NANYANG TECHNOLOGICAL UNIVERSITY

Teaching, Learning and Pedagogy Division

Reg. No. 200604393R

COURSE OUTLINE FOR STUDENTS AT NTU

Academic Year	2022-2023	**Semester**	1 & 2
Course Coordinator	TBD (1st semester), TBD (2nd Semester)		
Course Code	MA2024		
Course Title	Engineering Materials and Manufacturing Processes		
Pre-requisites	None		
No of AUs	3		
Contact Hours	Total hours: 39 (26 hours lecture + 13 hours tutorials)		
Proposal Date	22 June 2021		

Course Aims

This core Engineering course will introduce the fundamental knowledges of engineering materials—with emphasis on metals and alloys—and their manufacturing processes. The first half of the course will lay the foundations for the understanding of the relationships between structure at the atomic level to the properties of materials, the role of defects in determining properties, and the basics as to how alloys are designed. The second part of the course provides the student with a basic understanding of the manufacturing processes used in industry. These include their fundamental principles, theory, quality issues and applications. This course provides mechanical engineering students the foundations for designing and selecting materials for virtually any engineering application, as well as understanding the common manufacturing processes used in industry.

Intended Learning Outcomes (ILO)

By the end of the course, you should be able to:

1) Sketch crystal configurations and compute crystallographic quantities
2) Solve simple problems on mechanical deformation.
3) Evaluate the mechanical properties of solids as a function of their structure.
4) Distinguish between different types of alloys and how microstructures evolve in them.
5) Develop a basic understanding on various types of steels and some basic knowledge about the microstructural aspects of them.
6) Identify various ways to strengthen metals.
7) Describe the applications of common dimensional and surface measuring equipment.
8) Select basic manufacturing processes for manufacturing a component, for example by casting or polymer shaping or machining or sheet metalworking.
9) Apply metal casting fundamentals (e.g., solidification, riser design).
10) Calculate forces for sheet metalworking processes (cutting, bending, and drawing).

11) Use metal-cutting theory to calculate forces, power, and energy, select suitable tool materials and determine suitable machining conditions.
12) Explain the fundamentals of metal joining processes.
13) Apply welding fundamentals (e.g., effect of heat and pressure) to select suitable welding processes.
14) Describe the common engineering polymers, their mechanical properties, and describe major forming processes (e.g., injection moulding, extrusion, thermoforming, blow moulding) used in industry.

Course Content

PART I: Engineering Materials

- **Materials science and engineering: Introduction (1 h)**
  Materials as the cornerstone of society. Classification of materials and their basic characteristics: crystalline and non-crystalline solids; metals, ceramics, polymers, and composites. Importance of processing-structure-property relationships.
- **Crystals and defects (3 h)**
  Crystal systems and structures. Miller indices. Crystallographic directions and planes, packing efficiency. Polycrystalline and single crystalline materials. Types of Defects: Point, line, planar, and bulk. Properties affected by defects. Dislocations. Slip systems.
- **Phase diagrams (PDs) and microstructure formation (5 h)**
  Interpretation of (binary) PDs. Isomorphous PD. Eutectic PD. PD with Intermediate phases or compounds. Microstructure analysis. The iron-carbon PD; Cast Irons; Heat Treatment of Ferrous Alloys; Carbon and alloy steels; stainless steels.
- **Mechanical behaviour of materials (4 h)**
  Stress and strain. Elastic and plastic deformation. Ductility. Toughness. Strengthening mechanisms. Heat treatment of nonferrous alloys; precipitation hardening, Aluminium Alloys; Superalloys. Recovery, Recrystallisation, and grain growth.

PART II: Manufacturing

- **Introduction and overview of manufacturing (1h)**
  Introduction to manufacturing. Materials and manufacturing processes. Trends in manufacturing. Dimensions and tolerances. Conventional measuring instruments and gages. Surfaces finishing and measurement.
- **Metal Casting (2 h)**
  Fundamentals of metal casting. Metal casting processes. Casting quality, common defects, and design consideration. Expendable and non-expendable casting.
- **Metal Forming (3 h)**
  Hot/Cold rolling, Sheet metal forming, Blanking, Bending, drawing.
- **Metal Machining (2 h)**
  Theory of metal cutting. Machining operations and machine tools. Cutting tool technology.
- **Metal Joining (2h)**
  Fundamentals of welding. Welding processes and weld quality. Brazing, soldering and adhesive bonding.
- **Engineering Polymers and Polymer Forming (3h)**
  Engineering polymers: Polymer basics; thermoplastics, thermosets, and elastomers. Polymer Forming: Properties of polymer melts. Extrusion. Injection, compression, transfer, and blow mouldings. Thermoforming & casting.

Assessment (includes both continuous and summative assessment)

Component	Course LO Tested	Related Programme LO or Graduate Attributes	Weighting	Team/Individual	Assessment rubrics
1. Continuous Assessment 1 (CA1): Quiz	1 to 7	EAB SLO a, b, c	20%	Individual	
2. Continuous Assessment 2 (CA2): Quiz	8 to 14	EAB SLO a, b, c	20%	Individual	
3. Final Examination – Closed Book; 2.5 hrs	1 to 14	EAB SLO a, b, c	60%	Individual	
Total			100%		

* EAB SLO stands for the Engineering Accreditation Board Student Learning Outcomes. The list is below:

a) **Engineering knowledge:** Apply the knowledge of mathematics, natural science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.

b) **Problem Analysis:** Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

c) **Design/development of Solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.

d) **Investigation:** Conduct investigations of complex problems using research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

e) **Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

f) **The engineer and Society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues, and the consequent responsibilities relevant to the professional engineering practice.

g) **Environment and Sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for the sustainable development.

h) **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

i) **Individual and Teamwork:** Function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary settings.

j) **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

k) **Project Management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and economic decision-making, and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

l) **Life-long Learning:** Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

Formative feedback

You will be provided with formative feedback through the following channels:

- Tutorials: Tutors will address the main misconceptions that emerged from the tutorial questions and lectures.
- Online Feedback: You will be able to submit online feedback forms to ask questions anonymously on concepts that you find particularly difficult to assimilate.
- Live Feedback: You will be asked multiple choice questions during lectures. The lecturers will provide live feedback on the submitted questions.
- Consultations: You will be able to request individual or group consultations with lecturers.

Learning and Teaching approach

Approach	**How does this approach support students in achieving the learning outcomes?**
Lecture	Live lectures (or LAMS), which will integrate multiple choice questions to gauge your understanding of the topic.
Revision Session	Live revision sessions will be held once a week to review the main concepts presented in live lectures (or LAMS), to run demonstrations (e.g., mechanical testing of materials), and discuss case-studies (e.g., the causes of engineering failures in history). You will be challenged to discuss, analyze, and critique on fundamental concepts covered in the lectures.
Tutorial	During tutorials, you will have to solve and discuss different problem sets.

Reading and References

Textbook

1. William D. **Callister**, David G. Rethwisch, "Materials Science and Engineering – An Introduction" 9th Edition, John Wiley and Sons, 2014.
2. **Groover** Mikell P, Principles of modern manufacturing. 5th ed. SI version. John Wiley, 2013.

References

3. Sam Allen, Edwin L. Thomas, "The Structure of Materials", John Wiley and Sons, 1999.
4. William F. Smith, Javad Hashemi, "Foundations of Materials Science and Engineering". 5th Edition, McGrawHill, 2010.
5. James F. Shackelford, "Introduction to Materials Science for Engineers" 6th Edition, Pearson Prentice Hall, 2005.
6. DeGarmo, E. Paul, Black, J. Temple and Ronald A. Kohser, "Materials and Processes in Manufacturing", 10th Edition, Hoboken, New Jersey: Wiley, 2008.
7. Kalpakjian S and Schmid S R, Manufacturing engineering and technology, 7th edition, Pearson, 2013.

Course Policies and Student Responsibilities

1. *You are responsible to check regularly and follow-up with all courses, continuous assessment, and course related announcements.*

2. *You are expected to complete all prescribed reading materials (notes and chapters in recommended textbooks). The notes provided are not intended to be complete but serve as a summary of topics and concepts that are covered in the course. The readings of prescribed textbooks are necessary for complete coverage of course contents.*

3. *You are expected to attend and to actively participate during live lectures and tutorial classes, asking and answering questions and contributing to the discussion.*

4. *There will be **two** Continuous Assessments in the form of Quizzes, **each** constituting **20%** (total 40%) of the Course marks.*

5. *Your **Final Examination** constitutes **60%** of the Course Marks.*

6. *If you are unable to attend your tutorials or Continuous Assessments (CAs) because of illness or participating in a University Approved Event, You MUST submit your Medical Certificates (MCs) or Leave of Absence (LOA) respectively to the MAE Undergraduate Office promptly within 7 days. Failure to do so promptly will result in "ABS" and given "0" mark for that CA and tutorial participation components. The original MC or LOA form must be endorsed by your tutor and submitted to the MAE Undergraduate Office. Email a scanned version of the MC or LOA to the Course Co-ordinator and your tutor for reference.*

Academic Integrity

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values.

As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion, and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Course Instructors

Instructor	Office Location	Phone	Email
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Planned Weekly Schedule

Week	Topic	Course LO	Readings / Activities
1-2	**PART I: MATERIALS** Materials science and engineering: Introduction Crystals and defects	1, 3	Callister Ch. 1, 3, 4.1 to 4.5, and 6
3-4	Phase diagrams and microstructure formation	4, 5	Ch. 11
5-7	Mechanical behaviour of materials	2, 6	Ch. 8, 9
Recess week			
8	**PART II: Manufacturing:** Introduction, Dimensions (1h)	7	Groover Ch. 1, 1.1, 1.2, 1.3 and 1.6
9	Casting	8,9	Groover Ch.6 − 6.1 to 6.5 Groover Ch. 7 − 7.1 to 7.3 Groover Ch. 8 − 8.2.4, 8.3.1, 8.3.3, 8.5, 8.7
10	Sheet Metal Forming	10	Groover Ch. 3 − 3.1.1, 3.1.4 Groover Ch. 16 − 16.1 to 16.3
11	Machining	11	Groover Ch. 17 – 17.1 to 17.5 Groover Ch. 18 – 18.1 to 18.4 Groover Ch. 19 – 19.1 to 19.3
12	Welding & joining	12, 13	Groover Ch. 25 - 25.1 to 25.4 Groover Ch. 26 – 26.1 to 26.8 Groover Ch. 27 – 27.1 to 27.3
13	Engineering Polymer and Polymer Forming Process	14	Calister Ch 14, 15

			Groover Ch. 10 − 10.1, 10.2.1, 10.2.3, 10.6 to 10.10