UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria
ACADEMIC YEAR	2022/2023
MASTER'S DEGREE (MSC)	MECHANICAL ENGINEERING
SUBJECT	INTERNAL COMBUSTION ENGINES
TYPE OF EDUCATIONAL ACTIVITY	B
AMBIT	50370-Ingegneria meccanica
CODE	09088
SCIENTIFIC SECTOR(S)	ING-IND/08
HEAD PROFESSOR(S)	PIPITONE EMILIANO Professore Ordinario Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	9
INDIVIDUAL STUDY (Hrs)	144
COURSE ACTIVITY (Hrs)	81
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	1
TERM (SEMESTER)	1° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**PIPITONE EMILIANO** Monday 10:00 11:00 Wednesday 10:00 11:00 Studio del docente, edifico 8, plesso Macchine, piano primo

DOCENTE: Prof. EMILIANO PIPITONE

PREREQUISITES	Fundamental prerequisites are the main concepts and principles of fluid machinery, fluid mechanics, heat transfer, thermodynamics, and applied mechanics
LEARNING OUTCOMES	Knowledge and understanding: The student will develop knowledge and acquire methodologies necessary to study and solve problems concerning the use of internal combustion engine. Applying knowledge and understanding: The student will develop knowledge necessary for the design, the control and the optimal operation of internal combustion engines. Making judgements: The knowledge acquired will let the student to analyse and optimise the combustion, the pollutant emissions and the efficiency of internal combustion engines. Communication skills: The student will be able to efficiently communicate to engineer and technician about design, testing and managing of internal combustion engines. Learning skills: The knowledge acquired will let the student deal with advanced study on the use of internal combustion engines for vehicle, air-plane and naval propulsion and to investigate complex themes on the operation of new or advanced engines and fuels.
ASSESSMENT METHODS	The exam consists of a written examination, followed by an oral examination. During written examination, the use of any printed material is allowed, as well as programmable calculators. The use of computers, PDA, smartphones, tablets and any other connecting device is FORBIDDEN Both written and oral examination results are expressed on a scale of 30, with maximum mark 30/30. The final mark is obtained as mean value between written and oral marks. Classification: Excellent. 30-30 with praise. With a very good knowledge of the topics, an excellent correctness of language, and a good analytical ability, the student is able to autonomously solve all the proposed problems without errors. Very Good. 27-29. With a good knowledge of the topics, a good correctness of language, and an adequate analytical ability, the student is able to solve all the proposed problems with few errors. Good. 24-26. With a basic understanding of the topics, a discrete correctness of language, and a sufficient analytical ability, the student is able to face all the proposed problems with correct solutions on the average. Satisfactory. 21-23. With satisfactory correctness of language, the student has not fully mastered the main topics of the subject but is able to solve the main parts of the proposed problems with correct solutions on the average. Sufficient. 18-20. With a minimum understanding of topics and a sufficient technical language, the student is able to solve the main parts of the proposed problems with acceptable errors. Insufficient. The student does not have an acceptable knowledge of the topics, and is not able to solve the main parts of the proposed problems with acceptable errors.
EDUCATIONAL OBJECTIVES	This course will give the student the fundamental knowledge on the structure, the operation and the performance of internal combustion engines, for the vehicle application but also for naval and aeronautic purpose. The student will learn to manage problems regarding the optimal use of internal combustion engines for a given application, and will be able to evaluate or predict performances, efficiency and pollutants emissions.
TEACHING METHODS	Lesson: 5 hours a week, Practice: 3 hours a week
SUGGESTED BIBLIOGRAPHY	In lingua italiana: Beccari A. e C. Caputo : "Motori termici Volumetrici" ed. UTET, Torino 1987, ISBN: 8802041091 Beccari A. "Esercizi di Macchine" Ed, CLUT, Torino 1986, ISBN: 978-8879920438

	Giancarlo Ferrari, "Motori a combustione interna", Società Editrice Esculapio, 2à Edizione, 2016, ISBN: 8874889712 English language: Heywood J.B. "Internal Combustion Engine Fundamentals - Second Edition" McGraw-Hill Book Company, 2018, ISBN: 9781260116106 Giancarlo Ferrari, "Internal Combustion Engines", Società Editrice Esculapio, 2nd Edition, 2014, ISBN: 8874887655

SYLLABUS

Hrs	Frontal teaching
2	Introduction to Internal Combustion Engines (ICE) and comparison with external combusion engines or other power production system and plant.
6	Thermodynamic cycles: comparison between different heat introduction and extraction phases. Otto cycle, Diesel cycle and Sabathè cycle: efficiency evaluation and parameters. Real cycles and efficiencies, fuel consumption in full and part load operation, optimal combustion phase.
6	Engine power and torque equation; Indicated and Brake thermal efficiencies; Mean piston speed; Mechanical efficiency; Effect of ambient conditions on the performance of the internal combustion engines; Volumetric efficiency; Two Stroke and Four Stroke internal combustion engines.
4	Power and Torque produced by the engine, characteristics curve, road load curve, road performance.
8	Supercharging the ICE: methods and performance; Mechanical supercharging; Turbocharging;
8	Spark Ignition (SI) engine: mixture formation, power regulation, combustion process, turbulent flame propagation; abnormal combustion, knocking phenomena, fuel properties and octane number. Compression Ignition (CI) engine: combustion process, power regulation, fuel properties and cetane number.
6	Pollutant emissions from ICE; pollutant produced by SI and CI engines; Methods and systems for pollutant control and exhaust gas aftertreatment;
6	Direct and indirect injection systems for spark ignition engines; direct injection systems for compression ignition engines.
2	Variable Valve Timing (VVT) and Variable Valve Actuation (VVA) systems
3	Hybrid Propulsion Systems (Thermal-Electric)
1	Multi-cylinder engine configuration and torque pulsations
4	Internal combution engines for aircraft propulsion; effect of altitude on air density and power; density altitute, service ceiling and absolute celiling; engine performance (IMEP and BMEP) with altitude, critical altitude, part load operation and engine power chart; performance of supercharged aircraft engine with altitude.

Hrs	Practice
2	Introduction to internal combustion engines; thermodynamic cycles: comparison and efficiency calculation;
2	Power produced by internal combustion engines, specific fuel consumption and fuel mass flow evaluation, engine torque, indicated and mechanical efficiency, volumetric efficiency
4	BMEP, IMEP, FMEP evaluation; IMEP and BMEP variation with ambient conditions;
6	Supercharging the internal combustion engine: power, torque and efficiency evaluation;
3	Direct and Indirect fuel injection: evaluation of most important parameters;
6	Internal combustion engines for aircraft: absolute ceiling, engine performance, critical altitude; performance (IMEP and BMEP) with altitude of supercharged engines, fuel autonomy evaluation.
2	Fuel consumption calculation for a hybrid vehicle