

# AEROSPACE ENGINEERING (LM52)

(Brindisi - Università degli Studi)

## Insegnamento AIRCRAFT POWERPLANT DESIGN AND MAINTENANCE C.I.

GenCod A005802

**Insegnamento** AIRCRAFT POWERPLANT DESIGN AND MAINTENANCE C.I. **Anno di corso** 2

**Insegnamento in inglese** AIRCRAFT POWERPLANT DESIGN AND

**Lingua** INGLESE

**Settore disciplinare** ING-IND/09

**Percorso** Percorso comune

**Corso di studi di riferimento** AEROSPACE ENGINEERING

**Docente** Antonio FICARELLA

**Tipo corso di studi** Laurea Magistrale

**Sede** Brindisi

**Crediti** 9.0

**Periodo** Primo Semestre

**Ripartizione oraria** Ore Attività frontale: 81.0

**Tipo esame** Orale

**Per immatricolati nel** 2019/2020

**Valutazione**

**Erogato nel** 2020/2021

**Orario dell'insegnamento**

<https://easyroom.unisalento.it/Orario>

### BREVE DESCRIZIONE DEL CORSO

AIRWORTHINESS AND ENVIRONMENTAL CERTIFICATION; The Design Process; Engine Selection: Parametric Cycle Analysis; Engine Selection: Performance Cycle Analysis; Engine Component Design: Rotating Turbomachinery, Concept, Design Tools; Engine Component Design: Combustion Systems, Concept, Main Burner, Afterburners; Aircraft Engine Controls - Engine Modeling and Simulation; Aircraft Systems.

### PREREQUISITI

#### Course Requirements

Knowledge of the operating principles of fluid machinery and fluid dynamics. Basic elements of design and technology of fluid machines. Knowledge of aircraft propulsion and the basic principles of flight mechanics.

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## OBIETTIVI FORMATIVI

### **Aims of the course**

(knowledge and understanding)

- Specialist knowledge of propulsion, advanced elements of mechanical design of aircraft engines.
- Knowledge of the internal fluid dynamics.
- Insights on design and technological features and performance of different types of engines.
- Insights into automatic controls and system design aimed at providing an integrated view of the aerospace product.
- Knowledge of advanced propulsion systems.
- Knowledge of specific technical terms in English.

(applying knowledge and understanding)

- Understanding of the main features of a project of the engine.
- Ability to perform sketches and preliminary dimensioning of the components of an aircraft engine.
- Ability to take action in the main stages the project of an aircraft engine.
- Advanced capabilities for the analysis of systems and control techniques.
- Ability to see the product in the form of system integrated complex.

(making judgements)

- Ability to analyze the mission requirements of the aircraft and to evaluate the necessary engine performance.
- Ability to understand the technological issues and system integration for the engine.
- Ability to understand the problems of research and development of an aircraft engine or of an aviation system.

(communication skills)

- Ability to communicate with experts in other fields of engineering for the integrated design of the engine.

(learning skills)

- Development of learning skills that enable to continue to study for the most part autonomously.
  - Availability update the acquired knowledge.
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## METODI DIDATTICI

Lectures; practical experiences in laboratories; homework (design project).

### **Laboratory**

Engine performance Lab, Engine Monitoring Lab.

<https://sites.google.com/site/greenenginelab2/home>

### **Homework (design project)**

Software applications for the design of aircraft engines and systems. Application examples and design of aircraft engines and systems. Turbofan, turbofans with high bypass ratio, turboprop propeller design. Systems for Civil and military aircraft, helicopters, light aircraft. Fluid-dynamics numerical simulations applied to engines and systems design.

<http://www.aircraftenginedesign.com/index.html> (free software)

<http://www.aircraftenginedesign.com/custom3.html>

[http://www.grc.nasa.gov/WWW/K-12/freesoftware\\_page.htm](http://www.grc.nasa.gov/WWW/K-12/freesoftware_page.htm)

<http://www.cfdsupport.com/openfoam-for-windows.html>

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## MODALITA' D'ESAME

### **Exam procedures**

The exam consists in the preparation of a Homework (design project) and an oral interview (even remotely carried out).

A design project related to aircraft engines or systems will be conducted. Homework assignments will be due at least one month before the examination. The deliverables are a written report (in digital format, with any files used for calculations and the relevant bibliography) and the discussion of the work. You must acknowledge all references (both literature and people) used; all the deliverables will be sent by email to the instructor at least 10 days before the oral examination. The oral examination consists of the discussion of the work of the year and a series of questions on the matters stated in the course program for the evaluation of acquired knowledge on the principles of operation of engines and aircraft systems, their performance and the principles of design and in general on the technologies of these systems.

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## APPELLI D'ESAME

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## ALTRE INFORMAZIONI UTILI

### **OTHER REFERENCES**

An Introduction to Combustion, McGrawHill.

Combustion Physics, Chung K. Law, Publisher: Cambridge University Press; ISBN-10: 0521870526, ISBN-13: 978-0521870528.

Performance of Light Aircraft (Aiaa Education Series), ISBN-10: 1563473305, ISBN-13: 978-1563473302, <http://www.amazon.com>.

Aerothermodynamics of Aircraft Engine Components, Author W. S. Blazowski, E.E. Zukoski, ISBN 978-1-60086-005-8, Publisher AIAA.

Flight Performance of Fixed and Rotary Wing Aircraft - Elsevier (Butterworth-Heinemann), Antonio Filippone, ISBN: 978-0-7506-6817-0, ISBN10: 0-7506-6817-2, [http://textbooks.elsevier.com/web/product\\_details.aspx?isbn=9780750668170](http://textbooks.elsevier.com/web/product_details.aspx?isbn=9780750668170).

Civil Jet Aircraft Design - Lloyd R. Jenkinson, Paul Simpkin, Darren Rhodes, AIAA Education Series, ISBN-10: 1-56347-350-X, ISBN-13: 978-1-56347-350-0, <http://www.aiaa.org/content.cfm?pageid=360&id=621>.

Elements of Propulsion: Gas Turbines and Rockets, Jack Mattingly, Hans von Ohain, AIAA Education Series, ISBN-10: 1-56347-779-3, ISBN-13: 978-1-56347-779-9, <http://www.aiaa.org/content.cfm?pageid=360&id=1343>, <http://www.amazon.com>.

Jeppesen Aircraft Gas Turbine Powerplants, Charles E. Otis, ISBN: 0884873110, [http://www.flightstore.co.uk/jeppesen\\_aircraft\\_gas\\_turbine\\_powerplants.pilot.books/use.id.10.item\\_id.585/](http://www.flightstore.co.uk/jeppesen_aircraft_gas_turbine_powerplants.pilot.books/use.id.10.item_id.585/).

Principles of Helicopter Aerodynamics (Cambridge Aerospace Series), J. Gordon Leishman, Cambridge University Press, ISBN-10: 0521858607, ISBN-13: 978-0521858601, <http://www.amazon.com>.

PPSG Volume 1 - Piston Engines & Supercharging, <http://shop.pilotwarehouse.co.uk/product222023catno0.html>.

Aircraft Gas Turbine Engine Technology, Irwin E Treager, ISBN-13 9780028018287, McGraw-Hill, <http://catalogs.mhhe.com/mhhe/viewProductDetails.do?isbn=0028018281>.

Flow and Combustion in Reciprocating Engines, Arcoumanis, C.; Kamimoto, Take (Eds.), SpringerLink, Hardcover, ISBN 978-3-540-64142-1, Softcover, ISBN 978-3-642-08385-3, <http://www.springer.com/materials/mechanics/book/978-3-540-64142-1>.

### **INTERNET RESOURCES**

<http://www.aircraftenginedesign.com/index.html>

<http://www.aircraftenginedesign.com/custom2.html>

**FLUID MECHANICAL DESIGN OF AIRCRAFT ENGINE TURBOMACHINERY**

Turbomachinery flow physics

Turbomachinery losses, Efficiencies, Blades

The Design Process.

*Aircraft Engine Design, cap. 1.*

propDESIGNPRO2

for further study:

Propulsion Technologies for Future Commercial Aircraft

Combustion for aerospace

Constraint Analysis.

Mission Analysis.

*Aircraft Engine Design, cap. 2 (no par. 2.2.2, 2.2.3, 2.2.4, 2.2.6, 2.2.7, 2.2.8, 2.2.9, 2.2.10, 2.2.11, 2.2.12).*

*Aircraft Engine Design, cap. 3 (no par. 3.2.1, 3.2.2, 3.2.3, 3.2.6, 3.2.7, 3.2.8, 3.2.9, 3.2.10, 3.2.11).*

propCONSTRAINTRA01

propMISSIONRO2

propEXAMPLE-CONSTRAINTRO0

*for in-depth analysis:*

*constraintSTRALCIO2*

*constraintEXAMPLESTRALCIO*

*missionSTRALCIO*

*missionEXAMPLESTRALCIO*

Aircraft Engine Efficiency and Thrust Measures.

*Aircraft Engine Design, app. E.*

propMEASURESRO2

Engine Selection: Parametric Cycle Analysis.

Engine Selection: Performance Cycle Analysis.

Sizing the Engine: Installed Performance.

*Aircraft Engine Design, cap. 4 (for 4.2.3, 4.2.4, 4.2.7 only concepts, no 4.3.4, 4.4 only concepts).*

*Aircraft Engine Design, cap. 5 (5.2.4, 5.2.5, 5.4 only concepts).*

*Aircraft Engine Design, cap. 6 (6.2.2, 6.3, 6.4 only concepts).*

propPARAMETRICRO3

propPERFORMANCERO3

propINSTALLEDRO3

propEXAMPLE-PARAMETRICRO0

Engine Component Design: Global and Interface Quantities. Concept, Design Tools, Engine Systems Design.

*Aircraft Engine Design, cap. 7.*

propENGINEDESIGNRO3

Engine Component Design: Rotating Turbomachinery. Concept, Design Tools.

*Aircraft Engine Design, cap. 8.*

propROTATINGRO8

**COMBUSTION**

Engine Component Design: Combustion Systems. Concept, Main Burner, Afterburners.

*Aircraft Engine Design, cap. 9 (no par. 9.1.4.5, 9.1.5.4, 9.3).*

propCOMBUSTIONRO5

propCOMBUSTIONEXAMPLER02

THE NEW FRONTIERS FOR THE CONTROL-FICARELLAslidesR31

*for in-depth analysis:*

propCOMBUSTIONEXAMPLESR02

Some important chemical mechanisms, Pollutant emissions.

*Combustion Physics, cap. 3. (no 3.10, 3.11, 3.12)*

propOXIMECHRO0

CFoxidationMechanismOfFuelsB

Droplet evaporation and burning.

*Combustion Physics, cap. 13. (no 13.4.3, 13.4.4, 13.8, 13.9)*

propCOMBUSTION2PHFLOWR00

CFCombustionInTwoPhaseFlow

Introduction to turbulent flow, Turbulent premixed flames, Turbulent non-premixed flames.

*Combustion Physics, cap. 11.*

propCOMBUSTIONTURFLOWR00

CFCombustionInTurbulenFlow

### **DESIGN AND PRODUCTION OF INNOVATIVE TURBOMACHINERY**

Material Properties.

SUPERALLOYS FOR TURBINES and MANUFACTURING METHODS.

*Aircraft Engine Design, app. M.*

*Turbo-Machinery Dynamics, chap. 11, 12.*

propMATERIALR01

propTMDsuperalloysR00

propTMDmanufacturingR00 *for in-depth analysis:*

Turbomachinery\_DynamicsCh11, Turbomachinery\_DynamicsCh12.

Fan and Compressor Airfoils.

Turbine Blade and Vane.

*Turbo-Machinery Dynamics, chap. 6. (no 6.12, 6.18)*

*Turbo-Machinery Dynamics, chap. 8.*

propTMDfecairfoilsR01

propTMDturbinebvR00

propTMDimpellerbdR01

*for in-depth analysis:*

Turbomachinery\_DynamicsCh06

Turbomachinery\_DynamicsCh08

Additive manufacturing.

INTRANET:

OK01-Whitis

OK02-Aerospace\_Broschuere\_WEB\_en

Combustion system.

*Turbo-Machinery Dynamics, chap. 9.*

propTMDcombsysR00

### **ENGINE CONTROL**

Engine Control Systems.

*Aircraft Systems: Mechanical,*

*Electrical and Avionics Subsystems*

*Integration, Chap. 2.*

*Aircraft Engine Design, app. O.*

*The Jet Engine (Rolls Royce), cap. 2.6.*

propASEngineControlR00

propCONTROLR00

Aircraft Engine Controls.

- Engine Modeling and Simulation.

*Aircraft Engine Controls, chap. 2.*

propAECmodelingR03

*for in-depth analysis:*

AIRCRAFT ENGINE CONTROLSch02

## AIRCRAFT ENGINE CONTROLSapp

Design of Set-Point Controllers. Design of Transient and Limit Controllers.

*Aircraft Engine Controls, chap. 4, chap. 5.*

propAECdesignspcR02

propAECtransientIRO1

*for in-depth analysis:*

AIRCRAFT ENGINE CONTROLSch04

AIRCRAFT ENGINE CONTROLSch05

Advanced Control Concepts.

*Aircraft Engine Controls, chap. 7.*

propAECadvancedR00

## **AIRWORTHINESS AND ENGINE HEALTH MANAGEMENT**

Turbine Engine Life Management.

*Aircraft Engine Design, app. N.*

propLIFEMANR01

Engine Monitoring and Health Management, Integrated Control and Health Monitoring.

*Aircraft Engine Controls, chap. 8.*

propAECmonitoringR01

INTRANET:

OK01-EASN\_2018\_R06

## AIRWORTHINESS AND ENVIRONMENTAL CERTIFICATION

- Aircraft Certification and Production Standards.

- Type Certificates.

- Rules for Initial Airworthiness.

- Certification Specification (CS).

INTRANET:

OK01-General publications \_ EASA

OK02-Easy Access Rules for Engines (CS-E) (Amendment 4)

OK03-EASA IM.E.126 EASA TCDS issue 04\_20150803\_1.0

OK04-EASA E.001\_TCDS\_issue 09\_20150708\_1.0

OK05-217487\_EASA\_EPAS\_2018

OK06-documentiR00

## **ADVANCED PROPULSION CONCEPTS**

Aircraft Reciprocating Engines

Hybrid propulsion, electric propulsion, more electrical engine and aircraft.

INTRANET:

OK01-25-TVF2018-Danis-ESAero-Jan191

OK02-3-hybrid-power-in-light-aircraft

OK03-Rodger-Dyson-NASA-Hybrid-Electric-Aircraft-Propulsion-10-4-2017-FULL

OK04-2bfa6572afc09ad13008ca74cefdb0a9b130

OK05-EASN2018\_DONATEO

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## TESTI DI RIFERIMENTO

### **COURSE BOOKS**

Aircraft Engine Design, Second Edition - Jack D. Mattingly, William H. Heiser, David T. Pratt, AIAA Education Series, ISBN-10: 1-56347-538-3, ISBN-13: 978-1-56347-538-2, <http://www.aiaa.org/content.cfm?pageid=360&id=975>, <http://www.amazon.com>.

Turbo-Machinery Dynamics: Design and Operations, A. S. Rangwala, S. Rangwala a., McGraw-Hill Professional Publishing, ISBN: 0071453695, ISBN-13: 9780071453691.

Aircraft Engine Controls: Design, System Analysis, and Health Monitoring, Link C. Jaw, Jack D. Mattingly, AIAA Education Series, ISBN-10: 1-60086-705-7, ISBN-13: 978-1-60086-705-7, <http://www.aiaa.org/content.cfm?pageid=360&id=1759>.

Aircraft Fuel Systems, Roy Langton, Chuck Clark, Martin Hewitt, Lonnie Richards, AIAA Education Series, ISBN-10: 1-56347-963-X, ISBN-13: 978-1-56347-963-2, <http://www.aiaa.org/content.cfm?pageid=360&id=1741>.

Design and Development of Aircraft Systems, 2nd Edition, Ian Moir, Allan Seabridge, ISBN: 978-1-1184-6914-9, E-book, November 2012, Wiley.

Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration, 3rd Edition, Ian Moir, Allan Seabridge, ISBN: 978-1-1199-6520-6, E-book, August 2011, Wiley.

Contact the instructor ([antonio.ficarella@unisalento.it](mailto:antonio.ficarella@unisalento.it)) for more lecture notes.