ANNEX A

MA3001 Machine Element Design

Academic Year	AY2022/23	**Semester**	1/2
Course Coordinator	Hoon Kay Hiang		
Course Code	MA3001		
Course Title	Machine Element Design		
Pre-requisites	MA2001 Mechanics of Materials, MA2002 Theory of Mechanism and MA2005 Engineering Graphics (Note: Students just need to have read the above courses, a Pass is not required.)		
No of AUs	3		
Contact Hours	Lecture: 26 hours Tutorial & Class Exercises: 36 hours		
Proposal Date	May 2022		

Course Aims

This course aims to introduce how many of the most common machine elements such as belts, chains, gears and bearings operate; and how the information learned in previous mechanics of materials and theory of mechanism courses can be applied to solve the design problems encountered when using these elements.

You will learn the important features of these elements and the methods of analysing and designing them. You will also learn how machine elements are selected and integrated into common and commercially available mechanical devices and systems, so that these devices and system can satisfy their function and desired application. The use of industrial manuals will be part of the learning experience of this course.

Intended Learning Outcomes (ILO)

By the end of this course, you (as a student) would be able to:

1) Analyze and perform appropriate calculations required for the selection of standard machine components,
2) Design and select machine elements to satisfy the function of the machine for desired applications.
3) Integrate and interface machine elements in a mechanical device or system.

Course Content

	Topics	Hours
1	Introduction	1

2	Belt drives	2
3	Chain drives	2
4	Gear fundamentals, interference, speed ratio Gears – Spur, helical, bevel, & wormgears	5
5	Design against failures - Strength Rigidity, Stability, Wear	2
6	Shaft design	3
7	Key design, couplings, limits & fits	3
8	Roller bearings	2
9	Power screws & threaded fasteners Bolted & welded joints	4
10	Design of machine frames & parts	2

Assessment (includes both continuous and summative assessment)

Component	ILO Tested	EAB Graduate Attributes	Weightage	Team / Individual	Rubrics
1. CA1: Introduction to machine elements in a drill press	3	a, j, l	5%	Team	
2. CA2: Belt Drive	2	a, b, j, l	5%	Individual	
3. CA3: Chain Drive	2	a, b, j, l	5%	Individual	
4. CA4: Gear Drive	2	a, b, j, l	5%	Individual	
5. CA5: Assembly Drawing of Drill Press	3	a, j, l	5%	Team	
6. CA6: Design Project Report	1, 2, 3	a, b, c, j, l	25% Team: 20% Individual: 5%	Team	
7. Final Examination (Open Book, 2.5hrs)	1	a, b, c	50%	Individual	
Total			**100%**		

NOTE: CA1 – CA5 are in-class compulsory assignments.

EAB Graduate Attributes[1]	
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 systems, 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 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.

[1] *Reference: EAB Accreditation Manual*

Formative feedback

In this course, you will receive feedback in the following ways:

- Compulsory assignments with grades and comments are returned to you in the following week.
- Open ended compulsory assignments are used as a yard stick to measure your progress and stimulate the learning process.
- You are encouraged to participate in class by presenting your approach to tutorial problems to the class. The Instructor is to comment on your solutions to assist in your learning process and clarify any doubts. This also invites you to think about the subject matter critically.
- Design project reports are marked and graded. Comments are given in the reports. Besides, you are encouraged to discuss your ideas and design analysis with your tutors during the design class.
- Feedback will be welcome through the course, where you could feedback directly to your tutors in classes and write in to the lecturers for constructive suggestions.

Learning and Teaching approach

Approach	**How does this approach support students in achieving the learning outcomes?**
Lecture	Provides important fundamental knowledge and information, and include videos and worked examples to help you to achieve CLO 1, 2 & 3.
Compulsory Assignments - Problem-based learning/Interactive Classroom activities	You are required to read up on course notes to prepare for the in class assignments. The assignments are based on real practical problems. The problems will challenge students to use the internet and commercial publications to search for information, interact with fellow students to solve the problems as well as interact with the tutors. CLO 1 & 2.
Tutorial - Problem-based learning/Interactive Classroom activities	You are required to read up on course notes to prepare for the tutorial problems. The problem will challenge you to analyse and perform appropriate calculations required for the selection of standard machine components. CLO 1 & 2.
Team design project	You are required to use the knowledge acquired from the lectures, compulsory assignments and tutorials to work on a well- defined and guided design problem. The project will challenge the you working in a team to perform analysis, select appropriate standard components from manufacturer's catalogues, custom-design parts and shafts,

	integrate and interface them into a machine. You will also require to design suitable housing and mounting for all components and produce assembly drawings of the machine they have designed. CLO 1, 2 & 3.

Reading and References

References

1. Mott, Robert, *Machine Elements in Mechanical Design*, Prentice Hall, 4th Edition, 2003.
2. Shigley, JE, *et al*., *Mechanical Engineering Design*, McGraw-Hill, 7th Edition, 2004.
3. Relevant manufacturers' catalogues.

Course Policies and Student Responsibilities

(1) In Class Compulsory Assignments

Students are expected to complete all compulsory assignments at the end of each design class session. Students are expected to take responsibility to prepare for the compulsory assignments.

(2) Absenteeism

The completion of compulsory assignments requires to be in class to contribute to team work or individual work. Absence from compulsory assignment without a valid reason will affect overall course grade. Valid reasons include falling sick supported by a medical certificate and participation in NTU's approved activities supported by an excuse letter from the relevant bodies. There will be no make-up opportunities for compulsory assignments.

(3) Design Project Report

You are required to submit a design project report as a team on due date. The completion of the project report requires them to be actively contributing to teamwork. Students –are required to declare their contribution to the project and report, and where needed, to do a peer appraisal among members.

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
Dr Hoon Kay Hiang	N3-2c-94	67905523	mkhhoon@ntu.edu.sg
Holden Li King Ho	N3.2-02-06	67906398	holdenli@ntu.edu.sg

Planned Weekly Schedule

	Topic	Course LO	Readings/Activities
1.	Introduction to machine elements	Obtain a broad overview of the machine design and common machine elements to: • Identify the types of common machine elements that make up a machine. • Relate importance of the interfaces between machine elements. • Describe the design process of a power transmission. • Identify the type of standardised and customised machine elements. • Describe the general applications of belts, chains and gears in a power transmission. • Compulsory Team Assignment CLO (2)	Lecture slides Reference Books
2.	Design of belt drives	• Identify the basic features of a belt drive system. • Describe several types of belt drives and basic considerations. • Describe the standard industrial narrow section	Lecture slides Reference Books

		V-belts • Relate the interfaces of pulley/sheave bores and shafts • Use guidelines for design of belt drive • Select belts and sheaves • Analyse forces on sheave and shaft • Tutorial and Compulsory Individual Assignment CLO (1,2,3)	
3.	Design of chain drives	• Identify the basic features of a chain drive system. • Describe the standard roller chain and its classification. • Identify the types of chain sprockets • Use guidelines for design of chain drive • Select roller chains from basis of strength for static or very slow speed applications • Select roller chains and sprockets from basis of power transmission for high speed applications • Analyse forces on sprocket and shaft • Tutorial and Compulsory Individual Assignment CLO (1,2,3)	
4/5.	Gear drives	• Describe various types of gears, gear systems, their characteristics and their applications • Describe gear terminology • Select number of gear teeth to avoid interference for spur gears • Use simple equations to determine the speed ratios of various gear trains	Lecture slides Reference Books

		• Determine direction of rotation of gears, including idler gears • Determine outermost dimensions of gear layout • Analyse the gear forces exerted on spur and helical gears • Tutorial and Compulsory Individual Assignment CLO (1,2,3)	
6.	Design against failures	• Relate the importance of force and stress analyses, learned in Mechanics of Materials course, to design of machine elements. • Identify typical geometric discontinuities or stress concentrations in machine elements • Describe the 4 basic modes of failures • Describe the use of allowable stress and factor of safety in designing for strength. • Describe the allowable conditions in designing for rigidity, stability and resistance to wear • Identify the 3 modes of failures for columns in compression. CLO (1)	Lecture slides Reference Books
7.	Design of Shaft	• Determine the shaft rotation speed, power and torque • Determine the parts to be mounted on the shaft (gears, belts, etc) • Determine the location of bearings, keys and fillets • Analyze the forces acting on shaft and drawing the torque diagram • Solving the reaction forces on bearings	Lecture slides Reference Books

		• Selection of shaft material and specification of working conditions • Determine the appropriate design stress, considering the manner of loading (smooth, shock, etc) • Determine the final dimensions of shaft CLO (1,2,3)	
8.	Design of Keys; Couplings Selection; Limits and Fits	• Specify the suitable materials for keys • Determine the required key geometry: length, width and height • Describe several types of flexible couplings • Specify translational, interference, and force fits • Specify appropriate geometric dimensions and tolerancing controls for mating parts CLO (1,2,3)	Lecture slides Reference Books
9.	Selection of Roller Bearings	• Identify the types of rolling contact bearings that are commercially available • Use the relationship between forces on bearings and life expectancy for the bearings to determine critical bearing selection factors • Use manufacturers' data for performance of ball bearings to specify suitable bearings for a given application • Estimate design life of bearings in the system CLO (1,2,3)	Lecture slides Reference Books
10.	Selection of Screws and Threaded Fasteners; Bolted and Welded	• Use tables of data for various grades of steel	Lecture slides Reference Books

	Joints	materials used for bolts • Compute the forces experienced by the bolts by concentric loading and eccentric loading • Select the appropriate bolts and fasteners for a given system based on standard parts CLO (1,2,3)	
11.	Design of Machine Frames and Parts	• Apply the principles of stress and deflection analysis to propose a reasonable and efficient shape for a structure or frame and for the components involved • Specify materials that are well suited to the demands of a given load, environment, fabrication requirements, safety and aesthetics CLO (1)	Lecture slides Reference Books

MA3001 DESIGN PROJECT: STUDENT PEER REVIEW FORM

Your assessment is confidential and only your tutor will see it. Please tick on the boxes on the right for each of the students (except yourself) in your team. It is ***compulsory*** to include comments on him/her which you believe contributed to his/her performance. After the submission of your group report, upload this form in your tutorial course site by **xxxxxxx**.

Note: Your individual scores for the team assessments may vary as a result of the peer feedback.

Full Name of Student A:
Compulsory Comments: (at least 30 words)

	CRITERIA	POOR	AVERAGE	GOOD	VERY GOOD
1	His/her attendance in your group project meetings.				
2	His/her involvement in project task and discussions throughout the semester.				
3	The quality of his/her contribution to the project tasks.				

Full Name of Student B:
Compulsory Comments: (at least 30 words)

	CRITERIA	POOR	AVERAGE	GOOD	VERY GOOD
1	His/her attendance in your group project meetings.				
2	His/her involvement in project task and discussions throughout the semester.				
3	The quality of his/her contribution to the project tasks.				

Full Name of Student C:
Compulsory Comments: (at least 30 words)

	CRITERIA	POOR	AVERAGE	GOOD	VERY GOOD
1	His/her attendance in your group project meetings.				
2	His/her involvement in project task and discussions throughout the semester.				
3	The quality of his/her contribution to the project tasks.				

Individual effort for Design Project Report is evaluated from the Written Summary of Individual Contribution to the project attached to Report and the Student Peer Review Form. The grade is as follows:

Very Good: A (85 to 100%)
Good: B (70 to 84%)
Average: C (55 to 69%)
Poor: D (40 to 54%)