Università degli Studi della Basilicata
Scuola di Ingegneria

COURSE: Gasdynamics and Propulsion			
ACADEMIC YEAR: 2017-2018			
TYPE OF EDUCATIONAL ACTIVITY: Characteristic			
TEACHER: Aldo Bonfiglioli, Annarita Viggiano			
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Phone: +39.0971.205203, +39.0971.205204		mobile (optional):	
Language: Italian			
ECTS: 9	n. of hours: 81	Campus: Potenza School: Engineering Program: Mechanical Engineering (II level)	Semester: first (6 ECTS) and second (3 ECTS)

EDUCATIONAL GOALS AND EXPECTED LEARNING OUTCOMES

The course aims at providing knowledge on the equations that govern the one-dimensional, steady and unsteady, and quasi-one-dimensional steady flow of a compressible fluid. Such knowledge is aimed at providing the skills required to appropriately analyze the thermo-dynamical behaviour of those devices and fluid machines that operate with a compressible fluid. These include: combustion chambers, nozzles, shock tubes, reciprocating engines and pipelines.

The main knowledge provided will be:

1. in-depth knowledge of the one-dimensional Euler equations, both steady and unsteady;
2. in-depth knowledge of the techniques needed to solve the Euler equations, including the treatment of shock waves and contact discontinuities;
3. in-depth knowledge of Fanno, Rayleigh and pipeline flows;
4. elements of acoustic theory;
5. in-depth knowledge of conventional and novel propulsion systems;
6. technical solutions for performance optimization and reduction of emissions.

The main skills (i.e. the ability to apply their knowledge) will be:

1. to identify the most appropriate mathematical model that is capable to describe the flow through a given fluid device or machinery;
2. solve the aforementioned equations to determine the kinematic and thermodynamic properties of the fluid at all sections;
3. apply the theoretical models to the study of those devices and fluid machines that operate with a compressible fluid;
4. the use of theoretical knowledge to design propulsion systems;
5. the ability to propose novel solutions for optimized propulsion systems.

PRE-REQUIREMENTS

Students must have acquired and assimilated the following knowledge typically provided by the courses of "Analisi II", "Fisica Matematica", "Meccanica dei Fluidi" and "Fisica Tecnica":

1. Knowledge of differential calculus in two independent variable; directional derivative, gradient; transport equation; wave equation; the divergence theorem.
2. Knowledge of kinematics and dynamics of a material point;

3. Knowledge of basic concepts of thermodynamics, in particular those relating to the 1st and 2nd law of thermodynamics, entropy, ideal gases: equation of state, internal energy and enthalpy, specific heat, entropy, polytropic transformations;
4. Knowledge of basic concepts of fluid dynamics, in particular those relating to: fluid system and control volume; the principle of conservation of mass and momentum from both a Lagrangean and an Eulerian view-point; the transport theorem; Bernoulli's theorem.

SYLLABUS
Numbers in square brackets refer to the references in section TEXTBOOKS AND ON-LINE EDUCATIONAL MATERIAL

1. Compressible, quasi-one-dimensional flows (Q1D) [1, §1.2]; [7 ore di didattica frontale]
2. Compressibility and the speed of sound [1, §1.3]; [1 ora di didattica frontale]
3. Quasi-one-dimensional steady flows: [8 ore di didattica frontale + 4 ore di esercitazioni numeriche]
   a) Isentropic flow [1, §2.1];
   b) Total and critical quantities [1, §2.2];
   c) The area rule [1, §2.3];
   d) Mass flow [1, §2.4];
   e) Normal shocks [1, §2.5],[2];
   f) Converging nozzles [1, §2.6];
   g) Converging-diverging (De Laval) nozzles [1, §2.7];
   h) Applications of Converging-diverging (De Laval) nozzles [1, §2.8]; [3] the companion movie [4]).
4. One-dimensional, non-isentropic, steady flows: [5 ore di didattica frontale + 5 ore di esercitazioni numeriche]
   a) Fanno Flow [1, §3.1];
   b) Constant temperature pipeline flow [1, §3.2];
   c) Rayleigh Flow [1, §3.3].
5. One-dimensional unsteady flows [12 ore di didattica frontale + 10 ore di esercitazioni numeriche]
   a) Introduction [1, §8.1];
   b) Moving normal shocks [1, §8.2];
   c) Reflected shock waves [1, §8.3];
   d) Linear convection equation [5, §1.1-1.3];
   e) Characteristic formulation of the Euler equations [6, §3.1-3.4] e [7];
   f) Simple waves [6, §3.5] e [7];
   g) Expansion waves [1, §8.6];
   h) Shock tube relations [1, §8.7];
   i) Finite compression waves [1, §8.8].
   j) Elements of acoustic theory: [1, §8.4] e [8, §11.1-11.5].
6. Introduction to propulsion systems;
7. Thermo-fluid dynamics of internal combustion engines;
8. Conventional and novel combustion strategies and fuels.

TEACHING METHODS
The course consists in 81 hours of teaching, split between classroom lectures and numerical tutorials; the latter cover roughly 40% of the 81 hours of teaching. The course might be supplemented by seminars held by external (e.g. industrial) experts.

EVALUATION METHODS
The aim of the examination is to test the level of achievement of the previously mentioned educational goals.
The exam sessions consist in a **written test** that covers the first 6 ECTS and an **oral test** that covers the remaining 3 ECTS. The reservation for the tests is mandatory and must be made through the Web Services Teachers / Students

(ESSE3) software accessible from the home page of the University.

The written test consists of 3 exercises, regarding the practical / applied aspects covered in the course; each of these exercises is worth 10 points. The candidate will pass the exam if she/he receives a mark of at least 18/30.
During the oral examination the knowledge and skills acquired by the student, as well as his ability to solve problems, will be verified.
The overall grade will take into account both written and oral tests.

TEXTBOOKS AND ON-LINE EDUCATIONAL MATERIAL

Bibliography

1) M. Napolitano. Corso di gasdinamica. http://climeg.poliba.it/\verb1~1gasdinamica.
2) Ames Research Staff. Equations, tables, and charts for compressible flow. Technical report, NASA Ames Research Centre, 1953. NACA Report 1135, http://naca.larc.nasa.gov/reports/1953/naca-report-1135/.
3) Donald Coles. Channel flow of a compressible fluid. Online, 1968. http://web.mit.edu/hml/ncfmf/08CFCF.pdf.
4) Ascher Shapiro. National committee for fluid mechanics films (ncfmf). Online, 2008. http://web.mit.edu/hml/ncfmf.html.
5) Aldo Bonfiglioli. Lecture 1: linear advection. Online, 2010. http://oldwww.unibas.it/utenti/bonfiglioli/www.html.
6) Aldo Bonfiglioli. Lecture 3: the euler's equation. Online, 2010. http://oldwww.unibas.it/utenti/bonfiglioli/www.html.
7) Aldo Bonfiglioli. Characteristic formulation of the un-steady 1d euler's equation of gasdynamics. Online, 2010. http://oldwww.unibas.it/utenti/bonfiglioli/www.html.
8) I. G. Currie. Fundamental Mechanics of Fluids. McGraw-Hill, Inc., 1974. Disponibile in aula tutorato.
9) John L. Lumley. Eulerian and lagrangian descriptions in fluid mechanics. Online, 1968. http://web.mit.edu/hml/ncfmf/01ELDFM.pdf.
10) P.H. Oosthuizen and W. E. Carscallen. Compressible Fluid Flow. McGraw-Hill series in Aeronautical and Aerospace Engineering. McGraw-Hill, 1997. Disponibile presso la biblioteca interfacoltà (PZ).
11) R. W. Fox and A. T. McDonald. Introduction to Fluids Mechanics. John Wiley & Sons, 1978.
12) I. H. Shames. Mechanics of Fluids. McGraw-Hill series in Mechanical Engineering. McGraw-Hill, 1992. Disponibile presso le biblioteche di PZ e MT.
13) J. Anderson. Modern Compressible Flow: With Historical Perspective. McGraw-Hill Science/Engineering/Math; 3 edition (July 19, 2002), 2002. Disponibile presso la biblioteca ex-DIFA.
14) J.B. Heywood, Internal Combustion Engine Fundamentals, McGraw–Hill, New York, 1988.
15) Instructor's notes available at http://oldwww.unibas.it/utenti/viggiano/viggiano.htm

INTERACTION WITH STUDENTS
At the beginning of the course, after describing the objectives, program and methods of verification, the instructor provides students educational materials (shared folders, website, etc). Meanwhile, the instructor collects the list of students who wish to attend the course, along with their name, serial number and email.

EXAMINATION SESSIONS (FORECAST)[1]
07/02/2018, 13/03/2018, 16/05/2018, 24/07/2018, 25/09/2018, 28/11/2018

SEMINARS BY EXTERNAL EXPERTS YES □ NO □

FURTHER INFORMATION

1Subject to possible changes: check the web site of the Teacher or the Department/School for updates.