Program-Level Assessment: Annual Report

Program Name (no acronyms): Aerospace Engineering
Department: Aerospace & Mechanical Engineering

Degree or Certificate Level: BS
College/School: School of Science & Engineering

Date (Month/Year): Nov 2023
Assessment Contact: Ray LeBeau

In what year was the data upon which this report is based collected? 2022-23

In what year was the program's assessment plan most recently reviewed/updated? Fall 2023

Is this program accredited by an external program/disciplinary/specialized accrediting organization or subject to state/licensure requirements? YES – ABET accredits the engineering programs.

If yes, please share how this affects the program's assessment process (e.g., number of learning outcomes assessed, mandated exams or other assessment methods, schedule or timing of assessment, etc.): The HLC learning outcomes are derived from the ABET outcomes and the assessment process is similar to that of ABET.

1. Student Learning Outcomes

Which of the program's student learning outcomes were assessed in this annual assessment cycle? (Please provide the complete list of the program's learning outcome statements and **bold** the SLOs assessed in this cycle.)

Students should be able to

1. **Identify, formulate, and solve complex engineering problems in the aerospace domain by applying principles of engineering, science, and mathematics.**
2. Apply engineering methods to design aerospace systems that meet specified mission needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. **Communicate effectively with a range of audiences.**
4. Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
5. **Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.**
6. Develop and conduct appropriate experimentation in the aerospace domain, analyze and interpret data, and use engineering judgment to draw conclusions.
7. **Acquire and apply new knowledge applicable to an aerospace career using appropriate learning strategies.**

2. Assessment Methods: Artifacts of Student Learning

Which artifacts of student learning were used to determine if students achieved the outcome(s)? Please describe the artifacts in detail, identify the course(s) in which they were collected, and if they are from program majors/graduates and/or other students. Clarify if any such courses were offered a) online, b) at the Madrid campus, or c) at any other off-campus location.

The artifacts reviewed for each outcome are listed here and provided in further detail in the attached documents, including prompt examples.

Outcome 1:

ESCI/MENG 2150 Dynamics – A final exam problem on energy/work/kinematics

ESCI/MENG 3200 Fluid Dynamics – An exam problem which in the fall was a two-dimensional conservation, in spring was a dimensionless analysis, Buckingham Pi problem
AENG 4400 Stability and Control – For this assessment it was a review of overall graded performance, is being shifted to a specific artifact for future assessment reviews
MENG 2150 Dynamics and MENG 3200 Fluid Dynamics are taught in Madrid. These courses have other program students (Mechanical and Civil Engineering primarily), but results are sorted by degree program. AENG 4400 rarely has non-Aerospace students.

Deleted: Dynamics and Fluid Dynamics are taught in Madrid. MENG 2150 and MENG 3200 ...

Outcome 3:
AENG 2020 Introduction to Aerospace Engineering – Project reports written by teams of 2-3 students
ESCI/MENG 3201 Fluids Lab – Formal lab report written individually for the Flat Plate Boundary Layer Lab
AENG 4014 Flight Vehicle Analysis and Design – 1) Final project team presentation of 20-25 minutes covering complete senior design project presented to a panel of professional engineers, 2) Team Project Poster for SSE Showcase, a public event featuring poster from all senior design disciplines, 3) Team AIAA Paper, a paper written to conform to the expectations of the AIAA Region V Student Conference, in which some teams participate but all teams compose, 4) Final project report
Introduction to Aerospace Engineering is taught in Madrid. Fluids Lab has other program students (Mechanical and Civil Engineering primarily), but results are sorted by degree program. AENG 2020 and AENG 4014 rarely have non-Aerospace students.

Outcome 5:
ESCI/SE 1700 Engineering Fundamentals – Team project performance based on instructor observations, team questionnaire, and final project report/presentation
ESCI/MENG 3101 Solid Mechanics Lab – Team questionnaire
AENG 4014 Flight Vehicle Analysis and Design II – Instructor review of bi-weekly team meetings, final project team presentations presented to a panel of professional engineers
Engineering Fundamentals is taught in Madrid. Engineering Fundamentals includes students in all engineering majors as well as other majors, but results are sorted by degree program. Solid Mechanics Lab has Mechanical and Civil engineering students, and the results are not sorted by major. Senior Design rarely has non-Aerospace students.

Outcome 7:
ESCI/SE 1700 Engineering Fundamentals – Development and explanation of a bibliography related to the class project
AENG 3150 Astrodynamics – Case study of aerospace contractor or space mission
AENG 4014 Flight Vehicle Analysis and Design II - final project team presentations presented to a panel of professional engineers
Engineering Fundamentals is taught in Madrid. Engineering Fundamentals includes students in all engineering majors as well as other majors, but results are sorted by degree program. Astrodynamics and Senior Design rarely have non-Aerospace students.

3. Assessment Methods: Evaluation Process

What process was used to evaluate the artifacts of student learning, and by whom? Please identify the tools(s) (e.g., a rubric) used in the process and **include them in/with this report document** (please do not just refer to the assessment plan).

Outcome 1: All artifacts are evaluated by the instructor. Exam questions and assignments may be reviewed by a grader/teaching assistant before instructor review. Methodology/rubrics for assessed artifacts in this cycle are provided in the additional materials.

Outcome 3: All artifacts are evaluated by the instructor excepting those where a panel of invited professionals reviews the senior design presentations. Lab reports are generally graded by a grader/teaching assistant before instructor review. Methodology/rubrics for assessed artifacts in this cycle are provided in the additional materials.

Outcome 5: Student questionnaires are student evaluations of their and their team's performance. All other artifacts are evaluated by the instructor excepting those where a panel of invited professionals reviews the senior design presentations. Methodology/rubrics for assessed artifacts in this cycle are provided in the additional materials.

Outcome 7: All artifacts are evaluated by the instructor excepting those where a panel of invited professionals reviews the senior design presentations. Methodology/rubrics for assessed artifacts in this cycle are provided in the additional materials.

For all artifacts, the summary of the course assessment is presented to the department when the outcome is collectively reviewed and can undergo further review at that time.

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4. Data/Results

What were the results of the assessment of the learning outcome(s)? Please be specific. Does achievement differ by teaching modality (e.g., online vs. face-to-face) or on-ground location (e.g., STL campus, Madrid campus, other off-campus site)?

Outcome 1:
MENG 2150 - Across two semesters, 13 of 26 aerospace students at least met expectations and of those 10 exceeded expectations. This was below the target level of 70% at least meeting expectations. Those who did not meet expectations generally had difficulties setting up the proper equations and the subsequent mathematics. In Madrid, 4 of 5 aerospace students met expectations with one not meeting expectations.
MENG 3200 - Across two semesters, 9 of 29 aerospace students exceeded expectations, 12 met expectations, and 8 did not meet expectations. This was just above (72%) the desired level of 70% met/exceed expectations. Primary issues were proper equation set up, mathematical errors, and trouble with units. The math level was more at a high school level than college (trig, algebra), so the number of errors of this type were concerning. Possibly connected to COVID issues or time pressures.
AENG 4400 - One semester, 37 of 44 aerospace students met expectations of at least a 70% class grade. This exceeds the goal of 70% of students at least meeting expectations. Students in general seem to have reasonable grasp of the previous course work in controls, dynamics, and vibrations.

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Outcome 3:
AENG 2020 – All but one team of 18, covering 38 aerospace students, met expectations, with two teams exceeding expectations.
AENG 3201 – Too few aerospace students to be statistically relevant. This course is being phased out in favor of MENG 3111 for aerospace students.
AENG 4014 - Of the 10 teams consisting of a total of 44 students (including one Mechanical Engineering major and one Engineering Physics major who could not be separated from the team scores), all met or exceeded expectations for the project poster, the project report, and the project presentation. The industry panel scored six of the ten teams at 4.5/5, which exceeded expectations.

Outcome 5:
ESCI 1700 – Data from Madrid course with one aerospace student who met expectations.
AENG 3101 – All students met expectations, but data is not divided by major.
AENG 4014 – Of the 10 teams consisting of a total of 44 students (including one Mechanical Engineering major and one Engineering Physics major who could not be separated from the team scores), two teams had multiple marginal scores below the target threshold of 3 (Good), primarily on the management aspects. Two other teams had average scores above 4 (Excellent) and exceeded expectations. The other six teams met expectations; thus overall 8 of 10 teams met or exceeded expectations.

Outcome 7:
ESCI 1700 – 20 of 24 of graded aerospace students met expectations.
AENG 3150 – 21 of 25 aerospace students met expectations, with 19 exceeding expectations. Three students did not submit the assignment and one did not follow instructions.
AENG 4014 – All ten teams (44 students, including a Mechanical Engineer major and an Engineering Physics major who could not be separated from the team scores) achieved the target score of 3 (Good). Four teams exceeded 4 (Excellent) and therefore exceeded expectations.

5. Findings: Interpretations & Conclusions

What have you learned from these results? What does the data tell you? Address both a) learning gaps and possible curricular or pedagogical remedies, and b) strengths of curriculum and pedagogy.

Outcome 1
- Students had trouble with pre-req material (Math & Physics) and were not well-prepared. These concepts were retaught in the dynamics and fluid dynamics courses. This could be because of Covid.

Outcome 3
- Student overall written and oral communication skills (as opposed to specifically technical) have generally met or exceeded expectations.
- Students need improved technical writing skills as opposed to general writing skills – including incorporation of equations/tables/data/plots.

Outcome 5
- Most design teams (summative/achieved assessment) appear to at least meet expectations.
- Currently, we don't formally introduce team management skills in most of the curriculum until senior design even though there are many team activities.

Outcome 7
- Students generally demonstrate appropriate library and bibliography skills.
- Senior design teams naturally develop new knowledge to complete their projects.

6. Closing the Loop: Dissemination and Use of Current Assessment Findings

A. When and how did your program faculty share and discuss the results and findings from this cycle of assessment?

Faculty assessed outcomes 1 and 3 in April/May 2023 and outcomes 5 and 7 in Nov 2023.
The faculty provided assessment data including review sheets and artifacts. Then, the department faculty members reviewed the assessment materials in multiple meeting to identify strengths, weaknesses, and propose changes to the curriculum/courses/assessment methods.

B. How specifically have you decided to use these findings to improve teaching and learning in your program? For example, perhaps you've initiated one or more of the following:

Changes to the Curriculum or Pedagogies	• Course content • Teaching techniques • Improvements in technology • Prerequisites	• Course sequence • New courses • Deletion of courses • Changes in frequency or scheduling of course offerings
Changes to the Assessment Plan	• Student learning outcomes • Artifacts of student learning • Evaluation process	• Evaluation tools (e.g., rubrics) • Data collection methods • Frequency of data collection

Please describe the actions you are taking as a result of these findings.

Outcome 1
- Students had trouble with pre-req material (Math & Physics) and were not well-prepared. These concepts were retaught in the dynamics and fluid dynamics courses. This could be because of Covid.
- Action plan – We are monitoring student performance in Dynamics to see if issues continue with increased sample size. If necessary, we will coordinate appropriate action in collaboration with the math and physics departments.

- Artifact for AENG 4400 is being redone to be more specific, hopefully capture complex problem (ABET definition)

Outcome 3
- Students need improved technical writing skills as opposed to general writing skills – including incorporation of equations/tables/data/plots.
- Action plan – We are in the process of developing common definitions for report format, figures, equations, calculations, and sections to be used generally across the curriculum. We have also submitted AENG 4014 to Core as a Writing Intensive option which will increase the emphasis in technical writing for that course.

Outcome 5
- Currently, we don't formally introduce team management skills.
- Action plan – We are in the process of creating first-year team building exercises in collaboration with ROTC.

If no changes are being made, please explain why.

Outcome 7 is awaiting approval for Cura Personalis 3 as part of senior design, will evaluate potential changes after that approval.

7. Closing the Loop: Review of Previous Assessment Findings and Changes

A. What is at least one change your program has implemented in recent years **as a result of previous assessment data**?

A common first year Ignite course (SE 1700) was introduced in Fall 2022. Apart from satisfying the core requirement, the course provides an opportunity to work in interdisciplinary teams doing interdisciplinary work on a complex problem. The course was introduced based on the previous assessment data to effectively address outcomes 2 and 5.

B. How has the change/have these changes identified in 7A been assessed?

They were reviewed by the faculty during Summer 2023.

C. What were the findings of the assessment?

Engineering Methods – The design-build-test cycle is an integral part of engineering practice. The build/test portions were not sufficiently implemented. It resulted in a lack of student engagement and understanding.

D. How do you plan to (continue to) use this information moving forward?

All sections of the project now include a hands-on activity with associated engineering analysis.

IMPORTANT: Please submit any assessment tools (e.g., artifact prompts, rubrics) with this report as separate attachments or copied and pasted/appended into this Word document. Please do not just refer to the assessment plan; the report should serve as a stand-alone document. Thank you.

Additional course materials are provided by outcome, with each outcome headed by a summary page developed in the department review followed by course-specific information.

AEME ABET Assessment Review Form

This form is a summary of the collective departmental review of learning outcome assessment, to be used to record review group thoughts about assessment materials collected.

Program (AE or ME): AE   Date materials reviewed: 04/24/2023, 05/10/2023

Criterion reviewed (circle one): **1** 2 3 4 5 6 7

an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

Semester(s) reviewed: Fall 2022 (primarily)

Reviewers: Alexander, Condoor, Gururajan, Jayaram, LeBeau, Lei, Marmolejo, McQuilling, Swartwout

Courses and instruments:

Course	Semester	Description (ind/Grp)	Level	Math	Sci	Cplx
MENG 2150	AE (S) ME (F)	Final Exam problem on energy/work/kinematics in a system (Individual)	Early Formative	N	N	N
MENG 3200	AE (S) ME (F)	Ind Exam Problem 2D C mass/momentum, dimensionless analysis	Middle Formative	N	N	N
AENG 3150	AE (S then F)		Middle Formative	Y	Y	Y
AENG 4400	AE (F)	Find multiple ways to change flight characteristics (mainly ind, possibly grp) possibly project or exam prob	Late Summative	Y	?	Y

Strengths and weaknesses:

Aerospace students presented a sample size issue as most of these students take MENG 2150 and MENG 3200 in the spring. However, as this was the first assessment under the new system their results were reviewed. The aerospace students did not meet expectation standards in Dynamics. They did meet expectations in Fluid Dynamics.

Initial assessment of AENG 4400 Stability & Control was based on full course performance, where general expectations for students were met. Discussed shifting assessment to individual complex problem(s) with college-level math usage.

General observations on student preparedness including math and science knowledge retained from the first year of college. Several faculty found the need to re-teach concepts that are supposed to have been learned in pre-requisite courses.

Recommendations and proposed actions:

Develop specific assessment instruments for AENG 4400 Stability & Control (Gururajan)

Monitor AE student performance in Dynamics during spring semester to see if issues continue with increased sample size.

Review pre-requisite requirements, increase documentation of expectations from pre-requisite courses including physics, math courses.

Other comments: This was the first review of this outcome under the newly revised assessment plan of August 2022.

Learning Outcome:	**1 (Solve Problems using SEM)**	2 (Design in Global Context)	3 (Effective Communication)
[select 1]	4 (Ethics in Global Context)	5 (Functional Teamwork)	6 (Experiment and Draw Conclusions)
	7 (Lifelong Learning)		

Course: ESCI 2150 (Dynamics) (Fall 2022)

Location in Program: Early Middle End

Method: *As part of the final exam in the course, students are tasked with applying energy methods (work, potential energy, kinetic energy) to calculate the motion of a wheel*

Rubric: *To satisfy the outcome, students must identify the energy balance equation and its components, apply boundary conditions and solve for the unknown parameter. They must also identify geometric constraints (the no-slip condition) and use them to eliminate unknowns. The rubric is attached.*

Desired result: 70% of students will meet expectations, which is defined as earning at least 11 of 15 points on the problem. To earn that many points, the students must apply the correct equations and eliminate most of the unknowns

Student performance: 33% of students met expectations (2 of 6)

Observations: The students who met expectations had either a perfect score or missed 1 point for arithmetic errors.

The remaining students were not even close to expectations; 3 of the 4 parroted the basic equation and either gave up or quickly switched to incorrect equations (kinematics). The other student appeared to be creating his own version of the energy balance equations but got lost somewhere in the middle.

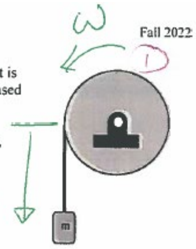
The AE students were in the same class as the ME students; of the 25 students assessed, the overall performance was 16 of 25 (64%).

Program Assessment: *Is this an outlier (small sample size) or a cause for concern?*

Action: *[Recommended responses]*

10) [15 pts] Déjà vu, All Over Again. A block (mass = 8.163 kg) is attached to a rope that is wound around a solid cylinder (mass 12.117 kg, radius 1.25 meters). The block is released from rest.

Calculate the angular velocity of the cylinder after the block has dropped 11.25 meters, **using energy methods**.



(5)

$$T_1 + U_1 + W_{1\to 2} = T_2 + U_2$$

T_1: 0 REST (1); U_1: $S=0$; $W_{1\to 2}$: NO EXTERNAL WORK (2)

Position 1: Rest, $S_B = 0$

Position 2: $S_B = 11.25\,m$

(2)
$$0 = \frac{1}{2} m_B V_B^2 + \frac{1}{2} I \omega^2 - m_B g S_B$$

(1) NO SLIP: $V_B = R\omega$ $\quad I = \frac{1}{2} m_W R^2$ (1)

Combine & solve

(1)
$$\frac{2 m_B g S_B}{m_B R^2 + \frac{1}{2} m_W R^2} = \omega^2 \qquad \boxed{\omega = 9\ \text{rad/s}}$$

Learning Outcome: **1 (Solve Problems using SEM)** 2 (Design in Global Context) 3 (Effective Communication)
[select 1] 4 (Ethics in Global Context) 5 (Functional Teamwork) 6 (Experiment and Draw Conclusions)
7 (Lifelong Learning)

Course: ESCI 2150 (Dynamics) (Spring 2023)

Location in Program: Early **Middle** End

Learning Outcome 1: an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

Instrument: 2D Kinematics Rigid Body Examination Problem

Methodology: Exam problem (included) is graded by instructor. Assessment is based on performance solving the problem and the rubric. The instructor can more precisely define the interpretation of rubric for the particular problem.

Rubric: See rubric below.

Desired result: 70% of students scoring Meets or Above Expectations

Students assessed: This assessment focuses on the 20 students who are majoring in aerospace engineering out of the total class size of 40 students. The remaining students consist of 5 majoring in mechanical engineering and 15 majoring in civil engineering.

Student performance: Out of the 20 aerospace engineering students, the performance assessment revealed that 8 students were classified as "Above Expectations," 3 students as "Meets Expectations," and 9 students as "Below Expectations."

Observations: Common errors were identified in the kinematic diagram among the aerospace engineering students. These errors primarily involved incorrect setup of the relative position vector $r_{B/A}$ or inaccurate equations for absolute velocity and acceleration. Additionally, some students made mistakes when solving cross products and improperly separating the *i* and *j* components in the final acceleration equation.

Assessment: 55% of the aerospace engineering students met or exceeded expectations.

Proposed Action: Based on the assessment results, it is evident that the aerospace engineering program is not meeting expectations in the areas evaluated. To address this issue, it is recommended to strengthen the students' understanding of basic kinematic concepts in the preceding courses. This can also be achieved by incorporating hands-on exercises and experiments during this course to enhance their comprehension of fundamental concepts. Furthermore, it is advisable to monitor the performance of future classes in subsequent semesters to assess whether the implemented measures have positively impacted the students' learning outcomes. Continuous evaluation and improvement will be crucial in ensuring the program meets the desired standards in the long term.
The current artifact primarily focuses on cross products, trigonometry, and linear algebra, resulting in a predetermined outcome. Exploring alternative assessment methods that encompass a wider range of skills will provide a more comprehensive evaluation of students' abilities.

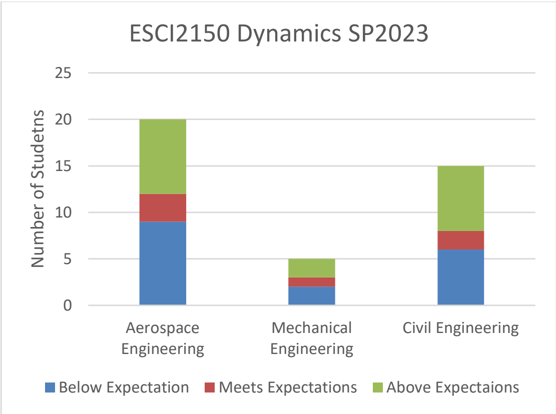
Indicator	Below Expectations	Meets Expectations	Above Expectations
Ability to analyze and solve two-dimensional rigid body kinematic problems involving rotation around an external instantaneous center of zero velocity.	Student fails to solve the problem due to significantly improper procedures, incorrect equations, incomplete work, and/or significant mathematical errors.	Student uses mostly proper procedures to formulate and solve the resulting governing equation with at most a few errors.	Student uses proper procedures to formulate and solve the governing equations with minimal errors.

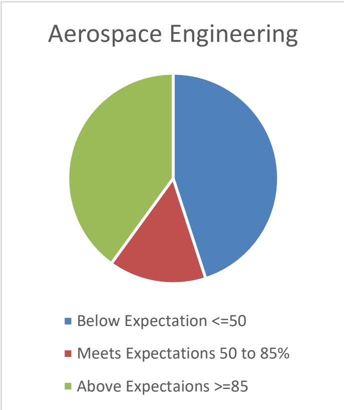
Proficiency in this area includes:

1. Demonstrating the ability to identify and understand the key components of a problem, including knowns, unknowns, givens, and constants.
2. Kinematic Diagram: Creating clear and accurate diagrams that depict the system, including relevant bodies, rotational axes, and the external instantaneous center.
3. Velocity Analysis: Determining the instantaneous velocities of different points or bodies within the system, considering both linear and angular velocities. This requires understanding the concept of an external instantaneous center of zero velocity.
4. Acceleration Analysis: Analyzing the accelerations of various points or bodies in the system, accounting for both linear and angular accelerations. This involves applying relevant principles, such as centripetal acceleration and tangential acceleration.
5. Equation Formulation: Developing appropriate equations that establish relationships between known and unknown quantities, incorporating the principles of rotational motion and the concept of the external instantaneous center of zero velocity.
6. Problem Solving: Applying mathematical techniques, such as trigonometry and vector algebra, to solve the formulated equations and obtain solutions for the desired quantities.

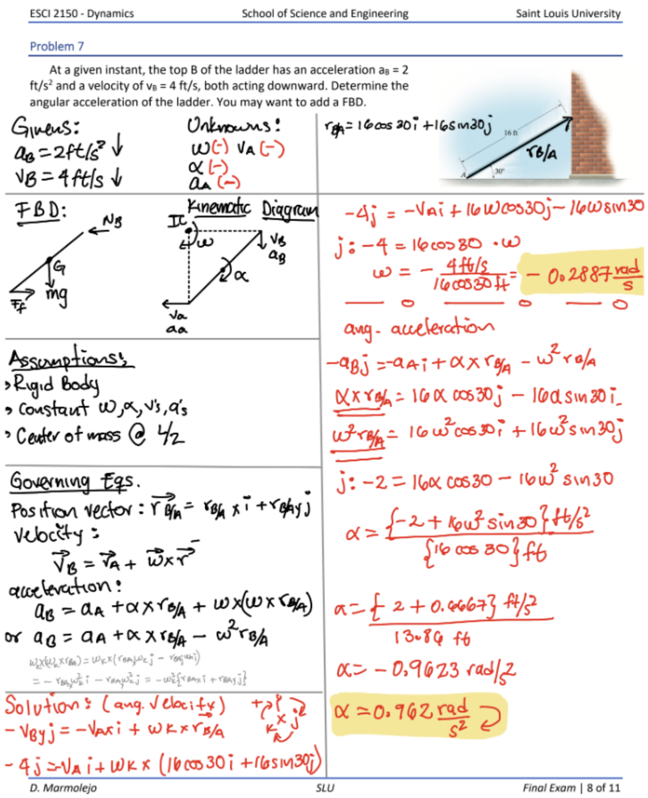
This skill set enables engineers to effectively analyze and solve complex motion problems encountered in various fields, including mechanical engineering, robotics, and dynamics. It plays a vital role in designing mechanisms, optimizing motion control systems, and ensuring the desired performance of rotational components.

In the assessment, a score below 50% was classified as automatically falling into the "Below Expectations" category. Conversely, a score above 85% was deemed automatically as "Above Expectations." For scores falling between these thresholds, an assessment of the nature of errors and how they aligned with the established rubric was conducted, with the possibility of categorizing them into any of the three categories: "Above Expectations," "Meets Expectations," or "Below Expectations."





This approach provided a clear framework for evaluating student performance and determining their level of achievement based on the established criteria. It allowed for a comprehensive assessment that considered both numerical scores and qualitative analysis, taking into account the specific errors made and their alignment with the performance expectations outlined in the rubric.



ESCI 2150 - Dynamics | School of Science and Engineering | Saint Louis University

Problem 7

At a given instant, the top B of the ladder has an acceleration $a_B = 2$ ft/s² and a velocity of $v_B = 4$ ft/s, both acting downward. Determine the angular acceleration of the ladder. You may want to add a FBD.

Givens: $a_B = 2 ft/s^2 \downarrow$, $v_B = 4 ft/s \downarrow$

Unknowns: ω (-), v_A (-), α (-), a_A (-)

$r_{B/A} = 16\cos 30 i + 16\sin 30 j$

FBD: N_B, G, mg, F_f

Kinematic Diagram: IC, ω, v_B, a_B, α, v_a, a_a

Assumptions:
- Rigid Body
- constant $\omega, \alpha, v's, a's$
- Center of mass @ L/2

Governing Eqs.

Position vector: $\vec{r}_{B/A} = r_{B/A\,x} i + r_{B/A\,y} j$

velocity: $\vec{v}_B = \vec{v}_A + \vec{\omega} \times \vec{r}$

acceleration: $a_B = a_A + \alpha \times r_{B/A} + \omega \times (\omega \times r_{B/A})$

or $a_B = a_A + \alpha \times r_{B/A} - \omega^2 r_{B/A}$

Solution: (ang. velocity)

$-v_{By} j = -v_{Ax} i + \omega k \times r_{B/A}$

$-4j = v_A i + \omega k \times (16\cos 30 i + 16\sin 30 j)$

$-4j = -v_A i + 16\omega\cos 30 j - 16\omega\sin 30$

$j: -4 = 16\cos 30 \cdot \omega$

$\omega = -\frac{4 ft/s}{16\cos 30 ft} = -0.2887 \frac{rad}{s}$

ang. acceleration

$-a_B j = -a_A i + \alpha \times r_{B/A} - \omega^2 r_{B/A}$

$\alpha \times r_{B/A} = 16\alpha\cos 30 j - 16\alpha\sin 30 i$

$\omega^2 r_{B/A} = 16\omega^2\cos 30 i + 16\omega^2\sin 30 j$

$j: -2 = 16\alpha\cos 30 - 16\omega^2\sin 30$

$\alpha = \frac{\{-2 + 16\omega^2\sin 30\} ft/s^2}{\{16\cos 30\} ft}$

$\alpha = \frac{\{2 + 0.6667\} ft/s^2}{13.86 ft}$

$\alpha = -0.9623 rad/s^2$

$\alpha = 0.962 \frac{rad}{s^2}$

D. Marmolejo | SLU | Final Exam | 8 of 11

Program Assessment Review: B.S. in Aerospace Engineering

Learning Outcome: **1 (Solve Problems using SEM)** 2 (Design in Global Context) 3 (Effective Communication) *[select 1]* 4 (Ethics in Global Context) 5 (Functional Teamwork) 6 (Experiment and Draw Conclusions) 7 (Lifelong Learning)

Course: ESCI 2150 Dynamics

Location in Program: Early Middle End

Learning Outcome1: an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

Instrument: Planar kinetics of a rigid body (force equations) exam problem

Methodology: Exam problem (included) is graded by instructor. Assessment is based on performance solving the problem and the rubric.

Rubric: See rubric below.

Desired result: 80% of students scoring Meets Expectations

Students assessed: The class consisted of 23 students, of whom 12 were majoring in mechanical engineering, 5 in aerospace engineering, 3 in civil engineering, 2 in biomedical engineering, and 1 in engineering physics. This assessment is based on 5 aerospace engineering students.

Student performance: The Aerospace Engineering students had 4 students in Meets Expectations, and 1 in Below Expectations.

Observations: Common errors were sign errors in moment of force terms and translational rotational kinematics relationships. But all students in Meets Expectations appeared to understand how to construct the equations.

Assessment: 80% of the mechanical engineering students met expectations.

Proposed Action: Results indicate that the AE program is meeting expectations here.

Program Assessment Review: B.S. in Aerospace Engineering

Indicator	Below Expectations	Meets Expectations	Above Expectations
Ability to formulate and solve the translational and rotational force equations of the planar motion of a rigid body.	Student fails to solve the problem due to significantly improper procedures, incorrect equations, incomplete work, and/or significant mathematical errors.	Student uses mostly proper procedures to formulate and solve the resulting governing equation with at most a few errors.	Student uses proper procedures to formulate and solve the governing equations with minimal errors.

A score below 60% was treated as automatically Below Expectations, above 87% was considered automatically Above Expectations. Scores in between were assessed based on the nature of the errors and how it fit in the rubric above, with all three categories possible.

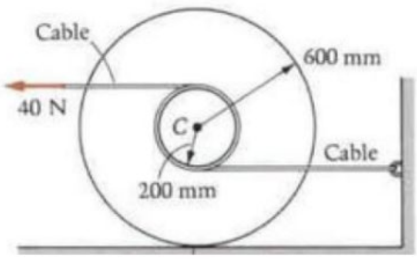
Program Assessment Review: B.S. in Aerospace Engineering

Learning Outcome: Communication)	1 (Solve Problems using SEM)	2 (Design in Global Context)	3 (Effective
[select 1] Draw Conclusions)	4 (Ethics in Global Context)	5 (Functional Teamwork)	6 (Experiment and
	7 (Lifelong Learning)		

Course: <u>ESCI 2150 Dynamics</u>

Exam problem and sample of students work

Two cables are wrapped around the hub, of radius r_i = 200 mm, of the 10-kg spool shown in the figure, which has an outer radius r_o = 600 mm and a radius of gyration of k_G = 500 mm. A constant force T_1 = 40 N is applied to the upper cable as shown. Find the acceleration of the center of mass if the coefficient of kinetic friction is μ_k = 0.20. ($I_G = mk_G^2$)



Learning Outcome:	1 (Solve Problems using SEM)	2 (Design in Global Context)	3 (Effective Communication)
[select 1]	4 (Ethics in Global Context)	5 (Functional Teamwork)	6 (Experiment and Draw Conclusions)
	7 (Lifelong Learning)		

Course: ESCI 3200 (Fluid Dynamics) (Fall 2022)

Location in Program: Early **Middle** End

Learning Outcome 1: an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

Instrument: 2D CV Conservation of Mass/Momentum exam problem

Methodology: Exam problem (included) is graded by instructor. Assessment is based on performance solving the problem and the rubric. The instructor can more precisely define the interpretation of rubric for the particular problem.

Rubric: See rubric below.

Desired result: 70% of students scoring Meets or Above Expectations

Students assessed: The class consisted of 40 students, of whom 19 were majoring in mechanical engineering, 11 in aerospace engineering, 9 in civil engineering, and 1 in engineering physics. This assessment is based on the 11 aerospace engineering students.

Student performance: The aerospace engineering students had 3 students in Above Expectations, 6 in Meets Expectations, and 2 in Below Expectations.

Observations: Common errors were a failure to include sines and cosines for the sloped pipe, sign errors in momentum flux terms. Multiple students in Meets Expectations appeared to understand how to construct the equations and potentially solve them but ran out of time or the like.

Assessment: 81% of the aerospace engineering students met or exceeded expectations.

Proposed Action: Results indicate that the AE program is meeting expectations.

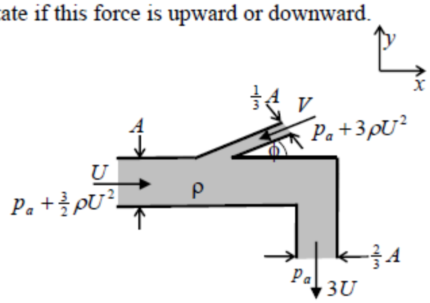
Consideration should also be given for a different assessment artifact that better evaluates math, science, and complex problem solving – the math here is primarily dot products, trigonometry, and algebra, and the outcome is of course foreordained.

Indicator	Below Expectations	Meets Expectations	Above Expectations
Ability to formulate and solve a two-dimensional control volume mass-momentum conservation problem.	Student fails to solve the problem due to significantly improper procedures, incorrect equations, incomplete work, and/or significant mathematical errors.	Student uses mostly proper procedures to formulate and solve the resulting governing equation with at most a few errors.	Student uses proper procedures to formulate and solve the governing equations with minimal errors.

A score below 60% was treated as automatically Below Expectations, Above 87% was considered automatically Above Expectations. Between was an assessment of the nature of the errors and how it fit in the rubric above, with all three categories possible.

1. A liquid flows into a system from two pipes and out one pipe as illustrated. Assume the flow is steady, horizontal (no body forces), incompressible, strongly rotational, and inviscid. All pipe cross-sectional areas are given in terms of A and have uniform cross-sectional properties. **(32%)**

   Given this information, determine the value of ϕ such that the net horizontal force on the pipe goes to zero. What is the net vertical force that the fluid is exerting on the pipe in this configuration in terms of ρ, U, and H? Clearly state if this force is upward or downward.



$$Mass: \quad -\rho UA + \rho(3U)\tfrac{2}{3}A - \rho V(\tfrac{1}{3}A) = 0$$

$$\Rightarrow \quad \tfrac{1}{3}V = -U + 2U = U \quad V = 3U$$

$x - momentum:$

$$-\rho U^2 A + \rho V^2 \cos\varphi(\tfrac{1}{3}A) = \tfrac{3}{2}\rho U^2 H^2 - 3\rho U^2(\tfrac{1}{3}A)\cos\varphi$$

$$\Rightarrow \quad -U^2 + \tfrac{1}{3}V^2\cos\varphi = \tfrac{3}{2}U^2 - U^2\cos\varphi$$

$$\Rightarrow \quad \cos\varphi\left[3U^2 + U^2\right] = \tfrac{3}{2}U^2 + U^2$$

$$\Rightarrow \quad 4U^2\cos\varphi = \tfrac{5}{2}U^2 \quad \Rightarrow \quad \cos\varphi = \frac{1}{4}\frac{5}{2} = \frac{5}{8}$$

$$\Rightarrow \quad \varphi = \cos^{-1}\left(\frac{5}{8}\right) = 51.3^\circ$$

$y - momentum:$

$$-\rho(3U)^2\tfrac{2}{3}A + \rho V^2\sin\varphi(\tfrac{1}{3}A) = -3\rho U^2(\tfrac{1}{3}A)\sin\varphi - F_y$$

$$\Rightarrow \quad -6\rho U^2 A + 3\rho U^2 A\sin\varphi = -\rho U^2 A\sin\varphi - F_y$$

$$\sin\varphi = \sqrt{1-\cos^2\varphi} = \sqrt{1-\frac{25}{64}} = \sqrt{\frac{29}{64}} = 0.7806$$

$$\Rightarrow \quad F_y = \rho A\left\{\sin\varphi\left[-3U^2 - U^2\right] + 6U^2\right\} = \rho U^2 A\{-3.1225 + 6\} = 2.8775\rho U^2 H^2$$

Program Assessment Review: B.S. in Aerospace Engineering

Learning Outcome: **1 (Solve Problems using SEM)** 2 (Design in Global Context) 3 (Effective Communication) *[select 1]* 4 (Ethics in Global Context) 5 (Functional Teamwork) 6 (Experiment and Draw Conclusions) 7 (Lifelong Learning)

Course: ESCI 3200 (Fluid Dynamics) (Spring 2022)

Location in Program: Early **Middle** End

Learning Outcome 1: an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

Instrument: Buckingham-PI dimensional analysis problem to assess students' understanding of engineering units, which is different than last year's 2D CV Conservation of Mass/Momentum exam problem; this change was done in order to assess a different aspect of complex problem solving that is important enough for all problems.

Methodology: Exam problem (included) is graded by instructor. Assessment is based on performance solving the problem and the rubric. The instructor can more precisely define the interpretation of rubric for the particular problem.

Rubric: See rubric below.

Desired result: 70% of students scoring Meets or Above Expectations

Students assessed: The class consisted of 30 students, of whom 22 were majoring in aerospace engineering (with 4 failures by no longer attending), 2 in mechanical engineering, 4 in civil engineering, and 2 in biomedical engineering. This assessment is based on the 18 aerospace engineering students who completed the course through the final exam.

Student performance: The aerospace engineering students had 6 students in Above Expectations, 6 in Meets Expectations, and 6 in Below Expectations.

Observations: Common errors were formulating the units of engineering variables (7 of 18), solving an algebraic system of equations with three variables (10 of 18), and not reading instructions properly or completing the problem (4 of 18).

Assessment: 67% of the aerospace engineering students met or exceeded expectations.

Proposed Action: Results indicate that the AE program is just below meeting expectations for this assessment. At this time, it is not clear what effects covid-era learning necessities had on this cohort of students, but I have noticed a general lack of engagement with the material and a lack of math skills compared to other groups. Instructors are encouraged to pay closer attention to making sure students include units in all calculations.

Indicator	Below Expectations	Meets Expectations	Above Expectations

Ability to formulate and solve a Buckingham-PI dimensional analysis problem.	Student fails to solve the problem due to significantly improper procedures, incorrect equations, incomplete work, and/or significant mathematical errors.	Student uses mostly proper procedures to formulate the proper dimensionless PI groups with at most a few errors.	Student uses proper procedures to formulate the proper dimensionless PI groups within minimal errors.

A score below 60% was treated as automatically Below Expectations, Above 87% was considered automatically Above Expectations. Between was an assessment of the nature of the errors and how it fit in the rubric above, with all three categories possible.

Problem 4

(10 pts) The energy released during an explosion, E, is a function of time after detonation, t, the blast radius, R, at time t, and the ambient air pressure, p, and density, ρ. Determine the form of the expression for E as a function of the other variables.

Learning Outcome:	**1 (Solve Problems using SEM)**	2 (Design in Global Context)	3 (Effective Communication)
[select 1]	4 (Ethics in Global Context)	5 (Functional Teamwork)	6 (Experiment and Draw Conclusions)
	7 (Lifelong Learning)		

Course: AENG 4400 (STABILITY AND CONTROL) (Fall 2022)

Location in Program: Early Middle End

Method: Composite score of homework, quizzes, projects, mid-term and final exams.
The class average is 82.60%.

Rubric: A score of 70% and above

Desired result: 70% of students will meet expectations

Student performance: 85% of students (37/44) met expectations.

Observations: Students have a reasonable understanding of vectors, concepts from dynamics, linear vibrations, and automatic controls. Will need to increase awareness of Simulink as a design/evaluation tool.

Program Assessment:

More than 90% of the students were able to identify, formulate, and solve engineering problems by applying principles of engineering, science, and mathematics.

Action: Provide additional numerical examples highlighting the relationship between foundational concepts in dynamics, vibrations and controls as applied to a rigid aircraft. Provide additional help (outside the classroom) to increase understanding of design tools using Matlab/Simulink.

AEME ABET Assessment Review Form

This form is a summary of the collective departmental review of learning outcome assessment, to be used to record review group thoughts about assessment materials collected.

Program (AE or ME): AE Date materials reviewed: 05/10/2023

Criterion reviewed (circle one): 1 2 **3** 4 5 6 7

an ability to communicate effectively with a range of audiences

Semester(s) reviewed: Fall 2022 (primarily)

Reviewers: Alexander, Condoor, Gururajan, Jayaram, LeBeau, Lei, Marmolejo, McQuilling, Swartwout

Courses and instruments:

Course	Semester	Description (ind/Grp)	Level	Type	Audience
AENG 2020	AE (F)	Technical Reports on Projects, 2-3 student teams	Early Formative	Written	Early Technical
MENG 3201/MENG 3111	ME (F) AE (S); ME (S), AE (F)	Formal Lab Report, individual	Middle Formative	Written	Technical
AENG 4014	AE (S)	AIAA Paper (group), Poster (group), Final Presentation (group), Final Report (group)	Late Summative	Written, Visual, Oral, Written	Technical, Public, Professional, Technical

Strengths and weaknesses:

Students need improved technical writing skills as opposed to general writing skills – including incorporation of equations/tables/data/plots.

Need to ensure that a variety of formats and audiences are covered as well individual versus group assignments and assessments.

Student overall written and oral communication skills (as opposed to specifically technical) have generally met or exceeded expectations.

Recommendations and proposed actions:

Develop common definitions for report format, figures, equations, calculations, sections, and the like to be used generally across the curriculum (Prof. Gururajan and McQuilling).

Develop proposal to integrate Core Intensive Writing attribute into AENG 4014 in conjunction with ABET outcomes (LeBeau)

Continue to encourage the development of diverse communication instruments

Other comments:

This was the first review of this outcome under the newly revised assessment plan of August 2022.

Learning Outcome: 1 (Solve Problems using SEM) 2 (Design in Global Context) **3 (Effective Communication)**
[select 1] 4 (Ethics in Global Context) 5 (Functional Teamwork) 6 (Experiment and Draw Conclusions)
7 (Lifelong Learning)

Course: AENG 2020 (Introduction to Aerospace Engineering) (F2022)

Location in Program: **Early** Middle End

Learning Outcome 3: an ability to communicate effectively with a range of audiences

Instrument: Project Reports. There are two reports, completed by teams of 2-3 students. The first is a rocket project, the second is a glider project.

Methodology: The student teams submit a technical report for their projects. In this case, the rocket project is evaluated against the provided rubric by the class instructor.

Rubric: See rubric below.

Desired result: 70% of students scoring Meets or Above Expectations

Students assessed: The evaluation of eight groups covering 17 aerospace students is provided for the assessment.

Student performance: Evaluation distributions for each indicator of the rubric are given in the table along with the percentage of students achieving Meets and Above Expectation. The average is a total score for each student based on a simple linear average of the five indicators where Below Expectations is 1, Meets is 2, and Above is 3.

Table of Performance Indicators by Group

Ind 1	Ind 2	Ind 3	Ind 4	Ind 5	Average
2	1	2	3	2	2.0
2	1	3	3	2	2.2
2	1	1	2	2	1.6
3	2	3	3	3	2.8
2	2	2	2	2	2.0
2	2	3	2	2	2.2
3	3	3	3	3	3.0
2	2	3	2	2	2.2

Observations: While most teams reasonably followed the provided outline of the report, most teams did not follow the AIAA format well or include all the expected figures, tables, and calculations. The writing was generally clear and followable, if incomplete in some cases. The writing was often on the casual side.

Assessment: All but one group had an average score of 2 or above, with two reports achieving average scores of 2.8 or higher, an overall performance above expectations. The net is that 7 of 8 groups met or exceeded expectations, or 88%. By indicator, the worst performance was indicator 2, with 3 of 8 groups scoring below expectations or 63% meets or exceeds.

Proposed Action: As an early foray of the students into technical report writing, these results suggest that more instruction might be helpful in terms of this introduction. Potential courses of action include:

1. Providing a more detailed outline or even a sample report based on a simplified set of results for the rocket project. The second project could be used to then evaluate writing skills in a less scripted assignment.
2. Increasing project time – both projects seemed rushed a bit in the transition from a 3 credit to a 1 credit course. While the overall time allocated for the students to work on each project was not that different, the degree of in-class interaction was considerably lower when only meeting once a week during the project periods. Extending the project time scale by 1-2 weeks and using flipped classroom techniques so that students conduct more work in the class time on this project might improve understanding and writing performance.

Indicator	Below Expectations	Meets Expectations	Above Expectations
1) Ability to communicate in an orderly and complete manner.	Sections of the project report are absent and/or have significant misplaced or missing material.	All required sections of the project report are included with only occasional misplaced or absent material.	All required sections of the report are included with the appropriate material in each section.
2) Ability to communicate technical concepts through written descriptions, equations, data, and figures.	Report does not include needed equations, data tables, plots, and/or figures, or these items are not clear, accurate, and/or properly constructed.	Report contains the equations, data tables, plots, and figures necessitated by the laboratory description. These are generally accurate, complete, and properly constructed.	The equations, data tables, plots, and figures are well-constructed, accurate, and complete and are integrated into the text so as to significantly enhance the understanding of the written report by the reader.
3) Ability to use proper grammar and spelling.	Report has numerous grammatical and spelling errors, no evidence of proofreading.	Report has several grammatical and spelling errors, appears to have been incompletely proofread.	Report has minimal grammatical and spelling errors, appears to have been proofread.
4) Ability to use effective writing syntax and voice.	Report has sufficient syntax, tense, and voice issues to significantly hamper the understanding of the report by the reader.	Report has occasional sections where the voice and tense are inconsistent or incorrect, or where the sentence/paragraph structure is not well-organized or lacks sufficient clarity.	Report uses readily comprehensible and followable syntax and uses proper voice and tense consistently throughout the report.
5) Overall communication quality.	Report fails to convey main points of the project without significant parsing and re-reading of sections, if at all.	Report conveys information in a sufficiently logical, efficient, precise, and complete manner such that the main points of the project are generally understood with a single read.	Report conveys information in a logical, efficient, precise, and complete manner such that the project is fully understood with a single read.

Model Rocket Payload Estimation

Given the model rocket, estimate a means by which the rocket will reach a maximum altitude of 150 ft above ground level. Conduct a launch under instructor's supervision and compare experimentally determined altitude to the target altitude of 150 feet.
Launch dates: October 19 & 24.
Launch site: Behind Oliver Hall

What do you conclude from this exercise?

Deliverables:

AIAA format report following the provided format.

The report should contain, among other things,
1. Creo (or similar CAD) drawing of rocket components and assembly.
2. Incompressible drag coefficient estimate for the rocket at burnout velocity, V_b
3. Center of gravity (CG) estimation and comparison to experimentally determined CG.
4. A MATLAB Trajectory estimate based on incremental analysis of Newton's Laws
5. An OpenRocket analysis of the trajectory and stability of the rocket
6. Comparison of results from (5) to your estimates
7. Sources of Error
8. Summary of your launch results
9. Conclusions

Appendix: MATLAB code for part 4 or submit as a separate MATLAB file.

Put Your Title Here in Place of Following the AIAA Conference Paper Format

First A. Author, Second B. Author Jr., and Third C. Author

Put in your abstract summarizing the project here. What did you do, why did you do it, and how did it come out in a few sentences so anyone reading this would have a sense of the project. Note that while this is the desired format for the paper, you are free to make other choices as long as the necessary material is covered.

Nomenclature (Optional)

A	=	if you don't use nomenclature, identify variables when they appear first in paper.
a	=	cylinder diameter
C_p	=	pressure coefficient
Cx	=	force coefficient in the *x* direction
Cy	=	force coefficient in the *y* direction
c	=	chord
d*t*	=	time step
Fx	=	*X* component of the resultant pressure force acting on the vehicle
Fy	=	*Y* component of the resultant pressure force acting on the vehicle
f, g	=	generic functions
h	=	height
i	=	time index during navigation
j	=	waypoint index
K	=	trailing-edge (TE) nondimensional angular deflection rate

Mission and Requirements

A couple of paragraphs about the project, not covering results or conclusions – more about the mission and requirements of the project.

Design

Describe your design – what did you come up with and what is your layout. How does your design get you to 150 ft. height? The CAD should be here as well as enough dimensional detail to properly define the key sizes of your rocket and your components.

Your Analysis

Here you should describe your method and work to estimate the trajectory. This should include:

Details of Drag Analysis

How did you estimate the drag/drag coefficient of the rocket? Show the equations and the numbers. What Re did you use and to what speed does it correspond? How did you modify the drag to meet your height objective?

Center of Gravity

How did you calculate the total weight and CG location? How well did your calculated CG do compared to balancing the rocket. Show a table of the components with data and the final results. How did you modify the weight of the rocket to meet your height objective?

Thrust Measurement

Describe your thrust analysis based on the experimental data taken. What was the result of your thrust analysis. How did it compare to the published data available for the rocket motor?

Details of Trajectory

How did you analyze the trajectory (height) of your rocket? How did you use the thrust data? How did you calculate your projected trajectory? What were your calculations and results? What thrust data did you use? Describe your MATLAB code here (but put the code in the Appendix).

Test Results

Here is where you describe your flight test and OpenRocket simulations. How did the rocket perform and how did it compare to your estimates. Compare the altimeter and/or simulation data to your trajectory estimates.

Sources of Error and Conclusions

So how did it turn out – did you rocket perform as expected? If not what were the sources of error that caused the differences (or the failure of the launch, depending) What would you do different next time? What did you learn?.

Appendix

If you have bigger figures or other things that do not fit well in the paper, this is where they can go. Some folks put their CAD here instead in the main paper. You should also include your MATLAB code in the Appendix. You can also submit your MATLAB code separately as a file.

Acknowledgments

If someone besides the authors helped with project, acknowledge it here. If not, skip.

References

If you have specific references that you used put them here in the appropriate format (below) depending on type. If none, skip it.

Example reference formats:

Periodicals

[1] Vatistas, G. H., Lin, S., and Kwok, C. K., "Reverse Flow Radius in Vortex Chambers," *AIAA Journal*, Vol. 24, No. 11, 1986, pp. 1872, 1873. doi: 10.2514/3.13046

[2] Alyanak, E. J., and Pendleton, E., "Aeroelastic Tailoring and Active Aeroelastic Wing Impact on a Lambda Wing Configuration," Journal of Aircraft, published online 10 Nov. 2016. doi: 10.2514/1.C033040

[3] Dornheim, M. A., "Planetary Flight Surge Faces Budget Realities," *Aviation Week and Space Technology*, Vol. 145, No. 24, 9 Dec. 1996, pp. 44–46.

[4] Terster, W., "NASA Considers Switch to Delta 2," *Space News*, Vol. 8, No. 2, 13–19 Jan. 1997, pp. 1, 18.

All of the preceding information is required. The journal issue number ("No. 11" in Ref. 1) is preferred, but the month (Nov.) can be substituted if the issue number is not available. Use the complete date for daily and weekly publications. Transactions follow the same style as other journals.

Books

[5] Peyret, R., and Taylor, T. D., *Computational Methods in Fluid Flow*, 2nd ed., Springer-Verlag, New York, 1983, Chaps. 7, 14.

[6] Oates, G. C. (ed.), *Aerothermodynamics of Gas Turbine and Rocket Propulsion*, AIAA Education Series, AIAA, New York, 1984, pp. 19, 136.

[7] Volpe, R., "Techniques for Collision Prevention, Impact Stability, and Force Control by Space Manipulators," *Teleoperation and Robotics in Space*, edited by S. B. Skaar and C. F. Ruoff, Progress in Astronautics and Aeronautics, AIAA, Washington, DC, 1994, pp. 175–212.

Publisher, place, and date of publication are required for all books. No state or country is required for major cities: New York, London, Moscow, etc. A differentiation must always be made between Cambridge, MA, and Cambridge, England, UK. Note that series titles are in Roman type.

Proceedings

[8] Thompson, C. M., "Spacecraft Thermal Control, Design, and Operation," *AIAA Guidance, Navigation, and Control Conference*, CP849, Vol. 1, AIAA, Washington, DC, 1989, pp. 103–115

[9] Chi, Y. (ed.), *Fluid Mechanics Proceedings*, NASA SP-255, 1993.

[10] Morris, J. D., "Convective Heat Transfer in Radially Rotating Ducts," *Proceedings of the Annual Heat Transfer Conference*, edited by B. Corbell, Vol. 1, Inst. of Mechanical Engineering, New York, 1992, pp. 227–234.

Reports, Theses, and Individual Papers

[11] Chapman, G. T., and Tobak, M., "Nonlinear Problems in Flight Dynamics," NASA TM-85940, 1984.

[12] Brandis, A. M., Johnston, C. O., and Cruden, B. A., "Nonequilibrium Radiation for Earth Entry," AIAA Paper 2016-3690, June 2016.

[13] Steger, J. L., Jr., Nietubicz, C. J., and Heavey, J. E., "A General Curvilinear Grid Generation Program for Projectile Configurations," U.S. Army Ballistic Research Lab., Rept. ARBRL-MR03142, Aberdeen Proving Ground, MD, Oct. 1981.

[14] Tseng, K., "Nonlinear Green's Function Method for Transonic Potential Flow," Ph.D. Dissertation, Aeronautics and Astronautics Dept., Boston Univ., Cambridge, MA, 1983.

Government agency reports do not require locations. For reports such as NASA TM-85940, neither insert nor delete dashes; leave them as provided. Place of publication *should* be given, although it is not mandatory, for military and company reports. Always include a city and state for universities. Papers need only the name of the sponsor; neither the sponsor's location nor the conference name and location is required. *Do not confuse proceedings references with conference papers*.

Electronic Publications

Regularly issued electronic journals and other publications are permitted as references. Include the DOI if provided; otherwise provide the full URL. Archived data sets also may be referenced as long as the material is openly accessible, and the repository is committed to archiving the data indefinitely. References to electronic data available only from personal websites or commercial, academic, or government ones where there is no commitment to archiving the data are not permitted in the reference list.

Deleted: doi

[15] Atkins, C. P., and Scantelbury, J. D., "The Activity Coefficient of Sodium Chloride in a Simulated Pore Solution Environment," *Journal of Corrosion Science and Engineering* [online journal], Vol. 1, No. 1, Paper 2, URL: http://www.cp/umist.ac.uk/JCSE/vol1/vol1.html [retrieved 13 April 1998].

[16] Vickers, A., "10-110 mm/hr Hypodermic Gravity Design A," *Rainfall Simulation Database* [online database], URL: http://www.geog.le.ac.uk/bgrg/lab.htm [retrieved 15 March 2006].

Break website addresses after punctuation, and do not hyphenate at line breaks.

Computer Software

[17] TAPP, Thermochemical and Physical Properties, Software Package, Ver. 1.0, E. S. Microware, Hamilton, OH, 1992.

Include a version number and the company name and location of software packages.

Patents

Patents appear infrequently. Be sure to include the patent number and date.

[18] Scherrer, R., Overholster, D., and Watson, K., Lockheed Corp., Burbank, CA, U.S. Patent Application for a "Vehicle," Docket No. P-01-1532, filed 11 Feb. 1979.

Private Communications and Websites

References to private communications and personal website addresses are not permitted. They may, however, be incorporated into the main text of a manuscript or may appear in footnotes.

Unpublished Papers and Books

Unpublished works can be used as references as long as they are being considered for publication or can be located by the reader (such as papers that are part of an archival collection). If a journal paper or a book is being considered for publication, choose the format that reflects the status of the work (depending upon whether it has been accepted for publication):

[19] Doe, J., "Title of Paper," *Name of Journal* (to be published).

[20] Doe, J., "Title of Chapter," *Name of Book*, edited by…, Publisher's name and location (to be published).

[21] Doe, J., "Title of Work," Name of Archive, Univ. (or organization), City, State, Year (unpublished).

Unpublished works in an archive *must* include the name of the archive and the name and location of the university or other organization where the archive is held. Also include any cataloging information that may be provided.

Learning Outcome: 1 (Solve Problems using SEM) 2 (Design in Global Context) **3 (Effective Communication)**
[select 1] 4 (Ethics in Global Context) 5 (Functional Teamwork) 6 (Experiment and Draw Conclusions)
7 (Lifelong Learning)

Course: AENG 2020 (Introduction to Aerospace Engineering) (F2022)

Location in Program: **Early** Middle End

Method: The two group projects required students to write technical report instead of a normal presentation. The communication aspect was evaluated based on technical writing rather than oral presentation. The technical writing had elements of modeling, CAD based visual presentation, numerical analysis and experimental evaluation.

Rubric: Each project was evaluated based on 10 points. Project 1 report was required to be submitted following AIAA conference paper format. Project 2 was just a technical analysis report.

Desired result: 70% of students will meet expectations

Student performance: 100% of the students (21 out of 21) met expectations.

Observations: While some of the technical writing and analysis were not as thorough as would have been desired, the delivery of the report by all teams was sufficient. There are rooms for improvement in the overall written communications

Program Assessment: All Student teams did well in delivery of the written reports of their projects.

Action:

In Fall 2023, we could implement a formal review process to provide feedback to student groups to improve their written communication skills.

Learning Outcome: [select 1] 1 (Solve Problems using SEM) 2 (Design in Global Context) **3 (Effective Communication)** 4 (Ethics in Global Context) 5 (Functional Teamwork) 6 (Experiment and Draw Conclusions) 7 (Lifelong Learning)

Course: ESCI 3201 (Fluid Dynamics Lab) (Fall 2022)

Location in Program: Early **Middle** End

Learning Outcome 3: an ability to communicate effectively with a range of audiences

Instrument: Formal Lab Report. For Saint Louis, this is the Flat Plate Lab. The lab is conducted and data collected as a group but the lab analysis and report is done individually.

Methodology: The lab report is to be written to communicate the laboratory purpose, procedures, findings, analysis, and conclusion to professional colleagues. The lab is graded by teaching assistants and/or the instructor based on a rubric specific to this lab. Once graded, the formal labs and grading of writing-specific subsections are reviewed by the instructor and an indicator level following the rubric provided for SLO assessment is determined.

Rubric: See rubric below.

Desired result: 70% of students scoring Meets or Above Expectations

Students assessed: No assessment was made for AE students this semester as the majority of AE students take the course in the spring semester and there was no section with a large concentration of aerospace students in this semester.

Student performance:

Assessment:

Proposed Action: The lab course is phasing out, but this lab is likely to remain a key lab in the new Mechanics Lab, so starting in Fall 2023 there will an aerospace assessment in this SLO.

Indicator	Below Expectations	Meets Expectations	Above Expectations
1) Ability to communicate in an orderly and complete manner.	Sections of the lab report are absent and/or have significant misplaced or missing material.	All required sections of the lab report are included with only occasional misplaced or absent material.	All required sections of the lab report are included with the appropriate material in each section.
2) Ability to communicate technical concepts through written descriptions, equations, data, and figures.	Report does not include needed equations, data tables, plots, and/or figures, or these items are not clear, accurate, and/or properly constructed	Report contains the equations, data tables, plots, and figures necessitated by the laboratory description These are generally accurate, complete, and properly constructed following the laboratory manual.	The equations, data tables, plots, and figures are well-constructed, accurate, and complete and are integrated into the text so as to significantly enhance the understanding of the written report by the reader.

3) Ability to use proper grammar and spelling.	Final report has numerous grammatical and spelling errors, no evidence of proofreading.	Final report has several grammatical and spelling errors, appears to have been incompletely proofread.	Final report has minimal grammatical and spelling errors, appears to have been proofread.
4) Ability to use effective writing syntax and voice.	Final report has sufficient syntax, tense, and voice issues to significantly hamper the understanding of the report by the reader.	Final report has occasional sections where the voice and tense are inconsistent or incorrect, or where the sentence/paragraph structure is not well-organized or lacks sufficient clarity.	Final report uses readily comprehensible and followable syntax and uses proper voice and tense consistently throughout the report.
5) Overall communication quality.	Report fails to convey main points of the lab without significant parsing and re-reading of sections, if at all.	Report conveys information in a sufficiently logical, efficient, precise, and complete manner such that the main points of the lab are generally understood with a single read.	Report conveys information in a logical, efficient, precise, and complete manner such that the lab is fully understood with a single read.

FLAT PLATE BOUNDARY LAYERS

OBJECTIVE

In this lab you will learn methods to:

- Measure flat plate boundary layer velocity profiles under laminar and turbulent conditions
- Compare velocity profile measurements to accepted theoretical values

INTRODUCTION

Flow in contact with a wall is assumed to match the velocity of the wall (no-slip condition). Thus moving away from the wall, the fluid must transition from the velocity of the wall to the velocity of the freestream, which is the primary flow velocity. This creates a region called the boundary layer in which the flow speed is between the wall and the freestream. The thickness of the boundary layer is often labeled as δ. In the case of flow over a stationary flat plate, this thickness increases as the flow moves down the plate as shown in Fig. 1.

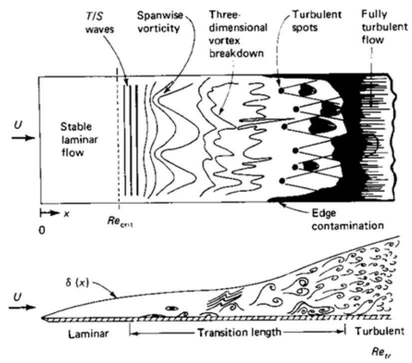


Figure 1: Natural transition of a laminar-turbulent boundary layer on a smooth flat plate

Initially, this example assumes the flow is laminar on the first part of the plate. Ideally, laminar flow has streamlines that do not interact and the flow moves in roughly parallel planes. However, as the flow moves further along the plate, small vortices begin to form near the surface. As these vortices decay, the flow becomes increasingly turbulent. Turbulent flow exhibits strong mixing of mass, momentum, and energy through vortices and eddies. The process of shifting from laminar flow to turbulent flow is called transition, and it is a complex process which can take multiple forms, one of which is shown looking down on the plate in Fig. 1.

The most common parameter used in determining if flow is laminar or turbulent is the Reynolds number (Re). Reynolds number is a dimensionless quantity representing the ratio of momentum or inertial forces to viscous forces in a boundary layer. It is a function of fluid density, freestream velocity, plate length from the leading edge to the point of interest, and fluid dynamic viscosity. A common approximation for a smooth flat plate is that transition from laminar to turbulent flow takes place when the Reynolds number as a function of the distance along the plate reaches a critical value, typically $Re_x = \rho Ux/\mu \sim 5\times10^5$., where x is the distance along the plate from the leading edge, U is the freestream velocity, and ρ and μ are the fluid density and viscosity. If the plate is rough, the turbulent boundary layer will begin at lower Reynolds numbers (i.e. closer to the leading edge assuming all else is equal).

A way to investigate boundary layers is to match experimental data to approximations of boundary layer profiles and then determine the flow characteristics based on the best-fitting approximations. The profile is typically written as a ratio of the local velocity u to the freestream velocity U equal to a function of the ratio of the normal distance to the surface of the plate y to the boundary layer thickness δ. Two approximations have been shown to work well:

$$\frac{u}{U}=\frac{3}{2}\left(\frac{y}{\delta}\right)-\frac{1}{2}\left(\frac{y}{\delta}\right)^3$$ Nikuradse cubic approximation for **Laminar B.L.** (1)

$$\frac{u}{U}=\left(\frac{y}{\delta}\right)^{\frac{1}{7}}$$ Power law profile for **Turbulent B.L.** (2)

EXPERIMENT

1. Record the ambient temperature and pressure in the room.
2. Determine the wind speed the tunnel must run below to ensure laminar flow over the smooth plate. This means the Reynolds number must be kept below the transitional value for air flow over a flat plate.
3. Knowing the wind speed and the Reynolds number, calculate the respective maximum dynamic pressure. Dynamic pressures measured during this lab should not exceed this value. If they do, you need to recheck your calculations or adjust the airspeed of the apparatus. Be aware that the probe is a Pitot-static tube where the tip of the tube reads total pressure $P_T = (½\,\rho V^2+P)$. The manometer in Lab View will present dynamic pressure based on comparing the static and total pressures.
4. Put the plate into the test section with the smooth side facing the probe and micrometer. Adjust the micrometer so that the probe *just* touches the plate surface. To ensure that it is placed correctly, you should be able to slide a piece of paper between the probe and plate while encountering only a slight resistance. Note the distance from the leading edge of the plate to the location of the pitot-static probe as this is the distance x in the Reynolds number calculation.

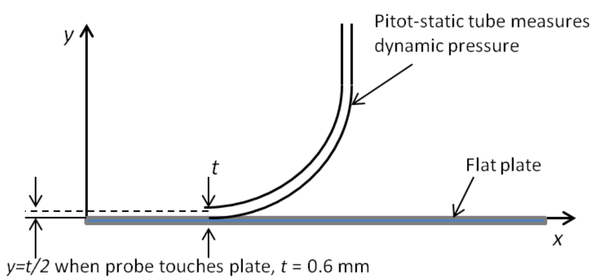


Figure 2: Pitot-static tube conventions

5. Take at least 5 pressure readings in Lab View for every 0.2 mm movement of the probe until the probe is out of the boundary layer. **(How does one know when the probe is out of the boundary layer?)** Once you have all your data, remove the highest and lowest values from each point and average the values that are left. That will be the value for that point. **(How many points might be appropriate to take given small sample errors?)**
6. Perform Step 4 and Step 5 with the **rough** side of the plate facing the probe to attempt to induce larger Reynolds numbers. You can also slide the plate further toward the wind inlet to assist in this endeavor since the Reynolds number also depends on the plate length covered by the flow before the pitot-static tube.

DATA ANALYSIS

1. Plot two figures.
    a. Experimental smooth side distribution AND both the laminar and turbulent velocity distribution approximations from Eq. (1) and (2).
    b. Experimental rough side distribution and its approximations from Eq. (1) and (2).

   Remember that the x-axis and y-axis are normalized so their maximum values should be about one.

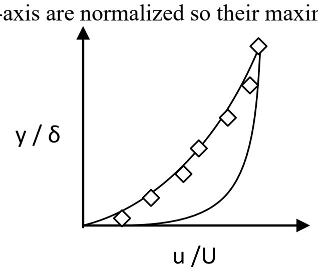


Figure 3: Example velocity profile graph

2. Compute the difference at each y/δ point between the experimental normalized velocity and both the laminar and turbulent approximations in equations 3 and 4. Place these differences in a table in your report. These differences can be multiplied by 100 to obtain the local percent error (you do not need to divide the difference in this case since all of the values are normalized already). These local percent errors should be aggregated together and averaged to obtain a mean percent error for that comparison. This should be done for four cases: smooth (experiment) vs. laminar (theory), smooth (experiment) vs. turbulent (theory), rough (experiment) vs. laminar (theory), rough (experiment) vs. turbulent (theory). Discuss these percent errors as indications of whether or not laminar or turbulent flow was observed in each side of the plate (it might not be smooth = laminar, rough = turbulent; if neither, what would it be? Refer to Fig. 1 to help answer this). Also discuss possible sources of error in these results and their possible effects.
3. Compute the small sample (t-distribution) error range on three selected points (one near the bottom, one in middle, one near the top of the boundary layer) for the rough and smooth plate data sets assuming 90%/95% confidence. What, if any, are the implications of this measurement error on the discussion of Step 2?
4. Obtain the percent error between the experimental calculation of δ/x (non-dimensional boundary layer thickness where x is the length term used in Reynolds number equation) and the empirical equations below. In total there should be four cases with percent error (same as step 2). Discuss what these results imply about the boundary layer structure (for example laminar v. turbulent) and uncertainties associated with this analysis approach.

	δ / x
Laminar Cubic Approximation	$4.6/(Re_x)^{1/2}$
Turbulent Power Law Approximation	$0.37/(Re_x)^{1/5}$

APPENDIX

Useful Equations

Density: $\rho = \frac{P_{room}}{RT_{room}}$ (R = 287.2 $\frac{Nm}{kgK}$ and T in K)

Coefficient of absolute viscosity: $\mu = 1.458 \times 10^{-6} \frac{T^{1.5}}{T + 110.4} \frac{kg}{s \cdot m}$

Reynolds's Number: $\mathrm{Re}_x = \frac{V \cdot x}{\nu}$ Kinematic viscosity: $\nu = \frac{\mu}{\rho}$

Distance from plate: y = micrometer reading - micrometer reading at plate + t/2

Boundary Layer thickness: δ Determine by observation of data (u/U = 1)

Learning Outcome: 1 (Solve Problems using SEM) 2 (Design in Global Context) **3 (Effective Communication)**
[select 1] 4 (Ethics in Global Context) 5 (Functional Teamwork) 6 (Experiment and Draw Conclusions)
7 (Lifelong Learning)

Course: AENG 4014 (Flight Vehicle Analysis and Design II) (S2023)

Location in Program: Early Middle **End**

Learning Outcome 3: an ability to communicate effectively with a range of audiences

Instrument: 1) Assessment of industry review panel of team student presentations at the end of the semester, 2) team project posters, 3) AIAA student conference paper, 4) Final project report

Methodology: 1) Each senior design team makes a 20-25 minute presentation about their work at the end of the spring semester, approximately equivalent to a detailed/protoype design review. This presentation is evaluated by a panel of professional engineers from industry. The overall relevant evaluation item is "Quality of Overall Presentation Skills" although this evaluation is also informed by the subcategories under Presentation/Communication Skills. 2) Each team is required to prepare a poster for the SSE showcase, a public event covering all SSE senior projects. These posters are evaluated by the instructor. 3) Each team is required to write a paper to conform to the expectations of the AIAA Region V Student Conference, which should ideally focus on a particular subset of notable technical topics associated with the design rather than the overall design process. This is evaluated by the instructor. 4) Each team is required to write a final report describing the design project which is evaluated by the instructor on its writing and ability to convey the project.

Rubric: 1) The evaluation uses a scale of 1 – Unsatisfactory, 2 – Marginal, 3 – Good, 4 – Excellent, and 5 – Outstanding. Full rubric below.
2) Rubric is provided below.
3) Rubric is provided below.
4) The overall report is assessed on the same scale as the presentation with a specific focus on communication to the reader and writing quality.

Desired result: 70% of teams scoring Meets or Exceeds Expectations or a score of 3.0 or above

Students assessed: There were ten teams ranging from 1-7 students for a total of 44 students. One student was a mechanical engineering major, one was an engineering physics major, the rest aerospace engineering majors. As these are team scores, it is not feasible to disaggregate the non-aerospace majors from this assessment.

Student performance: The evaluation for (1) and (4) uses a scale of 1 – Unsatisfactory, 2 – Marginal, 3 – Good, 4 – Excellent, and 5 – Outstanding.

Panel	Report
4.5	4.4
4	3.8
4.5	4.3
4.5	4.3
4.5	4
4.5	4
4	3.8
3.75	3.8

4.5	4.2
4	4

For the poster (2), evaluation distributions for each indicator of the rubric are given in the table. The average is a total score for each poster based on a simple linear average of the five indicators where Below Expectations is 1, Meets is 2, and Above is 3.

Table of Performance Indicators by Group

Ind 1	Ind 2	Ind 3	Ind 4	Ind 5	Average
2	1.5	3	3	2	2.3
1.5	1.5	3	2	2	2
2.5	2.5	3	2.5	2.5	2.6
2.5	2	3	2	2	2.3
2.5	2.5	3	2.5	2.5	2.6
2.5	2	3	2.5	2	2.4
3	3	3	2.5	3	2.9
2.5	2.5	3	2	2	2.4

Observations: Teams generally did a good job in oral, visual, and written communication, with all teams meeting or exceeding expectations overall. The powerpoint presentations had the highest overall scores with six of ten teams exceeding expectations at 4.5. Some reports had flaws in terms of what materials were available, incomplete analysis, or the like, but they were generally written and presented reasonably well. A few posters had figures that were not sufficiently explained or readily understood or missed key figures/tables that would have been useful.

Assessment: In all assessed artifacts, all ten teams met or exceeded expectations overall. Six of ten teams exceeded expectations in their final presentations where they were rated by the professional panel at above 4 (Excellent) overall in terms of communication.

Proposed Action: The plan is to submit this course to approval for the Core Writing Intensive attribute. Students who take this course to meet this attribute will be required to do additional writing work including individual writing assignments, one of which can be added to this assessment. These students will also be required to work through multiple drafts of the project report and AIAA paper and review their fellow students' work, which will hopefully result in improved team performance as well.

Poster Rubric

Indicator	Below Expectations	Meets Expectations	Above Expectations
1) Ability to communicate in an orderly and complete manner describing the project and its objectives, the final design, and the main findings of the project.	Sections of the poster are absent and/or have significant misplaced or missing material.	All necessary sections of the poster are included with appropriate material.	All necessary sections of the poster are included with the key design requirements, design decisions, and key findings emphasized.
2) Ability to communicate technical concepts through written descriptions, data, and figures.	Poster does not include sufficient data tables, plots, and/or figures, or these items are not clear, accurate, and/or properly constructed.	Poster contains appropriate data tables, plots, and figures. These are generally accurate, complete, and properly constructed.	The data tables, plots, and figures are well-constructed, accurate, and complete and significantly enhance the understanding of the project by the

			reader.
3) Ability to use proper grammar and spelling.	Poster has numerous grammatical and spelling errors, no evidence of proofreading.	Poster has several grammatical and spelling errors, appears to have been incompletely proofread.	Poster has minimal grammatical and spelling errors, appears to have been proofread.
4) Ability to use effective syntax and voice for a target audience of high school/college students	Poster has sufficient syntax and voice issues to significantly hamper the understanding of the report by the reader.	Poster has occasional sections where the voice and syntax are inconsistent/incorrect or are not at the appropriate audience level.	Report uses readily comprehensible and followable syntax and uses proper voice consistent with the target audience level.
5) Overall communication quality and visual appeal	Poster fails to convey main points of the project, is confusing to follow, and lacks aesthetic appeal.	Poster conveys the main points of the project in a way that maintains the observer's interest with acceptable aesthetics.	Poster conveys the main points in a readily understood manner that draws an observer's interest with attractive aesthetics.

AIAA Paper Rubric

Indicator	Below Expectations	Meets Expectations	Above Expectations
1) Paper format including appropriate sections, equations, tables, figures, and references	Necessary sections of the paper are absent and/or do not follow guidelines and format requirements.	Sections, equations, figures, tables, and references approximately follow guidelines and format requirements.	All appropriate sections, equations, figures, tables, and references of the paper are included, properly formatted, and clearly presented.
2) Project/problem description	Paper does not sufficiently define the project or technical challenges and does not provide any significant background information. Does not conform to expectations of a student AIAA conference paper.	Paper describes the project but with more of an emphasis of the design rather than specific technical problems and/or does not provide sufficient background and context. Conforms to expectations of a student AIAA conference paper.	Paper describes the project with the emphasis on specific technical problems to be addressed, including appropriate references to prior work establishing the context of the paper within the larger discipline. Conforms to expectations of a national AIAA conference paper.
3) Procedure/Testing	Paper procedure and testing leaves the reader with significant gaps of information needed to understand the work. Results are inadequate to support analysis. Does not conform to expectations of a student AIAA conference paper.	Paper describes the procedures and testing done to address design/technical problems in a sufficiently complete manner to be understood if not necessarily replicable. Technical results are insufficient to support more than a basic analysis. Conforms to expectations of a student AIAA conference paper.	Paper describes the procedures and testing done to address the technical problems in an appropriately complete and professional manner, with sufficient results to perform useful analyses. Conforms to expectations of a national AIAA conference paper.
4) Analysis and Conclusions	Paper has limited analysis	Paper presents some	Paper presents a

	and conclusions or has significant errors. Does not conform to expectations of a student AIAA conference paper.	analysis and conclusions, but an emphasis on broader design issues rather than technical challenges or with only limited application of testing results. Conforms to the expectations of a student AIAA conference paper.	considered analysis of the technical challenges, drawing on the data provided by testing, and draws reasonable conclusions. Conforms to the expectations of a national AIAA conference paper.
5) Grammar, spelling, syntax, and voice.	Paper has numerous grammatical and spelling errors, no evidence of proofreading and/or sufficient syntax and voice issues to significantly hamper understanding.	Paper has several grammatical and spelling errors, appears to have been incompletely proofread, and/or occasional sections where the voice and syntax are inconsistent/incorrect.	Poster has minimal grammatical and spelling errors, appears to have been proofread, and is readily comprehensible with followable syntax and a voice consistent with a technical paper.
6) Overall writing quality.	Paper fails to convey main points without significant parsing and re-reading of sections, if at all.	Paper conveys information in a sufficiently logical, efficient, precise, and complete manner such that the main points of the paper are generally understood with a single read.	Paper conveys information in a logical, efficient, precise, and complete manner such that it is fully understood with a single read.

OVERALL EVALUATION GUIDELINES METRIC
(Used for Panel Assessment)

5 - Outstanding:

Ready to proceed to next phase. No apparent design issues. Analysis clearly demonstrates that the key requirements can be satisfied. A portion of the engineering work (design, analysis and developmental testing) is already at the level of maturity for the next phase. (If applicable for flight competition; the manufacturing and testing approach is good). Would definitely invest in project funding.

Presentation was clear and well-organized. Audio and visual presentations complemented each other and enhanced understanding. Plots and tables were easily understood. Presenters conducted themselves in a professional manner.

4 - Excellent:

Ready to proceed for next phase. A few minor design issues that can be easily resolved in next phase of project. Analysis demonstrates that the key requirements can be satisfied. The engineering design and analysis is at high level of maturity for the current phase. (If applicable for flight competition; the manufacturing and testing approach is acceptable.) Would likely invest in project after getting more information about the design.

Presentation was mostly clear and well-organized, but occasionally incomplete or confusing. Audio and visual presentations enhanced overall understanding. Plots and tables provided the necessary information but needed to be clearer in some cases. Presenters conducted themselves professionally but were a bit rough around the edges.

3 - Good:

Ready to proceed/fund for next phase, with several minor design issues that can be resolved in the next phase of the project. Forward work plan should resolve any key requirements that are not currently satisfied. The engineering design and analysis is at an acceptable level of maturity for the current phase. (If applicable for flight competition; the manufacturing and testing approach has some gaps). Project has good potential and worth pursuing but would defer investment decision until next technical review milestone.

Presentation was understandable but had some significant flaws. Audio and visual presentations were redundant or inconsistent at times. Plots and tables were sometimes confusing. Presenters were largely professional but appeared inadequately prepared in some cases.

2 - Marginal:

Proceed to next phase with caution. Some major design challenges/issues that must be resolved at start of the next phase. A forward work plan is in place to address these technical issues. The engineering design and analysis has significant gaps. (If applicable for flight competition; manufacturing and testing approach is largely incomplete). Project has fair potential to succeed with focused effort in next phase.

Presentation was not fully understandable, required significant clarification in Q&A. Audio and visual presentations, plots, and tables covered the material inefficiently and lacked clarity. Presenters were less than professional and marginally prepared.

1 - Unsatisfactory:

Not approved to proceed to next phase. Many major design issues. Conceptual design unlikely to satisfy key requirements. Inadequate engineering design and analysis. End further project development.

Presentation was largely incomplete and/or significantly flawed. Presented material had major gaps and errors. Presenters were unprofessional and poorly prepared.

Category	Evaluation (1 to 5 or NA)	Comments
Project Description/CONOPS		
Executive Summary, Mission Description, Purpose, Profile		

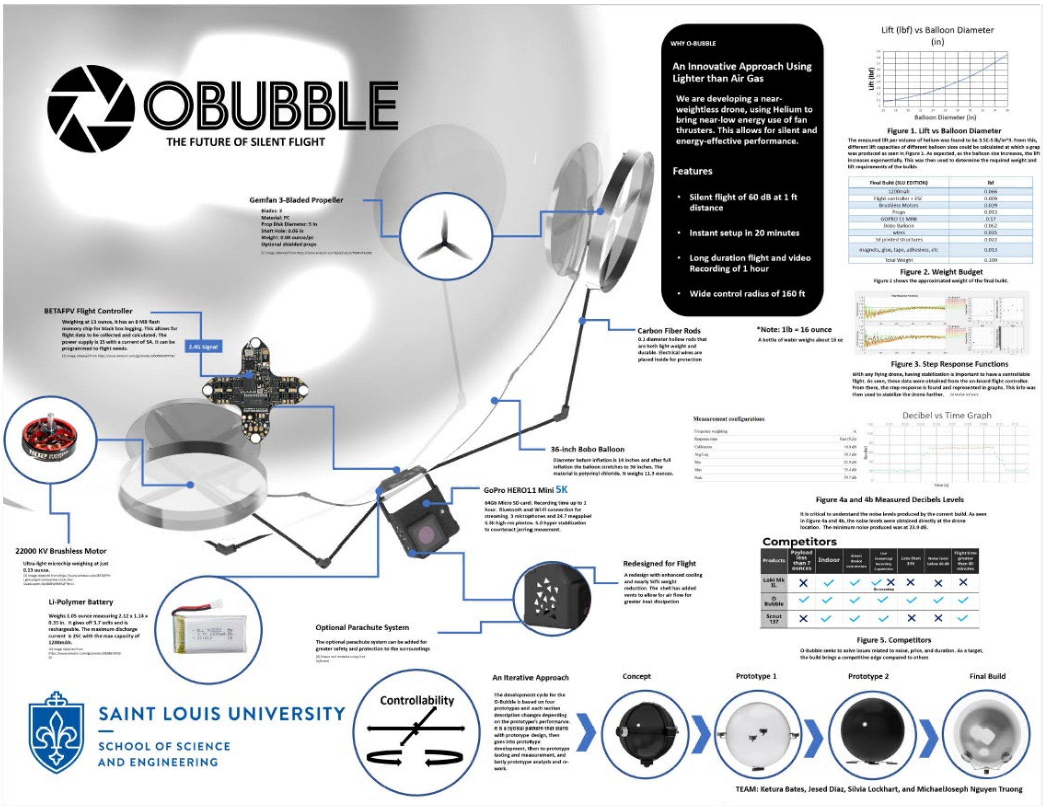
Requirement Definition		
Key Design Drivers, Primary Requirements, Derived Requirements, Requirement Verification		
Project Model		
Need Identification, Business/Project Case, Heritage/Peer Competitor Designs, Market/Customers, Value Proposition, Awareness of Broader Impacts		
System Development and Design		
Overall Vehicle Concept including subsystem design, Vehicle Layout with Critical Dimensions and Interfaces, Identification of Critical Components		
System Analyses		
Flight/Orbit/Trajectory Analysis: *Aerodynamics, Trajectory/Orbit, Power/Propulsion*		
Stability/Control Analysis: *Static Margin, Control Surfaces, Guidance Systems*		
Weight/Structural Analysis: *Mass Budget, Materials, Strength, CG, Manufacturability*		
Avionics/Communication Analysis: *Components, Layout, Functionality, Power Budget*		
Other Critical Subsystem Analysis (*as applicable*)		
Risk Assessment / Mitigations: *Operational, Developmental/Project, Broader Impacts*		
Manufacturing/Testing (*as applicable*)		
Technical Analysis, Simulation, and Modeling Tools Selection and Application		
Manufacturing/Assembly/Prototyping		
Physical Testing Approach, Results, Analysis, including Prototype Testing		
Requirement Compliance		
Performance and Key Requirement Compliance Assessment, Issue Identification, Forward Issue Resolution Plans		
Technical Management/Planning		
Team Management/Roles, Project Schedules w/Key Milestones, Cost Budget, Financial Plan		
Overall Student Team Project Assessment	**(1 to 5)**	
Quality of System Development Process		
Quality of Overall Design for Technical Review Milestone		

Category	Evaluation (1 to 5 or NA)	Comments
Presentation/Communication Skills		
Speaks clearly, audibly, and directly to the audience		
Presents ideas in a well-organized and clear manner		
Communicates with audio / visual aids, including clear graphics & models / demonstrations		

Presents in a professional manner including vocabulary, language style, and appearance		
Responds effectively to questions		
Demonstrates collaborative work activity and project focus		
Quality of Overall Presentation Skills		
ABET Assessment	**(1 to 5)**	
Design meets identified needs and considers some non-technical aspects like cost, safety, public welfare and/or financial, cultural, economic, societal, or environmental impacts		
Team recognizes ethical and professional responsibilities, including safety and broader impacts on society, culture, economy, and/or the environment.		
Team evidences an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.		

Other Comments:

Poster Example



AEME ABET Assessment Review Form

This form is a summary of the collective departmental review of learning outcome assessment, to be used to record review group thoughts about assessment materials collected.

Program (AE or ME): AE Date materials reviewed: 11/11/2023

Criterion reviewed (circle one): 1 2 3 4 **5** 6 7

an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives

Semester(s) reviewed: Fall 2022, Spring 2023 (primarily)

Reviewers: Alexander, Babaiasl, Condoor, Gururajan, Jayaram, LeBeau, Ma, Marmolejo, Swartwout

Courses and instruments:

Course	Semester	Description (ind/Grp)	Level	Team Mgmt	Collab
ESCI/SE 1700	AE (F); ME (F)	Instructor assessment, possibly some type of student survey	Early Formative	Y	Y
ESCI/MENG 3101	AE (S); ME (F)	Student survey	Middle Formative	Y	Y
MENG 3111	AE (F); ME (S)	Student survey	Middle Formative	Y	Y
AENG 4004	AE (F)	Final Presentation (group)	Late Formative	Y	Y
AENG 4014	AE (S)	Final Presentation (group), Planning Meetings (group, could be ind)	Late Summative	Y	Y

Strengths and weaknesses:

Where do we develop/teach teamwork skills (as opposed to practice)? We have many courses with team activities across the curriculum, but do not generally present teamwork skills, more of a learn as you go approach.

Project management is only formally presented in senior design. Need to better consider individual teamwork roles in assessment beyond student self-surveys

In final evaluation, most teams appear to at least meet expectations based on available data and other observations.

Recommendations and proposed actions:

Work with ROTC to create first-year team building exercise
Adapt MENG 3101 survey to MENG 3111, adapt MENG 4004 survey or similar to AENG 4004/4014 as additional data source
Consider using a team evaluation software package across multiple classes (see what happens in SE 1700)

Other comments:

This was the first review of this outcome under the newly revised assessment plan of August 2022.

Learning Outcome: 1 (Solve Problems using SEM) 2 (Design in Global Context) 3 (Effective Communication) 4 (Ethics in Global Context) **5 (Functional Teamwork)** 6 (Experiment and Draw Conclusions) 7 (Lifelong Learning)

Course: ESCI 1700 Engineering Fundamentals (F2022)

Location in Program: **Early** Middle End

Learning Outcome 5: an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives

Instrument: Final group project that includes a presentation and report.

Methodology: Students are grouped into teams and assigned a complex engineering design project to work on during the last three weeks of the semester. The instructor gauges the team behaviors and collaboration during work sessions. Students are asked to fill out a questionnaire to assess individual contributions and team dynamics. Finally, a team presentation and project paper are evaluated by the instructor to identify the application of team-based principles in delivering solutions.

Rubric: See rubric below.

Desired result: 70% of students scoring Meets or Above Expectations

Students assessed: The class consisted of 20 students, of whom 1 was majoring in aerospace engineering, 4 in biomedical engineering, 10 in computer science, 2 in electrical engineering, and 3 were undecided. This assessment is based on the only aerospace engineering student in the class.

Student performance: The Aerospace Engineering student score Meets Expectations.

Observations: The team including the Aerospace Engineering student presented sound and well-researched designs that are supported by analytical reasoning. However, not all team members seemed to have collaborated on most tasks. The objectives and goals were met by the group. The Aerospace Engineering student was the designated team leader.

Assessment: 100% of the aerospace engineering students met or exceeded expectations.

Proposed Action: Encourage further collaboration among team members.

Indicator	Below Expectations	Meets Expectations	Above Expectations
Ability to foster a collaborative and inclusive team environment.	Student often dominates conversations, dismisses others' ideas without consideration, and does not actively involve or seek input from all team members, leading to a noticeable exclusion of certain individuals.	Student actively listens to peers, ensures that all voices are heard, and encourages participation from all team members but may occasionally miss opportunities for full inclusivity.	Student consistently creates an inclusive space where every team member feels valued, their inputs are eagerly sought and incorporated, and proactive measures are taken to engage quieter team members, fostering true collaboration.

Learning Outcome: **1 (Solve Problems using SEM)** 2 (Design in Global Context) 3 (Effective Communication)
[select 1] 4 (Ethics in Global Context) 5 (Functional Teamwork) 6 (Experiment and Draw Conclusions)
7 (Lifelong Learning)

Course: ESCI 3101 (Mechanics of Solids Lab) (Fall 2022)

Location in Program: Early Middle End

Method: Survey

Rubric: 75% of students should have average or above average team performance score

Desired result: 100% of students will meet expectations of 75% or more (data not separated between AE and ME students in this case)

Student performance: 100% of students met expectations

Observations: None

Program Assessment: Acceptable performance

Action: No action needed

	Team members availability	Ability to listen to other members	Minutes of the meeting	Individual Contribution	Knowledge of other's contribution	Passive information gathering
	Rate the availability of members for discussion through a scheduled meeting, on-line chat, e-mail, phone etc	Listen to ideas and perspectives with an open mind	Documenting the discussion on each agenda item, dissemination to all members in a timely manner	Extent to which the members fulfilled their assigned task, additional voluntary contributions	Extent to which each member is aware of what other member contributed to the project	Ability to get information through books, magazines, journals, web search etc
Average	4.2	4.8	4.3	4.5	4.3	4.2
Median	5	5	4	5	5	4

Active information gathering	Appreciation for other's work	Completion of task on time in a collaborative inclusive manner	Overall effectiveness of team	Leadership qualities emerge in team members
Ability to get information through direct communication with faculty, industry, or other experts in the field	Ability to appreciate the work of other members without bias and prejudice	Ability of team members to make a schedule and follow it until the completion of task	Ability of members to work towards the common goal of the project by helping each other.	as the project moves through completion.
4.6	4.7	4.3	5	4.5
5	5	4	5	5

Learning Outcome:	1 (Solve Problems using SEM)	2 (Design in Global Context)	3 (Effective Communication)
[select 1]	4 (Ethics in Global Context)	5 (Functional Teamwork)	6 (Experiment and Draw Conclusions)
	7 (Lifelong Learning)		

Course: AENG 4014 Flight Vehicle Analysis and Design II (S2023)

Location in Program: Early Middle Late

Learning Outcome 5: an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives

Instrument: 1) Assessment of industry review panel of team student presentations at the end of the semester.
2) Instructor assessment of team collaboration and management via planning meetings and project development.

Methodology: 1) Each senior design team makes a presentation about their work at the end of the spring semester, approximately equivalent to a detailed/prototype design review. This presentation is evaluated by a panel of professional engineers from industry. The relevant evaluation items are “Technical Management and Planning” and “Demonstrates collaborative work activity and project focus” from the panel evaluation form.

2) Review by instructor of team collaboration and project management based on planning meetings and project development.

Rubric: The evaluation uses a scale of 1 – Unsatisfactory, 2 – Marginal, 3 – Good, 4 – Excellent, and 5 – Outstanding.

Desired result: 70% of teams scoring at or above 3.0

Students assessed: There were ten teams ranging from 1-7 students for a total of 44 students. One student was a mechanical engineering major, one was an engineering physics major, the rest aerospace engineering majors. As this is a team score, it is not feasible to disaggregate the non-aerospace majors from this assessment.

Student performance: Panel results are averaged panel score for each team

Table of Performance Indicators by Team

Panel Technical Mgmt	Panel Collaborative Work	Team Management	Collaborative Environment
4	4.5	4	3
2	3.5	2	2
3.5	4	4	4
4	5	4	5
4.5	4.5	3	4
4.5	4	4	3
3.5	4	3	3
2	3.75	2	3
5	5	5	3
3	4	3	4

Observations: Most teams had multiple planning meetings where they were not fully prepared with all necessary information, and some had persistent dominant members. However, most teams did have a consistent management structure and encouraged participation by all members. Work distribution was good for about half the teams. Some teams improved in these areas as the semester progressed leading to higher scores in the presentation evaluations.

Assessment: All four indicators had at least 8 of 10 teams achieving the desired level. A couple of teams performed below expectations in multiple indicators, particularly with regard to management. Two teams had average scores above 4 and exceeding expectations.

Proposed Action: Inclusion of some sort of peer-review with groups along with more formalized tracking of planning meetings would be useful. Consider plans for extra intervention with teams that are not functioning as well.

Comments: First time assessing this class/outcome in new assessment plan. Artifact documents can be found (Panel assessments) in SLO 2 folder.

	Unsatisfactory	Marginal	Good	Excellent	Outstanding
Team Management	Team fails repeatedly in terms of preparation, work structure, work expectations, and maintaining schedules.	Team has lapses in preparation, work structure, work expectations, and maintaining schedules which are sometimes allowed to linger.	Team has lapses in preparation, work structure, work expectations, and maintaining schedules, but consistently corrects these issues in a prompt fashion.	Team is mostly prepared, mostly follows a defined work structure and expectations, and is generally on schedule.	Team is consistently prepared, has a defined work structure and expectations, and is on or ahead of schedule.
Collaborative Work	Some team members are effectively excluded from participating in project planning, development, and work.	The full team does not regularly participate in project planning, development, and work efforts, with consistent unevenness in contributions.	All team members participate in project planning, development, and work efforts, but with some members consistently being more prominent than others.	All team members participate in project planning, development, and work efforts, but some transient unevenness.	All team members consistently participate in project planning and development and work efforts are cooperatively shared among team members.

OVERALL EVALUATION GUIDELINES METRIC
(Used for Panel Assessment)

5 - Outstanding:
Ready to proceed to next phase. No apparent design issues. Analysis clearly demonstrates that the key requirements can be satisfied. A portion of the engineering work (design, analysis and developmental testing) is already at the level of maturity for the next phase. (If applicable for flight competition; the manufacturing and testing approach is good). Would definitely invest in project funding.

Presentation was clear and well-organized. Audio and visual presentations complemented each other and enhanced understanding. Plots and tables were easily understood. Presenters conducted themselves in a professional manner.

4 - Excellent:
Ready to proceed for next phase. A few minor design issues that can be easily resolved in next phase of project. Analysis demonstrates that the key requirements can be satisfied. The engineering design and analysis is at high level of maturity for the current phase. (If applicable for flight competition; the manufacturing and testing approach is acceptable.) Would likely invest in project after getting more information about the design.

Presentation was mostly clear and well-organized, but occasionally incomplete or confusing. Audio and visual presentations enhanced overall understanding. Plots and tables provided the necessary information but needed to be clearer in some cases. Presenters conducted themselves professionally but were a bit rough around the edges.

3 - Good:
Ready to proceed/fund for next phase, with several minor design issues that can be resolved in the next phase of the project. Forward work plan should resolve any key requirements that are not currently satisfied. The engineering design and analysis is at an acceptable level of maturity for the current phase. (If applicable for flight competition; the manufacturing and testing approach has some gaps). Project has good potential and worth pursuing but would defer investment decision until next technical review milestone.

Presentation was understandable but had some significant flaws. Audio and visual presentations were redundant or inconsistent at times. Plots and tables were sometimes confusing. Presenters were largely professional but appeared inadequately prepared in some cases.

2 - Marginal:
Proceed to next phase with caution. Some major design challenges/issues that must be resolved at start of the next phase. A forward work plan is in place to address these technical issues. The engineering design and analysis has significant gaps. (If applicable for flight competition; manufacturing and testing approach is largely incomplete). Project has fair potential to succeed with focused effort in next phase.

Presentation was not fully understandable, required significant clarification in Q&A. Audio and visual presentations, plots, and tables covered the material inefficiently and lacked clarity. Presenters were less than professional and marginally prepared.

1 - Unsatisfactory:
Not approved to proceed to next phase. Many major design issues. Conceptual design unlikely to satisfy key requirements. Inadequate engineering design and analysis. End further project development.

Presentation was largely incomplete and/or significantly flawed. Presented material had major gaps and errors. Presenters were unprofessional and poorly prepared.

Category	Evaluation (1 to 5 or NA)	Comments
Project Description/CONOPS		
Executive Summary, Mission Description, Purpose, Profile		

Requirement Definition		
Key Design Drivers, Primary Requirements, Derived Requirements, Requirement Verification		
Project Model		
Need Identification, Business/Project Case, Heritage/Peer Competitor Designs, Market/Customers, Value Proposition, Awareness of Broader Impacts		
System Development and Design		
Overall Vehicle Concept including subsystem design, Vehicle Layout with Critical Dimensions and Interfaces, Identification of Critical Components		
System Analyses		
Flight/Orbit/Trajectory Analysis: *Aerodynamics, Trajectory/Orbit, Power/Propulsion*		
Stability/Control Analysis: *Static Margin, Control Surfaces, Guidance Systems*		
Weight/Structural Analysis: *Mass Budget, Materials, Strength, CG, Manufacturability*		
Avionics/Communication Analysis: *Components, Layout, Functionality, Power Budget*		
Other Critical Subsystem Analysis (*as applicable*)		
Risk Assessment / Mitigations: *Operational, Developmental/Project, Broader Impacts*		
Manufacturing/Testing (*as applicable*)		
Technical Analysis, Simulation, and Modeling Tools Selection and Application		
Manufacturing/Assembly/Prototyping		
Physical Testing Approach, Results, Analysis, including Prototype Testing		
Requirement Compliance		
Performance and Key Requirement Compliance Assessment, Issue Identification, Forward Issue Resolution Plans		
Technical Management/Planning		
Team Management/Roles, Project Schedules w/Key Milestones, Cost Budget, Financial Plan		
Overall Student Team Project Assessment	**(1 to 5)**	
Quality of System Development Process		
Quality of Overall Design for Technical Review Milestone		

Category	Evaluation (1 to 5 or NA)	Comments
Presentation/Communication Skills		
Speaks clearly, audibly, and directly to the audience		
Presents ideas in a well-organized and clear manner		
Communicates with audio / visual aids, including clear graphics & models / demonstrations		

Presents in a professional manner including vocabulary, language style, and appearance		
Responds effectively to questions		
Demonstrates collaborative work activity and project focus		
Quality of Overall Presentation Skills		
ABET Assessment	**(1 to 5)**	
Design meets identified needs and considers some non-technical aspects like cost, safety, public welfare and/or financial, cultural, economic, societal, or environmental impacts		
Team recognizes ethical and professional responsibilities, including safety and broader impacts on society, culture, economy, and/or the environment.		
Team evidences an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.		

<u>Other Comments</u>:

AEME ABET Assessment Review Form

This form is a summary of the collective departmental review of learning outcome assessment, to be used to record review group thoughts about assessment materials collected.

Program (AE or ME): AE   Date materials reviewed: 11/11/2023

Criterion reviewed (circle one): 1 2 3 4 5 6 **7**

an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Semester(s) reviewed: Fall 2022, Spring 2023 (primarily)

Reviewers: Alexander, Babaiasl, Condoor, Gururajan, Jayaram, LeBeau, Ma, Marmolejo, Swartwout

Courses and instruments:

Course	Semester	Description (ind/Grp)	Level		
ESCI/SE 1700	AE (F); ME (F)	Bibliography Exercise	Early Formative		
AENG 3150	AE (F)	Case study	Middle Formative		
AENG 4014	AE (S)	Final Presentation (group)	Late Summative		

Strengths and weaknesses:
Library personnel participation is effective for students
Students generally demonstrate appropriate library and bibliography skills
New knowledge acquisition comes naturally in AENG 4004/4014 as projects advance, need to create a better means of tracking this process.

Recommendations and proposed actions:
Consider if AENG 3150 assignment should move to AENG 3050/4050
Examine incorporating Cura Personalis 3 artifacts
Need improved/additional artifacts for senior design projects

Other comments:
This was the first review of this outcome under the newly revised assessment plan of August 2022.

Learning Outcome: 1 (Solve Problems using SEM) 2 (Design in Global Context) 3 (Effective Communication)
[select 1] 4 (Ethics in Global Context) 5 (Functional Teamwork) 6 (Experiment and Draw Conclusions)
7 (Lifelong Learning)

Course: ESCI 1700 (Engineering Fundamentals) (Fall 2022)

Location in Program: Early Middle End

Method: *As part of their design project, students were tasked with creating bibliographies. The bibliographies were separately submitted by each student. In the assignment, students were required to identify a research question, find 3 sources that addressed the question and justify their inclusion. The students also had to find and implement a citation style appropriate to their work (e.g., an AIAA or ASME style). Successful completion of this assignment required them to define an open-ended question and use the SLU library system for collecting the information and finding the citation style, all of which are evidence of early achievement in lifelong learning.*

Rubric: *A standardized rubric was used (included). The instructor for the student's section graded the assignment using the rubric. For each of three research questions, the student was graded on the quality of the research question relative to the design project (6pts), finding 3 relevant sources using the library (12 pts) and justifying the relevance of each source (9 pts) – 81 points total. An additional 9 points were for finding and implementing a technical citation style.*

Desired result: 70% of students will meet expectations (defined as scoring 80% or higher in the rubric)

Student performance: 27 of 28 students submitted the assignment
24 of 27 assignments were graded using the rubric
20 of 24 graded assignments (83%) met expectations

Observations: *Among those graded, the average score was 90% and the median was 96%. Three of the four who submitted the assignment but did not meet expectations were well below the threshold (73%, 66% and 56%, respectively). Generally speaking, those who did not meet expectations did not follow the assignment requirements, leaving parts blank and/or substituting general web searches for archival journal/article searches.*
It is observed that entry-level engineering students have been well-trained in gathering bibliographies and citing sources. They had little problems completing this assignment, and scored quite well compared to other parts of the design project.
The course had 150 students across 7 sections and 5 instructors, with the 28 AENG students scattered among all the sections. One of the instructors chose not to use the rubric in grading the assignment.

Program Assessment:
Assuming that the results are valid, then perhaps we can expect more of our entry-level students.
Action: *[Recommended responses]*

Student	Library Assignment (Part 2: Bibliography) (225427)	
Points Possible	**90**	
AE1	85	Meets Expectations
AE2	66	Does Not Meet Expectations
AE3	79	Meets Expectations
AE4	87	Meets Expectations
AE5	80	Meets Expectations
AE6	59.5	Does Not Meet Expectations
AE7	90	Meets Expectations
AE8	87	Meets Expectations
AE9	90	Meets Expectations
AE10	89	Meets Expectations
AE11	69.5	Does Not Meet Expectations
AE12	81	Meets Expectations
AE13	89	Meets Expectations
AE14		
AE15	90	Meets Expectations
AE16	85.5	Meets Expectations
AE17		
AE18	50	Does Not Meet Expectations
AE19		
AE20	88	Meets Expectations
AE21	87	Meets Expectations
AE22	87	Meets Expectations
AE23	87	Meets Expectations
AE24	81	Meets Expectations
AE25		
AE26	88.5	Meets Expectations
AE27	86.5	Meets Expectations
AE28	82	Meets Expectations

2/27/23, 12:52 PM Library Bibliography Rubric

Criteria	Ratings					Pts
First Research Question The research question is a) relevant to your part of the project, b) involves a question to be answered or something to be learned, and c) is narrow enough that it can be resolved with a search.	**6 pts** **Full Marks**	**5 pts** **Some answers are incomplete or missing**	**4 pts** **Mostly there**	**2 pts** **Lots of missing items**	**0 pts** **Didn't do this**	6 pts

Second Research Question The research question is a) relevant to your part of the project, b) involves a question to be answered or something to be learned, and c) is narrow enough that it can be resolved with a search.	**6 pts** **Full Marks**	**5 pts** **Some answers are incomplete or missing**	**4 pts** **Mostly there**	**2 pts** **Lots of missing items**	**0 pts** **Didn't do this**	6 pts
Third Research Question The research question is a) relevant to your part of the project, b) involves a question to be answered or something to be learned, and c) is narrow enough that it can be resolved with a search.	**6 pts** **Full Marks**	**5 pts** **Some answers are incomplete or missing**	**4 pts** **Mostly there**	**2 pts** **Lots of missing items**	**0 pts** **Didn't do this**	6 pts
Reference 1-1 [Note: the first number is the question, the second is the reference] The reference is from a Libraries search, and addresses the research question (Repeat for references 1-2, 1-3, 2-1, 2-2, 2-3, 3-1, 3-2, 3-3)	**4 pts** **Full Marks**	**3 pts** **Library search but relevance is iffy**	**2 pts** **Not from a library search**	**1 pts** **Not from the library, doesn't seem to address the question**	**0 pts** **Didn't do this**	4 pts

Explanation for Reference 1-1 [Note: the first number is the question, the second is the reference] Explains why this reference was selected and what was learned (Repeat for references 1-2, 1-3, 2-1, 2-2, 2-3, 3-1, 3-2, 3-3)	**3 pts** **Full Marks**	**2.5 pts** **Decent effort, but incomplete answers**	**1.5 pts** **Only did 1 of the 2 (why selected or what was learned)**	**0 pts** **Didn't do this**	3 pts

Found a technical citation style	**3 pts** **Full Marks**	**2.5 pts** **Found a style, but it's not a technical one**	**0 pts** **Did not cite a style**	3 pts

Implemented the Style consistently	**6 pts Full Marks**	**5 pts Mostly there**	**3 pts A few egregious mistakes**	**0 pts Wildly inconsistent or no style evident**	6 pts
Total Points: 90					

Learning Outcome: 1 (Solve Problems using SEM) 2 (Design in Global Context) 3 (Effective Communication)
[select 1] 4 (Ethics in Global Context) 5 (Functional Teamwork) 6 (Experiment and Draw Conclusions)
7 (Lifelong Learning)

Course: AENG 3150 (Astrodynamics) (Spring 2023)

Location in Program: Early Middle End

Outcome to Assess: *an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.*

Method: *Students are assigned an open-ended case study to choose an aerospace contractor or a space mission and answer specific questions. These questions require that the students pull information from a variety of sources (technical, financial, biographical).*

Rubric: *Students are assessed on their ability to find and cite sources concerning technical, financial and biographical information, and to interpret that information to answer questions.*

Desired result: 70% of students will score at least 80% on the rubric.

Student performance: 21 of 25 students met expectations (84%)
- 19 of 25 students exceeded expectations (scored > 90%)
4 students did not meet expectations
- 3 of those students did not participate
- 1 student participated but did not meet expectations

Observations:
- The student who did not meet expectations did not read the instructions; they chose to use their own template and did not address the questions.
- When given specific questions to answer, students are able to find basic sources of information and answer questions about it.
- Given that the overwhelming majority of students exceeded expectations, it may be worthwhile to further refine the rubric. There's not much that can be gleaned from the information as is.

Program Assessment: *Is this an outlier (small sample size) or a cause for concern?*

Action: *Further refine the rubric*

Copy of the assignment
Case Study of Spacecraft Contractor.

- **Topic** [1 pt]: Find a ***space mission*** or ***contractor*** that interests you. Please review the other parts of the assignment before settling on a topic. If you cannot find sufficient information, you will need to change topics.
    - A ***contractor*** is an organization that builds all or part of a space mission, such as: the spacecraft, the reaction wheels on the spacecraft, the launch vehicle, the on-board thrusters, the mission control center.

- Examples:
    - Missions: Galileo, OneWeb [*the constellation*], Curiosity, Ingenuity, MEV-1
    - Contractors: OneWeb [*the company*], SpaceX, Blue Canyon, Virgin Orbit, Ball Aerospace, Aerojet, MOOG. [I can provide guidance if you're unsure.]
    - "NASA" or "Boeing" are too big for this project; if you want to study something big like that, pick one of their missions. (For example, you could look at NASA's ISS Mission Operations center.)

- **Schedule** [10 pts]: Provide a brief overview of the mission or contractor
    - Contractor: When did the company start? What did they make when they started, and has the product line changed since then? How large is the company, today?
    - Mission: What was the purpose of this mission? Has it changed from its inception? What were the main contractors on the mission? What are the key points in the mission timeline (from the start of the contract until today)?

- **Cost** [5 pts]: Provide rough estimates of the financials (annual sales of the company, total cost of the mission).
  [***Pro Tip***: if you say that you can't find the financial data for a contractor, and I go over to Yahoo! Finance and find the financial data in 30 seconds, you're not getting points for this part.]
- **Performance** [10 pts]: Identify similar/competing missions/contractors.
    - Contractor: What other companies do the the things that this company does, and how do they distinguish themselves from the competition (i.e., stay in business)?
    - Mission: Is this mission part of a series of missions (e.g., the search for life on Mars)? In what unique ways does this mission contribute? (In other words, why spend money on this new mission when the other missions were already paid for?)

- **Risk** [5 pts]: What challenges has the mission or contractor overcome? Typical challenges are ***cost-related*** (budget overruns, bankruptcy or near-bankruptcy), ***schedule-related*** (projects running late), and/or ***performance-related*** (things break or don't work as expected).
- **Careers** [10 pts]: Identify one person (if able) or type of job that is performed at this company. How would one go from where you are now to holding that job? (Education, skills training, personal abilities.)
  [***Pro Tip***: as with the cost category, if you say that you can't find anyone on the Galileo project, but I type "NASA Galileo Chief Engineer" and notice that Rob Manning is in the first 10 responses, you're not getting any points for this part.]
- **Quality** [4 pts]: The report should be on the order of 3 pages (750 words), submitted in PDF format.
- **Je Ne Sais Quoi** [5 pts]: For going above and beyond the assignment, including reflecting on what you've learned.

Rubric

10 pts **Thorough**	**9 pts** **Good**	**7 pts** **Incomplete** Didn't answer one of the questions	**5 pts** **Very Incomplete** Only answered one question	**3 pts** **Minimal** There's something written down	**0 pts** **Missing**

Schedule

- Contractor: When did the company start? What did they make when they started, and has the product line changed since then? How large is the company, today?
- Mission: What was the purpose of this mission? Has it changed from its inception? What were the main contractors on the mission? What are the key points in the mission timeline (from the start of the contract until today)?

Cost

Estimate the financials

Performance

- Contractor: What other companies do the things that this company does, and how do they distinguish themselves from the competition (i.e., stay in business)?
- Mission: Is this mission part of a series of missions (e.g., the search for life on Mars)? In what unique ways does this mission contribute? (In other words, why spend money on this new mission when the other missions were already paid for?)

Risk

What were the setbacks?

Careers

Identify one person (if able) or type of job that is performed at this company. How would one go from where you are now to holding that job? (Education, skills training, personal abilities.)

Learning Outcome: 1 (Solve Problems using SEM) 2 (Design in Global Context) 3 (Effective Communication)
[select 1] 4 (Ethics in Global Context) 5 (Functional Teamwork) 6 (Experiment and Draw Conclusions)
7 (Lifelong Learning)

Course: AENG 4014 Flight Vehicle Analysis and Design II (S2023)

Location in Program: Early Middle Late

Learning Outcome 7: an ability to acquire and apply new knowledge as needed, using appropriate learning strategies

Instrument: Assessment of industry review panel of team student presentations at the end of the semester.

Methodology: Each senior design team makes a presentation about their work at the end of e spring semester, approximately equivalent to a detailed/protoype design review. This presentation is evaluated by a panel of professional engineers from industry. The relevant evaluation item for this SLO is:
Team evidences an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Rubric: The evaluation uses a scale of 1 – Unsatisfactory, 2 – Marginal, 3 – Good, 4 – Excellent, and 5 – Outstanding.

Desired result: 70% of teams scoring at or above 3.0

Students assessed: There were ten teams ranging from 1-7 students for a total of 44 students. One student was a mechanical engineering major, one was an engineering physics major, the rest aerospace engineering majors. As this is a team score, it is not feasible to disaggregate the non-aerospace majors from this assessment.

Student performance: averaged panel score for each team, from highest to lowest, were:
5.0, 4.5, 4.5, 4.5, 4.0, 4.0, 4.0, 3.5, 3.0, 3.0

Observations: The projects had advanced to a level where many teams naturally discussed the acquisition of new knowledge and its application. The team designs in general naturally required the development of this additional knowledge. Build teams typically also had to develop new skills related to construction and testing. Overall, this topic naturally flows from senior design projects and improves from first to second semester.

Assessment: Ten of ten teams achieved the target of 3.0.

Proposed Action: The planned inclusion of the core Cura Personalis 3 course into AENG 4004 might be a good opportunity for an individual assessment of this outcome using the proposed reflection paper. An individual assessment of new knowledge and skills required for the project might also be a useful reference.

OVERALL EVALUATION GUIDELINES METRIC
(Used for Panel Assessment)

5 - Outstanding:

Ready to proceed to next phase. No apparent design issues. Analysis clearly demonstrates that the key requirements can be satisfied. A portion of the engineering work (design, analysis and developmental testing) is already at the level of maturity for the next phase. (If applicable for flight competition; the manufacturing and testing approach is good). Would definitely invest in project funding.

Presentation was clear and well-organized. Audio and visual presentations complemented each other and enhanced understanding. Plots and tables were easily understood. Presenters conducted themselves in a professional manner.

4 - Excellent:

Ready to proceed for next phase. A few minor design issues that can be easily resolved in next phase of project. Analysis demonstrates that the key requirements can be satisfied. The engineering design and analysis is at high level of maturity for the current phase. (If applicable for flight competition; the manufacturing and testing approach is acceptable.) Would likely invest in project after getting more information about the design.

Presentation was mostly clear and well-organized, but occasionally incomplete or confusing. Audio and visual presentations enhanced overall understanding. Plots and tables provided the necessary information but needed to be clearer in some cases. Presenters conducted themselves professionally but were a bit rough around the edges.

3 - Good:

Ready to proceed/fund for next phase, with several minor design issues that can be resolved in the next phase of the project. Forward work plan should resolve any key requirements that are not currently satisfied. The engineering design and analysis is at an acceptable level of maturity for the current phase. (If applicable for flight competition; the manufacturing and testing approach has some gaps). Project has good potential and worth pursuing but would defer investment decision until next technical review milestone.

Presentation was understandable but had some significant flaws. Audio and visual presentations were redundant or inconsistent at times. Plots and tables were sometimes confusing. Presenters were largely professional but appeared inadequately prepared in some cases.

2 - Marginal:

Proceed to next phase with caution. Some major design challenges/issues that must be resolved at start of the next phase. A forward work plan is in place to address these technical issues. The engineering design and analysis has significant gaps. (If applicable for flight competition; manufacturing and testing approach is largely incomplete). Project has fair potential to succeed with focused effort in next phase.

Presentation was not fully understandable, required significant clarification in Q&A. Audio and visual presentations, plots, and tables covered the material inefficiently and lacked clarity. Presenters were less than professional and marginally prepared.

1 - Unsatisfactory:

Not approved to proceed to next phase. Many major design issues. Conceptual design unlikely to satisfy key requirements. Inadequate engineering design and analysis. End further project development.

Presentation was largely incomplete and/or significantly flawed. Presented material had major gaps and errors. Presenters were unprofessional and poorly prepared.

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ABET Assessment	**(1 to 5)**	
Design meets identified needs and considers some non-technical aspects like cost, safety, public welfare and/or financial, cultural, economic, societal, or environmental impacts		
Team recognizes ethical and professional responsibilities, including safety and broader impacts on society, culture, economy, and/or the environment.		
Team evidences an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.		

Other Comments: