UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria
ACADEMIC YEAR	2018/2019
BACHELOR'S DEGREE (BSC)	CIVIL AND BUIDING ENGINEERING
SUBJECT	HYDRAULICS
TYPE OF EDUCATIONAL ACTIVITY	B
AMBIT	50108-Edilizia e ambiente
CODE	03769
SCIENTIFIC SECTOR(S)	ICAR/01
HEAD PROFESSOR(S)	FERRERI GIOVANNI BATTISTA Professore Associato Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	9
INDIVIDUAL STUDY (Hrs)	144
COURSE ACTIVITY (Hrs)	81
PROPAEDEUTICAL SUBJECTS	13711 - MATHEMATICAL ANALYSIS I
MUTUALIZATION	
YEAR	2
TERM (SEMESTER)	2° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**FERRERI GIOVANNI BATTISTA** Monday 11:00 13:30 Stanza professore Wednesday 11:00 13:30 Stanza professore Friday 11:00 13:30 Stanza professore

DOCENTE: Prof. GIOVANNI BATTISTA FERRERI

PREREQUISITES	KNOWLEDGE OF MATHEMATIC ANALYSIS - Continuous functions of one or several variables; limit of a function; total and partial derivatives; derivative along a direction; gradient of a scalar function. Integral of a function of one variable; line integral; surface integral; volume integral; theorem of Green/Stokes. KNOWLEDGE OF PHYSICS - Scalar and vectorial quantities; operations on vectors; resultant vector (modulus, direction and line of action); moment of a force; force couple and the reted torque. - Discreet and contnuous systems of mass; centroid, static moment, moment of inertia of a plane figure and their properties. - Mechanics of a material point; velocity and acceleration. The three Newton's Laws. Energy, work and power. Momentum of a body. Principles of conservation of momentum and energy; the impulse-momentum theorem; the work-kinetic energy theorem. KNOWLEDGE OF REPRESENTATION - Monge representation of geometrical solids; assonometric representation; plant, sections and cutaway views of a geometrical solid.
LEARNING OUTCOMES	KNOWLEDGE AND COMPREHENSION ABILITY After the Course student will have acquired in-depth knowledge of the fundamental laws of Mechanics of fluid continuous systems and of the related mathematical equations expressing them. The student will have also acquired the theoretical bases and the mathematical tools for solving various practical problems concerning Statics and Dynamics of liquids (such as determining, for example: the pressure force on a tank containing the liquid, the characteristics of a pipe-flow or an open-channel flow, the high pressures caused by valve closing, etc.), of which the student will have understood Physics of the phenomena involved. All this will let the student to tackle and solve a number of practical problems of engineer work. ABILITY TO APPLY KNOWLEDGE AND COMPREHENSION Student will be able to tackle and solve the most common Civil Engineering problems concerning water and its employments, namely: -determining static and hydrodynamic pressure forces on surfaces and bodies; - planning and carrying out calculations for design and analysis of single pipe and simple pipe-networks, of pumping pipes as well as hydroelectric pipes; -predicting the intense stresses in pipe walls caused by valve closing or opening; - designing and analysing open-channels with normal flows or steady flows; determining the main characteristics (e.g., the flow depth and flow velocity) of flows in open-channels and rivers; -recognizing and choosing measure devices for the main hydraulic quantities; -drawing groundwater by wells and drainage trenches (basic knowledge only). EVALUATION SELF-SUFFICIENCY Student will be able to: understand the overall running of an hydraulic plant - even a complex one - and recognise the purpose of special devices and stratagems adopted; recognise the peculiar issues of specific hydraulic plants having even more complex schemes than the plants considered in the course; recognise the data needed to go ahead with calculation of the most common hydraulic works (pipelines and open-channels); recognise the hydraulically heaviest operation conditions of a given plant; compare different design hypotheses as well as different operation conditions; assess credibility and consistency of the calculation results. ABILITY TO COMMUNICATE Student will acquire the ability to expound, with competence and suitable talk, the operation of an hydraulic work as well as its fortes and criticalities. Moreover, student will be able to carry on technical conversations and to have debates about questions relating to natural water bodies and hydraulic works of various type. LEARNING ABILITY Student will be able to attend courses even belonging to study paths of higher level than three-year degree (such as Specialist Degree, Ph.D., Masters, etc.), in which issues and works concerning exploitation, management and preservation of water bodies and land are studied. Student, moreover, will be able to update and to broaden by himself his knowledge in fields relating to Hydraulics and Hydraulic Works, by the consultation of technical books and journals.
ASSESSMENT METHODS	Examination consists in an oral test only. Evaluation is expressed in thirtieths. The test aims at verifying the knowledge got by the student, his/her ability in using them for solving practical problems as well as ability in communicating clearly. Usually, the test consists of a theory question and two-three exercises, the latter

	being framed as practical cases to be solved in engineer work which on the whole include problems of tanks, pipelines, open-channels and sometimes groundwaters. All the questions allow the examining board to verify: 1) theoretical knowledge in the course topics; 2) ability of reasoning and logical rigour in connecting ideas; 3) capability to define a practical problem and to schematize it by critically assuming suitable simplifications; 4) evaluation self-sufficiency in choosing useful knowledge for problem solution; and 5) skill in expounding concepts clearly and with a suitable talk. Test evaluation is according to the following criteria: ● 30 - 30 e Lode: thorough knowledge of topics, excellent competence in problem analysis, excellent level of awareness and self-sufficiency in applying acquired knowledge for problem solution, very good correctness of language; ● 26 - 29: good knowledge of topics, good competence in problem analysis, good level of awareness and self-sufficiency in applying acquired knowledge for problem solution, good correctness of language; ● 24 - 25: fair knowledge of topics, fair competence in problem analysis, fair level of awareness and self-sufficiency in applying acquired knowledge for problem solution, fair correctness of language; ● 21 - 23: modest knowledge of topics, modest competence in problem analysis, modest level of awareness and self-sufficiency in applying acquired knowledge for problem solution, modest correctness of language; ● 18 - 20: just basic knowledge of topics, little but sufficient competence in problem analysis, little but sufficient level of awareness and self-sufficiency in applying acquired knowledge for problem solution, little but sufficient correctness of language.
EDUCATIONAL OBJECTIVES	The course aims at learning of basic topics of Fluid Mechanics, with special attention to Newtonian liquids (such as, water, petroleum, mineral oils, alcohol, glycerol, etc.) which most frequently concern practical applications. The course, that has hard theoretical contents, is however steered to engineering applications, in order to train student for his future professional job. For this reason theoretical lessons are associated with numerical and graphic exercises relating to practical issues. At the end of the course, student will be able to: 1) determine the action of a still fluid on plane or curved surfaces of the tank that contains it; 2) design a pipeline and analyse its operation in different flow conditions; 3) predict high surcharge following sudden closing or opening of a valve; 4) determine dynamic actions of a flow on specific parts of a pipeline; 5) calculate the energy needed for operation of a pumping plant or the energy obtainable from a hydroelectric plant; 6) analyse a simple water distribution system; 7) design an open-channel and analyse its operation in different flow conditions; 8) measure local flow velocity and flow-rate of a stream; 9) split total flow-rate among a few users, under fixed shares; 10) recognise operating characteristics of a well. The acquired knowledge constitute a reach grounding that will find comprehensive development in the courses of hydraulic constructions.
TEACHING METHODS	Lectures and practical lessons; several exercises have to be solved numerically with the help of a Microsoft Excel electronic spreadsheet.
SUGGESTED BIBLIOGRAPHY	CITRINI D. e NOSEDA G.: Idraulica, Casa Editrice Ambrosiana, Milano. ÇENGEL Y. A. e CIMBALA M.: Meccanica dei Fluidi, McGraw-Hill. CURTO G. e NAPOLI E.: Idraulica, Voll. I e II, Editoriale BIOS, Cosenza. ALFONSI Gc. e ORSI E.: Problemi di Idraulica e Meccanica dei fluidi, Casa Editrice Ambrosiana, Milano. Le DISPENSE DIDATTICHE fornite durante il Corso.

SYLLABUS

Hrs	Frontal teaching
3	FLUIDS AS CONTINUOUS SYSTEMS. Continuous systems; states of aggregation of matter - solid, liquid and gas -and their properties. The International System of Units and the Practical System of Units. The physical properties of fluids: density, specific weight, compressibility, surface tension, absorption of gases in liquids, viscosity; Newtonian and non-Newtonian fluids and the related rheological equations.
2	Forces acting in a continuous system: mass forces and surface forces. The Principle of D'Alembert; the force of inertia. The surface forces: the stress; the Cauchy thetraedron Theorem; normal stresses and shear stresses; the stress tensor; the principal stresses and the related principal planes, the linear invariant. The particular case o purely normal stresses; the concept of pressure.
5	STATICS OF FLUIDS. Equilibrium equations of Statics in indefinite and global forms. Statics of incompressible heavy fluids: the pressure distribution; relative and absolute pressure; relative and absolute hydrostatic plane; determination of the pressure force acting on a plane surface. Statics of gases: the equation of state; the pressure distribution; the particular case of tanks having a limited height; determination of the pressure force acting on plane and curved surfaces.

SYLLABUS

Hrs	Frontal teaching
3	KINEMATIC OF FLUIDS. Path-lines and flow; the main categories of flow: pipe flows, open-channel flows, jets, filtration flows. Types of flow: unsteady, steady, uniform. Flow regimes: laminar and turbulent. Flow cross-section; volumetric, mass and weight flow-rates; mean velocity. The characteristic elements of flow: particle velocity, particle acceleration, path-line, stream-line, streak-line; Lagrangian and Eulerian approaches. The Eulerian derivative. The Principle of mass conservation: the continuity equation in differential form, in integral form, for a stream-tube and for a whole flow.
1	FOUNDAMENTAL EQUATIONS OF FLUID DYNAMICS. The local equation of dynamic equilibrium. The momentum equation; the local inertia; the momentum flow and the related correction coefficient for plane cross-sections. Determination of dynamic pressure forces on a generic surface. The outflow reaction.
2	DYNAMICS OF PERFECT FLUIDS - THE BERNOULLI THEOREM. The Eulero equation. The pressure distribution over a flow cross-section. The Bernoulli Theorem and its geometric and energetic meanings. The energy line and the hydraulic grade line.
3	GENERALIZATION OF BERNOULLI THEOREM. Extension of Bernoulli Theorem to unsteady flows; the particular case of the start of motion in a pipe with a constant diameter. Extension of Bernoulli Theorem to real liquids; the friction slope; the continuous and localized head losses. The Bernoulli Theorem for unsteady flow of a real liquid. The power of a stream in a cross-section; the correction coefficient of the kinetic energy; the mean head; the power lost along a stream section. Generalized Bernoulli Theorem for real liquid flows in unsteady flow. Energy exchanges between a flow and an hydraulic machine: the schemes of an hydroelectric plant and a pumping plant, and the related equations.
3	REAL-FLUID DYNAMICS. Flow resistance in pipe uniform flow and in open-channel uniform flow; the dynamic meaning of the friction slope; the shear stress on the pipe wall; the hydraulic radius. Stresses in viscous fluids; static and deviatoric stresses; the static tensor and the deviatoric tensor. The normal and the shear stresses in Newtonian viscous fluids. The Navier-Stokes local and global equations.
6	PRESSURE FLOWS. Uniform flow. Reynolds experiment and flow regimes. Laminar flow in a circular pipe: distribution of shear stress and velocity along the radius; Hagen-Poiseuille laws. Turbulent flow and its characteristics: instaneous and mean local values; instantaneous fluctuation components. The Navier-Stokes equation in global form applying to the mean local values; the Reynolds equations. Viscous and turbulent shear stresses and their distributions along the radius in circular pipe; the viscous boundary sublayer. Distribution of mean local velocity in the cross-section. Laws of flow; the Reynolds number; the friction factor; the Darcy-Weisbach formula for the friction slope. Turbulent flow in smooth pipe: Blasius, Nikuradse and Prandtl-von Karman formulas. Turbulent flow in rough pipe: experiments in pipes with artificial roughness; the Harp of Nikuradse; purely turbulent flow and the Prandtl-von Karman formula. Experiments in pipes with natural roughness: the formula of Colebrook-White and the Moody diagram..
1	Local head losses caused by: pipe sudden expansion (Borda formula), pipe exit, pipe entrance, pipe sudden contraction, pipe gradual contraction, pipe gradual expansion, pipe bend, pipe sharp bend.
1	Pipe flow in the presence of sub atmospheric pressure; formation of a control cross-section; determination of the maximum flow-rate; open-channel flow downstream of the control cross-section.
3	LONG WATER PIPELINES. Simplifying assumptions. Simple pipe. Pipeline with water drawing or injection in intermediate nodes. Pipe distributing water uniformly along its course; the equivalent flow rate. Pipe distribution networks: network elements and available equations; mathemathical position of network analysis and network design problems. Outline of network design by minimum cost method. Pipelines running with sub atmospheric pressure; situations requiring pipe priming.
2	UNSTEADY FLOW IN PRESSURE PIPES. Types of unsteady flow: elastic oscillations (water-hammer), mass oscillations, slowly varied flow. Elastic oscillations in a forced pipe. Instantaneous closing operation; pressure wave celerity both in rigid and deformable pipe; first and second stroke; chronological diagrams of pressure and velocity. Sudden and slow cut-off operation and differences in the respective effects.
7	OPEN-CHANNEL FLOWS.
2	WEIRS.
1	GROUND WATER FLOW. Elements of ground waters. Phreatic and artesian aquifers: the piezometric surface. The Darcy's law; the filtration velocity; the permeability and the factors influencing it. 3-D flow; iso-potential surfaces. Flow and continuity equations for homogeneous and isotropic aquifer.

Hrs	Practice
2	Determination of the pressure force acting on a curved surface by using the method of the force components or that of the global equilibrium equation; pressure gauges (piezometer, simple manometer, Bourdon manometer, differential manometer). Determination of pipe wall thickness (Mariotte formula).
5	Practical lessons, some of which of numerical type, concerning: determination of pressure forces on plane surfaces, due to a liquid only or a few fluids together (liquids and gases); comparison among pressure diagrams, pressure forces and eccentricities as the hydrostatic plane changes its position; determination of pressure forces on curved surfaces by using the method of the components and the method of the static equilibrium equation; determination of relative and absolute pressure forces, and comparison of the results relating to a same surface.
3	Applications of Bernoulli Theorem: flow with constant pressure (such as downward, upward and inclined jets);flow with constant velocity; flow with constant elevation; general case with variation of elevation, pressure and velocity; flows with positive or negative pressures. Particular applications of Bernoulli Theorem for determining velocity and flow rate: the Pitot tube and the Venturi meter.

Hrs	Practice
2	Practical lessons, some of which of numerical type, concerning: analysis of a pipe between two tanks, having a few diameters, for various operation conditions, including the formation of the maximum negative pressure in a cross-section; analysis of a few pipes having various geometrical characteristics; determination of dynamic pressure forces on curves, reducers and enlargers in pipe flows; determination of dynamic pressure forces on surfaces hit by a jet.
1	Practical lesson on: numerical semi-design of an hydroelectric-plant conduit conveying real liquid; drawing of the energy and hydraulic lines, determination of the pipe wall thickness taking into account water-hammer surcharges, evaluation of the daily energy produced for fixed discharge chronological diagrams.
2	Solution of practical problems by the Colebrook-White formula. Practical formulas for calculation of the energy slope.
2	Practical numerical lessons concerning: 1) recognising the flow regime; 2) calculation and comparison of several dynamic and kinematic flow characteristics (such as: friction factor, friction slope, shear stress on the wall, velocity gradient at the wall, flow-rate, mean flow velocity) as data change; 3) change of flow regime and resistance parameters because of pipe ageing or diameter change.
1	Practical computation of a pipeline; flow-rate adjustment by a valve; the characteristic curve of a pipeline. Practical computation of a pumping pipeline; the head characteristic curve of a pump; the efficiency and power curves; flow-rate adjustment by a valve.
1	Practical lessons, some of which of numerical type, concerning calculation of minimum pressure in suction pipe of a pumping plant and maximum flow-rate as pressure hits the lowest possible value at pump entrance; examination of measures to allow a flow-rate increase in the latter case.
3	Practical lessons, some of which of numerical type, concerning: analysis of a pipe between two tanks with flow-rate drawing or injection in an intermediate node, as this flow rate varies noticeably; pipe design taking into account given altimetric and minimum-pressure conditions; pipe running when the pipe is new or aged; analysis of simple pipe systems, linking three or more tanks, running by gravity or by pumping.
1	Practical lesson on unsteady flow slowly varying, in simple cases such as slow start or slow stop of pipe flow; tank empting by a discharge pipe, taking into account or not inertia terms.
7	Practical lessons on open-channel flows.
1	Simple schemes of exploitation of grounwater by wells and drainage trenches. Water drawing from phreatic wells and drainage trenches; the Dupuit assumption. Water drawing from artesian wells. Well characteristic curve for a phreatic or an artesian aquifer. Practical methods for field determination of aquifer permeability.