UNSW Course Outline

AERO3660 Flight Performance and Propulsion - 2024

Published on the 15 Feb 2024

General Course Information

Course Code : AERO3660
Year : 2024
Term : Term 1
Teaching Period : T1
Is a multi-term course? : No
Faculty : Faculty of Engineering
Academic Unit : School of Mechanical and Manufacturing Engineering
Delivery Mode : Multimodal
Delivery Format : Standard
Delivery Location : Kensington
Campus : Sydney
Study Level : Undergraduate
Units of Credit : 6

Useful Links

Handbook Class Timetable

Course Details & Outcomes

Course Description

The course starts with an introduction to the atmosphere, especially the troposphere and lower stratosphere where aircraft spend most of their time. We discuss the difference between true and equivalent airspeeds. Then we introduce the basic equations that describe straight & level

flight.

You are introduced to the propeller as a means of propulsion. Propellers are often driven by reciprocating piston engines and so we discuss their behavior as well as the basics of chemical reactions and the behavior of gas mixtures.

Then we get back to flight mechanics introducing the basic equations that describe of climbing, gliding, and turning flight.

We introduce the fundamental equations associated with compressible flows, normal shocks, oblique shocks prior to looking at gas turbine engines.

Then we discuss the basic operation of helicopters and quad rotor drones. We give a very basic introduction to electric motors.

Finally, we return to flight mechanics again introducing the Breguet range equations, take-off, landing, and energy methods.

Course Aims

Both flight performance and propulsion is an important aspect of aerospace engineering education. The flight performance component will teach you how we analyse the performance of the aircraft. We can use the equations we develop to evaluate the thrust or power required by a aircraft to carry out particular manoeuvers. With this knowledge, we can choose propulsion systems to match this thrust or power requirement.

This course extends the basic thermodynamic and fluid mechanical principles which were learned in second year fluid mechanics and thermodynamics to aerospace engineering. The knowledge gained are crucial prerequisites for fourth year aerospace subjects.

Course Learning Outcomes

Course Learning Outcomes
CLO1 : Understand the difference between true and equivalent airspeeds.
CLO2 : Understand compressible flow analysis.
CLO3 : Apply mathematical analysis to predict flight performance and to recognise the short comings of analysis.
CLO4 : Understand the workings of modern propulsion systems (reciprocating piston engines, propellers, gas turbines)
CLO5 : Understand the thermodynamics of combustion and gas mixtures
CLO6 : Analyse the strengths and weaknesses of Cumpsty's approach in examining the behaviour of gas turbines.
CLO7 : Analyse the workings of helicopters, quadrotors and electric motors

Course Learning Outcomes	Assessment Item
CLO1 : Understand the difference between true and equivalent airspeeds.	• Final Exam • Assignment 1 • Assignment 2 • Bankstown Flight Experiments and Simulation
CLO2 : Understand compressible flow analysis.	• Final Exam • Assignment 1 • Assignment 2 • Bankstown Flight Experiments and Simulation
CLO3 : Apply mathematical analysis to predict flight performance and to recognise the short comings of analysis.	• Final Exam • Assignment 1 • Assignment 2 • Bankstown Flight Experiments and Simulation
CLO4 : Understand the workings of modern propulsion systems (reciprocating piston engines, propellers, gas turbines)	• Final Exam • Assignment 2 • Bankstown Flight Experiments and Simulation
CLO5 : Understand the thermodynamics of combustion and gas mixtures	• Final Exam • Assignment 2
CLO6 : Analyse the strengths and weaknesses of Cumpsty's approach in examining the behaviour of gas turbines.	• Final Exam • Assignment 2
CLO7 : Analyse the workings of helicopters, quadrotors and electric motors	• Final Exam • Assignment 2

Learning and Teaching Technologies

Moodle - Learning Management System

Additional Course Information

The use of AI (artificial intelligence) software will not be tolerated and will result in failure.

Assessments

Assessment Structure

Assessment Item	Weight	Relevant Dates
Final Exam Assessment Format: Individual	50%	Start Date: Not Applicable Due Date: Not Applicable
Assignment 1 Assessment Format: Individual	10%	Start Date: 12/02/2024 09:00 AM Due Date: 26/02/2024 09:00 AM
Assignment 2 Assessment Format: Individual	20%	Start Date: 01/04/2024 09:00 AM Due Date: 15/04/2024 09:00 AM
Bankstown Flight Experiments and Simulation Assessment Format: Individual	20%	Start Date: 18/03/2024 09:00 AM Due Date: 01/04/2024 09:00 AM

Assessment Details

Final Exam

Assessment Overview

Length: 2 hours

Course Learning Outcomes

- CLO1 : Understand the difference between true and equivalent airspeeds.
- CLO2 : Understand compressible flow analysis.
- CLO3 : Apply mathematical analysis to predict flight performance and to recognise the short comings of analysis.
- CLO4 : Understand the workings of modern propulsion systems (reciprocating piston engines, propellers, gas turbines)
- CLO5 : Understand the thermodynamics of combustion and gas mixtures
- CLO6 : Analyse the strengths and weaknesses of Cumpsty's approach in examining the behaviour of gas turbines.
- CLO7 : Analyse the workings of helicopters, quadrotors and electric motors

Assessment Length

2hrs

Submission notes

Solutions and working submitted via Moodle

Assessment information

The exam timetable will be published later in the session.

Criteria with marking rubric

Criteria: Markers will be looking for a logical and sensible solution. The use of AI software will not be tolerated and will result in failure.

Fail -

Pass -

Credit -

Distinction -

High Distinction -

Assignment submission Turnitin type

This is not a Turnitin assignment

Assignment 1

Assessment Overview

Introduction assignment to enable you to choose whether you want to continue with course. You will be expected to find mathematical solutions to problems and plot results on graphs. Length: 10-20 pages.

Results returned after two weeks along with feedback.

Course Learning Outcomes

- CLO1 : Understand the difference between true and equivalent airspeeds.
- CLO2 : Understand compressible flow analysis.
- CLO3 : Apply mathematical analysis to predict flight performance and to recognise the short comings of analysis.

Assessment Length

Shortish

Submission notes

Solutions and working submitted via Moodle

Criteria with marking rubric

Criteria: Markers will be looking for a logical and sensible solution. The use of AI software will not be tolerated and will result in failure.

Fail -

Pass -

Credit -

Distinction -

High Distinction -

Assignment submission Turnitin type

This is not a Turnitin assignment

Assignment 2

Assessment Overview

You will be expected again to find mathematical solutions to problems and plot results on graphs. Length: 10-20 pages.

Results returned after two weeks along with feedback.

Course Learning Outcomes

- CLO1 : Understand the difference between true and equivalent airspeeds.
- CLO2 : Understand compressible flow analysis.
- CLO3 : Apply mathematical analysis to predict flight performance and to recognise the short comings of analysis.
- CLO4 : Understand the workings of modern propulsion systems (reciprocating piston engines, propellers, gas turbines)
- CLO5 : Understand the thermodynamics of combustion and gas mixtures

- CLO6 : Analyse the strengths and weaknesses of Cumpsty's approach in examining the behaviour of gas turbines.
- CLO7 : Analyse the workings of helicopters, quadrotors and electric motors

Assessment Length

Longish but not too long

Submission notes

Solutions and working submitted via Moodle

Criteria with marking rubric

Criteria: Markers will be looking for a logical and sensible solution. The use of AI software will not be tolerated and will result in failure.

Fail -

Pass -

Credit -

Distinction -

High Distinction -

Assignment submission Turnitin type

This is not a Turnitin assignment

Bankstown Flight Experiments and Simulation

Assessment Overview

Bankstown Flight Experiments and Simulation

You will fly in a light aircraft flown by a pilot and read and record flight instruments to gather data so that you can estimate the flight parameters of the aircraft as well as estimate things like the flight ceiling of the aircraft. You will produce a structured report about 15-20 pages for marking.

Results returned after two weeks along with feedback.

You will operate the flight simulator under supervision to learn the basics of flying an aircraft and

how it differs from driving a car.

Course Learning Outcomes

- CLO1 : Understand the difference between true and equivalent airspeeds.
- CLO2 : Understand compressible flow analysis.
- CLO3 : Apply mathematical analysis to predict flight performance and to recognise the short comings of analysis.
- CLO4 : Understand the workings of modern propulsion systems (reciprocating piston engines, propellers, gas turbines)

Assessment Length

Longish

Submission notes

Solutions and working submitted via Moodle

Criteria with marking rubric

Criteria: Markers will be looking for a logical and sensible solution. The use of AI software will not be tolerated and will result in failure.

Fail -

Pass -

Credit -

Distinction -

High Distinction -

Assignment submission Turnitin type

This is not a Turnitin assignment

General Assessment Information

Grading Basis

Standard

Course Schedule

Attendance Requirements

Students are strongly encouraged to attend all classes and review lecture recordings.

General Schedule Information

Week 1, The Atmosphere, Airspeeds, Straight & Level Flight.

Week 2, Propellers.

Week 3, Chemical Reactions.

Week 4, Reciprocating Piston Engines, Gas Mixtures.

Week 5, Climbing Flight, Gliding Flight, Turning Flight.

Week 6, Flexibility Week

Week 7, Compressible Flows, Normal Shocks, Oblique Shocks.

Week 8, Gas Turbines.

Week 9, Helicopters, Quad Rotors, Electric Motors.

Week 10, Breguet Range Equations, Take-Off, Landing, Energy Methods

Course Resources

Prescribed Resources

E. Torenbeek & Wittenberg, 2002, Flight Physics, Essentials of Aeronautical Disciplines and Technology, with Historical Notes, Springer.

N. Cumpsty & A. Heyes, 2015, Jet Propulsion. A simple guide to the aerodynamic and thermodynamic design and performance of jet engines, 3rd edition, Cambridge University Press.

Recommended Resources

D. G. Hull, 2007, Fundamentals of airplane flight mechanics, Springer.

A. Terari, 2016, Basic Flight Mechanics: A Simple Approach Without Equations, Springer.

J. Kurzke & I. Halliwell, 2018, Propulsion and Power, Springer International Publishing AG.

A. Miele, 2016, Flight Mechanics, Theory of flight paths, Dover Publications Inc, Mineola, New York.

C. B. Millikan, 1941, Aerodynamics of the airplane, Dover Publications, Inc, Mineola, New York.

A. Filippone, 2012, Advanced aircraft flight performance, Cambridge University Press.

D. P. Raymer, 1992, Aircraft design: A conceptual approach, 2nd edition, AIAA, Washington, DC.

J. D. Anderson Jr., 2012, Introduction to flight, McGraw Hill, New York, 10020NY.

R. D. Archer & M. Saarlas, 1996, An introduction to aerospace propulsion, Prentice-Hall, Inc., Upper Saddle River, New Jersey, 07458.

D. F. Anderson & S. Eberhardt, 2010, Understanding flight, 2nd edition, McGraw Hill.

B. Gunston, 2006, The development of jet and turbine aero engines, 4th edition, Patrick Stephens Limited (an imprint of Haynes publishing).

B. Gunston, 1999, Development of piston aero engines, 2nd edition, Patrick Stephens Limited (an imprint of Haynes publishing).

K. Hünecke, 1997, Jet engines. Fundamentals of theory, design and operation, Airlife Publishing Limited, Shrewsbury, England.

A. Bejan, 2006, Advanced engineering thermodynamics, 3rd edition, John Wiley & Sons, Hoboken, New Jersey.

E. L. Houghton & P. W. Carpenter, 2003, Aerodynamics for engineering students, Butterworth-Heinemann (an imprint of Elsevier Science), Oxford.

J. A. Camberos & D. J. Moorhouse, 2011, Exergy analysis and design optimization for aerospace vehicles and systems, Editor-in-chief, F. K. Lu, Vol. 28, Progress in astronautics and aeronautics, AIAA, resto, Virginia.

M. H. Sadraey, 2013, Aircraft design, A systems engineering approach, Wiley.

G. Hoyland, 2020, Merlin, The Power Behind the Spitfire, Mosquito, and Lancaster, Williams

Collins.

G. Hoyland, 2022, Jet, The engine that changed the world, Key Books.

Q. Quan. 2017, Introduction to multicopter design and control, Springer.

J. G. Leishman, 2016, Principles of helicopter aerodynamics, 2nd edition, Cambridge Aerospacce Series, Cambridge University Press.

E. Torenbeek, 2013, Advanced aircraft design, Conceptual design, analysis and optimization of subsonic civil airplanes, John Wiley.

M. J. Moran, H. N. Shapiro, D. D. Boettner & M. B. Bailey, 2011, Fundamentals of engineering thermodynamics, 7th edition, John Wiley.

S. A. Brandt, R. J. Stiles, J. J. Bertin & R. Whitford, 2015, Introduction to Aeronautics, a design perspective, 3rd edition, AIAA.

J. L. Lumley, 1999, Engines, An Introduction, Cambridge University Press.

W. W. Pulkrabek, 2004, Engineering fundamentals of the Internal Combustion Engine, 2nd edition, Pearson Prentice Hall.

A. Schmidt, 2019, Technical thermodynamics for engineers, basics and applications, Springer. (Caveat: be very careful of the sign convention).

Y. A. Cengel, M. A. Boles & M. Kanoglu, 2019, Thermodynamics, an engineering approach, 9th edition, McGraw Hill Education.

Course Evaluation and Development

The ordering of the course has been changed. Now that COVID19 is no the threat it once was, the Bankstown flying exercises have been reinstated. The flight simulation exercises have also been reinstated.

Staff Details

Position	Name	Email	Location	Phone	Availability	Equitable Learning Services Contact	Primary Contact
Convenor	John Olsen		Ainsworth Building, 311C	9385 5217	during tutorials	No	Yes
Tutor	Zoran Vulovic		Ainsworth 311D	9385 6261	on-line	No	No

Other Useful Information

Academic Information

I. Special consideration and supplementary assessment

If you have experienced an illness or misadventure beyond your control that will interfere with your assessment performance, you are eligible to apply for Special Consideration prior to, or within 3 working days of, submitting an assessment or sitting an exam.

Please note that UNSW has a Fit to Sit rule, which means that if you sit an exam, you are declaring yourself fit enough to do so and cannot later apply for Special Consideration.

For details of applying for Special Consideration and conditions for the award of supplementary assessment, please see the information on UNSW's Special Consideration page.

II. Administrative matters and links

All students are expected to read and be familiar with UNSW guidelines and polices. In particular, students should be familiar with the following:

- Attendance
- UNSW Email Address
- Special Consideration
- Exams
- Approved Calculators
- Academic Honesty and Plagiarism
- Equitable Learning Services

III. Equity and diversity

Those students who have a disability that requires some adjustment in their teaching or learning environment are encouraged to discuss their study needs with the course convener prior to, or at the commencement of, their course, or with the Equity Officer (Disability) in the Equitable Learning Services. Issues to be discussed may include access to materials, signers or note-takers, the provision of services and additional exam and assessment arrangements. Early notification is essential to enable any necessary adjustments to be made.

IV. Professional Outcomes and Program Design

Students are able to review the relevant professional outcomes and program designs for their streams by going to the following link: https://www.unsw.edu.au/engineering/student-life/student-resources/program-design.

Note: This course outline sets out the description of classes at the date the Course Outline is published. The nature of classes may change during the Term after the Course Outline is published. Moodle or your primary learning management system (LMS) should be consulted for the up-to-date class descriptions. If there is any inconsistency in the description of activities between the University timetable and the Course Outline/Moodle/LMS, the description in the Course Outline/Moodle/LMS applies.

Academic Honesty and Plagarism

UNSW has an ongoing commitment to fostering a culture of learning informed by academic integrity. All UNSW students have a responsibility to adhere to this principle of academic integrity. Plagiarism undermines academic integrity and is not tolerated at UNSW. *Plagiarism at UNSW is defined as using the words or ideas of others and passing them off as your own.*

Plagiarism is a type of intellectual theft. It can take many forms, from deliberate cheating to accidentally copying from a source without acknowledgement. UNSW has produced a website with a wealth of resources to support students to understand and avoid plagiarism, visit: student.unsw.edu.au/plagiarism. The Learning Centre assists students with understanding academic integrity and how not to plagiarise. They also hold workshops and can help students one-on-one.

You are also reminded that careful time management is an important part of study and one of the identified causes of plagiarism is poor time management. Students should allow sufficient time for research, drafting and the proper referencing of sources in preparing all assessment tasks.

Repeated plagiarism (even in first year), plagiarism after first year, or serious instances, may also be investigated under the Student Misconduct Procedures. The penalties under the procedures can include a reduction in marks, failing a course or for the most serious matters (like plagiarism in an honours thesis or contract cheating) even suspension from the university. The Student Misconduct Procedures are available here:

www.gs.unsw.edu.au/policy/documents/studentmisconductprocedures.pdf

Submission of Assessment Tasks

Work submitted late without an approved extension by the course coordinator or delegated authority is subject to a late penalty of five percent (5%) of the maximum mark possible for that assessment item, per calendar day.

The late penalty is applied per calendar day (including weekends and public holidays) that the assessment is overdue. There is no pro-rata of the late penalty for submissions made part way through a day. This is for all assessments where a penalty applies.

Work submitted after five days (120 hours) will not be accepted and a mark of zero will be awarded for that assessment item.

For some assessment items, a late penalty may not be appropriate. These will be clearly indicated in the course outline, and such assessments will receive a mark of zero if not completed by the specified date. Examples include:

- Weekly online tests or laboratory work worth a small proportion of the subject mark;
- Exams, peer feedback and team evaluation surveys;
- Online quizzes where answers are released to students on completion;
- Professional assessment tasks, where the intention is to create an authentic assessment that has an absolute submission date; and,
- Pass/Fail assessment tasks.

Faculty-specific Information

Engineering Student Support Services – The Nucleus - enrolment, progression checks, clash requests, course issues or program-related queries

Engineering Industrial Training – Industrial training questions

UNSW Study Abroad – study abroad student enquiries (for inbound students)

UNSW Exchange – student exchange enquiries (for inbound students)

UNSW Future Students – potential student enquiries e.g. admissions, fees, programs, credit transfer

Phone

(+61 2) 9385 8500 – Nucleus Student Hub

(+61 2) 9385 7661 – Engineering Industrial Training

(+61 2) 9385 3179 – UNSW Study Abroad and UNSW Exchange (for inbound students)

School-specific Information

Short Extensions

Short extensions are not currently applicable to Mechanical and Manufacturing Engineering Courses.

Review of Results

The purpose of a review of results is if there was a marking error. Review of results is for when you have cause to believe that there is a marking error. Review of Results cannot be used to get feedback. If you would like feedback for assessments prior to the final exam, you are welcome to contact the course convenor directly. No feedback will be provided on final exams.

Use of AI

The use of AI is prohibited unless explicitly permitted by the course convenor. Please respect this and be aware that penalties will apply when unauthorised use is detected, such as through Turnitin. If the use of generative AI, such as ChatGPT, is allowed in a specific assessment, they must be properly credited, and your submissions must be substantially your own work.

School Contact Information

Location

UNSW Mechanical and Manufacturing Engineering

Ainsworth building J17, Level 1

Above Coffee on Campus

Hours

9:00–5:00pm, Monday–Friday*

*Closed on public holidays, School scheduled events and University Shutdown

Web

School of Mechanical and Manufacturing Engineering

Engineering Student Support Services

Engineering Industrial Training

UNSW Study Abroad and Exchange (for inbound students)

UNSW Future Students

Phone

(+61 2) 9385 8500 – Nucleus Student Hub

(+61 2) 9385 7661 – Engineering Industrial Training

(+61 2) 9385 3179 – UNSW Study Abroad and UNSW Exchange (for inbound students)

(+61 2) 9385 4097 – School Office**

**Please note that the School Office will not know when/if your course convenor is on campus or available

Email

Engineering Student Support Services – current student enquiries

- e.g. enrolment, progression, clash requests, course issues or program-related queries

Engineering Industrial Training – Industrial training questions

UNSW Study Abroad – study abroad student enquiries (for inbound students)

UNSW Exchange – student exchange enquiries (for inbound students)

UNSW Future Students – potential student enquiries

- e.g. admissions, fees, programs, credit transfer

School Office – School general office administration enquiries

- NB: the relevant teams listed above must be contacted for all student enquiries. The School will only be able to refer students on to the relevant team if contacted

Important Links

- Student Wellbeing
- Urgent Mental Health & Support
- Equitable Learning Services
- Faculty Transitional Arrangements for COVID-19
- Moodle
- Lab Access
- Computing Facilities
- Student Resources
- Course Outlines
- Makerspace
- UNSW Timetable
- UNSW Handbook