University of Macau
Department of Electromechanical Engineering
MECH408 Theory of Mechanisms
Syllabus
1st Semester 2012/2013
Part A – Course Outline

Elective course in Electromechanical Engineering

Course description:

Mechanisms Analysis and Synthesis, Displacement Analysis, Velocity, Acceleration, Static and Inertia Forces, Geometry of Mechanisms, Graphical Synthesis, Analytic Synthesis, CAMS.

Prerequisites:

- None

Textbook(s) and other required material:

- Robert L. Norton, ***Kinematics and Dynamics of Machinery***, 1st Edition in SI units, 2009, McGraw-Hill (Required)
- (Robert L. Norton, ***Design of Machinery***, 4th Edition, 2008, McGraw-Hill)
- Joseph Edward Shigley and John Joseph Uicker, Jr., ***Theory of Machines and Mechanisms***, 3rd Edition, 2003, Oxford

References:

- Kenneth J. Waldron, & Gary L. Kinzel, Kinematics, Dynamics, and Design of Machinery, John Wiley & Sons

Course objectives:

1. To develop skills of using vector, complex numbers, linear algebra for analyzing and designing linkages, cams, and other mechanisms. [a, c, e]
2. To learn the use of mathematics to formulate and solve problems in mechanisms analysis and synthesis through examples and homework assignment. [a, e]
3. To provide a foundation for the study of machine design and introduce real-world mechanisms. [a,e]
4. To use interactive PC-based computer program to visualize machine motions and to solve kinematics problems. [c]
5. A combination of graphical, analytical and computer-based techniques is used for mechanisms study. [a, e]

Topics covered:

1. **Introduction -** Kinematics and Kinetics, Mechanisms and Machines; Application of Kinematics
2. **Kinematics fundamentals -** Degree of Freedom or Mobility; Types of links and joints; Kinematic inversion, Grashof law
3. **Position analysis -** Graphical Linkage Synthesis: two position synthesis, three position synthesis, quick-return mechanisms; loop closure equation; closed-form and iterative solutions
4. **Velocity analysis** - Velocity Polygon; Velocity image; Instant Centers; Aronhold-Kennedy theorem; Algebraic Method in Fourbar linkage
5. **Acceleration analysis -** Acceleration Polygon; Algebraic Method in Fourbar linkage; Coriolis Acceleration
6. **Cam Design -** Cam terminology; Follower motion synthesis; S V A J Diagrams
7. **Dynamic force analysis -** Newtonian solution method; Single Link in Pure Rotation; Dynamics force analysis in threebar crank-slide linkage;
   Dynamics force analysis in fourbar linkage; Dynamics force analysis in fourbar slider-crank

Class schedule and credits:

Timetabled work in hours per week			No of teaching weeks	Total hours	Total credits	No / Duration of exam papers
Lecture	Tutorial	Practice				
3	1	0	14	56	3	1 / 3 hours

Topic Outline:

Week	Date	Tentative Lecture / Topic	Reading	
			Norton	Uicker
1	8/27	Kinematics and Kinetics, Mechanisms and Machines, Application of Kinematics	§1.1-§1.6	
	8/31	Kinematics fundamentals, Degree of Freedom or mobility	§2.1-§2.6	
2	9/3	Kinematic inversion, Grashof condition	§2.12 §2.13	
	9/7	Grashof condition, Graphical Linkage Synthesis: two position synthesis	§3.1-§3.3	
3	9/10	Graphical Linkage Synthesis: three position synthesis		
	9/14	Graphical Linkage Synthesis: quick-return mechanisms	§3.4	
4	9/17	Position analysis: displacement, translation, and rotation	§3.5	
	9/21	Position analysis: complex numbers as vectors	§4.1-§4.5	
5	9/24	Position analysis:, vector loop equation for a fourbar linkage	§4.5-§4.6	
	9/28	**Quiz – Mobility, Position Analysis**	§4.6-§4.7	
6	10/1	**Holiday: The Day following Mid-Autumn Festival/National Day of the People's Republic of China – No class**		
	10/5	Analytical linkage synthesis, Graphical velocity analysis: velocity polygon, velocity image	§5.1-§5.8 §6.1 §6.2	§3.4 §3.5
7	10/08	Graphical velocity analysis: velocity polygon, velocity image, velocity of slip		§3.4 §3.5
	10/12	Velocity analysis: instant centers of velocity, Aronhold-Kennedy theorem	§6.3-§6.4	
8	10/15	Analytical velocity analysis: algebraic method in fourbar Pin-Jointed linkage	§6.7 §6.9	
	10/19	Analytical velocity analysis: algebraic method in fourbar slider-crank mechanism	§6.7 §6.9	
9	10/22	**Quiz – Velocity analysis**		
	10/26	Graphical acceleration analysis: acceleration polygon	§7.1 §7.2	§4.4
10	10/29	Graphical acceleration analysis: acceleration image, Coriolis acceleration, Analytical acceleration analysis: algebraic method in fourbar Pin-Jointed linkage	§7.3	§4.5
	11/2	**Holiday: All Soul's Day – No class**	§7.3	
11	11/5	Analytical acceleration analysis: algebraic method fourbar slider-crank mechanism	§7.3 §7.5	
	11/9	**Mid-Term – Instant Center & Velocity analysis**		
12	11/12	Cam design, Cam terminology	§8.1 §8.2	
	11/16	Follower motion synthesis, S V A J Diagrams	§8.3	
13	11/19	Dynamics force analysis, Newtonian solution method, Single Link in Pure Rotation	§11.1 §11.2	
	11/23	Dynamics force analysis in threebar crank-slide linkage	§11.3	
14	11/26	Dynamics force analysis in fourbar linkage	§11.3 §11.4	
	11/30	Dynamics force analysis in fourbar slider-crank	§11.4	
15	12/2-5	**Study Period**		
15, 16	12/6-18	**Final Exam**		

Contribution of course to meet the professional component:

This course prepares students to work professionally in the area of **mechanism design**.

Relationship to EME Programme objectives and outcomes:

This course primarily contributes to Electromechanical Engineering Programme outcomes that develop student abilities to:
(a) an ability to apply knowledge of mathematics, science, and engineering.

(c) an ability to design a system, component, or process to meet desired needs within realistic constraints, such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability.
(e) an ability to identify, formulate, and solve engineering problems.

Course content:

Maths	Basic Science	Engineering Science	Engineering Design and Synthesis	Complementary Studies	Computer Studies	Total 100%
10	10	50	20	5	5	100

Persons who prepared this description:

Prof. Vai Kuong Sin

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Part B – General Course Information and Policies

1st Semester 2012/2013

Instructor: Prof. Vai Kuong Sin Office: N318
Office Hour: MW 3:30 – 5:30PM or by appointment Phone: (853) 8397-4368
Email: vksin@umac.mo

Time/Venue:

Every Monday, 9:30 a.m. – 11:30 a.m., Room U102 (Tutorial + Lecture)
Every Friday, 2:30 p.m. – 4:30 p.m., Room U103 (Tutorial + Lecture)

Assessment:

Final assessment will be determined on the basis of:

Homework:	15%
In-class Quizzes:	20%
Mid-term:	25%
Final Exam:	40%

Grading System:

This credit is earned by the achievement of a grade from 'A' to 'D', 'F' carries zero credit.

Grades are awarded according to the following system:

Letter Grades	Grade Points	Percentage
A	4.0 (Excellent)	93-100
A-	3.7 (Very good)	88-92
B+	3.3	83-87
B	3.0 (Good)	78-82
B-	2.7	73-77
C+	2.3	68-72
C	2.0 (Average)	63-67
C-	1.7	58-62
D+	1.3	53-57
D	1.0 (Pass)	50-52
F	0 (Fail)	Below 50

Comment:

All students are expected to attend all lectures, quizzes, and examinations. Although classroom attendance does not mathematically contribute to the final course grade, active class participation is expected of all students and may help to boost up the course grade in those "borderline cases" between failing and passing. It is your responsibility to read the relevant chapters in the text before and after class and to ask questions during class discussion. In order to be successful in this course, you should get as much practice as possible in solving problems outside the class hours. This must be done on a timely and regular basis, as a good understanding of the material covered in any particular section of this course depends heavily on an equally good understanding of the material covered in previous sections.

Homework Policy:

All homework must be an individual effort unless specifically noted. Your work must be neat, with answers clearly noted and supporting information provided. Late homework will not be accepted in general.

Quizzes

Quizzes will be closed book and notes. The format will primarily be problems that are similar to homework problems.

Note

- Cheating in any form will not be tolerated. STUDENTS WHO CHEAT ON ANY ASSIGNMENT, OR DURING ANY QUIZ OR EXAMINATION WILL BE ASSIGNED A FAILING GRADE FOR THE COURSE AND MAY RESULT IN SUSPENSION OR EXPULSION FROM THE UNIVERSITY. Therefore avoid all appearance of improper behavior. Students who witness cheating should report the incident to the instructor as soon as possible.
- Photocopies of the textbooks are illegal and are violation of the Macao copyright laws.

Appendix - Rubric for Programme Outcomes

Rubric for (a)	5 (Excellent)	3 (Average)	1 (Poor)
Understand the theoretic background	Students understand theoretic background and the limitations of the respective applications.	Students have some confusion on some background or do not understand theoretic background completely	Students do not understand the background or do not study at all
Use a correct model and formulation correctly	Students choose a model correctly and properly apply correct techniques	Students choose a wrong model sometime, use a wrong formula, or a different technique	Students use a wrong model and wrong formula, or do not know how to model
Compute the problem correctly	Students use correct techniques, analyze the problems, and compute them correctly	Students sometime solve problem mistakenly using wrong techniques	Students do not know how to solve problems or use wrong techniques completely

Rubric for (c)	5 (Excellent)	3 (Average)	1 (Poor)
Design capability and design constraints	Student understands very clearly what needs to be designed and the realistic design constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.	Student understands what needs to be designed and the design constraints, but may not fully understand the limitations of the design constraints	Student does not understand what needs to be designed and the design constraints.
Process to meet desired needs	Student understands very clearly the process of the design	Student understands what the needs of the process design, but may not fully understand the limitations of the design constraints	Student does not understand the process.

Rubric for (e)	5 (Excellent)	3 (Average)	1 (Poor)
Identify applications in engineering systems	Students understand problem and can identify fundamental formulation	Students understand problem but cannot apply formulation, or cannot understand problem	Students cannot identify correct terms for engineering applications
Modeling, problem formulation and problem solving	Students choose and properly apply the correct techniques	Students model correctly but cannot select proper technique or model incorrectly but solve correctly accordingly	Students at loss as to how to solve a problem