Materials Science and Engineering: Concepts, Properties, Selection, and Applications of Metals, Polymers, Ceramics, and Composites

Course general description:

Materials science is the foundation of engineering innovation, as the choice of materials directly impacts the performance, durability, and sustainability of systems and products. This course provides a comprehensive exploration of the fundamental principles of materials science, including the properties, selection criteria, and applications of metals, polymers, ceramics, and composites. Participants will learn how to analyze material behavior, select appropriate materials for specific engineering applications, and understand the latest advancements in material technologies.

Audience:

This course is designed for:

1. Engineers (mechanical, civil, aerospace, chemical, etc.) involved in product design and material selection.
2. Researchers and academics working in materials science and engineering fields.
3. Manufacturing professionals seeking to optimize material usage and performance.
4. Students in engineering disciplines looking to build a strong foundation in materials science.

Course objectives:

By end of the course participants will gain:

1. Understand the fundamental concepts of materials science, including structure-property relationships.
2. Learn the properties, characteristics, and applications of metals, polymers, ceramics, and composites.
3. Develop skills in material selection based on engineering requirements such as strength, durability, and cost.
4. Explore advanced topics such as nanomaterials, biomaterials, and smart materials.
5. Apply material science principles to solve real-world engineering problems through case studies and practical exercises.
6. Gain awareness of sustainability considerations and emerging trends in materials engineering.

Course duration:

5 days

Course location:

Dubai

Course contents:

Day 1: Fundamentals of Materials Science

- Introduction to Materials Science – Overview, importance, and classification of materials (metals, polymers, ceramics, composites).
- Structure-Property Relationships – Atomic bonding, crystal structures, and material defects.
- Mechanical Properties – Stress-strain behavior, elasticity, plasticity, and fracture mechanics.
- Testing Methods – Tensile tests, hardness tests, and impact tests.
- Pretest & Case Study – Assess baseline knowledge and analyze material failure in a structural component.

Day 2: Metals and Alloys

- Properties of Metals – Ferrous vs. non-ferrous metals, corrosion resistance, and surface treatments.
- Alloying & Heat Treatment – Strengthening mechanisms, phase diagrams, and microstructure analysis.
- Advanced Metallic Materials – Superalloys, lightweight metals, and metal additive manufacturing.
- Practical Applications – Selecting metals based on mechanical properties for engineering applications.
- Quiz & Exercises – Predicting alloy microstructures using phase diagrams and application-based selection.

Day 3: Polymers and Plastics

- Polymer Chemistry – Thermoplastics, thermosets, elastomers, and their molecular structures.
- Processing Techniques – Injection molding, extrusion, and 3D printing of polymers.
- Engineering Applications – Biodegradable polymers, smart materials, and high-performance plastics.
- Sustainability Challenges – Recycling, environmental impact, and polymer degradation.
- Case Study & Quiz – Evaluating polymer use in medical devices and sustainability discussions.

Day 4: Ceramics and Composites

- Ceramic Properties & Applications – Brittleness, hardness, thermal stability, and advanced ceramic materials.
- Composite Material Fundamentals – Fiber-reinforced, particle-reinforced, and laminate composites.
- Composite Manufacturing & Applications – Aerospace, automotive, and high-performance sports equipment.
- Hands-On Simulation – Stress distribution analysis in a composite laminate.
- Group Activity – Designing a composite material for lightweight structural applications**.**

Day 5: Material Selection, Sustainability, and Final Assessment

- Material Selection Strategies – Ashby charts, decision matrices, and engineering trade-offs.
- Sustainability in Materials – Life cycle assessment, bio-based materials, and recycled composites.
- Emerging Trends – Nanomaterials, biomaterials, and metamaterials in modern engineering.
- Final Assessment – Comprehensive test to evaluate knowledge gained.
- Feedback & Discussion – Reviewing key takeaways, comparing pretest and post-test results, and career guidance.

Methodology:

- 50% lectures & concepts
- 10% Videos
- 15% Case studies
- 15% Exercises
- 10% Discussions

Course code: (TGRL005)