NANYANG TECHNOLOGICAL UNIVERSITY

Teaching, Learning and Pedagogy Division

Reg. No. 200604393R

COURSE OUTLINE FOR STUDENTS AT NTU

Academic Year	2018	**Semester**	2
Course Coordinator	Dr Chow Wai Tuck		
Course Code	MA2700		
Course Title	Aerospace Materials & Manufacturing Processes		
Pre-requisites	Nil		
No of AUs	3		
Contact Hours	Lectures: 26 hours Tutorials: 13 hours		
Proposal Date	November 2018		

Course Aims

The aim of this subject is to equip you with the knowledge on the various characteristics of aerospace materials and their manufacturing processes and how to successfully deploy these materials in aerospace structures.

Knowledge of the relationship between processing, microstructure and properties of various types of aerospace materials is important for aerospace engineers especially in the selection of materials for designing aerospace structures and components.

This course will also provide you with the knowledge required for assessing the failure modes of aerospace components and how to prevent material failures. You will also gain an overview of the various manufacturing processes associated with the aviation industry. You will be made aware of the limitations and advantages of each process as well as the criteria for quality assurance.

Intended Learning Outcomes (ILO)

Upon the successful completion of the course, you would be able to:

1) Compare the various types of aerospace materials and their characteristics.
2) Describe the principles of material requirements for aerospace applications.
3) Evaluate the properties of aerospace materials and how they arise as a result of processing.
4) Explain key factors that determine the performance of aerospace materials.
5) Describe the major failure modes of aerospace materials and how to prevent these failures.
6) Describe the various manufacturing processes associated with aircraft components.
7) Evaluate the suitability of manufacturing techniques to produce an aircraft component.

Course Content

	Topic	Hours
1.	**Introduction** Various types of materials used in aerospace engineering and some catastrophic failures of aircrafts, recent development in aerospace industry and new ideas of future aircrafts and related materials issues. Manufacturing processes in aerospace industry, challenges and progresses.	**1**
2.	**Atomic Structures, Crystal Structures, Solidification** Atomic structures and types of bonding (metallic, ionic, covalent, secondary bonds), crystal structures and Miller indices, melting and solidification (homogeneous and heterogeneous nucleation), single crystal and polycrystalline materials.	**4**
3.	**Crystal Defects, Mechanical Properties, Deformation Mechanisms, Strengthening Mechanisms** Crystal defects (point defects, dislocations, grain boundaries, lattice, twinning, precipitates, etc.), stress-strain relation, deformation mechanisms, strengthening mechanisms (solid solution strengthening, grain size refinement, work hardening, precipitation hardening), slip systems, Schmid's law, recovery and recrystallization, shape memory alloys.	**4**
4.	**Failures of Aerospace Materials, Phase Diagrams** Ductile and brittle failures, impact test, fracture toughness, fatigue and fatigue life estimation, creep and LM parameter, binary phase diagrams, phase rule, phase transformations, heat treatments, precipitation process.	**4**
5.	**Special Aerospace Materials** Alloy steels, Al alloys, Ti alloys, superalloys, intermetallic compounds, refractory metals and alloys, thermal barrier coatings.	**3**
6.	**Composites** Various types of composites: polymer matrix composites, metal matrix composites, ceramic matrix composites, Carbon-fibre-reinforced Carbon (C/C) composites, interfacial cracking and delamination, toughening mechanisms.	**3**
7.	**Manufacturing Processes** Introduction to powder metallurgy, casting, metal forming (rolling, forging, extrusion, drawing), plastic moulding, fiber reinforced composites manufacturing.	**4**
8.	**Machining, Joining and Finishing Processes** Machine tool elements, machining (turning, drilling, milling), introduction to welding (types of welding, types of welds, welding defects, power, etc.).	**2**
9.	**Industry 4.0** Introduction to latest trend of automation and data exchange in manufacturing technologies. Visit to Advanced Remanufacturing and Technology Centre (ARTC) to be arranged.	**1**

Assessment (includes both continuous and summative assessment)

Component	Course LO Tested	Related Programme LO or Graduate Attributes	Weighting	Team/Individual	Assessment rubrics
1. Final Examination (2.5 hrs; Closed Book)	LO1 – LO7	* EAB SLO a, b, c	60	Individual	
2. Continuous Assessment 1: Quiz 1	LO1 – LO3	EAB SLO a, b, c	10	Individual	
3. Continuous Assessment 2: Quiz 2*	LO3 – LO5	EAB SLO a, b, c, l	15 (12 + 3)	Individual	
4. Continuous Assessment 3: Project	LO1 – LO5	EAB SLO a, b, c, i	15	Team	
Total			100%		

**If ARTC visit is arranged during semester, may include 3 marks given for reflection piece based on the ARTC visit.*

The list for the Engineering Accreditation Board Student Learning Outcomes is as follows:

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 Team Work:** 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

http://www.ntu.edu.sg/tlpd/tlr/obtl/4/Pages/41.aspx

Formative feedback

The feedbacks are given through the face to face tutorial sessions with tutors. Additional Lecture briefings are also given during designated lecture hours to give review of the contents and take questions in person with you.

Learning and Teaching approach

Approach	**How does this approach support students in achieving the learning outcomes?**
Online Lecture	Online lectures provide content knowledge, theory and explanation on each topic in the syllabus with appropriate examples. Practice questions to the key concepts are included in the online lecture modules to ensure your understanding of most important concepts.
Tutorial	Tutors provide guidance to solve sample tutorial problems in class. There will be opportunity for you to ask questions.
In-class Lecture	Offered the same content as online lecture for selected lectures. The aim is to provide more interaction between the lecturers and students. You can have opportunities to meet main lecturers for consultation.

Reading and References

Textbooks

1. W.F. Smith and J. Hashemi, Foundations of Materials Science and Engineering, 5th Edition, International Edition, McGraw-Hill Companies, Inc., 2011.
2. M.P. Groover, Principles of Modern Manufacturing, 6th Edition, John Wiley & Sons, Inc., 2017.

Reference Books

1. A.P. Mouritz, Introduction to Aerospace Materials, Woodhead Publishing Ltd., 2012.
2. F.C. Campbell, Manufacturing Technologies for Aerospace Structural Materials, Elsevier, 2006.
3. B. Cantor et al., Aerospace Materials, Institute of Physics Publishing, 2001.
4. W.D. Callister, David G.Rethwisch, Materials Science and Engineering – An Introduction, John Wiley and Sons, 2014.
5. D.R. Askeland et al., The Science and Engineering of Materials, Cengage Learning, 2011

Course Policies and Student Responsibilities

As a student of the course, you are required to abide by both the University Code of Conduct and the Student Code of Conduct. The Codes provide information on the responsibilities of all NTU students, as well as examples of misconduct and details about how students can report suspected misconduct. The university also has the Student Mental Health Policy. The Policy states the

University's commitment to providing a supportive environment for the holistic development of students, including the improvement of your mental health and wellbeing. These policies and codes concerning students can be found in the following link.
http://www.ntu.edu.sg/SAO/Pages/Policies-concerning-students.aspx

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, and 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
Chow Wai Tuck	N3.2-02-29	6790 5087	wtchow@ntu.edu.sg
Brian Stephen Wong	N3-02c-108	6790 5594	mbwong@ntu.edu.sg

Planned Weekly Schedule

Week	Topic	Course LO	Readings/ Activities
1	Introduction, atomic structures	1	Smith Ch. 1,2
2	Crystal structures	1,2	Smith Ch. 3
3	Solidification, Crystalline imperfections	2,3	Smith Ch. 4
4	Deformation mechanisms, strengthening mechanisms	3,4	Smith Ch. 5,6
5	Failure of metals	5	Smith Ch. 7
6	Equilibrium phase diagram, precipitation	3,4	Smith Ch. 8
7	Martensitic Transformation in Steels and Non-equilibrium Phase Diagram	3,4	Smith Ch. 9
8	Al alloys, Ti alloys	1,4,5	Smith Ch. 9
9	Superalloys, composites (I)	1,4,5	Smith Ch. 9,12
10	Composites (II)	1,4	Smith Ch. 12
11	Casting	6,7	Groover Ch. 7,8
12	Metal Forming, PM & PMC	6,7	Groover Ch. 11,12,14,15
13	Machining, Welding	6,7	Groover Ch. 17,18,25,26