ACE 182 – Machines Theory

Lecture 1

Introduction to the Course

Dr. Ahmed Khalifa

Assistant Professor

Department of Industrial Electronics and Control Engineering

Faculty of Electronic Engineering

Menofia University

Spring 2017

Agenda

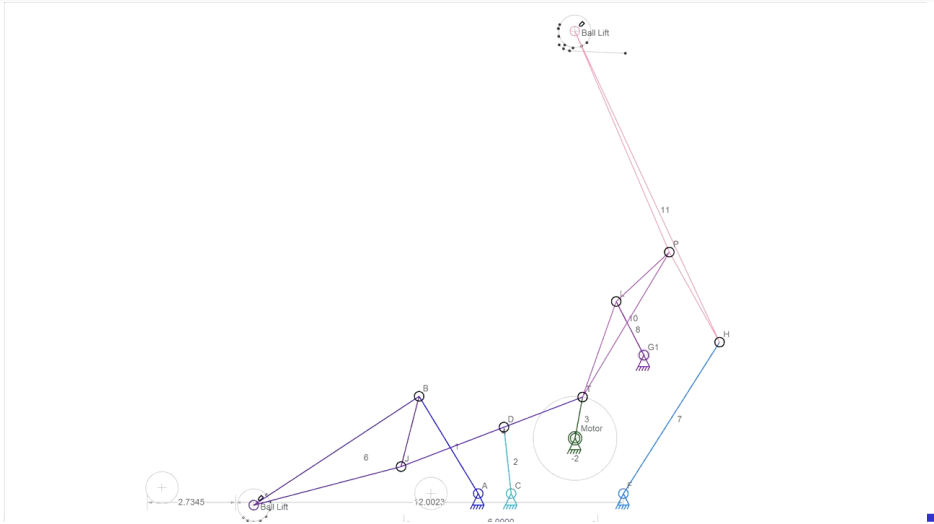
- **Rule of Theory of Machines**
- **Basic Definitions**
- **Course Description**
- **What is expected of you in this course?**

Agenda

- **Rule of Theory of Machines**
- Basic Definitions
- Course Description
- What is expected of you in this course?

Rule of Theory of Machines

- **The theory of Machines and Mechanisms provides the foundation for the study of displacements, velocities, accelerations, and static and dynamic forces, and balancing required for:**
  - **The proper design of mechanical linkages, and**
  - **Analysis and modification of existing mechanisms.**



Rule of Theory of Machines

COMPUTATIONAL DESIGN OF MECHANICAL CHARACTERS

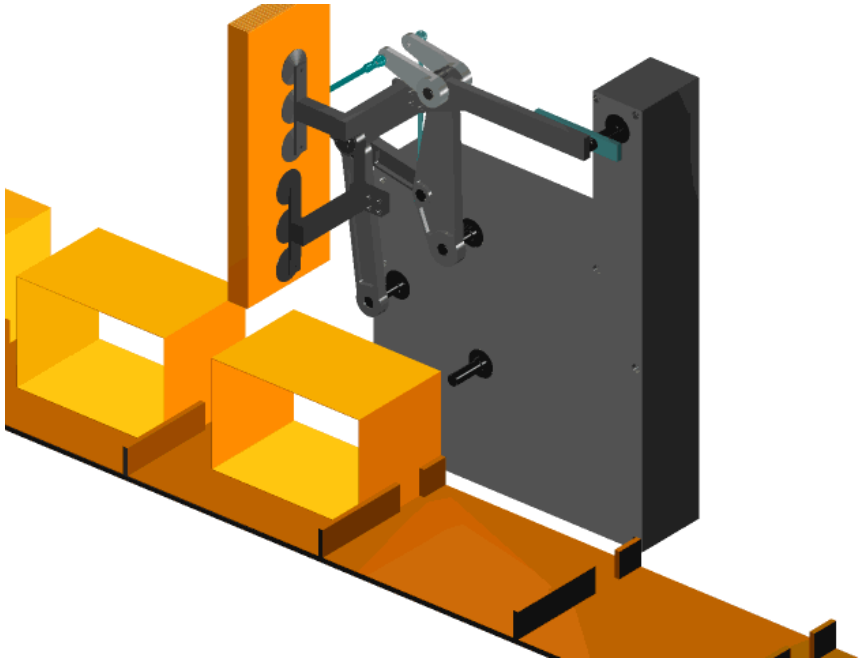
S. COROS[1] B.THOMASZEWSKI[1]

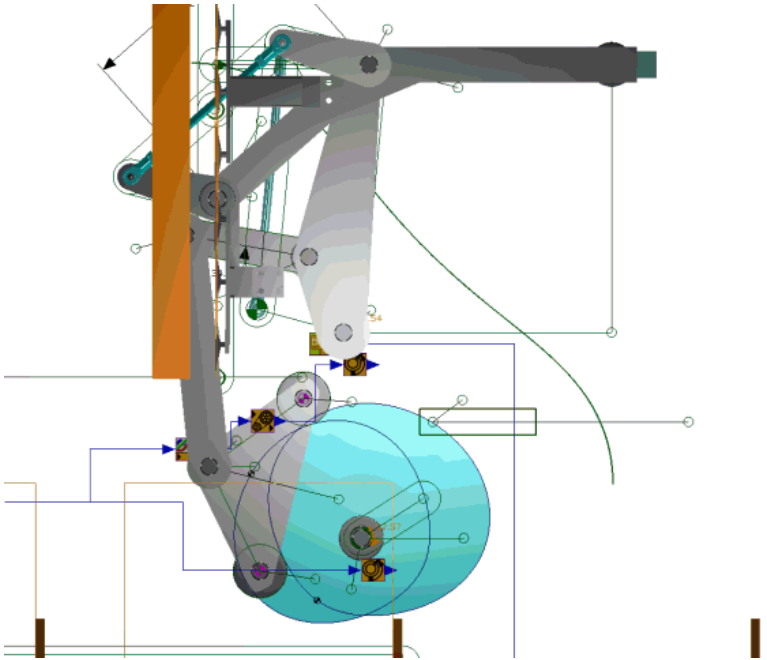
G. NORIS[1] S. SUEDA[2] M. FORBERG[2]

R. SUMNER[1] W. MATUSIK[3] B. BICKEL[1]

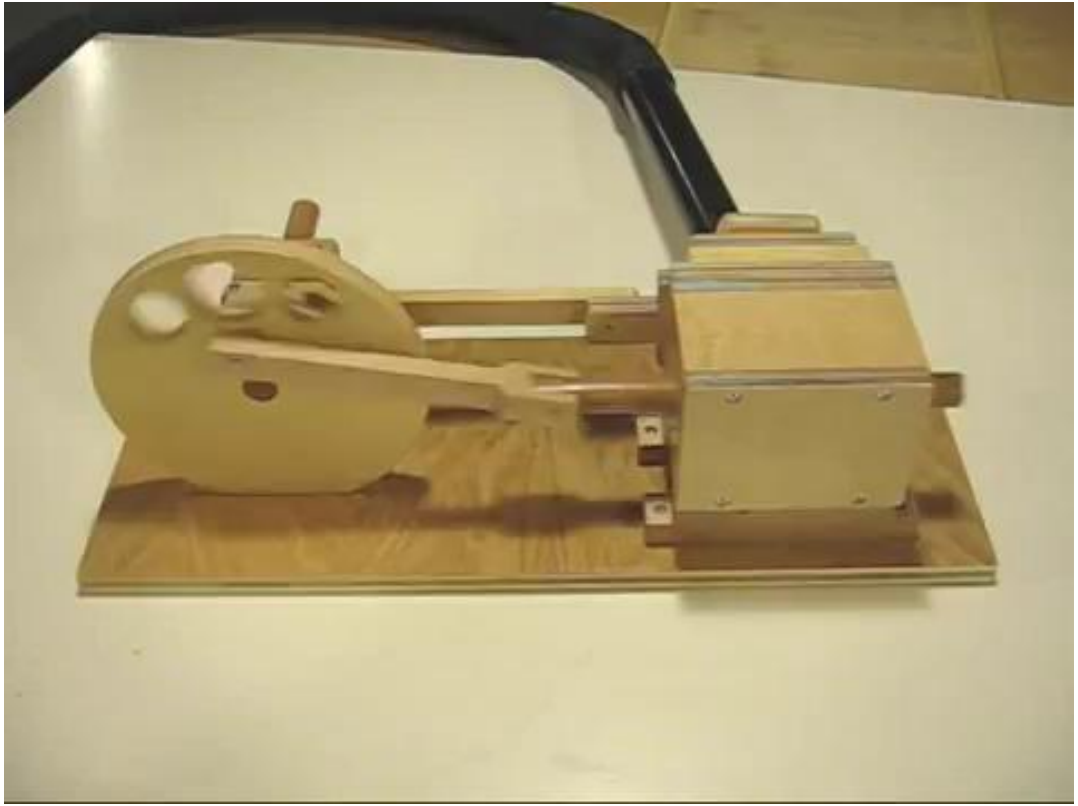
[1]DISNEY RESEARCH ZURICH [2]DISNEY RESEARCH BOSTON [3]MIT CSAIL

Rule of Theory of Machines



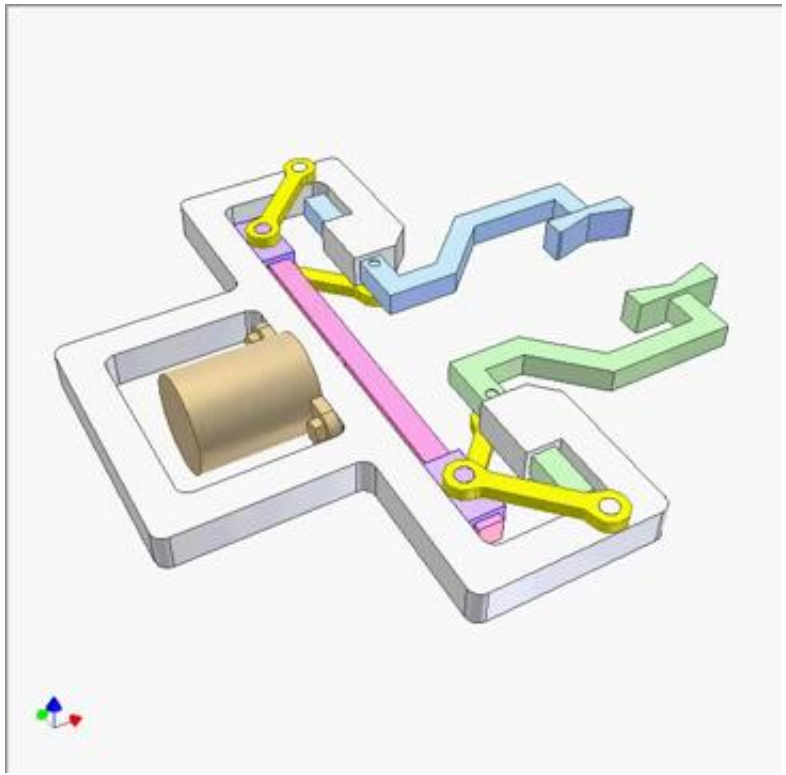


Rule of Theory of Machines

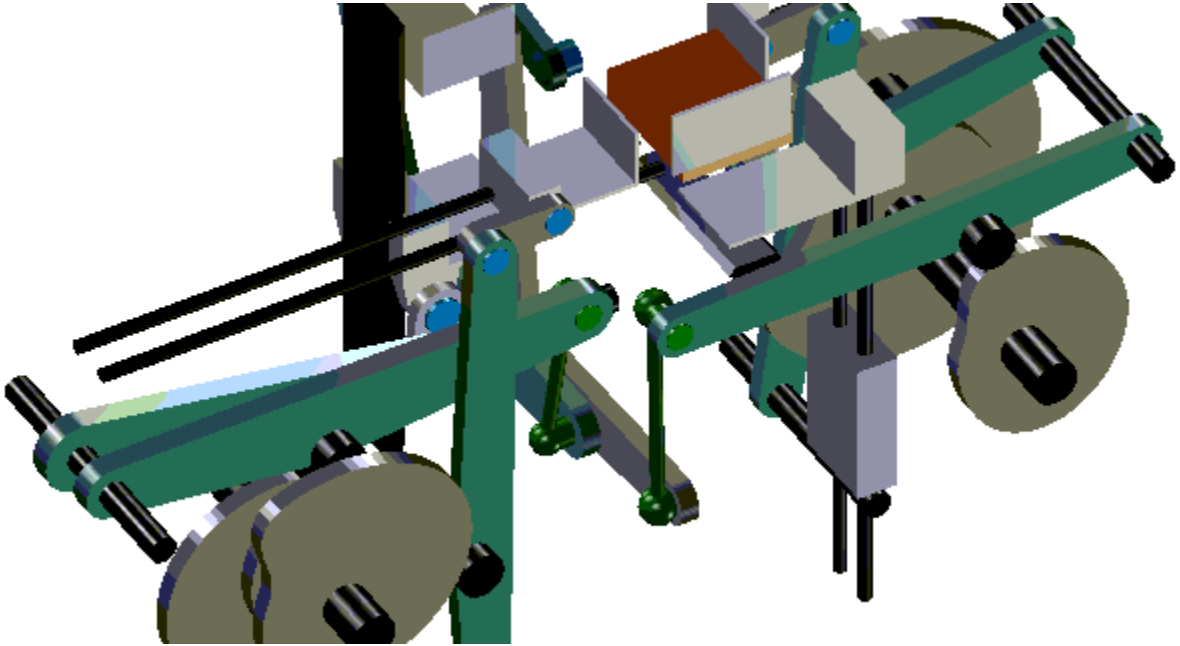


Rule of Theory of Machines

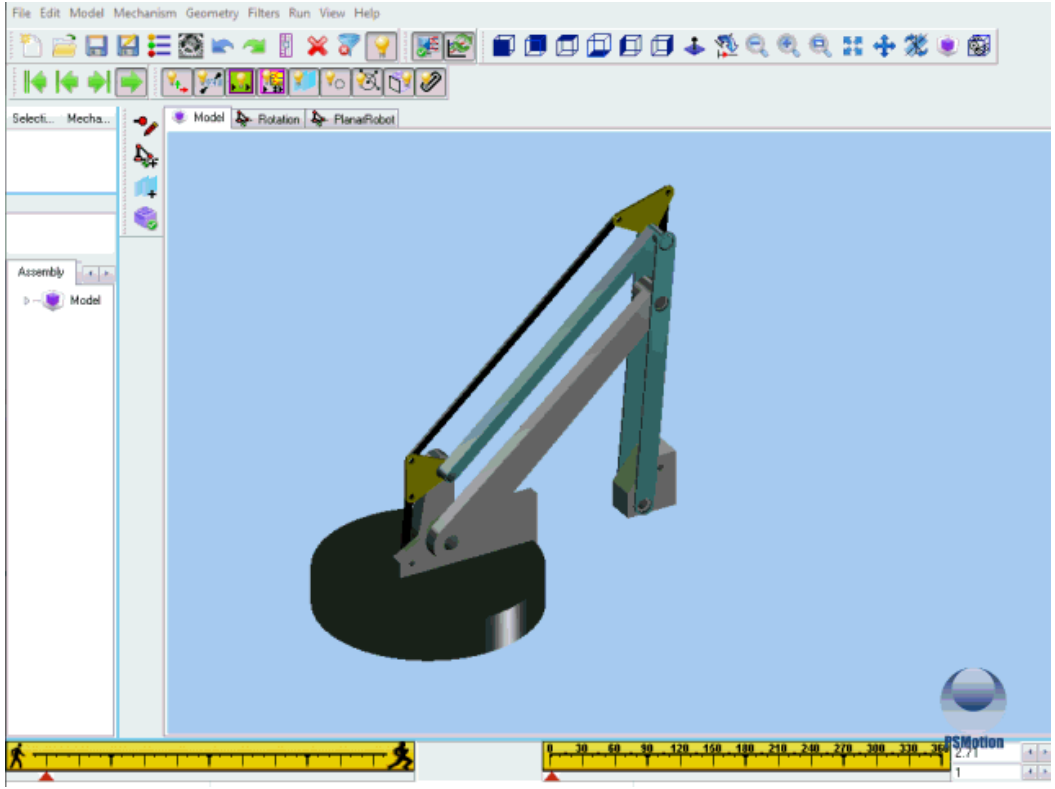
Rule of Theory of Machines



Rule of Theory of Machines



Rule of Theory of Machines



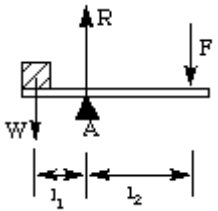
Agenda

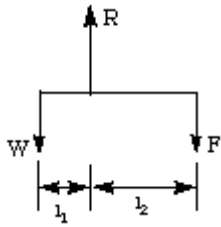
- Rule of Theory of Machines
- **Basic Definitions**
- Course Description
- What is expected of you in this course?

Definitions

- **Force:**
  - **An agent or influence that, if applied to a free body results chiefly in an acceleration of the body and sometimes in elastic deformation and other effects.**
  - **Every day we deal with forces of one kind or another. A pressure is a force. The earth exerts a force of attraction for all bodies or objects on its surface.**

- **Torque:**
  - **Something that produces or tends to produce rotation and whose effectiveness is measured by the product of the force and the perpendicular distance from the line of action of the force to the axis of rotation.**
  - **F x l_2 is the torque of F about fixed point A**





Definitions

- **Motion:**
  - **A change of position or orientation.**
  - **Linear: Position – Velocity – Acceleration - Force**
  - **Angular: orientation – Angular velocity – Angular acceleration - Torque**

- **Rigid Body:**
  - **is that body whose changes in shape are negligible compared with its overall dimensions or with the changes in position of the body as a whole.**

- **Absolute motion:**
  - **the motion of body in relative to another body which is at rest or to a fixed point located on this body.**

- **Relative motion:**
  - **the motion of body in relative to another moved body.**

Definitions

- **Theory of Machines**
  - **The subject Theory of Machines may be defined as that branch of Engineering-science, which deals with the study of relative motion between the various parts of a machine, and forces which act on them.**
  - **The knowledge of this subject is very essential for an engineer in designing the various parts of a machine.**
  - **Theory of Machines may be sub- divided into the following four branches:**

- **Kinematics:**
  - **is that branch of theory of machines which is responsible to study the motion of bodies without reference to the forces which are cause this motion, i.e it's relate the motion variables (displacement, velocity , acceleration) with the time.**

- **Kinetics:**
  - **is that branch of theory of machines which is responsible to relate the action of forces on bodies to their resulting motion.**

Definitions

- **Theory of Machines**
  - **The subject Theory of Machines may be defined as that branch of Engineering-science, which deals with the study of relative motion between the various parts of a machine, and forces which act on them.**
  - **The knowledge of this subject is very essential for an engineer in designing the various parts of a machine.**
  - **Theory of Machines may be sub- divided into the following four branches:**

- **Dynamics:**
  - **is that branch of theory of machines which deals with the forces and their effects, while acting upon the machine parts in motion.**

- **Statics:**
  - **is that branch of theory of machines which deals with the forces and their effects, while the machine parts are rest.**

Definitions

- **Link:**
  - **is defined as a rigid body having two or more pairing elements, which connect it to other bodies for the purpose of transmitting force or motion. It is assumed to be rigid bodies**
  - **In every machine, at least one link either occupies a fixed position relative to the earth or carries the machine as a whole along with it during motion. This link is the frame of the machine and is called the fixed link.**

- **Joint:**
  - **is defined as a connection between two links that is formed through direct contact between them.**

- **Kinematic chain:**
  - **Assemblage of links and joints, interconnected in a way to provide a controlled output motion in response to a supplied input motion. The combination of links and pairs without a fixed link.**

Definitions

- **Mechanism**
  - **A kinematic chain in which at least one link has been grounded or attached to the frame of reference.**
  - **is a combination of rigid bodies which are formed and connected together by some means, so that they are moved to perform some functions, such as the steering mechanisms of automobiles.**
  - **is a device that transforms motion to some desirable pattern and typically develops very low forces and transmits little power. Examples: pencil sharpener- a camera shutter - an analog clock - a folding chair - umbrella**
- **Machine**
  - **typically contains mechanisms that are designed to provide significant forces and transmit significant power.**
  - **Examples: food blender - a bank vault door - an automobile transmission - a bulldozer - a robot.**
- **Machinery**
  - **generally means machines and mechanisms**

Definitions

- **Structure:**
  - **It is an assemblage of a number of resistant bodies (known as members) having no relative motion between them and meant for carrying loads having straining action. A railway bridge, a roof truss, machine frames etc., are the examples of a structure.**
- **Design**
  - **The creation of something that did not exist before**
- **Synthesis**
  - **To create a mechanism to give a certain motion.**
- **Analysis**
  - **To determine the motion characteristics of a given mechanism.**

Agenda

- Rule of Theory of Machines
- Basic Definitions
- **Course Description**
- What is expected of you in this course?

Course Objectives (ILO's)

Upon successful completion of the course, the student will be able:

- **Identify mechanisms** and **predict their motion**
- Calculate the **degrees of freedom** of mechanisms
- Determine the **positions**, **velocities** and **accelerations** of links and points on mechanisms
- Calculate dynamic **joint forces** of mechanisms
- **Balance** simple rotating objects
- Analyze and modify existing mechanisms
- **Synthesize**, analyze, and simulate a mechanism in a **computer aided software**
- **Work cooperatively on teams**
- Prepare and present **technical reports**

Course Topics

- **Introduction to the Course**
- **Kinematics Fundamentals**
- **Graphical Linkage Synthesis**
- **Position Analysis**
- **Velocity Analysis**
- **Acceleration Analysis**
- **Dynamics Fundamentals**
- **Dynamic Force Analysis**
- **Balancing**

Assessment

Weight	Evaluation Method
40%	**Final** (you must score at least **50% in final to pass**)
20%	**Midterms** (2 x 10% midterms, **all counted**)
10%	**Pop quizzes** (5 to 10 randomly distributed – **all counted**)
30%	**Project** (Include 2 x 5% follow up reports)

Course Project

Topics

- **The topics should include the synthesis, analysis, simulation of a mechanism.**

Course Project

Teams

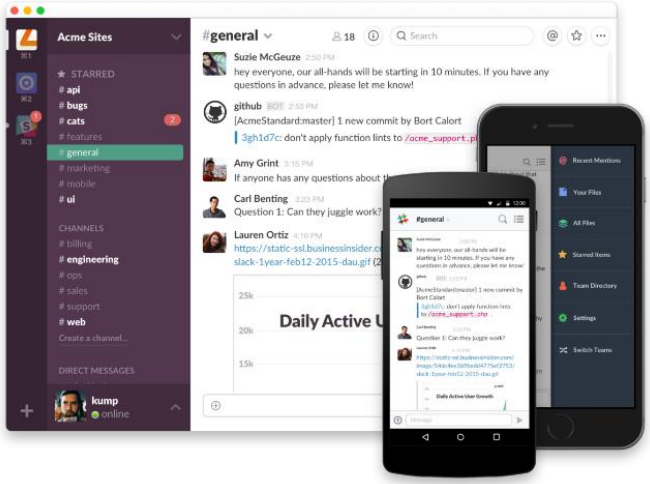
- **To register in a project, the team must submit a file with the following items to your course instructor's email address before the 5^{th} weak:**
  - **Names of team members, IDs, email address.**
  - **Project title**
  - **Project introduction (motivation and objective)**

Course Policy

- **Late Submission Policy:**
  - **Anything submitted after 11:59PM on the due date will be penalized by 50% for each 24 hours of lateness.**
- **Absence Policy:**
  - **Attendance in all academic activities is mandatory.**
  - **Students who are absent more than 25% of the time in the course should not be permitted to attend the final examination and should receive a W grade.**
- **No makeup exams should be offered for missed exams.**
- **Projects and all other assignments will be submitted in electronic format.**
- **No homework need to be submitted, they are just for personal practice and solutions will be provided to you.**

Course Resources

- **Course Website:** **Slack Page: https://fee-ace182-spring17.slack.com**
- **Course material - Course announcements – Discussions - etc. . .**
  - **Desktop/Mobile app: https://fee-ace182-spring17.slack.com/downloads/windows**
- **Textbook:**
  - **R. L. Norton, Design of Machinery "An Introduction to the Synthesis and Analysis of Mechanisms and Machines", 3rd edition**
- **Course Instructor**
  - **Dr. Ahmed Khalifa**
  - **Email: ahmed.khalifa0687@gmail.com**
  - **Office:** Control Building - Ground floor
  - **Office hours:** 2 hrs. after lecture



Agenda

- Rule of Theory of Machines
- Basic Definitions
- Course Description
- **What is expected of you in this course?**

What is expected of you in this course?

- **Download all handouts from the specified internet site and check it frequently.**
- **Attend all lectures.**
- **Read the assigned portions of the book (The lectures are not a substitute for reading the book).**
- **Do all homework on time.**
- **Do all projects and submit them in a standard form.**
- **You really must start the projects when assigned - you cannot throw them together at the last minute and have a good result!**
- **ALL your work must be your own or your group's.**

What is expected of you in this course?

- You are expected to approach this course with the philosophy of education in mind, as described in the undergraduate catalog, "...The educated people should be able to cope with change, to learn by themselves, to think for themselves, to analyze and deal with problems in a confident and realistic manner."

- Theory of Machines is a very broad and interesting subject, and a moderately difficult one.
- It is not possible to cover all of its varied aspects in the lectures.
- Therefore, the readings, quizzes, and projects may deal with topics NOT specifically covered in class lectures.
- Nevertheless, you are expected, in the spirit of the education philosophy, to extend yourself, learn on your own, and rise to the challenges of the course objectives.

Lecture End

Questions?

ahmed.khalifa0687@gmail.com

ahmed.khalifa@el-eng.menofia.edu.eg

ACE 182 – Machines Theory

Core Course: 3 Credits (2 Lecture + 1 Tutorial)

Prerequisite(s):

Semester: Spring 2017

Instructor: Dr. Ahmed Khalifa

E-mail: ahmed.khalifa0687@gmail.com

Schedule: Thursday 10:40 - 12:45

Location: **FPGA Room**

Office: Ground floor – Control Building

Office Hrs.: 2 hrs. after lecture

Text Book: R. L. Norton, Design of Machinery "An Introduction to the Synthesis and Analysis of Mechanisms and Machines", McGraw Hill Higher Education; 3rd edition

Important Requirements

All students are required to

- Projects, and all other assignments will be submitted in electronic format.
- No homework need to be submitted, they are just for personal practice and solutions will be provided.

Assessment Tools

T1: Examinations/Tests

T3: Group Projects

T6: Student Survey

Course Objectives

The course provides students with instruction in the fundamentals of theory of machines. The theory of Machines and Mechanisms provides the foundation for the study of displacements, velocities, accelerations, and static and dynamic forces, and balancing required for (1) the proper design of mechanical linkages, (2) analysis and modification of existing mechanisms.

Course Intended Learning Outcomes

Students combine theory, graphical and analytical skills to understand the Engineering Design. Upon successful completion of the course, the student will be able:

ILO#	Description	Assessment Tool
1	Identify mechanisms and predict their motion	T1,T6
2	Calculate the degrees of freedom of mechanisms	T1,T6
3	Determine the positions, velocities and accelerations of links and points on mechanisms	T1,T6
4	Calculate dynamic joint forces of mechanisms	T1,T6
5	Balance simple rotating objects	T1,T6
6	Analyze and modify existing mechanisms	T1,T6
7	Synthesize, analyze, and simulate, a mechanism in a computer aided software	T1,T6
8	To increase the ability of students to work cooperatively on teams	T3
9	Prepare and present technical reports	T3

Topics and Schedule

Week #	Topic	Practice and Assessment
1	Introduction to the course • Rule of theory of machines • What are we doing here? • Syllabus and Course Outline • What is expected of you in this course? • Introductory Topics	
2	Kinematics Fundamentals • Mobility • Types of Motion • Links, Joints, and Kinematic Chains • Determining Degree of Freedom or Mobility	HW #02 Software Tutorial
3	Kinematics Fundamentals • Number Synthesis • Isomers • Inversions • Grashof Condition • Examples	HW #03 Software Tutorial
4	Graphical Linkage Synthesis • Definitions and Synthesis Types • Limiting Conditions	HW #04 Software Tutorial

	• Two-Position Synthesis • Three-Position Synthesis	
5	Graphical Linkage Synthesis • Quick Return Motion Mechanisms • Coupler Curves • Cognates • Straight-Line Linkages • Dwell Mechanisms • Four-bar Crank-Rocker Quick-Return Linkage for Specified Time Ratio	HW #05 Software Tutorial
6	Position Analysis • Coordinate systems • Position and Displacement • Translation, Rotation, and Complex Motion	HW #06 Software Tutorial
7	**Midterm #1**	
8	Position Analysis • Algebraic Position Analysis of linkages • The Four-bar Slider-Crank Position Solution • Position of any Point on a linkage	HW #08 Software Tutorial **Follow up #01 due**
9	Velocity Analysis • Graphical Velocity Analysis • Velocity Analysis with Instant Centers • Analytical Solutions for Velocity Analysis • Velocity of any Point on a Linkage	HW #09 Software Tutorial
10	Acceleration Analysis • Graphical Acceleration Analysis • Analytical Solutions for Acceleration Analysis • Acceleration of any Point on a Linkage	HW #10 Software Tutorial
11	Dynamics Fundamentals • Newton's Laws of Motion • Dynamic Models • Basic definitions	HW #11 Software Tutorial
12	**Midterm #02**	

13	Dynamic Force Analysis • Newtonian Solution Method • Single link in pure rotation • Force Analysis of a Four-bar linkage	**Follow up #02 due**
14	Balancing • Static Balance • Dynamic Balance • Balancing Linkages	HW #11 Software Tutorial HW #10 Software Tutorial
15	**Project Evaluation**	
16	**Final Exam**	

Assessment (Grading)

40% Final (you must score at least 50% in final to pass)
20% Midterms (2 midterms, all counted)
10% Pop quizzes (5 to 10 randomly distributed – all counted)
30% Project (Incl. 2 x 5% follow up reports)

Course Project

Topics

- The topics should include the synthesis, analysis, simulation of a mechanism.

Teams

- To register in a project, the team must submit a file with the following items to your course instructor's email address before the 5^{th} weak:
  - Names of team members, IDs, email address.
  - Project title
  - Project introduction (motivation and objective)

Project Delivery: 3 days before the project presentation due

- Before the presentation and to complete evaluating the project, the team must prepare a CD/Memory stick for the course instructor containing all materials related to the project and a well-documented project technical report.

Project Presentation: 15^{th} weak

Project Evaluation:

- The project team presents the developed project in 30 minutes plus 5 minutes for a question

period.

- Each presentation is attended by the course instructor, some critiquers (maybe), and the project team.
- During the presentation, the team members can share the speaking equally.
- All team members must be on the stage. Absent members need to provide documentation excusing their participation, e.g., a doctor's note.
- The critiquers will mark the presentation.

- The project evaluation will be based on the following criteria:
  - Project management (15%)
    - Planning
    - Follow up
    - Corrective actions and re-planning
  - Software (20%)
    - Open source or your own
    - Accuracy
    - Output graphics
  - Final Report (30%)
    - Technical report format (Cover, TOC, Introduction and literature survey, mathematical background, results, conclusions, reference, appendices)
    - Rigor of literature survey
    - Details of the model analysis
    - Numerical results
  - Final presentation (15%)
    - Public decimation of knowledge (Website. Wiki, videos, public slides, public reports, design graphics and charts, etc...)
    - Presentation graphics and appeal
    - Accuracy of presentation content
    - Comprehensibility of presentation content
    - Audience capturing
    - Audience participation and reply to questions
    - Timing

Course Policies

Late Submission Policy:

- Anything submitted after 11:59PM on the due date will be penalized by 50% for each 24 hours of lateness.

Absence Policy:

- Attendance in all academic activities is mandatory.

- Students who are absent more than 25% of the time in the course should not be permitted to attend the final examination.
- No makeup exams should be offered for missed exams.

Academic Integrity Policy:

Students are required to refrain from all forms of dishonorable or unethical conduct related to their academic work including;

- **Plagiarism**:

Submitting material that is in part or whole is not entirely one's own work without properly citing sources. Plagiarism includes, but is not limited to:

1. Submitting a copied piece of writing as original work
2. The quotation or other use of another person's words, ideas, opinions, thoughts, or theories (even if paraphrased into one's own words) without acknowledgment of the source
3. The quotation or other use of facts, statistics, or other data or materials (including images) that are not clearly common knowledge without acknowledgment of the source.

- **Fabrication**:

Falsifying or inventing any information, data, or citation; presenting data that were not gathered in accordance with standard guidelines defining the appropriate methods for collecting or generating data and failing to include an accurate account of the method by which the data were gathered or collected including the incorrect documentation of a source;

1. The citation, in a bibliography or other list of references, of sources that were not used to prepare the academic work.
2. The inclusion in an academic work of falsified, invented, or fictitious data or information, or the deliberate and knowing concealment or distortion of the true nature, origin, or function of such data or information.
3. The unauthorized submission of an academic work prepared totally or in part by another.

- **Cheating:**

Cheating is defined as fraud, deceit, or dishonesty in an academic assignment, or using or attempting to use materials, or assisting others in using materials that are prohibited or inappropriate in the context of the academic assignment in question.