Integrating Electric Propulsion Standards into Aerospace Education

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Project Goal

- Increase student knowledge of the relationship between electric propulsion technologies and the applicable standards related to design and airworthiness.

Lesson Modules and Their Standards

- Airworthiness Requirements for Electric Propulsion, based on ASTM F3239-22.
- Minimum Design Requirements for Electric Propulsion, based on ASTM F3338-21.

Module Components

- A lesson plan document outlining instructional objectives, aligned standards, student engagement strategies, and content structure.
- A scripted narrative to accompany instructor delivery or self-paced study.
- Short instructional videos to reinforce core concepts and provide visual explanations.
- A bank of at least ten assessment questions per module, formatted as multiple choice, allowing instructors flexibility in classroom use or remote learning.
- A printable and digital lesson module card with key topic highlights and a link to supporting resources.
- Supporting linked resources for students and faculty.

Airworthiness Requirements for Electric Propulsion

- Introduction to Airworthiness Requirements for Electric Propulsion (with and without captions): 2:57 minutes with 10 assignment questions.
- Terminology in ASTM F3239 (with and without captions): 3:56 minutes with 10 assignment questions.
- Requirements in ASTM F3239 (with and without captions): 5:15 minutes with 10 assignment questions.

Minimum Design Requirements for Electric Propulsion

- Introduction to Minimum Requirements for Electric Propulsion (with and without captions): 4:56 minutes with 10 assignment questions
- Terminology in ASTM 3338 (with and without captions): 3:34 minutes and 10 assignment questions.
- Requirements and Ratings in ASTM F3338-24 (with and without captions): 5:03 minutes and 10 assignment questions.
- Endurance and Durability Testing in ASTM F3338 (with and without captions): 3:37 minutes and 10 assignment questions.

Pilot Testing

- The pilot phase involved 49 students across multiple course sections.
- Data was collected through:

  Student responses to assessment items.

  Feedback surveys regarding instructional clarity, engagement, content relevance, and the website.

  In-class performance and participation metrics.

Assessment Analysis

- Cronbach's Alpha (Internal Consistency): 0.80, indicating a strong level of reliability
- Overall Mean Score: 27.33 out of 30 points (91.1%)
- Standard Deviation: 3.15 points
- Each item consistently demonstrated acceptable PBS values (> 0.15), indicating that questions effectively distinguished between high- and low-performing students. Mean scores ranged between 0.67 (67%) and 0.94 (94%), with 24 out of 30 mean scores over 0.90 (90%).

Item Analysis *(slide 1 of 2)*

Airworthiness Requirements for Electric Propulsion

Question	Mean Score	Standard Deviation	PBS
TITLE: AIRWORTHINESS REQUIREMENTS FOR ELECTRIC PROPULSION			
Topic 1: Introduction to Airworthiness Requirements for Electric Propulsion			
1. Why are industry standards important in making air travel safer?	0.92	0.02	0.26
2. Who certifies the safety of civilian aircraft in the United States?	0.92	0.10	0.30
3. What types of flights fall under 'general aviation' in the United States?	0.80	0.00	0.36
4. How does the FAA share information about safety updates and recommendations?	0.93	0.09	0.50
Topic 2: Terminology in ASTM F3239			
5. Why must each engine on an electric aircraft have an independent energy source?	0.91	0.11	-0.08
6. What is one important requirement for an energy system on an electric aircraft?	0.91	0.10	0.00
7. What types of hazards must electric aircraft systems be protected against?	0.81	0.14	0.39
8. Which part of the aircraft must be carefully controlled and monitored according to the standards?	0.91	0.10	0.00
Topic 3: Requirements in ASTM F3239			
9. Why are standards and FAA guidelines compared to 'pieces of a puzzle'?	0.92	0.10	0.19
10. What is the main purpose of the 'Terminology' section in the standards?	0.91	0.10	0.25
11. What does an electric propulsion system mainly do?	0.91	0.10	0.00
12. What is the energy storage system most like in a regular gasoline aircraft?	0.91	0.10	0.00
13. Why do we need standard definitions like 'capacity' and 'quantity'?	0.91	0.10	0.00

Item Analysis *(slide 2 of 2)*

Minimum Design for Electric Propulsion

Question	Mean Score	Standard Deviation	PBS
TITLE: MINIMUM DESIGN FOR ELECTRIC PROPULSION			
Topic 1: Introduction to Minimum Requirements for Electric Propulsion			
14. What is the main purpose of endurance and durability testing?	0.92	0.09	0.53
15. What does the over torque test check for?	0.92	0.09	0.45
16. What happens in a rotor locking test?	0.93	0.09	0.47
17. What is the purpose of the final teardown inspection?	0.91	0.11	0.02
18. Why are electric aircraft considered to be more environmentally friendly?	0.67	0.08	0.60
Topic 2: Terminology in ASTM F3338			
19. Which organization in the U.S. is responsible for certifying electric aircraft?	0.67	0.08	0.62
20. What is the purpose of the “special conditions” created by the FAA for electric engines?	0.80	0.10	0.26
21. Which of the following is an example of an electric aircraft used for pilot training?	0.94	0.09	0.47
22. Why is there pressure to create more specific rules for electric aircraft certification?	0.92	0.09	0.48
Topic 3: Requirements and Ratings in ASTM F3338			
23. Why is it important for engine parts to have defined limits and ratings?	0.87	0.09	0.49
24. What does ‘overspeed protection’ ensure in an electric engine?	0.94	0.07	0.64
25. What are the critical parts in an electric engine?	0.92	0.09	0.53
26. Why is safety analysis important in electric engine design?	0.92	0.10	0.39
Topic 4: Endurance and Durability Testing in ASTM F3338-24			
27. Why is using common definitions important in aviation?	0.93	0.09	0.55
28. What is the main difference between an electric engine and a motor?	0.93	0.09	0.42
29. What is ‘takeoff power’ in simple terms?	0.92	0.09	0.43
30. Which of the following is an example of periodic duty?	0.94	0.09	0.56

Post Pilot Test Refinements

- Improve the clarity of specific assessment items.
- Increase alignment with the specific language used in ASTM standards and FAA rulemaking documents.
- Improve the website's layout for better usability and navigation, ensuring that educators can quickly locate and integrate lesson materials into their course platforms

Distribution

- A public website.
- Conference presentations and journal publications at professional networks such as the American Society of Engineering Education (ASEE), University Aviation Association (UAA), and Aviation Technician Education Council (ATEC).

Aviation Technician Education Council (ATEC)

Yother, T., & Johnson, M. E. (2024, March). Elevate A&P coursework with electric engine standards. Oral Presentation. Aviation Technician Education Council Annual Conference, Tucson, AZ, United States

University Aviation Association (UAA)

Yother, T., & Johnson, M. (in review). Perceptions of the inclusion of electric propulsion curriculum in collegiate aviation maintenance programs by faculty and industry professionals. Collegiate Aviation Review International.

Elevate A&P Coursework with Electric Engine Standards (ATEC Presentation)

Group Response to "What student outcomes do you think should be considered to include electric propulsion in your aviation maintenance programs?"

- What student outcomes do you think should be considered to include electric propulsion in your aviation maintenance programs?

  High voltage/amp/torque safety

    Manual disconnect

  Weight and balance

    Weight should stay more stable since fuel isn't being burned

    Max take off weight (may need to be lower) vs landing weight

  High amp electrical connections

    Different connectors

    Different testing equipment

  Battery management and storage

  System reliability (how will it change the reliability of the aircraft)

  How do we handle changes in materials, configurations, etc for batteries (and other equipment)

  "Refueling" methods. Standard connectors, charging systems

  Aircraft infrastructure (charging and energy storage)

Publication

Perceptions of the inclusion of electric propulsion curriculum in collegiate aviation maintenance programs by faculty and industry professionals (Collegiate Aviation Review-International Journal) (pending publication)

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Website

Aircraft Electric Propulsion

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