb and cross slip. Dislocation sources, Dislocation point defect interaction and pileups.


Impact toughness, Charpy V-Notch, fracture, ductile, brittle, Griffith criteria for brittle failure, creep, creep mechanisms, fatigue-mechanism-factors to improve fatigue resistance.


3. Material Science – Callister.

IM12 - ADVANCES IN METAL CASTING

Periods / week: 4       Credits: 4       Sessionals: 30       Exam: 70

New and emerging casting techniques:
Counter gravity low pressure casting, squeeze casting, semi solid metal casting and forging, plaster molding, ceramic molding, replicast process

Design Considerations:
Risers, gating, casting, dimensional tolerances and allowances.

Computer applications in metal casting:
Modeling of solidification heat transfer, fluid flow, combined fluid flow and heat / mass transfer, microstructural evolution.

References:
1. Principles of Metal Casting - Rosenthal
2. Foundry Technology – Beely
3. Metals Hand Book - Casting
IM13 – ADVANCES IN FORMING

Periods / week: 4  Credits: 4  Sessionals: 30  Exam: 70

**Mechanical Testing:**
Hardness Testing, tensile properties, Fatigue and Creep Properties of metals.

**Fundamentals of metal working:**
Classification of forming processes, mechanics of metal forming, temperature of metal working, hot working, cold working, friction and lubrication.

**Forging:**
Classification of forging processes, forging of plate, forging of circular disc, open-die and close-die forging, forging defects and powder metallurgy forging.

**Rolling of metals:**
Rolling processes, forces and geometrical relationship in rolling, simplified analysis of rolling load, rolling variables, theories of cold rolling and hot rolling, problems and defects in rolled variables, torque and horsepower.

**Extrusion:**
Classification of extrusion processes, hot extrusion, analysis of extrusion processes, defects in extrusion, extrusion of tubing, production of seamless pipe.

**Drawing of tubes, rods and wires:**
Introduction, wire drawing dies, tube drawing processes, analysis of wire and tube drawing.

**Sheet metal forming:**
Forming methods, bending, stretch forming, deep drawing, forming limit criteria, defects in formed parts.

**Advanced metal forming process:**
High Energy rate forming operation, electromagnetic forming.

**TEXT BOOKS:**
1. *Mechanical Metallurgy* - G.E.DIETERR
2. *Principles of Metal working* - SURENDER KUMAR
3. *Principles of Metal working* - G.W.ROWE

**REFERENCE:** *ASM Metal hand book*
IM14 – ENGINEERING MATERIALS

Periods / week: 4  Credits: 4  Sessionals: 30  Exam: 70

**Engineering Alloys:**
Low carbon steels, Mild steels, Medium carbon steels, High strength structural steels, Tool steels, Stainless steels, High temperature alloys, Cast irons, The light alloys, Copper and its alloys, Bearing alloys

**Composites:**
Introduction, Matrix materials, Reinforcements, Mechanical behaviour of composites, Metal matrix composites, Polymer matrix composites, Ceramic matrix composites, Carbon fiber composites

**Ceramics:**
Silicate ceramics, Imperfections in ceramics, Diffusion in ionic materials, Brittle fracture, Stress - Strain behavior, Fabrication and processing of ceramics, Powder pressing, Refractories, Abrasives and Advanced ceramics

**Smart Materials:**
Introduction to sensors and actuators, Piezo-electrics, shape memory alloys, Basics of MEMS

**Text Books:**
1. Introduction to Physical Metallurgy - SH Avner

**Reference Books:**
1. Introduction to Ceramics - Kingery, Bowen and Uhlmann
2. ASM Handbook Volume 21: Composites
Flux assisted GTAW process
Lead Free Soldering
Friction welding processes, Friction stir welding and Friction surfacing
Micro Joining, Microwave Joining and Hybrid Welding.
Heat flow and temperature distribution in and around weld metal.
Calculation of heat input and heat affected zone width.
Problems during welding of carbon steels,
Welding of Stainless steels. Schaffler diagram.
Welding of Aluminum alloys
Welding of Titanium alloys and Nickel base alloys.
Welding of Dissimilar metals.
Corrosion of welds.

REFERENCE: ASM Metal hand book
### IM16P – CASTING LAB

<table>
<thead>
<tr>
<th>Periods/week: 3P</th>
<th>Credits: 2</th>
<th>Sessionals: 50</th>
<th>Exam: 50</th>
</tr>
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**List of Experiments:**

A laboratory project on any one of these topics.

1. CO₂ Molding
2. Shell Molding
3. Vacuum Molding
4. NDT of Castings
5. Design of Gating systems
6. Sand Testing

### IM17P – MATERIALS TESTING LAB

<table>
<thead>
<tr>
<th>Periods/week: 3P</th>
<th>Credits: 2</th>
<th>Sessionals: 50</th>
<th>Exam: 50</th>
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</thead>
</table>

1. Annealing and normalizing
2. Hardening and tempering
3. Hardenability- Jominy End Quench Test
4. ASTM grain size determination
5. Microstructural studies of plain carbon steels
6. Microstructural studies of cast irons
7. Microstructural studies of alloy steels
8. Microstructural studies of stainless steels
9. Microstructural studies of Al alloys
10. Microstructural studies of Ti alloys
11. Microstructural studies of Mg alloys
12. Microstructural studies of Superalloys

**REFERENCES:**

1. *Elements of Heat Treatment* - ZAKHAROV
2. *Physical Metallurgy for Engineers* - D.S CLARK & W.R.VARNEY
3. *Introduction to Physical Metallurgy* - S.H.AVNER
Sources of Failures, Steps in Failure Analysis, Characteristics of ductile and brittle fracture, ductile to brittle transition. High Temperature failures, fatigue failures, corrosion failures and their identification, failures of industrial components like casting and welding. Some case studies in failure analysis.

*Reference:* Analysis of Metallurgical failures - VJ Collangelo and PA Heiser.
**IM22 - STRENGTHENING MECHANISMS**

Periods / week: **4**    Credits: **4**    Sessionals: **30**    Exam: **70**

Strengthening from grain boundaries, Hall-Petch relation, ASTM grain size measurement, yield-point phenomenon, strain aging, strengthening due to point defects.

Solid solution strengthening: Elastic interaction, modulus interaction, stacking fault interaction, electrical interaction, short range order interaction, long range order interaction.

Cold working, Strain hardening of single crystals, annealing of cold worked metal, recovery, recrystallization and grain growth.

Strengthening from fine particles, Principle, mechanisms and examples of Precipitation hardening (age hardening), Dispersion hardening. Fiber strengthening, strength and moduli of composites (Iso-strain and Iso-stress condition), influence of fiber length, orientation and concentration

Strengthening by phase transformations, annealing, normalizing and hardening. Martensite strengthening.

**Text Books:**

1. *Mechanical Metallurgy* - George E Dieter
2. *Mechanical Behaviour of Materials* - Thomas H Courtany
4. *Materials Science and Engineering* – V Raghavan
IM23 – INDUSTRIAL HEAT TREATMENT

Periods / week: 4  
Credits: 4  
Sessionals: 30  
Exam: 70

Heat Treatment Equipment:
Furnaces, salt bath equipment, fluidized bed equipment, vacuum furnaces and auxiliary equipment, energy efficient furnace design and operation.

Process and quality control considerations:
Temperature control, furnace atmosphere control, control of surface carbon, evaluation of C control in processed parts, furnace safety

Heat treatment of Cast iron, tool steels, stainless steel and heat resistant alloys, non-ferrous alloys: Al, Cu, Mg, Ti. Annealing of precious metals.

Thermo mechanical processing of steels

References:
1. Nanomaterials – AK Bandyopadhyay, Newage International (p) limited publishers.
2. Nanomaterials- J Dutta and H Hofmann
3. Nanostructured materials processing, properties and applications- Carl C Koch, Jaico publishing house.
Advantages and limitations of powder metallurgy.

**Powder production methods:**

**Powder characteristics:**
Composition and structure, particle size, shape, specific surface, surface topography, flow rate, apparent and tap density, pressing properties.

**Shaping of metal powders:**

**Principles and practice of sintering:**

Applications of powder metallurgy. Cermets, bearing materials, friction parts, magnets, dispersion strengthened materials and other miscellaneous applications.

**REFERENCES:**

1. *Powder Metallurgy* – J.S. HIRSCHHORN
IM25 – NON-DESTRUCTIVE TESTING

Periods / week: 4  Credits: 4  Sessionals: 30  Exam: 70

Visual Examination. Leakage Testing:

**Penetrant methods:**
Principles, equipment, applications and limitations.

**Magnetic methods:**

**Ultrasonic testing:**
Types of ultrasonic waves. Flow detection and ultrasonic energy. Interpretation of results and limitations.

**X-ray radiography:**

**Gamma ray radiography:**
Production of gamma-rays, interpretation of the radiograph. Safety precautions.

**Electrical methods:**

**Thickness measurements:**

**Non contact gauging:**
Measurements by radiation absorption.

**REFERENCES:**

1. Metals Hand Book Vol.11 (Non-Destructive Testing)
2. Non-Destructive Testing-W.J.Me GONNANGLE
IM26P – FORMING LAB

1. Rolling of Copper, brass, stainless steel and plain carbon steel using laboratory rolling mills
2. Determination of tensile properties, n & k
3. Study on mechanical properties and microstructural change of cold worked copper, brass and stainless steel.
4. Study on mechanical properties and microstructural change of cold worked and annealed brass and stainless steel.
5. Ericsen ductility test
6. Determination of minimum bend radii.
7. Study on heat affected zone (HAZ) of steels joined by MMAW
8. Study on stress corrosion cracking of brass.

IM27P – WELDING LAB

About 6 experiments on welding methods and parameters.
III - SEMESTER

IM31 – ADVANCES IN IRON AND STEEL MAKING
(Seminar course)

Periods / week: 4  Credits: 3  Sessionals: 50

Iron making:
Modern trends in Blast Furnace Operation, alternative routes of Iron Production (COREX, MBF), direct reduction process: HYL, SL/RN processes, Midrex, fluidized bed.

Steel making:
Review of electric and L.D. Steel making processes, Hybrid steel making processes, Ajax, Twin hearth, Tandem, SIP, OBM, high tension electric steel making, plasma arc steelmaking processes.

Continuous Steel making processes: WORCRA, IRSID, Spray steel making, INRED, ELRED processes.

Production of High purity steel: Nonmetallic inclusions and their effect on properties of steel. Refining techniques, ESR, VAR, and Vacuum Degassing of liquid steel.
Alloy steel making, Tool steels and stainless steel making practice.
Review of Iron and steel Industry in India.

REFERENCES:
1. Reduction of Iron Ores – VAN BOGDANDY.
3. IIM-Silver Jubilee Symposium on Recent Developments in Materials Science and Technology.
6. Introduction of Steel making – R.H.TUPKARY
IM32 – CORROSION ENGINEERING  
(Seminar course)

Periods / week: 4  
Credits: 3  
Sessionals: 50


Text books:
1. An introduction to Electrometallurgy, Sharan and Narain, Standard Publishers

IM33 – MINOR PROJECT

Periods / week: 12  
Credits: 4  
Sessionals: 50

A technical / research problem to be handled by the candidate and submit a report.
IV – SEMESTER

Periods / week: Semester Credits: 6 Sessionals: 100

The student has to submit a comprehensive Design/Experimental project report on a selected topic.