Purpose of the Independent Lab.

Through this project, students shall:

- Develop, plan and conduct an experiment to answer an engineering design question.
- Demonstrate an understanding of professional responsibility by **developing an engineering decision and defending it to a group of your professional peers and the instructors.**

Experienced engineers are typically paid more than recent college graduate engineers. This is ***not*** because they have *experienced* more, it is because they have ***learned*** from those experiences! Therefore, they are more valuable (better) engineers. The Independent Lab gives you an opportunity to learn the way good engineers learn: through experience. It is the faculty's expectation for the Independent Lab that you become highly knowledgeable in one specific topic and that knowledge is reflected in the final letter and oral presentation for the Independent Lab. You will be the expert, you will need to be capable of defending your conclusions and recommendations!

Engineers have the ability to contribute significantly to the well-being of others and to society as a whole. This should be a great source of pride to all engineers! Being able to contribute positively is a great thing, and to accomplish this sort of greatness, professionals must be willing and able to form opinions and be willing to stand up for their beliefs – be they technical, ethical or moral. Professional quality work is expected and you are capable of achieving this! This means you need to "take ownership" and assume responsibility for developing an answer to an engineering question.

The lab work itself will be a part of the learning, but before you can do a meaningful experiment, you have to understand the subject matter (learn through a literature search). This is where much of the learning will take place in this project – the experiment will validate or challenge the literature. For the oral presentation at the end of the semester, you will be asked questions. If your answer is something like "*the book said…*"… well, let's just say that's not an acceptable professional answer. You are expected to ***understand*** what the literature says, not merely parrot it!!! You need to ***understand*** your experiment, not just do an experiment. That is professional level work – that is experience that makes you a better engineer now and throughout your career.

Project Description:

Each small group (2 to 4 students) will conduct a very simple experiment outside of class (referred to as the "Independent Laboratory"). The following describes an engineering problem – your task as a team is to design and conduct an experiment to answer the engineering question. While each of these describes a fictitious situation, the situation is very realistic. Engineers must be able to evaluate various alternatives through analysis, testing, literature search, experience, etc. to determine the "best" engineering solution, and you must have confidence in your work in order to stand behind your decisions. For all groups, the course instructor will be your primary customer.

Group A. You are working for an outdoor sporting goods company and they want to produce a new product that will be used in mountain search and rescue operations. This product needs to have a highly "stretchable" component to absorb impact of someone falling. Your engineering manager requests you evaluate rubber for this application. Since you are an observant individual, you have noticed that rubber bands when left outside seem to deteriorate quickly. This is referred to as “weathering” – which can occur in many different polymers. You express this concern to your boss, and although she knows nothing about weathering, she does know that there are products available at automotive part stores for protecting tires, dashboards, etc. She would like you to make an engineering decision: *for various reasons, the company would really like to use rubber for this “stretchable” component – yes or no, should they?* You have about three months and very limited budget to provide an answer.

Group B. You are working for a crane manufacturing company. In order to reduce the need of mined metals, they would like their next product to be highly innovative – especially with material selection. All of their current products use steel for structural members, but they are seriously considering using plastic for lightly loaded structural members on the new crane (not composites, but good old “plastic”). Your engineering manager believes that the strength of plastic would be good enough for certain applications, but he does have some concerns about creep. The cranes will be used in both very cold climates (such as the artic) as well as very hot climates (such as Saudi Arabia). He would like you to make an engineering decision: *should the company proceed with this desirable cost-saving innovation or not?* You have about three months and very limited budget to provide an answer.

Group C. You are working for a small bicycle manufacturing company. Most of the frames the company produces are 2024-T351 aluminum. They would like to produce a new design that would use plain carbon steel for the frame, and use aluminum fasteners. You seem to recall hearing the phrase “galvanic corrosion” some time ago, and although you don’t recall details, you seem to remember it may be something to be concerned with when you are using two different metals. You mention this to your engineering manager, who knows nothing about corrosion, so she is unable to help you. She says you have about three months and very limited budget before making the following engineering decision: *although desirable for various reasons, is your concern about corrosion sufficient to recommend the company pursue other designs*?

Group D. You are working for an oceanography engineering company (they specialize in all-things ocean related). They are investigating a rather novel request from a customer. They customer is hoping to build a small under-ocean hotel to raise the public’s interest and knowledge in protecting the oceans. The customer would like to machine 2024-T351 aluminum alloy parts underwater in the Pacific Ocean, and then to use those parts in various ways under the ocean. Some time ago, you seem to remember hearing that aluminum, while on one hand is quite corrosion resistant, may be quickly corroded in certain environments. You also recall that the reason aluminum is generally corrosion resistant is that it quickly develops a protective oxide layer when exposed to oxygen. If machined underwater, it may or may not develop the oxide layer. You discuss your concerns with your engineering manager, but knowing nothing about corrosion he can’t help you. He says you have about three months and very limited budget before making the following engineering decision: *the customer really wants to pursue this concept of underwater machining – are you going to recommend they abandon this concept (that they really want to pursue for various reasons) or give them the “go ahead” to proceed?*

Group E. You are working as an engineer for a company producing dock-side lifting cranes (this is part of the project that Group D is involved with). The company will be using plain carbon steel, and for environmental reasons they would need to avoid painting exposed parts. They would be willing to use zinc galvanized steel if necessary, but would like to avoid it also if possible. Also, for the application you are involved with, it is likely that small areas of the zinc will be abraded away and therefore, will not be covering 100% of the surface of the steel. Your engineering manager wants you to make the following engineering decision: *should the parts be zinc galvanized or not, and if so, would lacking 100% coverage be acceptable*. You have about three months and very limited budget to provide an answer.

Group F. You are working for an oceanography engineering company (they specialize in all-things ocean related). A customer (the same customer that Group D is working with) is currently using a piece of underwater machinery and they are satisfied with its corrosion behavior. They would like to use similar machinery in shallow water which would result in the equipment being partially submerged (rather than completely submerged). The machinery is made from plain carbon steel. Your engineering manager would like you to make the following engineering decision: *can you recommend using the equipment in shallow waters, or should the company pursue other more costly alternatives?* You have about three months and very limited budget to provide an answer.

All groups:
All work for the Independent Laboratory will be conducted by the small group teams and will be done entirely outside of class. All submitted work must be single spaced (double space between paragraphs), 12 point Times New Roman font, and standard margins. See Section IV – Tests and Experiments in the ME Laboratory Handbook for information on experiments and testing.

The following are the due dates for various assignments for the Independent Laboratory.

PROBLEM STATEMENT AND BACKGROUND
Due week of January 25 (3rd week) during respective lab sections

Problem statement (one sentence): explain the purpose of the experiment to be conducted. For example: *Problem Statement: determine the effectiveness of umbrellas in 20 mph wind and rain for keeping ones hair dry*.

Background: describe similar test or experiments (including standardized tests) and any other information to “set the scene” for the experiment or test. It should discuss the basic principles behind the testing.

Summary of concerns: Based on the literature search, you should gain appreciation for the physics and chemistry related to the question you are trying to answer. Include one sentence explanation describing your concerns (what could go wrong and why) about the design you’ve been asked to evaluate.

Specifically, respective groups are to discuss the following at a ***minimum***:

Group A: What is the molecular structure of rubber, what effect does weathering have on its molecular structure and hence mechanical performance? What causes the molecular structure to change (i.e. what causes weathering) and why? What can be done to prevent weathering of rubber bands if weathering is a problem?

Group B: What is creep and what are the stages of creep? What is occurring at the crystalline level of metals that results in creep macroscopically? In other words, what is the mechanism of creep in metals? What is occurring at the crystalline level of polymers that results in creep macroscopically? Are both thermosetting and thermoplastic polymers equally susceptible to creep? What is role of temperature in creep, and do you expect polymers to behave similarly to metals?

Group C: What is corrosion in general and in particular what is galvanic corrosion? What is the EMF series and how is it useful in this situation? How does relative surface area of the anode and cathode affect galvanic corrosion? Do parts have to be physically in contact for galvanic corrosion to occur? Does using relatively small aluminum fasteners on relatively large bike from pose potential problems?

Group D: What is corrosion in general and what is pitting corrosion? What is meant by passivity or passivation and how is that relevant for this situation? What environmental conditions are conducive to corrosion in aluminum? What are the concerns you may have regarding this unique proposal?

Group E: What is galvanic corrosion? What is the EMF series and how is it useful in this situation? What is meant by "sacrificial anode"? Would you expect steel to corrode quickly if zinc plating is damaged/worn away in a small area? Why is zinc used to plate steel – why does zinc not corrode quickly in ambient environments? Do you expect the zinc to protect the steel even if it has been scratched away in a small area? What about if it has been worn away in a larger area?

Group F: What is corrosion, and what is the role of oxygen and what is the role of an electrolyte? What sort of corrosion would one expect from plain carbon steel in this environment? Do you expect the partially exposed steel to corrode faster/slower/same as fully submerged, why or why not?

Don't forget to cite references! See the School of Engineering's *Writing for Engineers* for description of backgrounds in general.

All groups, this assignment is one page *maximum (not including figures or bibliography). It must include the following details:*

- At least one figure (sketch, diagram, data table, etc.) that communicates relevant background information.
- Must properly cite and reference using MLA, Chicago, or other common format
- Citations must include at least one of each of the following:
  - ASTM test (include specific test number and title such as: *ASTM E8 / E8M - 09 Standard Test Methods for Tension Testing of Metallic Materials).* The library has ASMT Standards in the Reference section, first floor. TA401.
  - ASM Handbook (except Group A – ASM is mostly metals, but you still need at least 3 references so if there is nothing in ASM, then add at least one other reference or ASTM test). The library has hardcopies of ASM Handbooks, and electronic copy is also available through the library.
  - One other source (book, journal article, university web page)

Draft of TEST PLAN that includes the following:
due week of February 15 (6th week) during respective lab sections

The *Mechanical Engineering Laboratory Handbook* may be helpful with this assignment, especially if some the terminology used here is not familiar to you.

- A clear description of the purpose (why is this being done) – same or similar to that submitted in week 3, but includes revisions suggested by the instructor.
- Background information – similar or same to that submitted in week 3, but includes revisions suggested by the instructor.
- In **table form**: Description of the controlled test variables and their magnitudes/values
- Response variable(s) (what are you measuring)
- List of required resources, including quantities (see last page in this document for list of available supplies).
  - Materials and test specimens (be sure to include extra materials and specimens for pre-test trials and mistakes that may occur during testing that may "ruin" the specimens).
  - Supplies and equipment
  - Anything else required
- Procedures and methods clearly described in **list format**. Also include:
  - **Sketches** of samples or specimens
  - **Sketches** of experimental setup (sketches are important!)
- Attach the original problem statement and background submitted in week 3 and returned to you with comments.

BLANK DATA SHEETS AND REVISIONS TO PREVIOUS WORK

Due the week of February 29 (8^{th} week) during respective lab sections

Revise the problem statement, background, procedures, etc. per instructor feedback on previously submitted work. (When submitting the revisions, attach the original marked up copies that were returned to the team).

Data Sheets

"Data sheet" (a.k.a. "check sheet" or "run sheet" – a table or similar document showing the conditions of the experiment with blank values to be recorded during the experiment. It must include variable names and units). A hardcopy of the run sheet should be created even if all data is to be recorded electronically. You have used several data sheets – one has been provided to you for each of the labs this semester.

Laboratory data sheets are used to record critical information prior to and during laboratory work. They are created during the planning stages of an experiment (pre-lab work). They should be sufficiently detailed so as to ensure all critical information will be recorded during the experiment. They should include the following where applicable for EGR270:

- Name of the experiment
- The name of the participants
- The name of the person recording the data (or blank to be entered later)
- The date(s) that the laboratory was conducted (blank space for now).
- To assist with data taking, a sketch of the laboratory setup including location of the transducers may be required. Sketches can and should be used to communicate details that are not easily described with words.
- A table or list with blank places to record the data. It must be clear in this table what the test conditions are for each set of data. The blanks should appear in the order they are to be filled in. The data may include extraneous, dependent, and independent variables.

LAST WEEK OF CLASS (Week of April 18)

- Technical letter due for the independent lab. Be sure to have improved the background per instructor comments on previous submissions. Two pages maximum (plus attachments). Include the "graph" and "memo" grading checklists.
- Formal oral technical presentation using PowerPoint (given last week of class), printout of the PowerPoint slides (6 slides per page preferred). Bring the a the softcopy of the presentation on a USB drive and also be sure to email it to yourselves (to minimize historical technical troubles)

<u>LIST of AVAILABLE SUPPLIES – these should be sufficient for all experiments:</u>

Zinc plated steel nails
"bright" steel nails (not plated)
2024-T351 aluminum (broken Charpy bars, broken tensile bars, heat treat "pieces")
AISI 1018 and 1045 steel (broken Charpy bars, broken tensile bars)
Commercially pure copper (cold-worked then annealed)
Aluminum foil (specific alloy is unknown)
Rubber bands
Armor All (or equivalent)
Plastic and wire coat hangers
NaCl
Ammonia
Ethel alcohol
Vegetable oil
Electrical wire
"Sand paper"

The following are also available, but must be returned upon completion of semester:

Small wood boards with nails
Ammeter/volt meter
Small plastic containers (cups)
Small weights

The following are available for use in the lab:

Microscopes
Digital scale to measure weight
Test oven with 120°F, approximately 1mX1mX1m (shared by all sections)
Small test ovens (12"X8"X4") – limited quantity – may or may not be available for all groups.
Digital Single Lens Reflex (DSLR) camera and photography table