

LAFAYETTE  
MECHANICAL ENGINEERING

Senior Design Project  
Handbook

Mechanical Engineering Department  
Lafayette College

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# 1. Course Information

The following is the course catalog description of ME 497/8, Senior Design Project:

Project of the student's choice is carried through from problem formulation to completion. This sequence represents the students' major design experience and is based on knowledge and skills acquired in earlier courses. Design criteria and objectives are formulated, and realistic constraints including economic, environmental, sustainability, manufacturability, ethical, health and safety, social, and political are considered. Engineering analysis and synthesis techniques are applied and iterated to obtain an optimal design solution. Students design and conduct experiments to verify design performance. Students document their achievements through oral and written presentations.

ME 497/8 is a capstone design experience, providing students with the opportunity to apply knowledge gained in previous courses and to extend that knowledge. The **educational objectives** of this yearlong project are that students will:

*Gain experience with the nature, demands, and ramifications of real-world problems:*

- Decisions and tradeoffs
- Adequate reporting
- Project control via schedule and budget
- Vendor relations
- Resource limitations
- Confidentiality and client-specific concerns

*Develop leadership and teamwork skills:*

- Divisions of work
- Delegation
- Authority/responsibility/accountability
- Resolution of conflict
- Utilization of a variety of talents and skills
- Personnel evaluation and constructive criticism

*Increase understanding of the engineering design process:*

- Proposal, negotiation, execution, evaluation
- Feasibility study
- Preliminary design
- Detail design
- Revision
- Field test
- Manufacturing

*Apply and synthesize course material:*

- Recognize applications and limitations
- Reality vs. model
- Prediction of performance
- Optimization
- Communication of technical concepts

*Gain real-world insights:*

- Professional practice

- Standards and regulations

The **ABET outcomes** associated with this yearlong course are:

- Ability to work on multi-disciplinary teams (outcome D)
- Ability to understand professional and ethical responsibility (outcome F)
- Ability to communicate effectively (outcome G)
- Develop a recognition of the need for, and an ability to engage in, life-long learning (outcome I)

The primary requirement of the Senior Design Project is the successful execution of the project. The students in a team are jointly responsible to the faculty advisor, to the ME department and to each other for organizing, scheduling, budgeting, implementing, time-managing, and reporting.

Additional course requirements include:

- Weekly meetings with the faculty advisor
- Weekly meetings of the team
- Presentations to the ME department throughout the year
- Interfacing with Engineering technicians and support staff

**Grades** are assigned by the faculty advisor. Grading criteria are as follows:

*1. Technical Contribution*

- Adequacy and appropriateness of analyses, syntheses, tests, conclusions – includes library, field, laboratory, computer, and shop work

*2. Project Management and Collaboration*

- Initiative and imagination in taking responsibility as a leader or volunteering as a team member
- Giving and receiving criticism effectively
- Keeping team and advisor informed of progress
- Quality of written, graphic, and oral communication
- Meeting deadlines
- Attendance and participation at team meetings

*3. Overall Contribution to Project Success*

Team members will be asked to complete self- and team-evaluations. A sample rubric for this evaluation can be viewed [here](#).

## 2. Important Deadlines

Senior design projects in ME at Lafayette typically involve the following major deliverables.

- **Conceptual Design Report (~3 pages, week 3)**
- **Preliminary Design Study (~5 pages, week 5)**
- **Design Proposal (Week 7)**
- **Progress Report (Week 14)**
- **Midterm Presentation (Week 15)**

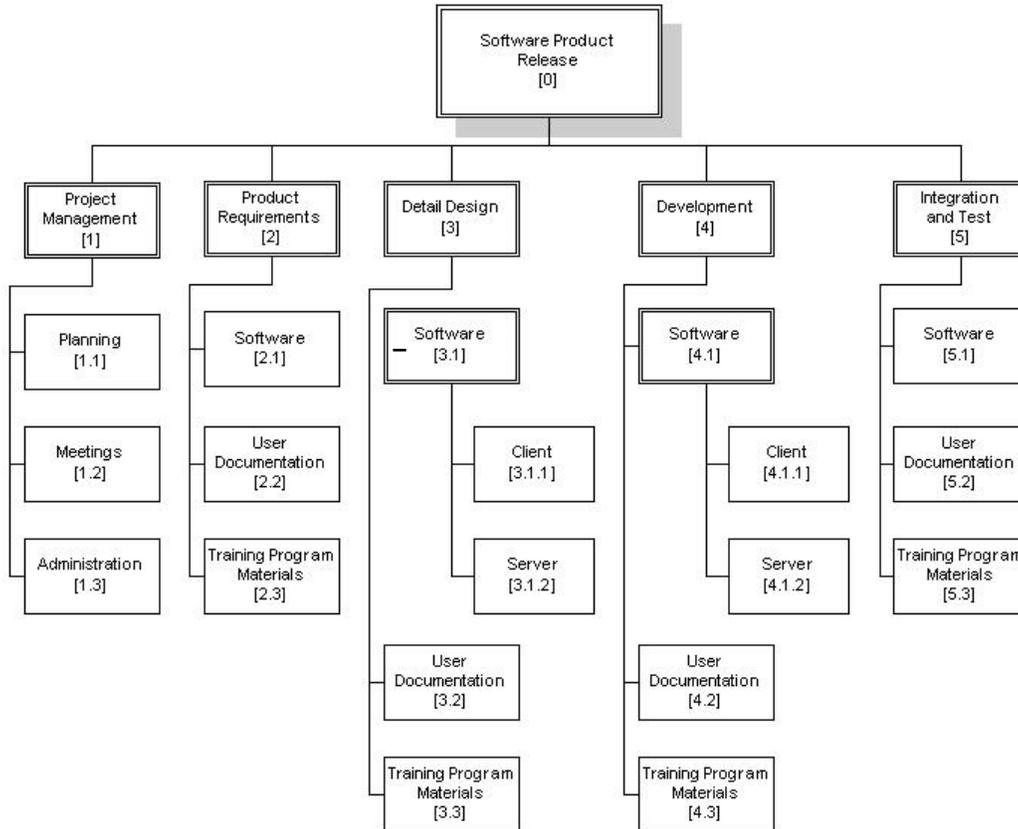
## 3. Project Planning and Communication

### *Planning*

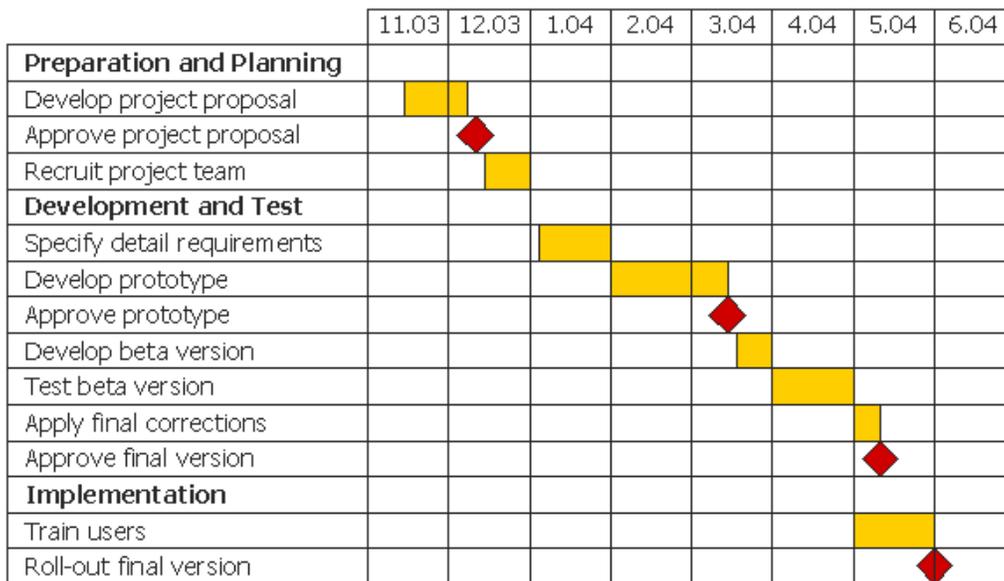
Effective time management is THE KEY to successful completion of Senior Design Projects. Various tools are available to assist in planning your time, setting schedules, and assigning resources; software programs can be used to prepare these project management tools.

- (a) Work Breakdown Structure (WBS) diagrams phases of the design process
- (b) Linear Responsibility Chart describes the participation by various roles in completing tasks
- (c) Gantt Chart represents duration of tasks with bar chart
- (d) Description of Progress Monitoring is what it sounds like

Each of these tools has advantages and disadvantages; teams should work together and with their faculty advisors to select the project management strategy that works best for them. The following are some examples:



**Figure 1.** Sample Work Breakdown Structure. Source: Cornell University



**Figure 2.** Sample Gantt Chart. Source: Andersen Consulting

### *Keeping Records*

Some record should be retained of all transactions of team meetings throughout the year. The record should include major decisions and basic assumptions made, and should clearly identify **action items** to be completed and **by whom**. Keep meeting agendas and minutes is encouraged; they are a record of what your team has learned, decided, and accomplished; and what you have planned to do and how you plan to accomplish it.

Minutes should include:

- Date, location, time, and people present
- Items accomplished since the last meeting
- Individual responsibilities for next week's work
- New facts and data; changed work plan; problems or questions, etc.

### *Communication*

The effective communication of technical ideas is a critical skill for engineers. By giving careful consideration to the needs of your audience, the purpose(s) of your writing, and the relevance of your work, you will be most effective. Organization, writing and revision are all important aspects of the writing process. Please consult your FYS textbook, *The St. Martin's Handbook*, for the fundamentals; you may also be interested in the ideas and strategies presented by more focused manuals such as *The Chicago Guide to Communicating Science* (Scott Montgomery), and *A Guide to Writing as an Engineer* (Beer & McMurrey).

### *Project Manager / Team Leader Responsibilities*

Design Project Teams are student-led. Faculty advisors are not project managers, but academic advisors for these student projects. The responsibility for project management and production of deliverables lies with the team, and with the team's project manager. Successful supervision of engineering projects involves the following ongoing tasks:

- Clarify roles and responsibilities
- Define objectives
- Provide information (to and from team, faculty advisor, and others)
- Monitor progress
- Solve the unsolvable problems
- Motivate (praise and blame)
- Evaluate results
- Sell the product

The project manager should have a mental plan for the goals of each team meeting. This plan may be documented in the form of a written agenda.

### *Team Building*

How well students work together as a team correlates strongly with project success. It is critical that the team members communicate with each other, and ensure that all members contribute meaningfully to each meeting and to the project as a whole. You all depend on each other, and the project's success depends on all of you.

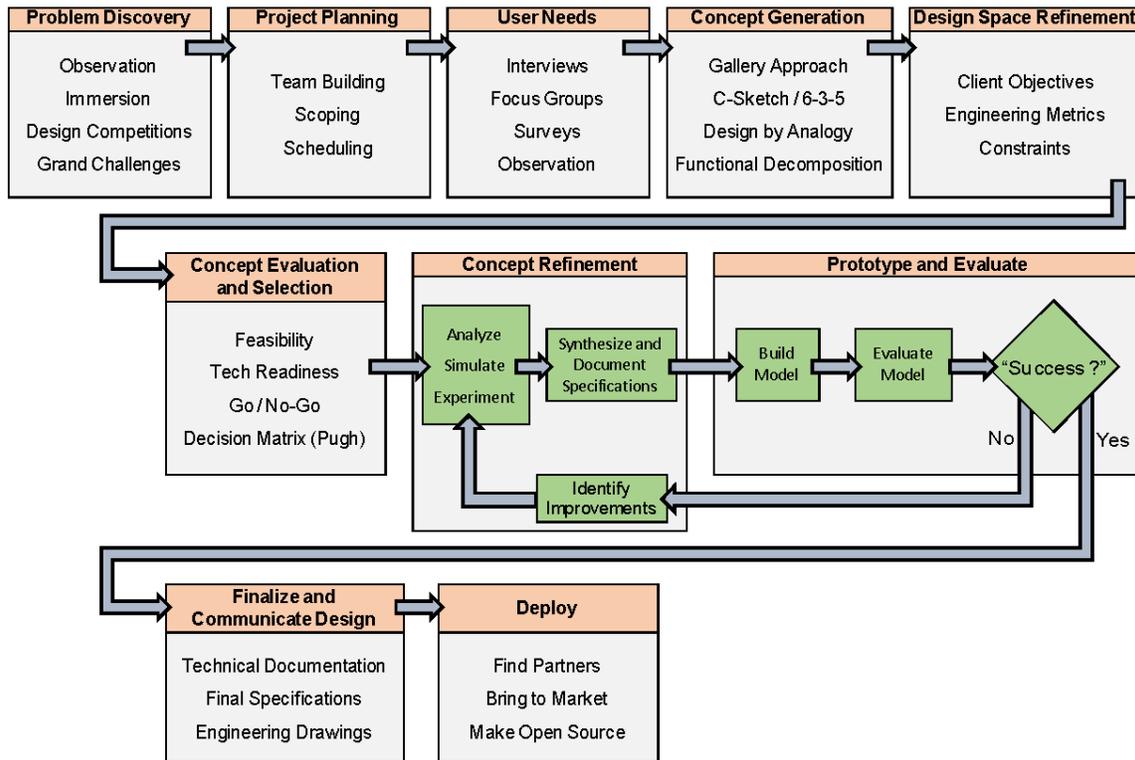
Conflicts and disagreements often arise during team projects. Conflicts must be faced and resolved, whether by compromise, discussion, or through an external arbitrator. The sooner early conflicts can be resolved, the sooner your group will function as a true team.

When a team is performing effectively, members trust each other enough to voice opposing opinions, and to accept both positive and negative feedback from other members. This should be your goal!

### *Termination*

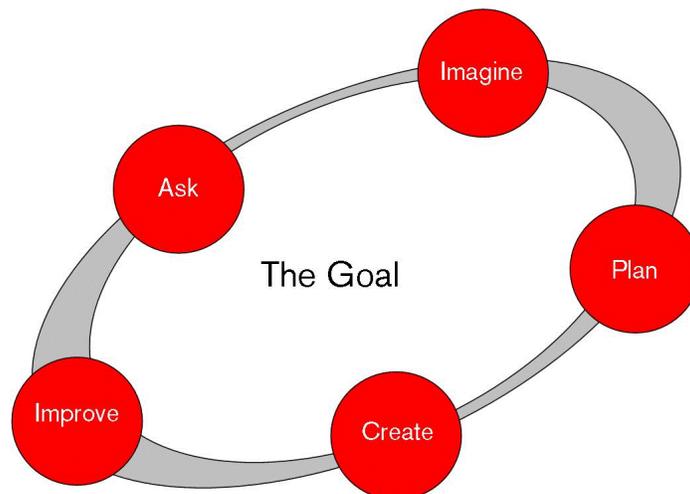
This project requires a team effort to be successful. Members of the team who demonstrate that they cannot work on the team may be terminated from the team. Before termination occurs, the instructor will provide the student with a document explaining how their effort is lacking. If the student continues to perform at a level below that of which is required, the student will be terminated. Once terminated, the student will switch into an independent study with the faculty member as their advisor. The faculty member has sole discretion to terminate a student.

## 4. Engineering Design



**Figure 3.** An engineering design methodology

Figure 3 shows one useful illustration of the engineering design process by which engineers solve problems. Students are familiar with this process from their prior experience in ME 210 and other courses. This process is iterative, involving feedback and revision at each step. Figure 4 provides another way of envisioning this process.



**Figure 4.** Another view of the engineering design process. Source: Boston Museum of Science

## 5. Professionalism and Policies

### *Collaborative Work & Accountability*

Each team member is accountable for the content and quality of each team product. Any drawing, spreadsheet, document, or presentation is the shared responsibility of all team members. Likewise, all members of the team will be held accountable for any plagiarized material in your reports. Some teams may wish to formalize this shared responsibility by asking all team members to sign off on all reports; even if not formalized, you should be cognizant of your role as a member of your senior design team.

### **Safety**

The department safety rules and procedures are included in Section 7 and are also available on the department web site. Compliance with these rules and procedures is mandatory for your safety and the safety of staff, faculty and visitors to the department.

When working in Engineering Laboratory, Project, and Shop Areas:

1. If you're not sure whether you should be wearing safety glasses, **wear safety glasses.**
2. Rotating elements should be surrounded by a protective shield to prevent accidental user contact, or to contain parts should the rotating element fail. If a shield is impractical then appropriate procedures are required to ensure the equipment can be operated safely.
3. Students should not be *wiring* equipment that is 110V. Contact the shop technicians or your faculty advisor for support.
4. Before using hazardous materials, liquids or gases, refer to the Material Safety Data Sheets (MSDS) – available in each laboratory – for special handling, storage, and disposal methods. The appropriate personal protective equipment (PPE) such as eye protection and special clothing must be used in accordance with the MSDS.
5. **KEEP THE WORK AREAS ORGANIZED AND CLEAN.** This is for your safety, but it will also improve your effectiveness.

It is the responsibility of the project teams and faculty advisor to ensure that the testing and experiments performed under their direction meet the appropriate safety standards.

As specified in the department safety rules and procedures, a risk assessment must be performed prior to any experiments or testing. The risk assessment should include an identification of the **hazards** and their **risks**. In this case a hazard is an act or condition that can cause injury, illness or harm to the environment. The risk is the **likelihood** of the hazard causing harm and the **impact** of that harm. Figure 5 shows a suggested risk ranking matrix that can help identify the highest risk hazards.

		LIKELIHOOD					Risk Rank
		1 Practically Impossible	2 Unlikely to Occur	3 Likely to Happen	4 Has Occurred	5 Common or Repeating	
IMPACT	5 Catastrophic	5	10	15	20	25	9-25 High
	3 Serious	3	6	9	12	15	5-8 Medium
	2 Moderate	2	4	6	8	10	1-4 Low
	1 Minor	1	2	3	4	5	

#### IMPACT RATING GUIDANCE

	Safety	Environmental	Typical Controls Present
5	Loss of limbs or death	Requires immediate external response (Fire, Environmental Protection Agency, etc.)	
3	Permanent injury	Requires College response and reporting to outside agency	Administrative controls
2	Professional medical attention required	Requires College response (spill, leak)	One engineering & administrative controls
1	Minor injury	Policy violation	Multiple independent, redundant engineering controls and administrative controls

**Figure 5.** Risk ranking matrix based on impact and likelihood of an event.  
Source: United Technologies Research Center

The risk matrix and assessment forms are available at:

[me.lafayette.edu/safety/](http://me.lafayette.edu/safety/)

Performance of unauthorized experiments is cause for dismissal from the course and further disciplinary action.

### *Working with the Machine Shop Staff*

The shop supervisor and technicians act as both consultants and contractors on your senior design project. Clear, timely communication with the machine shop supervisor is vital, and must be carried out in a professional manner. The established procedures exist for efficiency and fairness, and must be respected. The supervisor maintains a detailed schedule for each member of the shop staff, who work in support of all ME senior design projects and other ME projects, as well as the other engineering departments. Your own parts receive priority based on when you submit correct, complete drawings to the staff.

It is important to recognize that the machine shop supports classes for the entire engineering division. Many of these classes, such as ME210, place significant demands on the shop resources near the end of the semester, so plan accordingly.

The most important form of communication with the technicians will be your detailed part drawings. A complete drawing that meets the standards set forth in ME 210 is required.

#### Quick checklist for a complete drawing

- Ensure the drawing is the most current part/fixture
- Fully dimensioned (even for parts to be made via CNC).
- Material is specified
- Lafayette or project specific boarder is used
- Complete title block with all information including part number and revision

#### Some tips:

- For parts to be milled, please orient the datum to the top left corner, to simulate the corner touching your “dead” jaw and a stop, if using one.
- For lathe parts, please orient datum to the face of the part.
- Inventor/GibbsCAM files MUST be oriented to absolute zero relative to the drawing datum, AND must have the proper “layer” selected. This also applies to .dxf and .dwg files.
- Just as you prepare an agenda for team meetings in other locations, have a plan of action for your machine shop time. Arrive on time, and stay on task.

The technicians are available to assist you from 8am-3:45pm. The time from 3:45pm-4:00pm is reserved for clean-up and you will not request work be completed by the technicians during this time. If you are working on a machine, you will begin cleanup no later than 3:45 pm as well.

### *Purchasing*

As a member of a design team, you may need to purchase equipment, software, parts, etc. Before making a purchase, check first with your faculty advisor and with the machine shop supervisor to ensure that the item you require is not already available.

If your item must be purchased or leased, you should complete a Purchase Order request form (see Appendix). Please ship to the following address:

Lafayette College  
Attn: (Name and Design Project Team)  
AEC Room 130  
740 High St.  
Easton, PA 18042

Orders will be submitted to your faculty advisor by noon on either Tuesday or Friday. A purchase order form will be provided the project teams.

When orders arrive, please check to make certain everything has arrived and all is intact. If there is a discrepancy with your order, please notify your faculty advisor.

**Always provide your faculty advisor with any and all packing slips or invoices.**

### *Travel*

Your team may have the opportunity to travel to a competition or other off-site facility. The department secretary, Serena Ashmore, will make your travel arrangements for you; please inform her of your plans as early as possible, and contact her with any changes in your plans while away from Lafayette College.

### *Reimbursements*

If you wish to purchase an item yourself and be reimbursed, please see Serena Ashmore. Lafayette College has a policy for reimbursement of expenses for travel and other project expenses. There are some vendors with whom the College already has a business relationship; there are other vendors from which all expenses may not be reimbursed. Please note that when you are traveling, your transport and housing, but not your meals, will be reimbursed by the College. To learn about the College policy and to obtain reimbursement forms, contact your advisor *before* the purchase is made. If a student chooses to buy something with their own money and is charged tax, the College will not reimburse the tax.

## 6. ASME Code of Ethics of Engineers

### **The Fundamental Principles**

Engineers uphold and advance the integrity, honor and dignity of the engineering profession by:

- I. using their knowledge and skill for the enhancement of human welfare;
- II. being honest and impartial, and serving with fidelity their clients (including their employers) and the public; and
- III. striving to increase the competence and prestige of the engineering profession.

### **The Fundamental Canons**

1. Engineers shall hold paramount the safety, health and welfare of the public in the performance of their professional duties.
2. Engineers shall perform services only in the areas of their competence; they shall build their professional reputation on the merit of their services and shall not compete unfairly with others.
3. Engineers shall continue their professional development throughout their careers and shall provide opportunities for the professional and ethical development of those engineers under their supervision.
4. Engineers shall act in professional matters for each employer or client as faithful agents or trustees, and shall avoid conflicts of interest or the appearance of conflicts of interest.
5. Engineers shall respect the proprietary information and intellectual property rights of others, including charitable organizations and professional societies in the engineering field.
6. Engineers shall associate only with reputable persons or organizations.
7. Engineers shall issue public statements only in an objective and truthful manner and shall avoid any conduct which brings discredit upon the profession.
8. Engineers shall consider environmental impact and sustainable development in the performance of their professional duties.
9. Engineers shall not seek ethical sanction against another engineer unless there is good reason to do so under the relevant codes, policies and procedures governing that engineer's ethical conduct.
10. Engineers who are members of the Society shall endeavor to abide by the Constitution, By-Laws and Policies of the Society, and they shall disclose knowledge of any matter involving another member's alleged violation of this Code of Ethics or the Society's Conflicts of Interest

Policy in a prompt, complete and truthful manner to the chair of the Committee on Ethical Standards and Review.

## 7. Department Safety Rules and Procedures

All students working on Thesis/Sr. Projects are required to know the safety rules, procedures and policies adopted by the Department. The most recent version of the department rules can be found at:

[me.lafayette.edu/safety/](http://me.lafayette.edu/safety/)

## Appendix

### *Sample Team Meeting Report (Minutes)*

Team Meeting Feb. 14, 2004			
Present: Joe, Erika, Steve, Nikhil, Prof. Rossmann			
Agenda:			
<ol style="list-style-type: none"> <li>1. Report of week's activities (including photometer purchase)</li> <li>2. Work assignments</li> <li>3. Progress Report oral presentation, March 2</li> <li>4. Effect of utility rate structure on estimated energy savings</li> <li>5. Brief biographies for revised proposal</li> </ol>			
Minutes:			
	<b>DONE:</b>		<b>TO DO:</b>
Joe	Received info from Mainstem Co on vehicle system for Palo Alto. Found book on IES light standards at library.	Joe	Contact mfrs re: filters for YAC. Recommend light filter to buy.
Team	Measured light levels at YAC building. Problems in transmissivity ratios.	Erika	Meet Brontzman re: street lights
Erika	Found light meters to range from GE \$50 ( $\pm 15\%$ ) to Weston \$170 ( $\pm 7\%$ )	Joe	Get vehicle data from J. Kennedy
Nikhil	Has info on lamp mfrs.	Team	Get light measurements at Baseline today, noon
Steve	Tried to get info on projections of energy prices from DoE	Nikhil	Get ANSI standards and market data on lights
		Steve	Talk to factory re: theory of heat-flux meter
		Prof. R.	Check LWV on use of new Home Energy Audit forms
		Team	Meeting Thurs 4 pm re: oral presentation

Notes:

*Sample Purchase Order Request*

## Senior Design Purchasing Request - 2010/11

*Team/Student Information:*

<b>Name:</b>	<input style="width: 95%;" type="text"/>		
<b>Team:</b>	<input style="width: 45%;" type="text"/>	<b>Contact E-Mail:</b>	<input style="width: 45%;" type="text"/>

*Order Information:*

**Date:**

<b>Name:</b>	<input style="width: 95%;" type="text"/>		
<b>Address:</b>	<input style="width: 95%;" type="text"/>		
<b>City:</b>	<input style="width: 100px;" type="text"/>	<b>State:</b>	<input style="width: 40px;" type="text"/>
		<b>Zip Code:</b>	<input style="width: 40px;" type="text"/>
<b>Telephone:</b>	<input style="width: 95%;" type="text"/>		
<b>Fax:</b>	<input style="width: 95%;" type="text"/>		

#	Qty	Unit	Part #	Description	Unit Price	Price
1						\$0.00
2						\$0.00
3						\$0.00
4						\$0.00
5						\$0.00
6						\$0.00
7						\$0.00
8						\$0.00
9						\$0.00
10						\$0.00
11						\$0.00
12						\$0.00
13						\$0.00
14						\$0.00
15						\$0.00
<b>Total</b>						\$0.00

**Advisor Signature:** \_\_\_\_\_

**Comments**

