MECH 522  Mechanical CAD/CAE/CAM– Technical elective
Catalogue description  MECH 522 Mechanical CAD/CAE/CAM
Pre-requisite:      MECH 320 (Mech. of Materials) & MECH 420 (Mechanical Design I).

Credits: 3

The course seeks to expose the senior M.E. students to the realm of computer-aided design (CAD), computer-aided engineering (CAE), and computer-aided manufacturing (CAM). The course teaches the students to harness the power of these powerful tools in the solution of various problems of mechanical engineering. The course utilizes several commercially available software packages but the emphasis is placed on Pro/Engineer.

Coordinator    Prof. R. Hamade, x3481, Raymond Ghosn Bldg 406, rhamade@aub.edu.lb

Wildfire Textbooks (all available through the Eng. Library)

CADD:    • REF 1, Pro/Engineer Wildfire 5.0™ by Louis Gary Lamit, with technical assistance provided by James Gee

CAE:    • REF 2, Pro/Engineer wildfire 4.0™ Mechanica structure tutorial: Integrated Mode / Roger Toogood (Interactive Pro/Mechanica -Structure)
• REF 3, Pro/MECHANICA Motion Wildfire 3.0™: Mechanism Design & Analysis; Kuang-Hua Zhang, SDC Publications 2008 (Interactive Pro/Mechanica - Motion) E 620.004:Z632m:c.1.
(On order “Mechanism Design With Creo Elements/Pro 5.0, 2012”; Kuang-Hua Chang).

CAM:    • REF 4, CAM: A Pro/Manufacturing Wildfire 2.0™ tutorial, Funk, Paul E., (CAM – CNC Machining) E 620.004:F982p:2005:c.1

Also, tutorials from PTC will be shared with the class.

Many more Pro/Engineer Reference books are all available through the Eng. Library. Including:

CADD:    • Pro/Engineer wildfire: tutorial and multimedia CD / text by Roger Toogood, multimedia CD by Jack Zecher (Basic-intermediate level w/ CD containing 11 training sessions)
• Pro/Engineer wildfire advanced tutorial / Roger Toogood (advanced level).
• Inside Pro/ENGINEER wildfire / Dennis Steffen and Gary Graham. - 4th ed.
• Modeling using Pro/Engineering wildfire / Sridhar S. Condoor
• Pro/ENGINEER Wildfire for Designers / Tickoo, Sham
• Parametric modeling with Pro/Engineer wildfire / Randy H. Shih
• Pro/Engineer wildfire instructor
• Pro/ENGINEER tutorial and multimedia CD release 2000i2: a click-by-click primer / text by Roger Toogood; E 620.004:T668pr:c.1 & multimedia CD-ROM by Jack Zecher; 620.004:T668pr:c.1 CD-ROM (Intro-Intermediate Level)


CAM:    • A Pro/Manufacturing tutorial (release-2000i2). - 3rd (1999), Funk, Paul E., c.1-2154031 (CAM - Machining)
Additional Revision 2000i References (all available through the Eng. Library)

- **Mechanical engineering design with Pro/ENGINEER Release 2000i2 / Dr. Mark Archibald (c2000). E620.004:A673m:c.1**
- **PTC Complete Training Documentation: CD PLUS a printed set of manuals** are placed on non-open reserve basis at the engineering library.

EVEN MORE HELP IS AVAILABLE THROUGH:

- The instructor.
- Additional class notes and handouts.
- Teammates
- The world wide web, of course.
- **PTC Internet Sites:**
  - [http://www.ptc.com](http://www.ptc.com)
  - [http://www.prouser.org](http://www.prouser.org) --- The site for PTC’s Annual Award Competition where users are invited to submit design entries created using Pro/Engineer.

Resources The textbooks and a numerous number of other reference books (Eng. Library), class notes and handouts, the instructor, teammates, library material, vendors product catalogs, the World Wide Web, etc.

Prerequisite by topics, Basics of engineering Computer-aided design & drafting, CADD, Mechanics of Materials, Mechanical Design, Machine Mechanisms, Metal Machining (including G&M code).

Professional Components Examples from industrial quality CADD/CAE/CAM data bases are emulated. Students do a 2-phase team project. Phase I, students in the entire class cooperate to build a CADD database of a worthwhile design (automotive, other) while exercising their cooperation in a PDM environment (one group is responsible for assembly and become by default the systems engineering group which also coordinates efforts across the various groups). Phase II, students perform several CAE analyses on their CAD design (in phase I).

Computer usage
1. Use of an integrated CAD/CAE/CAM package: Pro/Engineer
2. Other related computer software: perhaps Surf CAM

Topics
1. Introduction to 3-D solid modeling in the Integrated Product Development (IPD) process
2. Explanation of the Graphic User Interface (GUI).
3. CADD:
   4.1 **Part:** modeling: sketcher tools, feature creation and management.
   4.2 **Drawing & Detailing:** drawing formats, view generation, setup & creation, BOMs, dimensioning and tolerancing (includes GD&T), and drafting practices.
   4.3 **Assembly:** modeling, restraints, tasks, creation, and modification.
4. CAE:
   5.1 static and dynamic simulations (Integrated Pro/Mechanica) REF 2
   5.2 dynamic & motion (Pro/Motion) with animation REF 3
5. CAM:
6.1 CNC metal machining (Pro/NC Machine) REF 4
6.2 plastic mold flow (Pro/Mold) Maybe!

6. Rapid prototyping??

Assessment
1. Mandatory Attendance (5%)
2. Cooperative Team Assignments (15%)
3. 1.5-hour term hands-on quiz I (Tuesday MARCH 27) (20%)
4. 1.5-hour term hands-on quiz II (Thursday MAY 3) (20%)
5. Midterm Project Phase I (CADD) (20%)
   - 2000-01 was a mold for blow molded bottle
   - 2001-02 was a Formula Race Car
   - 2002-03 was an earthmover
   - 2003-04 was a tank
   - 2004-05 was a machine gun
   - 2005-06 was NC machined plastic mold
   - 2006-07 (Miscellaneous Designs)
   - 2007-08 (I was on sabbatical)
   - 2008-09 (helicopter and car toys)
   - 2009-10 (Miscellaneous Designs)
   - 2011-12 Car Engine

6. Project Phase II (CAE / CAM) of the same CAD project in Phase I (20%)

7. PLUS, you know about those speed demon BONUS POINTS

Course Objectives: Upon completion of this course, the student will
1. Become current with evolving computer-aided design/drafting (CADD) practices.
2. Get to practice building complete mechanical designs using virtual CADD tools
3. Get to practice generating industrial quality detailed drawings using the drafting tools learned in CADD
4. Get to witness, apply, and practice the power of computer-aided engineering, CAE, using computational techniques such as finite element analysis, FEM, in the solution of mechanical engineering problems.
5. Work and produce as team members in a multidisciplinary engineering mindset that relates upstream designs, to their fabrication (using CAM machining and sheet-metal working for example), and to other downstream utilization and use.
6. Practice and develop the skills necessary in the successful introduction of products into the market place using the integrated product development, IDP, methodology which relates the CAD, CAE, CAM.
7. Become familiar with such contemporary issues in CAD data base management (i.e., file configuration) for example as in the use of a product database management, PDM.

Course Learning Outcomes:

<table>
<thead>
<tr>
<th>At the end of the course, students will have the ability to</th>
<th>Correlation to program outcomes*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>H</td>
</tr>
<tr>
<td>1. produce professional-quality solid models of mechanical components (parts). These models should reflect professionalism in the use of the following: solid features, layers, sweeps and blends, patterns and groups, parametric relations, family tables, and views</td>
<td>a, c, e, j, k</td>
</tr>
<tr>
<td>2. produce professional-quality solid models of mechanical assemblies. These models should reflect professionalism in the use of the following: constraints, exploded views, assembly views and sections.</td>
<td>a, c, e, j, k</td>
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<tr>
<td>3. produce professional part drawings that are fully dimensioned with orthographic, auxiliary, and sectional views to describe solid objects.</td>
<td>a, c, e, j, k</td>
</tr>
</tbody>
</table>
4. produce professional assembly drawings that are fully dimensioned with orthographic, auxiliary, and sectional views to describe assemblies. These drawings should contain bill of materials (BOM) and balloons.

5. produce a mid-semester CADD project of a mechanical-engineering relevant theme. CADD Database should contain all necessary parts, sub-level assemblies, and top level assembly solid models as well as formatted drawings.

6. produce an end-of-semester project that reflect good grasp of CAE (motion and/or stress analysis and/or dynamic analysis) and CAM (NC turning or milling) skills.

7. able to deliver 1-6 above while working in teams

8. able to develop good CAD practices while managing CAD files (revisions, etc.).

9. Outcomes 1-8 above collectively cater to the professional development of students including Pro/Engineer (a leading CAD/CAE/CAM package) use and Surf CAM (a leading CAM package)

H: High correlation, M: Medium correlation, L: Low correlation

Course outcomes correlate to outcomes (a), (c), (d), (e), (f), (h), (i), (j), (k) of ABET
(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(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
(d) an ability to function on multidisciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Course Administration:
Moodle: Your access to Moodle is mandatory. Class administration will be conducted mainly through the web: announcements, important milestones and their required dates, grades, etc..

Your Action Item 1: self-register during the first week of classes.

Student Conduct: I will hold you (AUB’s ME graduating seniors) to an ethical standard higher than the one prevailing in the rest of the country. The measure (or the yard stick) being the AUB’s Student Code of Conduct.

Your Action Item 2: Students are required to (re)familiarize themselves with the definition (and the accompanying disciplinary actions) posted on: http://pnp.aub.edu.lb/general/conductcode/

Attendance Policy:
Per FEA regulations, students need to attend no less than 2/3 of the class lectures. Students who do not meet minimum attendance will be force dropped from class.

Class schedule: Three fifty minute or two seventy-five minute lectures per week.

Person who prepared this description and date of preparation
Department of Mechanical Engineering: Ramsey Hamade

Date of last revision: February 15, 2010
This schedule is based on Pro/Engineer’s Revision: Wildfire 5.0.

REF 1, CADD (computer-aided design & drafting): Pro/Engineer Wildfire 5.0™; Louis Gary Lamit (CAE: Pro/Design: Parts, drawings, and assemblies)

REF 2, CAE (Finite Elements Analysis, FEA): Pro/Engineer Wildfire 5.0™ Mechanica structure tutorial: Integrated Mode; Roger Toogood (CAE: Interactive Pro/Mechanica –Structural analysis)

REF 3, CAE (Motion Simulations using Interactive Pro/Mechanism, Pro/Animation): Pro/MECHANICA Motion: Mechanism Design & Analysis; Kuang-Hua Chang, SDC Publications

REF 4, CAM (computer-aided manufacturing using Pro/NC module): A Pro/Manufacturing tutorial, Funk, Paul E., (NC Machining)

<table>
<thead>
<tr>
<th>Week Start</th>
<th>Lecture</th>
<th>Lecture Topic</th>
<th>Milestones</th>
<th>HW</th>
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<tbody>
<tr>
<td>Feb 13</td>
<td>1</td>
<td>Holiday!</td>
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<tr>
<td><strong>CADD: Part Modeling</strong></td>
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<tr>
<td>2 Feb 20</td>
<td>1</td>
<td>Syllabus and Course Overview</td>
<td>Sign up on Moodle</td>
<td>Read REF 1 Introduction</td>
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<td>2</td>
<td>Lecture: The 3D database &amp; product development</td>
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<td>3 Feb 27</td>
<td>1</td>
<td>Pro/Engineer WF 5.0 Overview</td>
<td>REF1 Ch 1</td>
<td>see Moodle</td>
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<td>2</td>
<td>Pro/Engineer WF 5.0</td>
<td>REF1 Ch 2</td>
<td>see Moodle</td>
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<tr>
<td>4 March 5</td>
<td>1</td>
<td>Direct Modeling</td>
<td>REF1 Ch 3</td>
<td>see Moodle</td>
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<td>2</td>
<td>The Sketcher</td>
<td>REF1 Ch 4</td>
<td>see Moodle</td>
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<td>5 March 12</td>
<td>1</td>
<td>Datums, layers, and sections</td>
<td>REF1 Ch 5</td>
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<td>2</td>
<td>Revolved features</td>
<td>REF1 Ch 6</td>
<td>see Moodle</td>
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<td>6 March 19</td>
<td>1</td>
<td>Feature operations</td>
<td>REF1 Ch 7</td>
<td>see Moodle</td>
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<td>2</td>
<td>Patterns</td>
<td>REF1 Ch 13</td>
<td>see Moodle</td>
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<td>7 March 26</td>
<td>1</td>
<td>Shell, reorder, and insert mode</td>
<td>REF 1 Ch 17</td>
<td>see Moodle</td>
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<td>Drafts, suppress and text extrusions</td>
<td>REF 1 Ch 18</td>
<td>see Moodle</td>
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<td>8 April 2</td>
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<td><strong>QUIZ I: CAD Part Modeling (March 27)</strong></td>
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<td>Blends</td>
<td>REF 1 Ch 14</td>
<td>see Moodle</td>
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<td><strong>CADD: Assemblies</strong></td>
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<td>8 April 2</td>
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<td>Sweeps</td>
<td>REF 1 Ch 15</td>
<td>see Moodle</td>
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<td>9 April 9</td>
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<td>Assemblies</td>
<td>REF 1 Ch 8</td>
<td>see Moodle</td>
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<td>1</td>
<td>Exploded Assemblies</td>
<td>REF 1 Ch 9</td>
<td>see Moodle</td>
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<tr>
<td>Date</td>
<td>CADD: Drawings</td>
<td>CAE: Structural Analysis (Pro/Mechanica)</td>
<td>CAM: Machining (Pro/NC)</td>
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<td>9 April</td>
<td>2 Intro to Drawings, Part Drawings, Assembly Drawings</td>
<td>2 Pro/Mechanica Structural: Sensitivity Studies &amp; Optimization CAE/CAM Project (phase II) assigned</td>
<td>1 Pro/NC</td>
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<td>10 April</td>
<td>1 Intro to Drawings, Part Drawings, Assembly Drawings</td>
<td>1 Pro/Mechanica Structural: axisymmetric &amp; shells</td>
<td>2 Pro/NC</td>
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<td>11 April</td>
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<td>2 QUIZ II: CADD: Part, Assembly and Drawing (Thursday May 3)</td>
<td>1 Pro/NC</td>
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<td>12 April</td>
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<td>2 Pro/NC</td>
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<td>13 May</td>
<td>1 Pro/NC CADD Project (Phase I) Due</td>
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<td>14 May</td>
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<td>2 Pro/NC</td>
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<td>15 May</td>
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<td>1 Pro/NC</td>
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<td>2 CAE/CAM Project (Phase II) &amp; Team Presentations Due</td>
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<td>Reading Period May 26, 2012</td>
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