UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria
ACADEMIC YEAR	2022/2023
MASTER'S DEGREE (MSC)	CYBER-PHYSICAL SYSTEMS ENGINEERING FOR INDUSTRY
INTEGRATED COURSE	APPLIED MECHANICS - INTEGRATED COURSE
CODE	21515
MODULES	Yes
NUMBER OF MODULES	2
SCIENTIFIC SECTOR(S)	ING-IND/13
HEAD PROFESSOR(S)	CAMMALLERI MARCO Professore Ordinario Univ. di PALERMO
OTHER PROFESSOR(S)	CAMMALLERI MARCO Professore Ordinario Univ. di PALERMO
CREDITS	12
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	1
TERM (SEMESTER)	Annual
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**CAMMALLERI MARCO**

Monday	11:00	18:00	lo studio del docente o a distanza tramite piattaforma MS-Teams. L'orario riportato e' puramente indicativo e subordinato alla effettiva disponibilita del docente ed ai suoi impegni istituzionali (lezioni, organi collegiali, etc..). Il giorno e l'orario effettivo vanno SEMPRE concordati prima tramite email o messaggio su MS-Teams.
Tuesday	09:00	18:00	lo studio del docente o a distanza tramite piattaforma MS-Teams. L'orario riportato e' puramente indicativo e subordinato alla effettiva disponibilita del docente ed ai suoi impegni istituzionali (lezioni, organi collegiali, etc..). Il giorno e l'orario effettivo vanno SEMPRE concordati prima tramite email o messaggio su MS-Teams.
Wednesday	09:00	18:00	lo studio del docente o a distanza tramite piattaforma MS-Teams. L'orario riportato e' puramente indicativo e subordinato alla effettiva disponibilita del docente ed ai suoi impegni istituzionali (lezioni, organi collegiali, etc..). Il giorno e l'orario effettivo vanno SEMPRE concordati prima tramite email o messaggio su MS-Teams.
Thursday	09:00	18:00	lo studio del docente o a distanza tramite piattaforma MS-Teams. L'orario riportato e' puramente indicativo e subordinato alla effettiva disponibilita del docente ed ai suoi impegni istituzionali (lezioni, organi collegiali, etc..). Il giorno e l'orario effettivo vanno SEMPRE concordati prima tramite email o messaggio su MS-Teams.
Friday	09:00	13:00	lo studio del docente o a distanza tramite piattaforma MS-Teams. L'orario riportato e' puramente indicativo e subordinato alla effettiva disponibilita del docente ed ai suoi impegni istituzionali (lezioni, organi collegiali, etc..). Il giorno e l'orario effettivo vanno SEMPRE concordati prima tramite email o messaggio su MS-Teams.

DOCENTE: Prof. MARCO CAMMALLERI

PREREQUISITES	The discipline is self-preparatory, apart from the basics of calculus, geometry and classic mechanic laws.
LEARNING OUTCOMES	Knowledge and understanding The student will acquire the general methodologies to address the kinematic and dynamic study of machines, as well as the main methods for the modeling them in order to determine the conditions of equilibrium and motion also of a complex mechanical system. Moreover, he will know how to derive the most appropriate models according to the physical phenomenology of the problem. Ability to apply knowledge and understanding The student will acquire adequate methods to describe and calculate the transmission of movements and forces in any real mechanism. Moreover, he will be able to address the effects of inertia forces on the machine operation. More specifically, it will be able to deal with problems relating to balancing, transients, smoothing out of the power flow and mechanical vibrations. Judgement skills Lessons and practices do not consist of the exposition of a mere subject and their purpose is not to give the solution to all possible problems. Thanks to a continuous dialogue with the professor the students will be stimulated to improve their reasoning skills about the kinematic and dynamic behavior of the machines. In the end, they can build a model, autonomously and with the right approximation, suitable for fully describing a real mechanical system. Communication skills The student will acquire the correct technical language used in the field of the mechanics of machines to effectively communicate with other technicians and engineers in their professional life. Learning ability Students will have learned the basic laws of mechanics of machines but, mostly the ability to apply them effectively to the resolution of other case studies not directly dealing with the course. Moreover, they will be able to continue the engineering studies and to cope with challenges that will arise in their professional life.
ASSESSMENT METHODS	The final examination is oral. To access it's required to perform some homework assignments to be periodically returned. The reports are the basis of the discussion at the oral examination. Alternatively, admission to the oral examination is subject to passing a prior written examination. The reports must be logically structured, drawn up in an orderly manner and with any graphic constructions made by CAD. They must also include the MatLab scripts implemented for the execution of the calculations with a clear description of all phases of the implementation. The student has to prove to know and to know using, the methodology to model and study the mechanics of machines. The final evaluation will be formulated according to the following graduation of knowledge of the student. Evaluation. Vote. Outcome. Excellent. 30-30 and praise. Very good knowledge of the topics, excellent the correctness of language, good analytical ability, the student can apply in complete autonomy knowledge to effectively solve problems proposed. Very Good. 27-29. Good command of the topics, full correctness of language, the student is able to apply the knowledge to solve with good autonomy problems proposed. Good. 24-26. Basic understanding of the main topics, discrete correctness of language, with limited ability to apply independently the knowledge to the solution of proposed problems. Satisfactory. 21-23. The student has not fully mastered the main teaching subjects but he knows, satisfactory correctness of language, poor ability to apply independently the knowledge acquired. Sufficient. 18-20. Minimum basic understanding of the major teaching and technical language issues, very little ability to apply independently the knowledge acquired. Insufficient. He doesn’t have an acceptable knowledge of the contents of the topics covered in the teaching.
TEACHING METHODS	Lectures, classroom exercises, visits to the laboratories and the room of applied mechanics models.

MODULE
DYNAMICS OF MECHANICAL SYSTEMS

Prof. MARCO CAMMALLERI

SUGGESTED BIBLIOGRAPHY

G. Belforte, Meccanica Applicata alle Macchine, Ed. Giorgio Torino, 1993
E. Funaioli, A. Maggiore, U. Meneghetti, Fondamenti di Meccanica delle
Meccanica delle Macchine, Patron Editore 2005.
M. Callegari, P. Fanghella, F, Pellicano, Meccanica applicata alle macchine,
Città studi edizioni, 2° edizione, 2017.
Leonard Meirovitch, Fundamentals of Vibrations, 2001, McGraw-Hill Science /
Engineering / Math, ISBN: 0072881801.
Slide e appunti forniti dal docente.

AMBIT	50356-Ingegneria dell'automazione
INDIVIDUAL STUDY (Hrs)	96
COURSE ACTIVITY (Hrs)	54

EDUCATIONAL OBJECTIVES OF THE MODULE

The course aims to provide students with a methodology to identify and to model any real machine to study their dynamic and vibrational behaviour.

SYLLABUS

Hrs	Frontal teaching
4	Kinetostatic of mechanisms by analytical methods – thrust crank mechanism, the Fairbairn guide, rotating glyph, four-bar linkages. The generic method of the closing equation.
2	Inertial properties of rigid bodies: centre of gravity, moments of inertia, matrix of inertia and ellipsoid of inertia.
16	Machine dynamics. Physics callbacks. Inertial actions and dynamic imbalances. Balancing of in-line or V reciprocating engines. Gyroscopic effects. Rotor balancing. Influence Coefficient Method. Dynamic reduction of mechanical systems and differential motion equation. Machines at periodic speed: calculation of flywheels and counterweights. Mechanical characteristics of engines and loads. Load motor coupling and study of transients, clutch and brake engagement.
11	Mechanical Vibrations - 1 DOF vibration recalls. Hysteretic damping. Half power band method. 2 DOF vibrations. Dynamic vibration damper. DOF n-DOF vibration. Modal analysis. Applications to vehicle dynamics and vehicle motion dynamics. Vibrational analysis for machine diagnostics.
5	Regolazione e stabilita' delle macchine e dei sistemi meccanici. Controllori PID. Applicazioni: cruise control.

Hrs	Practice
2	Rotors balancing
4	Kinetostatic study and implementation of multiple chain mechanisms in MatLab.
4	Flywheel design
6	Studio del transitorio di avviamento e di arresto di macchine. Scelta e dimensionamento di una frizione. Implementazione in Matlab.

MODULE
PRINCIPLES OF MECHANICS

Prof. MARCO CAMMALLERI

SUGGESTED BIBLIOGRAPHY

* R. Monastero: "Appunti per il corso di Elementi di Meccanica Teorica ed Applicata"
* R. Monastero: "Appunti per il corso di Meccanica Applicata alle Macchine"
* Slide ed animazioni a cura del docente.
* G. Belforte, Meccanica Applicata alle Macchine, Ed. Giorgio Torino, 1993

Parte del materiale didattico e' fornito gratuitamente dal docente.
Ulteriori testi:
* C. Ferraresi, T. Raparelli: "Meccanica Applicata" CLUT, 1997
* E. Funaioli, A. Maggiore, U. Meneghetti: “Fondamenti di Meccanica delle Meccanica delle Macchine”, Patron Editore 2005.

AMBIT	50356-Ingegneria dell'automazione
INDIVIDUAL STUDY (Hrs)	96
COURSE ACTIVITY (Hrs)	54

EDUCATIONAL OBJECTIVES OF THE MODULE

The course aims to provide students with a methodology to identify and to model any 1 DOF real machine or mechanism to study their kinetostatic and vibrational behaviour.

SYLLABUS

Hrs	Frontal teaching
4	Classification of members, kinematic pairs, contacts, mechanisms, machines. Identification and schematic of real systems.
6	Applied Kinematics. The planar motion of constrained rigid bodies: position, displacement, velocity, acceleration. Superposition of motion. Planar linkage mechanisms: four-bar linkages, slider-crack mechanisms, quick-return mechanisms. Kinematic equivalence.
5	Applied Kinetostatic. Applied and constraint forces. Conditions for equilibrium. Free body diagrams and forces transmission. Mechanical power losses. Traction problems.
10	Gears. Spur and helical gears: modulus and standardization, interference, action line and forces, efficiency. Supports efficiency. Notes on bevel gears and worm gear. Ordinary gearings and gearboxes. Epicyclic gear trains: Willis formula, external equilibrium conditions. Comparison between the behaviour of a three shafts ordinary gearing and a planetary gearing.
7	Mechanisms with highly flexible members. Belts classification. Equilibrium conditions of 1-dimension highly flexible body: sliding and adhesion arc; Traction belt drives. Belt tensioning: constant load shaft, constant shaft displacement; kinematic efficiency. Torque limiters. Losses due to flexural rigidity. Hoisting systems; fixed and mobile pulleys; ordinary, exponential and differential tackles; hoists.
2	Friction brakes. Reye’s wear theory. Disk brakes. Drum brakes by simplified approach. Braking efficacy.
8	Mechanical vibrations Problem recognition and modelling of 1-DOF mechanical systems. Free vibration: natural frequency, damping factor, dynamic response. Experimental identification of vibration parameters. Forced vibrations: sinusoidal forcing, inertial forcing, viscous forcing, generic periodic exiting forces. System response: dynamic magnifier and phase lag.

Hrs	Practice
6	Mobility and standstill configurations of four-bar linkages, slider-crack mechanisms, quick-return mechanisms.
3	Kinetostatic analysis using graphic vectors of four-bar linkages, slider-crack mechanisms, quick-return mechanisms.
2	Kinematic synthesis of a gear coupling and gearbox
1	Study of a belt drive