AME 441aL Senior Projects Laboratory
Spring 2021

Laboratories: **M,W 10:00 – 12:50**
ZOOM, BHE 310

Lectures: **T 11:00 – 12:20**
ZOOM

Professors: Dr. Matthew Gilpin
OHE 500 H / ZOOM
gilpin@usc.edu

Office Hours: See Piazza for Faculty and TA Lab Times and Office Hours

Laboratory Technicians:	Jeffrey Vargas	Rodney Yates	William Colvin
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Teaching Assistants: TBD

Recommended Texts (not required):

- Beckwith, T.G. & R.D. Marangoni. *Mechanical Measurements*, 6th ed., Addison Wesley.
- Holman, J.P. *Experimental Methods for Engineers*, 7th ed., McGraw Hill.
- Figliola & Beasley, *Theory and Design for Mechanical Measurements,* Wiley.

COVID-19 Posture - 12/15/2020

As directed by the Provost, we will be starting the Spring semester with **Fully Online Instruction**. Students are not allowed in the BHE labs at this time.

The Provost's guidance does leave the door open for a return to the classroom later in the semester. This is an optimistic message and any return to campus this Spring is highly uncertain if not unlikely. Thus, we need to plan and operate as if we will be fully online throughout the semester.

What does this mean for AME 441?

First – All students are currently registered for hybrid instruction. As you form your groups, discuss if you are planning to return to campus if on-campus instruction is allowed. On-campus projects should consist of ALL on-campus students in the event that we return.

Second – All groups need to plan their projects to ensure that there is a clear pathway for analysis, modeling and simulation that will allow you to successfully complete your design remotely. A return to campus cannot be a project necessity.

Third – All projects will place an emphasis on the presentation of a fully realized design complete with analysis and professional quality drawings. Imagine that you are designing an experiment or product for physical testing in a hypothetical AME 441b. Students in AME 441 are asked to prove their design at the end of the semester. Typically, this is done with the physical object in the lab, but this semester you'll need to prove your design purely via engineering analysis.

We're continuing to work through this dynamic situation and our doors are open for any questions or concerns you may have

Fight On!

-The AME 441 Team

Important Information for Spring 2021:

Due to the ongoing COVID-19 pandemic, AME 441aL will be offered fully online and potentially in a hybrid mode if students are able to return to the USC campus. Rest assured that both the online and offline versions of the course will both allow students to successfully complete AME 441aL.

However, we are requiring that if you are planning to be on-campus for a hypothetical return to the lab, that you only form groups with other students wishing to return to campus. For both academic and logistic reasons, we are **not allowing** mixed groups of potentially on and off-campus students.

This decision was made with the knowledge that on and off-campus groups will each face a unique set of challenges during the semester, in both the coordination and completion of their senior projects. It should also be emphasized that both on and off-campus versions of the course will be of the same difficulty and be subject to the same academic rigor.

All projects will be graded based on (1) how each group addresses their unique engineering challenges and (2) on how each group demonstrates consistent progress towards the goals set out in their project proposal on a weekly basis. This is how AME 441aL has *always* been graded. But, it is important to emphasize here that while the ultimate deliverable for an off-campus project will be different than a project utilizing on-campus resources, the process throughout the semester and what determines your final grade will be largely the same.

We fully intend to be flexible, in the event that we do return to on-campus instruction, regarding individual/personal situations, individual health concerns and what will surely be a dynamic COVID posture on campus. But, we do ask that you are respectful of what we are offering as instructors. If you are truly expecting to be off-campus for the semester, don't form a group with those hoping to return to on-campus instruction. Do not take advantage of the fact that we must be flexible in this environment and surreptitiously form mixed teams.

Details for the course are as follows. Please read them thoroughly.

Fight On!

- AME 441aL Team

AME 441aL – General Details

All functions of AME 441aL will be conducted on Zoom including the scheduled lecture session, office hours and group meetings. If USC returns to campus, *only* lab time in BHE will be in-person.

The scheduled lecture session (11am – 12:20pm Tuesdays) for AME 441aL will be used for project presentations starting in April and for the delivery of course content during multiple scheduled lectures. You *may not* schedule over this time. **Attendance during project presentations is required.**

In addition to lecture and general group meetings, each group will have a weekly 30-minute meeting with the instructor. These one-on-group meetings will be used to track progress and set goals throughout the semester and will be an integral part of the course evaluation. These meetings will be scheduled throughout the week at a time that works for each individual group.

Outside of these scheduled times, it is up to each group to coordinate on their own. Note that while you are registering for only 6 hours of "lab time," significantly more effort will be required to complete a successful project. It will be *your* responsibility to work with your group and establish regular work times prior to the start of the semester.

AME 441aL – Off-Campus (Fully Online) Details

AME 441aL is being offered in a fully online format. Online groups will have to rely on engineering analysis and simulations for your final project output. But, as stated previously, the process and expectations of the course remain the same. The online version of AME 441aL has an identical timeline and identical deliverables to the on-campus version.

Traditionally, AME 441aL is about delivery of a physical experiment or product whose performance can be quantitatively assessed based on stated design goals. The only difference in this logic for online AME 441aL is that the "experiments" you conduct remotely will be on the computer. We will also be placing a larger emphasis on engineering analysis as we are not able to do lab experiments to "find out" if your design is functional. You will be expected to consider the effects of design variables on your analysis and the physics which determine your expected behaviors. You will also be expected to present a progressive analysis plan which gradually increases the fidelity of your design.

The AME 441aL team will be offering online "lab hours" for student questions and discussion.

AME 441aL – On Campus Details

COVID Posture - December 15, 2020: The Provost, as of their memo on November 11th, 2020, has directed that all instruction for the Spring semester begin as Fully Online Instruction. While USC is keeping the option open for on-campus hybrid instruction later in the semester, a return to campus is highly uncertain.

All groups regardless of registration need to plan their projects as if Spring 2020 will be fully online. This means that ALL projects will be completed using simulation and analysis tools. You may not proceed with a project that requires physical hardware or laboratory data to be successful.

We **are not** allowing groups to construct remote physical projects. With in-person instruction we are able to provide necessary hardware and troubleshooting expertise. On campus, we are also able to leverage our machine shop, staff and other USC resources to assist groups when (inevitable) crises arise throughout the semester. In a remote environment without these resources, we would be setting remote groups up to fail. We also need to consider a level playing field for the course which considers what will be available to all AME 441 students.

Consider your work this semester to be the lead up to an eventual physical product or experiment.

The on-campus plan below will be implemented if there is a return to campus.

During Summer 2020, a plan was created to ensure that the "traditional" on-campus version of AME 441aL can be available to those students who wish to participate on-campus. All of the standard lab equipment and on-campus manufacturing capabilities will be available.

The use of the BHE labs, as well as other USC facilities, will be governed by the prevailing USC rules on social distancing and required PPE in addition to AME specific requirements.

At a minimum, we are requiring that all students on the BHE 3rd floor wear a cloth mask, a face shield (which will be provided) and practice social distancing.

The entire 3rd floor of BHE is dedicated to AME 441 this semester and we can support up to 30 students on the floor at a time. To facilitate this, lab time will be broken into 2 hour segments which can be reserved by individual students. The lab will have sufficient bandwidth so that every on-campus student can reserve in excess of 8 hours per week of lab time so there should be ample "bench time" to go around.

Please be respectful of other students and reserve only time that you need and only time where you *need* to be in the lab working with lab specific equipment or physical hardware. If it is clear that you are taking advantage of the reservation system to the detriment of other students or staff, your lab performance and course grade will be severely affected.

The BHE floor has been divided into multiple workstations which are separated by acrylic dividers where 6ft distancing isn't possible. All pathways in the lab are one way, are clearly marked and maintain a minimum 6ft distance from all others in the lab to maintain easy movement throughout the floor. Work areas available include fully equipped Mech-Op benches, work bench space and divided table "pods" which enable collaboration.

TAs and lab staff will ensure that the lab is staffed and open during all available times. Instructors will hold regular lab hours throughout the week.

If you have questions or concerns about the set-up of the lab, please contact an instructor.

Lab reservations will be handled through the online reservation platform Skedda.

Senior Projects in Aerospace and Mechanical Engineering
Spring 2021

v1, all dates are subject to change as COVID posture is adjusted

I. Introduction

The aim of this course is to complete an original project of your own creation which you will shepherd through the entire engineering process. The semester starts with planning and design and ultimately ends with validation. This course gives students the responsibilities associated with an industrial research project while keeping them within a teaching environment. Students will experience similar problems and challenges that will be faced upon graduation and develop a more thorough understanding of the steps involved to complete an actual engineering project. An emphasis on novel work means that one's ingenuity and initiative are a major factor in success.

Students work in groups of **four or five** (4 – 5) on a project of their choice for the entire semester. Topics for these projects are ideally provided by the students themselves. **Think about where you want to be next year and make this project the centerpiece of your academic and budding professional portfolio.** A well-executed senior project is an excellent interview topic!

The extent of the subjects covered is quite broad. Project topics have ranged from traditional areas such as fluid dynamics, structural mechanics, heat transfer, and dynamic control, to less-traditional studies on fishing line motion, plant growth in varying pressure environments, structural fire behavior, etc. The primary requirement in the selection of a topic is that the student must have a strong personal interest. More pragmatically, the project needs to be scoped to fit within a 16 week semester.

We also encourage students to contact any of the faculty listed in Appendix F and Appendix G at the end of this handout directly for ideas in their respective fields of interest and expertise.

The AME 441 schedule compresses an entire design project into a single semester. So, we need to hit the ground running! You will have an assignment due the **first day of lecture** **(11am Tuesday, January 19th).** Prior to beginning the semester, you need to form your team, select your project, and conduct a **literature review**. The requirements for this can be found in Appendix A. This will enable us to begin the semester with educated discussions on your topic.

The next deliverable is the **project proposal**. Before detailed work can begin on any project, acceptance of this formal, written proposal is required. The proposal is due **Friday, February 5th before 12pm**. The proposal will be promptly returned with feedback so work may begin. If a project is not approved, required changes must be made promptly and documented. Work on the project *cannot* begin until project approval has been given.

Starting Friday, February 26th, written group progress reports are due every 3 weeks at 12pm (Feb 26, March 19, April 9)**.** These will be graded on technical content and progress made, as well as quality, clarity, and professionalism. See Appendix C for format requirements as well as the progress milestones required. Each group will give one formal **Zoom oral presentation** on their work to the rest of the class; presentations will take place during the lecture section in April.

Finally, one **Final Report** of publishable quality will be required by each *group* at the end of the semester; this report is due **Tuesday, May 11th at 11am** in accordance with the University Final Examinations Schedule. Students will be evaluated on the quality and content of their reports and presentations as well as their performance throughout the semester; this includes technical competency, attendance/participation in scheduled meetings and overall project contribution.

Document Submission

TurnItIn will be used for submitting all assignments. This includes the Literature Review, Proposal, Progress Reports, and Final Report. Look in \\Blackboard\Assignments\ for document submission links. **Peer Evaluations** will be submitted online via a Google Form.

INCLUDE YOUR GROUP #, DATE, TITLE AND NAMES OF THE AUTHORS ON ALL ASSIGNMENTS

File naming convention: name all files submitted through TurnItIn starting with your two-digit group number (G##). For example:

- G42_literature_review.pdf
- G42_progress_report_1.pdf
- G42_progress_report_2.pdf
- G42_progress_report_3.pdf
- G42_final_report.pdf

II. AME Lab Procedures and Protocol

For groups who are participating on-campus, the following general lab rules will apply in addition to precautions which will be taken for COVID-19.

Safety and Space Management

- ***CLOSED-TOE SHOES* AND *LONG PANTS* ARE REQUIRED IN THE LAB AT ALL TIMES. *NO EXCEPTIONS!*** Shoes need to provide protection; hence, "Toms", boat shoes, flats, slippers, etc. don't qualify. Pants need to be pants.
- Safety precautions (gloves, eye protection, hair ties, etc.) are mandatory. Ask a staff member if you are unsure of any safety precautions you should be taking when working in the lab.
- According to University rules, students are not allowed in the lab without supervision. Therefore, all experiments must be performed within the scheduled lab times.
- Store your personal belongings out of walking paths – under work tables for instance. It is important to keep a clear and safe walkway through the laboratory.
- Keep the lab clean. ***No food or drinks*** in the lab areas. You are welcome to have food or drinks in the hallway, near the stairs, or in the BHE 301 presentation room (outside of AME 341 lab hours).
- **Return all lab equipment to its original location** after use (cables, beakers, drill bits, etc.).
- There is a small engineering library in BHE 301. These resources are to be shared and ***are not to leave BHE.***

Supply Room and Device Access

- Access to the BHE 301 Supply Room is restricted to staff. Most tools and equipment are provided for student access in BHE 310.
- Any/all resources and devices that leave the Supply Room ***must*** be approved, checked out, and signed for by an AME 441 staff member.
- Please promptly report any/all broken or non-functioning equipment and devices to the staff. This is *extremely* important, and will save everyone time and trouble in the future!
- When requesting equipment, students must be prepared to give all the pertinent characteristics they require so that the staff can act on the requisition effectively.
- On some occasions, it becomes necessary to share equipment with other groups. Under these circumstances all parties involved are expected to be considerate and cooperative.
- **When requesting to have parts fabricated/machined, ensure that your designs are complete** – design by trial and error will not be permitted. Be prepared to thoroughly present and explain your design in order to facilitate the approval and scheduling of part fabrication/machining. See manufacturing notes in Section IV.

Computer/Printing Rules

- Do ***not*** customize any computer workstations. This includes modifying the desktop, any/all computer settings, or installing any software without staff approval.
- Save files **only** in the following directory: **D:\home\JStude**. *Other locations will be deleted!*
- Remember to save your work to the computer's hard drive before moving it to a USB key or portable storage device. This serves as a backup.

III. Facilities

The AME Lab in BHE has served *decades* of AME 441 classes and is well stocked with the *majority* of the tools needed to support a successful project. The lab will provide PC's, data acquisition devices and software for design, data capture and analysis. Common instrumentation is also available including digital image and video recorders, high-speed cameras, various pressure transducers, low power lasers, thermocouples, etc. If the required instrumentation is not readily available in the lab, it can often be procured from other departments on a loan basis (*e.g.*, a micropipette could be borrowed from the chemistry department).

In addition to basic scientific equipment, the BHE labs have larger test facilities. The AME Lab has a low-turbulence, open-circuit wind tunnel located in BHE 301. The test section measures 46 x 46 x 91 cm, and can provide freestream velocities from 3 m/s to 46 m/s with less than 1% variation from the mean. It is equipped with two, six-component force balances: one is capable of measuring lift and drag forces of up to 67 N and 35 N, respectively, and the other to 12 N. A low-speed water channel, built as a previous AME 441 project, is also available and located in room BHE 110. The test section of this water channel measures 0.18 m x 0.20 m x 0.91 m, and has a test velocity range of 0.05 to 0.15 m/s. Flow visualization can be performed through the transparent, acrylic test section walls. Data acquisition for these facilities is possible through a multifunction DAQ device and LabVIEW.

For well-planned projects, advanced AME department facilities can also be made available for AME 441. One such facility is the large water channel in RRB 107. The test section of this water channel has a cross-section of 0.91 m x 0.14 m, and has a usable length of approximately 3.5 m. Test velocities range from 0.12 m/s to 0.40 m/s. Flow visualization is possible through the transparent side walls and drag force measurements can be performed using the existing force balance setup. An advanced Particle Image Velocimetry (PIV) system, capable of measuring 2-D velocity fields, may also be made available for well-designed projects which require this capability. Due to the limited availability, operational complexity and safety requirements of the PIV system, students who intend to use this system are required to discuss their project with AME 441 instructors and Dr. Luhar before including its use in their project proposal.

Online Groups will have access to all software available via the Viterbi Virtual Desktop Interface (VDI) including Siemens NX as well as the software available on the SAL computers via a remote desktop. Additional software will be considered on a project-by-project basis.

IV. Manufacturing

On-campus projects require some fabrication and the AME lab has multiple facilities allowing you to create custom fabricated components for your project. Note, that this is a design course, so all parts must be justified with quantitative reasoning about key design decisions.

The AME lab has a pair of laser cutters. Each cutter has a 60cm x 30cm bed and is capable of cutting 2D shapes from balsa wood, thin plywood and acrylic. When designing parts for AME 441, the laser cutters should be your ***FIRST*** thought. Unlike other manufacturing facilities, the laser cutters are capable of producing *same day* parts for your project. Think about how you can build up multiple 2D shapes into 3D structures. Also think about your structural requirements and if cast acrylic can be a viable material.

The AME lab also has multiple PRUSA 3D printers. While additive manufacturing is an exciting topic in all disciplines of engineering, it is asked that students restrict 3D print jobs to parts and designs that actually ***need*** to be 3D printed. The 3D printers have a long lead time during the semster and successful prints typically require multiple iterations. 3D printers are *not* a tool for lazy design. Typically, the majority of jobs submitted for additive manufacture can be produced faster and with higher quality using conventional techniques.

Finally, the AME lab has a full machine shop enabling in-house manufacturing. Rod Yates has decades of machining experience; if you can think of it, it can likely be made. Students *must* be involved in the manufacturing of their components and training is available to enable students to craft their own parts. The AME 441 shop is not a place where you submit drawings and walk away. It is a place for you to learn how things are manufactured by being actively involved in the process. Missed manufacturing appointments will result in parts being bumped from the machining schedule and these delays will cause your project to suffer.

ALL machine shop jobs must be scheduled through Rod Yates and will be completed on a first-come first-served basis. The scheduling deadline for the AME 441 machine shop corresponds with the due date of the first progress report on **February 26th**. Parts approved and submitted by this deadline will set the manufacturing schedule and will have completion priority. It is *strongly* encouraged that parts be submitted before this deadline.

For all of the above facilities, manufacturing will not be scheduled until the part has been approved by both "Engineering" (AME 441 Instructors) and "Manufacturing" (Jeffrey Vargas: Laser Cutter & 3D printer, Rod Yates: Machine Shop). Drawings must be submitted on paper, *in-person* and be initialed by both "Engineering" and "Manufacturing" staff for complete approval. (This semester, drawing consultations MAY be held via ZOOM).

Drawings must be professional quality, computer generated using the provided templates and have at a minimum:

- 3-View
- Dimensions
- Necessary tolerances
- Part material
- Signature block for approvals
- Accompanying assembly drawing

Additional manufacturing facilities are available include the Baum Maker Space and the USC machine shop in KAP B-1B (M-F, 6:30 AM – 2:30 PM). If these facilities are used, it is the responsibility of the student to submit and schedule parts.

V. Budget

FULLY ONLINE UPDATE: You still need to consider a budget when planning online projects. Assume that you are still constrained by your group's laboratory budget and assumed testing hardware. Without budget constraints you are missing a key aspect of the project design. AME 441 isn't intended to be an open design "sandbox". The goal is to produce a targeted design withing meaningful constraints.

Each *student* is allotted approximately $100 for the purchase of expendable materials. While this appears to be a small amount, nearly all of the required components for successful projects are already available in the AME Lab. Typically, project groups will only need to charge 1 or 2 items to their project budget and the *majority* of groups do not exceed their allotment. The total amount of funding for a project will be based on the budget submitted with the proposal and may exceed the specified amount if it is deemed necessary for the project's success. Should you need to make a purchase, follow the guidelines below:

Prior to making any purchase, approval is required by your instructor. The detailed procedure for making purchases from online retailers will be discussed during the first week of class. In general, you will prepare an order, print the detailed summary but **do not** submit the order confirmation. Bring the printout to your instructor for a signature and give the order summary to the TA in charge of placing the orders.

If your project is able to utilize reusable hardware kept in a standard configuration, which can be used for later AME 441 semesters, this hardware will not be considered "consumable" and will ***not*** be charged against your group's project budget. Examples include 80/20 channel, diagnostic equipment, tooling, etc. Care must be taken to ensure reusability at the end of the semester and instructor approval is required before orders can qualify for this exemption.

Students may make smaller purchases and be reimbursed upon presentation of an original receipt. ***Pre-approval is required from an AME 441 instructor prior to making small purchases.*** Items from the Engineering Machine Shop (KAP Basement), Electronic Store (OHE 246), and Chemistry Store (SGM 105) can only be obtained on an Internal Requisition; student purchases from these places cannot be reimbursed.

No reimbursements will be made if the above procedures are neglected. No exceptions!

VI. Grading

Grades are based on both individual and group performance. Descriptions for all deliverables and a sample grade sheet for the oral presentations are provided in Appendix A through Appendix E. All assignments are expected to be of professional quality. Everyone has completed AME 341 and those standards should be followed.

Students will also be graded on their individual performance. To facilitate this, and provide guidance on each group's project, conferences with one or more instructors will be held weekly. During these conferences, current work and problems are to be discussed and evaluated. The instructors should be notified immediately of any difficulties in the project, as delays will have an adverse effect on performance assessments. **It is essential that these projects are worked on continuously; waiting until the last few weeks will surely be detrimental to your grade.** Successful projects are the result of a sustained effort that begins on week one.

If you are working in the BHE labs, part of the laboratory performance grade will also be adherence to safety guidelines. Each safety violation will result in a 3 point reduction in your lab performance grade. This is a serious penalty for a serious issue. There is no such thing as a "quick cut" or "quick job"; that is how you quickly loose an eye.

All students are required to attend the oral presentations during the registered lecture section. Attendance will be recorded and one absence will be permitted; use it wisely (e.g. for a job interview, etc.). A 10% penalty will be applied to your oral presentation score for each additional absence. Arriving late or leaving early counts as an absence.

Each group is required to keep a laboratory notebook as described in Section VII. This is to be turned in with the final report at the end of the semester. This year we have put added emphasis on the maintenance of this laboratory notebook – incomplete and untidy entries will result in a 5% penalty, applied to your final grade. The notes, thoughts and sketches contained in the notebook should be informative and useful. Write in this notebook as if you were planning on giving it to another 441 group next year. They should be able to easily continue your project based solely on the information contained within. A lab notebook *can* be a well kept and well formatted digital document. Simply submitting your groups google doc folder doesn't count.

All on-campus students must complete mandatory lab safety training and workshop within the first two weeks of labs. **Lab work on your project will NOT be permitted until this training has been completed**. Failure to complete the training within the announced time frame will result in a 5% penalty on your final grade.

The grade distribution for the course is detailed in Table 1. This distribution is subject to change. Also note that overall performance in this class is cumulative. It is difficult to write a high-quality Final Report if your project doesn't begin with a high-quality proposal.

Table 1. Final Grade Weight Distribution (%)

Literature Review & Proposal	10
Progress Reports	20
Oral Presentation	15
Lab Performance	15
Final Report	40
TOTAL	**100**

VII. Deliverables

INCLUDE YOUR GROUP #, DATE, TITLE AND NAMES OF THE AUTHORS ON ALL ASSIGNMENTS

Table 2: Schedule of Deliverables

Literature Review	January 19th, 11am
Project Proposal	February 5th, 12pm
Progress Report 1	February 26th, 12pm
Progress Report 2	March 19th, 12pm
Progress Report 3	April 9th, 12pm
Oral Presentations	April, TBD
Laboratory Notebook	**Tuesday May 11th, 11 am**
Final Report	**Tuesday May 11th, 11 am**

- **The first deliverable is the Literature Review**. This is due on the **FIRST DAY OF LECTURE.** This document should be 3-4 pages in length and include your team members, your project idea and a summary of research which has led you to your topic. Submit one Lit Review per group. More details are given in Appendix A.

- **The second deliverable is the Project Proposal.** At a minimum, the proposal should follow the guidelines provided in Appendix B. Only one document per group is required. Proposals are due **Friday, February 5th at 12pm**. It is recommended that you discuss any ideas and/or approaches with your instructors, TA's and lab staff before and during this process. Remember, work may not begin until the project has been approved.

- **A progress report is due every three weeks at 12pm, starting Friday, February 26th.** Only one per group is required and the contents should follow the suggested guidelines presented in Appendix C. A total of three (3) progress reports will be handed in throughout the semester. These will be graded on the amount of project progress achieved, as well as clarity in technical communication.

With every progress report, **each** group member is required to submit a **Group Evaluation Form** online via a Google Forms. The link will be provided on Piazza. Responses will be kept confidential and are intended to assess the involvement of each group member and the group dynamics of each team.

- **Oral presentations will be given on Zoom during the scheduled lecture sessions** starting in April. The order of presentations will be determined by lottery. Presentations will be 20 minutes long, which includes time for questions. A sample grade sheet for the oral presentation can be found in Appendix E.

- **<u>Each group is required to maintain a laboratory notebook and/or binder</u>.** The notebook should be a record of the design process. Raw data, calculations, construction and set-up drawings, uncertainty analysis, etc., should all be contained in this notebook. Highlight problems encountered and how they were solved. **The notebook should be kept neat and legible so that an individual assigned to take over the project at a later time can easily continue the project.** In the back of the notebook, a log of hours spent on the project for each group member should be detailed. With each entry, a brief description of what was done at particular times should be listed as well. Noting the hours logged will help to create a plan of corrective action if/when it appears that time or effort is running short. **This notebook is to be submitted with the final report and will be graded.** The notebook CAN be a well formatted, well-kept digital document. Simply submitting your group's Google Drive folder doesn't count as a notebook.

- **<u>The Final Report is due Tuesday May 11th at 11am</u> in accordance with the University Final Examinations Schedule. Each group is required to submit *one* final report. Late reports will be penalized -10% per day.** The *suggested* format for the final report can be found in Appendix D.

<u>INCLUDE YOUR GROUP #, DATE, TITLE AND NAMES OF THE AUTHORS ON ALL ASSIGNMENTS</u>

Appendix A: Literature Review

File name: GXX_literature_review.pdf

The "literature review" is a document that summarizes the state of current knowledge on your chosen project topic. The literature review should contain numerous *scholarly* references and present the tools you will use to formulate your project proposal. If successfully completed, having this document will facilitate constructive project discussions during the proposal writing process. In fact, this will likely end up being the majority of your proposal introduction. **To complete this assignment, you will need to have formed your project group and decided on your project topic before the beginning of the semester.**

<u>This assignment is due on the **FIRST DAY OF LECTURE** so we can begin the semester immediately!</u>

<u>Suggested Format</u>

- **Cover Page:** Includes group members, potential project title and a one paragraph abstract
- **Topic Summary** (1-2 pages): Discuss why this project is important. Why do we care about this topic? Include the state of current knowledge and what you propose to improve. You should also highlight anticipated design challenges and the technical knowledge that will be required to complete your project. Think back to the AME 441 discussion given at the end of Mech-Op – how will you answer all of the questions required needed to create a successful project proposal?
- **Literature Review** (2-3 pages): In this section, summarize key resources you intend to use during your project. What knowledge was gained from each reference and how will it help formulate your proposal? Don't just write a list of papers and a sentence for each; condense your research into a clear and informative *narrative*.
- **Reference List**: References should be *scholarly* (*i.e.* Journal articles, conference papers, books, etc. *NO INSTRUCTABLES!*) and sufficient to demonstrate a purposeful investigation of your topic. Don't stop with one or two good papers; look at what *they* referenced and take your investigation one step further. Present the references list in a professional format, i.e. AIAA.

<u>**INCLUDE YOUR GROUP #, DATE, TITLE AND NAMES OF THE AUTHORS ON ALL ASSIGNMENTS**</u>

Appendix B: Suggested Proposal Format

File name: GXX_proposal.pdf

Section Title	No. of Pages
1. Introduction/Historical Background	1
2. Theory/Basic Equations	1-3
3. Experimental Setup/Procedure (including a sketch of the apparatus)	2-4
4. Cost Estimate	1
5. Timetable	1
6. Reference List	1

The objective of the proposal is to convince the reader that your project will provide useful information and can be successfully completed within the time, budget, and other given constraints. A proposal isn't meant to present sweeping, general knowledge. It is intended to be a concise document limited in scope to the specific project under development. **The proposal should be no more than 10 pages of typed single-spaced text.** Although short in length, the proposal must be thorough. The reader must be convinced that you have sufficiently researched your topic and that you have sufficient understanding to produce meaningful results. Reference previous and current work and give legitimate reasons for the goals you've chosen and the testing you'll perform. **Your project goal must be explicitly stated.**

The proposal also must present a clear picture of how you are going to conduct your experiment. Calculations and results are required which enable an intelligent preliminary design. Additionally, it is highly important, and required, that the proposal contain an estimate of your expected results. Determine what you will need to both produce and capture *meaningful* data. What facilities and equipment will you be using? How large will your device be? What are the important parameters? What kind of data will be taken? **You should have researched your topic in enough detail and performed initial calculations to be able to quantitatively answer these types of questions. Include a sketch of the proposed set-up along with calculations, graphs and figures that will help explain what you will do.**

The cost estimate must provide an accurate account for the ***total*** cost of your project. It should include all equipment, devices, materials, etc. that are required to perform and complete your experiment. This should be presented in a tabular format and an example is provided on Blackboard. A clear distinction must be made between the devices and materials that are currently available in the AME Lab and what needs to be purchased using your allocated AME 441 budget.

Note, **that ALL groups must submit a cost estimate**. Even in a virtual environment you need to set cost constraints for your design.

The timetable should be presented as a Gantt chart, highlighting the project milestones required for completion, the resources available, and the course deliverables due throughout the semester. The Gantt chart should contain milestones which are broken down into various sub-tasks. All tasks need to be assigned to individual group members. Ensure that this is readable so the proposed timeline can be assessed. An example is provided on Blackboard.

Write your proposal in a manner which can be easily followed by a competent engineer even if they are not a specialist in your project's field. A good rule is to define any terms or concepts that you were not familiar with before starting your literature search. As a test, have one of your classmates (not a group mate) read your proposal to see if they understand and can envision what you want to do!

Appendix C: Progress Report Format

File name: GXX_progress_report_N.pdf

Progress reports should be written in third person past tense, as with all technical communications. The task of writing the progress report for the group should be distributed evenly between the group members. These reports will be graded primarily on content; however, professional quality documents are still the expectation. Progress reports should ideally be no longer than 5 pages.

Each progress report will have associated deliverables and project milestones. Failure to meet these progress requirements will have a *severe* impact (i.e. >50% deduction) on your progress report grade. These documents are the primary record of your progress through the semester.

- **For On-Campus Groups**

Progress Report 1: Due February 26th before 12pm

Project Milestones:

- Completed experimental / hardware design
- Identification of all essential project components
- Issues identified in the proposal have been resolved

Deliverables:

- Drawings that have not been previously been approved must be submitted with the proposal for approval. *All construction drawings must be completed and approved with submission of this report.* This progress report is the last time to seek approval for drawings before the machining scheduling deadline.
- Orders for enabling components that have not yet been placed must be submitted with the proposal for approval. Enabling components includes items essential for project completion such as sensors, non-stock hardware, etc. If components have been ordered already, list them along with their estimated lead time.

Progress Report 2: Due March 19th before 12pm

Project Milestones:

- Project is under construction and substantial integration has been completed
- Issues identified in Progress Report 1 have been resolved

Deliverables:

- Preliminary data and analysis. This should/could include calibration data for sensors, results from mechanical integration, results from complex manufacturing, etc. Progress should be quantitative and specific goals will be discussed on a group by group basis.
- Documented integration of project components and identification of any modifications required beyond the initial design.

Progress Report 3: Due April 9th before 12pm

Project Milestones:

- Project integration is complete
- Issues identified in Progress Report 2 have been resolved

Deliverables:

- **PROJECT DATA.** This progress report requires you to have data that directly relates to your research question. You must have a functional device / experiment.
- Test matrix for the remainder of the semester. What is your test plan and how will you use the remaining weeks of the semester to provide a concrete answer to your "research question"?

For Off-Campus Groups

Fully Online Update: The Provost's current guidance that all instruction will begin remotely requires us to assume *all* projects will be completed remotely. ALL groups should consider these updated progress report guidelines when planning their projects.

Progress Report 1: Due February 26th before 12pm

Project Milestones:

- This progress report is effectively a Preliminary Design Review (PDR) for your project. You need to present relevant problems and how you plan to solve them. Imagine that you are seeking the green light to continue funding your effort. (Labor is funding, in fact, it's often the majority cost)
- Identification of essential engineering questions & targeted unknown
- Documentation of underlying physics which govern the design
- What project components do not have a "ready" solution?

Deliverables:

- Complete requirements documentation driven by proposed design goals
- Documented pathways for design and simulation including an analysis plan which progressively adds fidelity to analysis. (You don't start a model by doing everything at once, you start small and sanity check everything along the way). What simulation tools do you need?

Progress Report 2: Due March 19th before 12pm

Project Milestones:

- Substantial analysis has been completed
- Sensitivity analysis and documentation for all design variables
- Low-Fidelity simulations demonstrating effective use of simulation tools

Deliverables:

- Progress must be quantitative and specific goals will be discussed on a group by group basis.

Progress Report 3: Due April 9th before 12pm

Project Milestones:

- The final progress report is effectively a Critical Design Review (CDR). The goal is to show that everything works. You job is to convince your "investors" (i.e. us) that your system works, your solution it the best, and you deserve funding for the final phase of construction.
- Core modeling and analysis are complete
- Issues identified in Progress Report 2 have been resolved

Deliverables:

- **PROJECT DATA.** This progress report requires you to have data that directly relates to your fundamental research question. Incremental development throughout the semester should lead to the final full-fidelity analysis given in this PR.
- Detailed drawing package, detailed cost breakdown including expected manufacturing costs
- What remains to provide a concrete answer to your "research question"? What must be accomplished before the final engineering report is submitted?

All progress reports should include the following:

- **Cover Page:** Project Title, Group Members, Group Number, Date Range and one paragraph project abstract

- **Progress Update**: The main contents of the progress report. Specifically detail what was accomplished during the previous three weeks. Include calculations, descriptions of designed components, drawings etc. – any and all information helpful to assessing your progress. If you have acquired data, present results and discuss their meaning. This is what you've ***done*** and should be presented in a *professional*, third person past tense format.

- **Project Setbacks**: What issues or problems were encountered? Don't just list problems – you also need to present a path forward. Include what happened, plans for mitigation and the ultimate effect on your timeline. **Note that machining, shipping and other delays do *not* count as project setbacks. These inevitabilities should have been considered in your project planning.**

- **Future Work**: A concise explanation of the tasks to be performed during the upcoming progress period. Identify group members who are responsible for completing these tasks.

- **Updated Gantt Chart**

- **Peer Evaluation Forms**: *Each* group member is required to submit a confidential Group Evaluation through Google Forms.

Appendix D: Suggested Format for Final Report

File name: GXX_final_report.pdf

Section Title	No. of Pages
Abstract (on title page)	1
Introduction	2-4
Experimental Technique	2-4
Results	3-6
Discussion	2-3
Conclusion	1
References	1
Appendices	No more than 5

Note: No more than 20 pages of typed single-spaced text, not including appendices. Look at long-format journal articles for the tone and style required of a professional project report.

Assume the reader knows nothing about your work! The final report should stand alone with no references to your proposal or progress reports. (You may of course reference other papers or books.) The introduction should state the goal/objective, give some historical background and/or the state of the art of the subject, and any theoretical derivations pertinent to the project.

The experimental technique section should give the important details of the set-up; **a schematic must be included** as well as the procedure. Mention all the equipment used, type of data taken, how the data was processed, etc. When writing this section, keep in mind that you want to give the reader the impression that you were careful when you took your measurements and your data is reliable. Towards this end, you can mention your estimates of uncertainty without going into excessive detail. (Do not clutter the main body of your final report with lengthy uncertainty derivations. Detailed uncertainty analysis *should* be in your lab notebook and may be included in an appendix if further explanation is required in your report)

Additionally, do not go into a narration of all the trouble you went through to get to your final set-up! While troubleshooting does take up a *tremendous* amount of time, the process isn't necessarily "report worthy." Describe what worked and why.

Results and Discussion can be two separate sections or combined. It can even be subdivided into the different aspects of the investigation. The only requirement is that you present your results and then discuss them in a manner that can be easily followed. This is by far the most important part of your report and should be worded carefully to enhance the virtues of your work.

In the Conclusion, assess whether you have achieved your goal/reached your objective as stated in the Introduction. You may restate your important findings briefly. Also, you could suggest an alternate approach to solving the same problem or, talk about improvements to the work and applications.

Appendix E

AME-441 Senior Projects Laboratory

Oral Presentation Grade Sheet

Group # ______________ Date: ______________________

Title of Project: ____

Name(s) of Speakers: ____

Grade for each category is based on the scale shown below.

	Grade	Comments
1. **Organization and Delivery** (Was project clearly defined? Continuous thoughts? Speech easy to understand? Visual aids: timing, sufficient number of slides, neatness, clarity, etc.)	________ (35)	
2. **Technical Content** (Scientific merit appraised? Symbols and parameters defined? Technically sound arguments? Logical methods of experimentation and evaluation? Etc.)	________ (50)	
3. **Overall Performance** (Did presentation hold audience's attention? Questions answered, etc.)	________ (15)	
Total Score	________ **(100)**	

Appendix F: Faculty List – ASTE Department

Name	Area of Interest	Email
Prof. D. Erwin	Spacecraft propulsion, optics and optical instruments, kinetics of gases and plasmas	erwin@usc.edu
Prof. D. Barnhart	Spacecraft design, bus architecture, mission concepts and testing	barnhart@serc.usc.edu
Prof. M. Gruntman	Spacecraft and space mission design, propulsion, space physics, space sensors and instrumentation, space plasmas.	mikeg@usc.edu
Prof. J. Kunc	Atomic and molecular interactions, transport of particles and radiation in non-equilibrium gases and plasmas, molecular dynamics, classical and statistical thermodynamics.	kunc@usc.edu
Prof. A. Madni	Complex system analysis and design; complexity management; socio-technical systems; modeling and simulation; model based engineering; engineered resilient systems; integration of humans with adaptable systems; STEM education simulations/games.	azad.madni@usc.edu
Prof. H. Schorr	Artificial intelligence, advanced computing systems, information technology	schorr@isi.edu
Prof. F. Settles	Engineering management, integrated management and design, quality management, manufacturing for biomedical/biotechnical applications	settles@usc.edu
Prof. J. Wang	Electric propulsion, space environment and spacecraft interactions, particle simulation algorithms for gases and plasmas, microfluidics	josephjw@usc.edu

Appendix G: Faculty List – AME Department

Name	Area of Interest	Email
Prof. I Bermejo-Moreno	Computational fluid mechanics, turbulent flows, fluid structure interaction, combustion, hypersonic propulsion, high performance computing	bermejom@usc.edu
Prof. J. Domaradzki	Computational fluid mechanics, environmental and geophysical fluid mechanics, turbulence	jad@usc.edu
Prof. F. Egolfopoulos	Aerodynamic and Kinetic Processes in Flames, High-speed air-breathing propulsion, Microgravity Combustion, Mechanisms of Combustion-Generated Pollutants, Heterogeneous Reacting Flows, Conventional and Alternative Fuels, Detailed Modeling of Reacting Flows, Laser-Based Experimental Techniques	egolfopo@usc.edu
Prof. H. Flashner	Dynamics and control of systems, control of structurally flexible systems, analysis of nonlinear systems, biomechanics	hflashne@usc.edu
Prof. S. K. Gupta	Computer Aided Design, Manufacturing Automation, and Robotics	skgupta@usc.edu
Prof. Y. Jin	Collaborative engineering, design theory and methods, knowledge-based design and manufacturing systems, intelligent agents for engineering support	yjin@usc.edu
Prof. E. Kanso	Dynamical systems, animal hydrodynamic propulsion	kanso@usc.edu
Prof. M. Luhar	Turbulence, Environmental Fluid Mechanics, Flow-Structure Interaction	luhar@usc.edu
Prof. P. Newton	Nonlinear dynamical systems, fluid mechanics, vortex dynamics, probabilistic game theory, mathematical modeling of cancer metastasis	newton@usc.edu
Prof. Q. Nguyen	Highly dynamic robotics, control of legged robots, nonlinear control, real-time optimal control, trajectory optimization, reinforcement learning of robotics	quann@usc.edu
Prof. A. Oberai	Computation and Data Driven Discovery, data- and physics-based models to solve engineering problems	aoberai@usc.edu
Prof. N. Pahlevan	Biofluid Dynamics, Fluid-Structure Interaction, 3D quantitative flow visualization, hemodynamics, Bio-inspired design, Mathematical physiology	pahlevan@usc.edu
Prof. C. Pantano-Rubino	Turbulent flows with special focus to combustion, fluid-structure interaction and numerical methods for accurate simulation of the Navier-Stokes equations in simple and complex domains	pantanor@usc.edu
Prof. N. Pérez-Arancibia	Mechatronics, robotics, feed-back control, signal processing, dynamics, applied optics, fabrication of microrobots, and biologically inspired engineering	perezara@usc.edu
Prof. P. Plucinsky	Solid mechanics, material science and mathematics, material behavior	plucinsk@usc.edu
Prof. P. Ronney	Combustion, micro-scale power generation and propulsion, biophysics and biofilms, turbulence, internal combustion engines and control systems, low-gravity phenomena, radiative transfer	ronney@usc.edu
Prof. S. Sadhal	Drops and bubbles in acoustic fields, thermo-capillary flows with drops in low gravity, heat conduction in composite solids	sadhal@usc.edu
Prof. G. Shiflett	Kinematics and dynamics of mechanical systems, computer-aided design, optimal design techniques, micro-electromechanical systems	shiflett@usc.edu
Prof. G. Spedding	Geophysical fluid dynamics, animal aero- and hydrodynamics, turbulence	geoff@usc.edu
Prof. A. Uranga	Fluid mechanics, aerodynamics, computational fluid dynamics, aircraft design, airframe-propulsion system integration, boundary layer ingestion	auranga@usc.edu
Prof. B. Yang	Dynamics, vibration and control of mechanical systems, distributed-parameter systems, modeling and control of space structures, computational mechanics	bingen@usc.edu
Prof. H. Zhao	Mechanics-driven manufacturing	hangbozh@usc.edu