ME 471: COMPUTER-AIDED ENGINEERING APPLICATIONS

FINAL PROJECT DESCRIPTION AND REQUIREMENTS

Dec. 16th, 2011, 14:30 MT
(Submitted to Dr. Jensen)

Project Scenario

Upon graduation you will accept a position with an international remote control (RC) vehicle manufacturer. In the months before graduation you decided to take an advanced CAE applications course that will teach the extended principles and procedures of multi-dimensional computer-aided engineering applications. As an added benefit you learn that the semester project will focus on the modeling, redesign, analysis, and prototype manufacturing of a high-end RC vehicle.

You also learn that the two assigned classmates, who will be working with you on the semester-long project, have likewise accepted positions with the same RC vehicle manufacturer. As an added twist, you learn that your local team will be collaborating with three students from another university which will enable you and your classmates to learn the tools and techniques of global product design. Over the course of the semester you will use the following suite of CAx and communication tools to model, analyze, and rapid prototype parts of an RC vehicle:

Siemens TcE	NX or CATIA FEA	ANSYS-Fluent	Google Presentation
Siemens TcC	NX or CATIA Motion	Google Docs	Skype
NX or CATIA	Altair HyperMesh	Google Spreadsheet	Video Conferencing

The degree and quality to which your team collaborates will have a direct impact on the fit and finish of your team's parametric part and assembly models. Your collaboration will directly impact the accuracy and usefulness of the team's topology, mass properties, FEA, and CFD analyses. Your team's collaboration will ultimately influence each team member as they create individual vehicle body designs and prototypes.

Project Goals:

1. Demonstrate correct understanding of topology optimization applied to individual components.

2. Use data exchange methods and techniques to import/export results/models from one CAx application to another. Data exchange techniques will also be used to retrieve models of purchased hardware that get integrated into your master assembly.
3. Correctly apply both top-down and bottom-up modeling strategies to create parametric surface/solid part and assembly models.
4. Use mass properties and FEA analyses to adjust the parameters of the topology optimized surface/solid part and assembly models to achieve their optimal size and shape.
5. Demonstrate the appropriate application of 2D CFD analysis to evaluate the air flow over the surface of your vehicle.
6. Demonstrate the use of motion analysis to check and correct the kinematics linkages of your vehicle subsystems.
7. Finally use visualization and rapid prototyping to present a convincing "award winning" presentation to display your semester's achievement.

Project Description:

Given an actual RC vehicle, you are assigned to work as a team of six (6) to model and re-engineer the platform of this vehicle. This includes modeling all vehicle components, subsystems, and final assembly based upon your team's engineering analyses. The analyses you are to consider include: topology optimization to guide initial and preliminary models, mass properties, FEA, CFD and motion analyses to guide the final size and shape of components, subsystems, and the final vehicle assembly. Each team member is to also create their own car body as a surface only part. Your design is to be fully parametric such that a simple change in one or more key parameters (i.e., track width, vehicle height, wheel base, etc.) will morph the entire vehicle, including your team's individual car bodies.

In the final presentation:

1. Clearly show the breadth and depth of the team's CAx knowledge, skills, and techniques that were used to design, analyze and digitally manufacture/prototype vehicle parts, subassemblies and overall assembly.
2. Demonstrate that each team member has a clear understanding of how to apply the CAx applications discussed to individual parts and/or assemblies of parts.

As mentioned above each team member must design and rapid prototype a vehicle body that is both aesthetically pleasing, and conforms to the original platform of the provided RC vehicle. This requirement is to challenge your individual surface modeling skills and is to encourage you, the engineer, to consider aesthetics in your design. The size of your rapid prototype is based on what you can afford, see the Rapid Prototyping section below.

Instructions:

After being assigned to a team, use the class lectures and the labs to first, learn the various CAx engineering application, and second, apply your knowledge to the RC vehicle project. The sections below are intended to provide an allocation and breakdown of project points while providing some guidance and direction as to what is expected over the course of the semester.

Team Collaboration (50 pts):

Apply what was taught in lab to contact your team, arrange a meeting or meetings to organize your team. Use and become comfortable with all of the communication technologies discussed in class. While doing this get acquainted (i.e., become friends and associates) with all your team members. Next you will need to decide who will be the team lead, lead designer, lead analysts, lead manufacture personnel, systems interface lead, standards/parameter controller, etc. This does not imply that only one person will do all the modeling ... but rather that this person will track the overall team's progress for modeling ...

Make sure to track and keep records/minutes of all team meetings. Use Google Docs, Spreadsheet, Presentation to track attendance, task assignments, action items, map weekly progress for modeling, analysis, etc. Make sure meetings end with goals and objectives for the coming week. **Do not go more than one week without a team meeting.**

Beyond the organization of your virtual team, here are some other things to consider during meetings held early in the semester.

1. What are the differences in modeling, analysis and manufacturing standards, methods and processes that are used by the two (or more) cultures represented on your virtual team? Which standard will your team use?
2. What are the key control parameters that will be used to morph your team's vehicle?
3. Who will model which parts?
4. If you worked for a RC manufacturer what parts are purchased and what parts are manufactured?
5. Discuss and agree upon how "presence" will be used.
6. Discuss and agree upon how your team will deal with non performance issues (i.e. when to vote a member off of the team).
7. Etc.

Become networked friends with your teammates.

No one likes attending meetings, especially meetings that are poorly organized and led. The use of "presence" can greatly reduce the need for long drawn out meetings where only two people are in dialog with each other. Also remember that meetings (planning, design reviews, training, stage-gate) are an important part of day-to-day engineering; use your project meetings to refine your participation and collaboration skills.

Assembly Parametrics (40 pts):

Apply what was taught in lab to your semester project. The end goal is to have your team's virtual vehicle controlled by a master parametric assembly skeleton. If done correctly a small set of parameters can be used to drastically change the look/design of your vehicle. It is absolutely vital that you completely specify the wave/published links, inter-part relationships and expressions such that your vehicle represents a family of similar designs.

There are four distinct phases to this activity:

1. Develop a master parametric assembly skeleton that is linked via a top-down methodology to all non-purchased parts and assemblies. All of these files are to be stored and saved within your team's TcE folder. TcE will help you manage your part and assembly versions.
2. Create all top-down parts and assemblies. No parts or assemblies should ever be stored locally (i.e. your local hard drive). Model editing should begin with checking out the model from TcE and end with checking the model back into TcE.
3. Create all bottom-up purchased hardware. These models are also to be created and managed as TcE data items.
4. Add the purchased hardware models to the master parametric assembly.

Phases 1 and 3 can begin almost immediately after your team has been formed. Phase 2 requires that Phase 1 be essentially completed; however, once completed all non-purchased parts can be modeled concurrently. As a final step to completing the assembly, purchased hardware models are linked using a bottom-up methodology. You will need to link your purchased hardware (models) to points/locations that adjust and morph when key parameters are changed.

Note: To receive full credit for this portion of the project the body shells must morph with parametric adjustments to the platform, i.e. adjusts such as track width and length. This is a challenging aspect of parametrics to execute correctly, but careful planning and linking will allow your surfaces to morph with the adjusted platform.

<u>Topology Optimization (40 pts):</u>

Apply what was taught in the topology lab to your semester project. Over the course of the semester create conceptual envelopes for the structural parts of your vehicle. Model these envelopes (including design points and fixed geometries) in a CAD system. Then, import the models into HyperMesh where you will define loads, constraints and parameters used in the topology optimization. Although topology optimization could be applied to every part of your chosen vehicle, you must decide which components are most significant and could experience the greatest optimization benefit.

From past experience this has been the most challenging part of the vehicle project so it is recommended that you start with simple shapes until you are comfortable with this tool and the topology optimization process.

Note: there should be at least one HyperMesh model contributed by each team member to receive full credit for this portion of the project.

<u>Data Transfer /Wireframe Parametrics/Re-parameterization (40 pts):</u>

Apply what was taught in the data exchange, wireframe parametrics and re-parametrization labs to your semester project. Import your HyperMesh results into your

CAD system and create parametric wireframe control structures and solid models of these parts.

Apply the concept of wireframe parametrics to your semester project. Non-purchased parts should have a set of fully constrained sketches that will allow them to be quickly and easily modified. These fully constrained surface- and solid-modeled parts should have their parametric sketches wave linked or published to the master assembly. Sketches should account for tolerances, allowances, and fits between mating parts. Ensure that parts are robust and that they correctly update when key parameters are changed.

Models of purchased items can generally be found in neutral file formats. Any imported hardware should be re-parameterized and made to work with your overall parametric schema.

Wireframe parametrics, data exchange, and the subsequent re-parameterization of imported models are the foundation upon which robust parametric models and assemblies are built. If done correctly your final vehicle assembly will be robust and easy to modify.

Surface & Solid Modeling (40 pts):

Apply what was taught in the surface and solid labs to your semester project. Good modeling and layering conventions and standards should be followed as you create your components. All parts (except your individual car body) are to be created as a robust intelligent parametric solid. Some of your complex parts may start out as parametric surfaces, but you should eventually join their surfaces into a solid, with these solids being controlled parametrically by their underlying surfaces. As you create your components you can either use a top-down or bottom-up modeling approach. Truth be known, most complex assemblies are a marriage of both styles of modeling.

NOTE: All part and assembly files must be kept under TcE control to avoid two people working on the same part at the same time.

FEM/FEA (50 pts):

Apply what was taught in the FEA lab to your semester project. Based on the parts chosen for topology optimization, conduct finite element analyses of these CAD parts to ensure that the components are appropriately sized. If your parts appear significantly over designed, demonstrate the application of shape and size optimization by parametrically varying thickness, length, diameter, etc. parameters to refine the design of your semester project.

Note: Each team member should apply FEA to selected parts and an assembly of parts to ensure that the assembly is designed correctly. If problems are encountered in your assembly, show that changes in part and assembly parameters can quickly resolve structural concerns.

Mass Properties (30 pts):

Apply what was taught in the mass properties lab to your semester project. Do a comprehensive study of the mass properties of your parts, subassemblies and overall assembly. Through the use of part and assembly parametrics, demonstrate that you have significantly improved the overall mass properties of your final design.

Motion/Kinematics (30 pts):
Apply what was taught in the motion/kinematics lab to your semester project. Because it is not uncommon for a mechanical engineer to create something that moves, it is expected that your semester project can be improved through the use of motion or kinematic analyses. If necessary, use part and assembly parametrics to show improvement to your final design.

CFD (30 pts):
Apply what was taught in the CFD lab to your semester project. Flow analysis will help you evaluate the pressures applied to and drag caused by the overall design of your car body shell. Demonstrate improvement of your design by changing parameters that ultimately reduce drag or pressures.

Visualization (30 pts):
Apply the visualization methods and techniques covered in lab to your semester project. Show your team's understanding and skill level by correctly applying rendering methods to parts and subassemblies. Show your individual understanding and skill level by correctly applying rendering methods to your version of the vehicle (i.e. the platform combined with your car body). With a little time and practice you will be able to create an award winning presentation and portfolio pieces.

Note: Many of the CAx vendors run competitions each year to gather rendered images that subsequently find their way into calendars and marketing brochures. For example, last year Siemens gave the person who submitted the winning rendered image a 65" flat screen TV. Also, over your career you will be promoted based on the quality and quantity of your engineering work and how well you can sell and promote your engineering/designs. You can do all of the engineering in the world, but if you cannot get the funds to physically make the product then what good is the engineering, other than an exercise?

PMI/Rapid Prototyping (20 pts):
Apply what was taught in PMI and rapid prototyping labs to your semester project. Demonstrate that each member of your team can correctly produce a model with appropriate PMI dimensions, tolerances and feature control. Also demonstrate that each team member can produce a scaled rapid prototype of their car-body shell. Each team member can decide what type and size of RP model make based on how much they want to spend.

Submission:
Your team will need to determine how to best demonstrate the extent to which each CAx application has been robustly and correctly applied to the semester project. At a minimum

each team is to submit a CD which contains the work done for ME 471 credit. The organization of the CD is to be as follows:

At the first directory level on the CD there should be a "Readme" Word .doc file, a presentation folder, and a project folder.

The <u>Readme</u> file should contain;

- *Explanation of what is on the CD*
- *How to use the CD*
- *What software packages (and versions) are necessary to view the models, data files, images, etc.*
- *What was learned, accomplished, complete, etc.*
- *What was attempted, not yet finished, incomplete, etc.*

In the <u>presentation folder</u> there should be the PPT file and any avi's, mpeg's, animated gif's, etc; anything needed to make the presentation run correctly needs to be in this folder. These files may be duplicated elsewhere on the CD but they must be in the same folder as the presentation. The <u>PowerPoint presentation</u> should cover all aspects of your semesters work. It should proceed in a logical fashion through the modeling, analyses, and manufacturing that was accomplished. It should discuss both the greatest accomplishments as well as the most difficult struggles that the group experienced. The presentation should last 15 minutes with an additional 3 minutes for questions and answers.

In the <u>project folder</u> there should be a series of subfolders

- *<u>Final</u> PowerPoint presentation folder with the PPT file and all avi/mpeg/mov files that are referenced in your PowerPoint presentation*
- *<u>OptiStruct folder</u> with all of the models and results files*
- *<u>Modeling folder</u> with all of the part and assembly files; this folder should also contain an appropriate short <u>CADReadMe</u> file to instruct the user on how to load, access and run your models.*
- *<u>Data transfer folder</u> with both what was sent to and received from another CAD system. Also include copies of the original CAD part files you sent and the reparameterized/fixed CAD models you repaired from what you received*
- *<u>Visualization folder</u> with all of the renderings and movies, anything that was not put into the final PPT*
- *<u>Mass properties folder</u> with all of the results well organized and explained*
- *<u>FEA folder</u> with all of analyses results and models*
- *<u>CFD folder</u> with all of the analyses results and models*
- *<u>Motion folder</u> with the models and results organized and explained*
- *<u>Rapid Prototyping folder</u> with the models and images organized and explained*

Presentation Date: 16 Dec 2010, 14:30 - 17:30 MT

Grading:

Your presentation and CD will be graded based on the *application/use, completeness, complexity, and appropriateness* of the following topics in your project:

- Topology Optimization
- Parametric Part and Assembly Modeling
- Mass Properties
- FEA and CFD Analysis
- Visualization
- Animation/Kinematics
- File Transfer
- PMI/Rapid Prototyping
- Overall Presentation *(logical flow, appropriate use of visuals, grammar, ability to understand and answer questions)*

Your final project and presentation are worth 400 and 140 points respectively or ~40% of your final grade.

The presentation is limited to 18 minutes which includes time for questions and answers. One or all members of your team can present. Each team member will receive the same grade for the presentation. The presentation score will be the sum of a 50% weight from your peers and 50% weight from Dr. Jensen, faculty mentors, and the TA's.

Note: Your final project score will be weighted based on the percent project load you carried or contributed (i.e. the average of team member's perceptions of your participation and involvement in the project).