Indian Institute of Technology, Kanpur
Proposal for a New Course

1. Course No. DESxxx
2. Name of the Course: ***Material Thinking & Exploration for Industrial Design***

Course Type: Elective (B.Tech/B.S/ M.Des / M.Tech/PhD)

3. Per Week Lectures: 02 (L), Tutorial: 0 (T), Laboratory: 3 (P), Additional Hours: 0

Credits (2*L+0*T+3P+0*A): 9 Duration of Course: Full Semester

4. Proposing Department: Design

5. Proposing Instructor(s): Prof. J. Ramkumar and Mr. Girish

Course Overview

This course introduces material selection and exploration through a designer–engineer lens, combining material science fundamentals with hands-on design thinking. Using Ashby's approach (function–material–process–shape), students explore traditional and emerging materials including sustainable, bio-inspired, and advanced composites.

Course Learning Objectives

By the end of the course, students will be able to:

- Understand relationships between material properties, processes, and form
- Apply Ashby's material selection methodology in design projects
- Evaluate materials based on performance, aesthetics, and sustainability
- Explore emerging materials (eco-friendly, smart, bio-based, composites)
- Develop material-driven design concepts
- Communicate material decisions using charts, samples, and prototypes

6. Course Structure (40 Lectures)

Sr. No.	**Topic Description**	Remark
Module 1: ***Introduction to Material Thinking***	Lecture 1: Material thinking in industrial design	
	Lecture 2: Role of materials in product experience (visual, tactile, emotional)	
	Lecture 3: Overview of Ashby approach (Function–Constraints–Objectives–Variables)	
	Lecture 4: Market Research & User Needs	
Module 2: ***Materials & Sustainability***	Lecture 5: Life Cycle Thinking (LCA)	
	Lecture 6: Eco-friendly and low-impact materials	
	Lecture 7: Circular design principles	
	Lecture 8: Material ethics and responsibility	
	Lecture 9: Product Launch & Lessons Learned	

	Case Study: Sustainable product analysis	
Module 3: ***Advanced & Emerging Materials***	Lecture 10: Emerging material for new Era	
	Lecture 11: Bio-inspired and bio-based materials	
	Lecture 12: Multifunctional & "Smart" Composites for Designers	
	Lecture 13: Smart & Shape Memory Materials (responsive materials)	
	Lecture 14: Material innovation in industry	
	Activity: Material experimentation workshop	
Module 4: ***Material Exploration Studio***	Lecture 15: Material-Driven Design Process(material discovery, material thinking framework, from through material+ process, concept generation)	
	Lecture 16: Studio Methods & Exercises (Material First Challenge, Constraint-Led Design, Sensory Mapping with material, Process exploration)	
	Lecture 17: Integration of Ashby Method (Applied, Not Theoretical)	
	Lecture 18: Tools for Material Thinking (Digital, Physical, Visual)	
	Lecture 19: Hands-on exploration and prototyping	
	Lecture 20: Integration of engineering logic + design sensibility	
Module 5: ***Materials & Their Properties***	Lecture 21: Mechanical properties (strength, stiffness, toughness)	
	Lecture 22: Physical properties (density, thermal, electrical)	
	Lecture 23: Sensory and experiential properties (texture, finish, perception)	
	Activity: Material sample study + sensory mapping	
Module 6: ***Material Families***	Lecture 24: Metals – Classification and Types	
	Lecture 25: Metals – Properties and Design Exploration	
	Lecture 26: Ceramics – Types and Classification	
	Lecture 27: Ceramics – Properties and Design Applications	
	Lecture 28: Wood, Bamboo, and Natural Fibers – Types	
	Lecture 29: Wood, Bamboo, and Fibers – Design Exploration	
	Lecture 30: Polymers – Types and Classification	
	Lecture 31: Polymers – Contemporary Design Applications	
	Lecture 32: Composites and Advanced Ceramics – Overview	
	Lecture 33: Composites and Ceramics – Design Exploration	
Module 7: ***Material***	Lecture 34: Translating design requirements into material specs	
	Lecture 35: Performance indices (Ashby method)	
	Lecture 36: Trade-offs: cost vs performance vs sustainability	
	Tool: Material selection charts and CES-type databases	

Selection Method	Assignment: Material selection report for a product	
Module 8: ***Manufacturing Processes & Form***	Lecture 37: Shaping processes: casting, molding, forming, additive manufacturing and new tech. for material printing	
	Lecture 38: Process–material–form relationship	
	Lecture 39: Design for Manufacturing (DFM)	
	Lecture 40: Process-Material Interaction from designer Prospective	
	Final Project: Design a product where material is the primary driver, supported by: • Material selection justification (Ashby method) • Sustainability considerations • Prototype / mock-up • Material board	
	Total Lectures	40

*Each module typically includes a small project that requires applying the concepts learned in both the current and previous modules, helping to reinforce understanding and build practical skills.

Pre-requisites, None. Only attentiveness and a willingness to grasp new concepts in material thinking for product, industrial design are desirable.

Assessment Scheme

Assignments- 20%
Mid-semester exam - 20%
Final project - 20%
End Semester - 40%

References (suggested readings):

1. Materials and Design: The Art and Science of Material Selection in Product Design by Michael F. Ashby & Kara Johnson
2. Material Matters: New Materials in Design by Thomas Schröpfer
3. Materials for Design by Chris Lefteri (Laurence King Publishing)
4. Manufacturing Processes for Design Professionals by Rob Thompson
5. Sustainable Materials: Processes, Applications and Case Studies by Julian Allwood & Jonathan Cullen
6. Biomimicry: Innovation Inspired by Nature by Janine Benyus
7. Making It: Manufacturing Techniques for Product Design by Chris Lefteri, 2018 (third edition)
8. Industrial Design: Materials and Manufacturing Guide by Jim Lesko, 2nd Revised Edition, 2007.
9. Universal Principles of Design, by William Lidwell
10. Research papers and other reference materials (based on project)

Additional References

1. Manufacturing and Design: Understanding the Principles of How Things Are Made – Erik Tempelman
2. Materials Science and Engineering: An Introduction – William D. Callister Jr.
3. The Design Thinking Playbook (2018), by Michael Lewrick, Larry Leifer, and Patrick Link

Dated: 14.04.2026 Proposer: Prof. J. Ramkumar and Mr. Girish

Dated:_____ DUGC/DPGC Convener: _____

This Course is approved / not approved

Chairman, SUGC/SPGC

Dated_____