Mech 403 Computer Aided Design, Rice University,
Fall 2016 (revised 6/24/16)

This class is mainly a self-pace course with a few formal lectures until the mid-term break. The SolidWorks (SW) system will be our main software resource. It was selected because of its shorter 'learning curve' and wide range of tools to support mechanical analysis and design. SW has more than a million users worldwide. The numerical simulation (finite element analysis) capabilities within SW were previously marketed under the name CosmosWorks (CW). You can find reference materials under that name at several web sites. The class website has several Help and Demo files, see www.clear.rice.edu/mech403. Grading will be as follows: The third draft of the solid model with dimensioned drawings hardcopy 20 %, Group project report and presentation 35 %, Required SW and SWS tutorials 35 %, Simulation knowledge quiz 10 %.

This course requires several tutorials to be completed for SW solid model building and simulation (stress analysis, heat transfer, vibrations, etc) capabilities; SnagIt for screen captures for report writing; TK Solver as an introduction to non-procedural 'case solvers'. See the list of required tutorials at http://www.clear.rice.edu/mech403/403_Tutorial_Schedule.pdf After completing a few tutorials, you are required to construct a specific solid part and prepare standard drawings, with complete dimensions sufficient to construct that part (see the part assignment at http://www.clear.rice.edu/mech403/403_Solid_Part.pdf).

After completing the required solid part, and its drawings, the main task in this course is to complete a group design roject. The project may be a senior design project (or junior observer project), an Engineers Without Borders project, a project for another class, or a fun task for your group. If you do not select a project in a timely fashion, then you will be assigned one of the two default projects to be listed in the Default Group Projects on the main class web page. Projects involving dynamic motion or fluid flow are discouraged due to time limits.

The group project, beginning about midterm, will be the main variable part of the course grade (35%). It will require the construction of solid parts and an assembly and some type (stress, thermal, vibration, etc.) of finite element analysis (FEA) of the assembly, along with a written report and oral presentation. The group project report is graded on writing style and the communication value of the technical images (from SnagIt) and less on the actual results presented. (Because a first design is almost never acceptable after a review process and time restraints do not allow for re-designs.) Groups will have the option of accepting the group grade received on the draft report, or revising the draft during the last week of class for a final report grade. If you do not suggest an acceptable project you will be assigned the default project. Samples of prior reports will be provided.

SolidWorks solid modeling reference materials:
Various texts and other software manuals provide additional material (see bookshelf in ME241) and examples that may not be covered in required tutorials. The reference materials are not to be removed from the room without written permission. YouTube has many SolidWorks examples.

3-D Printing
Rice does have 3-D printers (rapid prototype device) that can make physical copies (scaled up or down) of any valid solid built in SolidWorks (and saved as a stereoligography file, *.stl). The Rice printers use mainly polymer materials and rubber. Commercial printers can use casting sand, wax, polymer, gold, steel, etc. to build parts. However, they are expensive. Printed 3-D samples of models previously built on SW will be passed around the class.

Schedule Fall 2016

Class	*Day*	*Date*	*Topic*	*Assignment* / ***Reading****
1	Tue	8/23	Organization, Sketches	Hand sketches in class **1.1, 1.2**
2	Thur	8/25	SW, SWS, demos	Begin SW solids tutorials & 3D body **1.4**
3	Tue	8/30	SW, Tutorials	Continue SW solids tutorials **2.1, 2.2**
4	Thur	9/1	SW, Tutorials	Continue SW solids tutorials **1.6**
5	Tue	9/6	SW, Tutorials	Continue SW solids tutorials **3.1, 3.2**
6	Thur	9/8	SW, Tutorials	Continue 3D body construction **3.3, 3.4**
7	Tue	9/13	SW, Tutorials	SWS simulation, start body drawings **3.9, 3.10**
8	Thur	9/15	SWS, Tutorials	See Help Files re dimensions, **3.11-3.14**
9	Tue	9/20	SWS, Meshing solids	Submit 3D body drawings **Tables 3.7-10**
10	Thur	9/22	SWS, Thermal concepts	Revise 3D drawing/dimensions **3.17**
11	Tue	9/27	SWS, Stress concepts	See Help File 6, select group members **4.1-4.3**
12	Thur	9/29	SWS, Vibration concepts	All tutorials, Design project abstract **4.5, 1.6**
13	Tue	10/4	SWS, Tutorials	Discuss project. **13.1 Figs 13.2-3**
14	Thur	10/6	Select group project	Discuss project with instructor **12.1-12.3**
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15	Thur	10/13	Begin group project	Tutorials, discuss project with team
16	Tue	10/18	Group Project	Build parts
17	Thur	10/20	Group Project	Build parts, attempt to mesh parts
18	Tue	10/25	Group Project	Build parts, analyze parts
19	Thur	10/27	Group Project	Make 1st draft of part(s) drawing/dimensions
20	Tue	11/1	Group Project	Build assembly
21	Thur	11/3	Group Project	Build assembly, attempt to mesh assembly
22	Tue	11/8	Group Project	Analysis of project assembly
23	Thur	11/10	Group Project	Analysis of project assembly
24	Tue	11/15	Group Project	Outline project presentation PowerPoint
25	Thur	11/17	Group Project	Complete project report
26	Tue	11/22	Complete presentation PPT	Design report hardcopy due
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27	Tue	11/29	Group presentations	Attend presentations and critique them
28	Thur	12/1	Group presentations	Final design report hardcopy due

***Reading**

The *recommended* text gives some basic theory and example applications for stress analysis, heat transfer, etc.:, Finite Analysis Concepts via SolidWorks, J.E. Akin, World Scientific Publishers, 2010, contains a detailed index. The reading assignments above refer to **section numbers** in that text. An electronic draft copy is located at the site http://www.clear.rice.edu/mech517/old_pdf/FEAC_final.pdf Courses on detailed finite element theory, like Mech 417, Mech 427 and Mech 454 are available as electives, as are their graduate versions.

Simulation warning:

The finite element analysis (FEA) simulation capabilities are too easy to use and provide impressive color outputs. However, since there are no pre-requisites for this course almost all of the students are not yet qualified to judge whether the simulation inputs and/or results are correct or just pretty pictures from an invalid simulation (garbage in – garbage out leads to computer aided stupidity, CAS). To be able to validate simulation outputs you need to complete several other courses including (but not limited to): statics and dynamics (mech 211), mechanics of solids and structures (mech 311), materials science (msci 301), finite element analysis theory (mech 417) or numerical methods for partial differential equations (caam 452) or matrix methods in structural mechanics (mech 427), heat transfer (mech 481), and vibrations (mech 412).

Advanced mechanics of materials (mech 400) is also recommended for validating stress studies.

If you use the optional fluid flow simulation (not recommended) you will need the fluid mechanics (mech 331), computational fluid mechanics (mech 454) and probably heat transfer (mech 481) courses to be qualified to judge if the simulation answers are physically possible. Flow problems are nonlinear and numerical solutions can converge to an incorrect answer.

If you use the optional motion (kinematics and kinetics) simulation you will need dynamics (mech 211) and probably dynamics and control (mech 411) to understand the results.

It is best to also complete graduate courses in the same fields to avoid CAS in any simulation study.

Note: a simulation is NOT a test (do not use that word in your design reports to refer to a computation). It is a numerical approximation based on many assumptions.

Finite element analysis reference material

In Mech 403 we use the SW simulation software as a black box tool, with only very limited lectures on the theory behind it. It is very risky to use such tools without an understanding of its basic theoretical foundation and limitations. The tutorials just show you how to locate icons for a task and almost never give you the engineering insight into the best choice for a particular feature. The recommended text gives more examples of how to validate or check a simulation result.

If you actually heavily use CAD and FEA after graduation it is very strongly recommended that you read the book: Building Better Products with Finite Elements Analysis, by V. Adams & A. Askenazi, OnWord Press, 1999.

ANSYS

The SolidWorks simulation has about five element types and can do about 90% of what most mechanical engineers need to do. ANSYS is also available on the class computers and can import solid models from SW. ANSYS has hundreds of element types and can do anything a mechanical engineer needs to do; including multi-physics and optimization. Having experience with ANSYS increases the demand for your skills in the job market. However, since ANSYS is an extremely powerful tool it is difficult to use and has a very long learning curve. If you have extra time for CAD/FEA studies try using the ANSYS Workbench.