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340056 - ETER-M6O29 - Thermal Engineering

Coordinating unit: 340 - EPSEVG - Vilanova i la Geltrú School of Engineering
Teaching unit: 729 - MF - Department of Fluid Mechanics
Academic year: 2018
Degree: BACHELOR'S DEGREE IN MECHANICAL ENGINEERING (Syllabus 2009). (Teaching unit Compulsory)
BACHELOR'S DEGREE IN INDUSTRIAL DESIGN AND PRODUCT DEVELOPMENT ENGINEERING (Syllabus 2009). (Teaching unit Optional)
BACHELOR'S DEGREE IN ELECTRICAL ENGINEERING (Syllabus 2009). (Teaching unit Optional)
BACHELOR'S DEGREE IN INDUSTRIAL ELECTRONICS AND AUTOMATIC CONTROL ENGINEERING (Syllabus 2009). (Teaching unit Optional)
ECTS credits: 6 Teaching languages: Catalan

Teaching staff

Coordinator: JAUME MIQUEL MASALLES

Others: JAUME MIQUEL MASALLES
CARLOS PRUDENCIO DE GRACIA

Prior skills

Differential and integral calculus.
Differential equations.
Knowledge of: Fundamentals of thermal engineering
Knowledge of: Fluid mechanics.

Requirements

340025 - Differential Equations
340026 - Advanced Calculus
340038 - Fundamentals of Thermal Engineering (in case you have not studied: 340032 - Thermal Engineering and Fluid Mechanics)
340039 - Fluid Mechanics (in case you have not studied: 340032 - Thermal Engineering and Fluid Mechanics)

Degree competences to which the subject contributes

Specific:

1. CE21. Applied thermal engineering knowledge.

Transversal:

2. SELF-DIRECTED LEARNING - Level 3. Applying the knowledge gained in completing a task according to its relevance and importance. Deciding how to carry out a task, the amount of time to be devoted to it and the most suitable information sources.
3. EFFICIENT ORAL AND WRITTEN COMMUNICATION - Level 3. Communicating clearly and efficiently in oral and written presentations. Adapting to audiences and communication aims by using suitable strategies and means.
4. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.
5. TEAMWORK - Level 3. Managing and making work groups effective. Resolving possible conflicts, valuing working with others, assessing the effectiveness of a team and presenting the final results.
6. EFFECTIVE USE OF INFORMATION RESOURCES - Level 3. Planning and using the information necessary for an academic assignment (a final thesis, for example) based on a critical appraisal of the information resources used.

340056 - ETER-M6O29 - Thermal Engineering

Teaching methodology

- IMPARTITION OF KNOWLEDGE: Expository and participatory theoretical sessions, consisting of the exposition and development of the theoretical foundations and, if necessary, the resolution of type exercises. The material to be used will be available for the student in the section of the Digital Campus enabled for the subject.
- APPLIED APPRENTICESHIP OF KNOWLEDGE: Practical sessions of resolution of problems, where the maximum participation of the student will be tried, through his direct implication in the resolution of exercises.
Later in the presentation and resolution of a problem by the teacher, students must solve in class / out of class, individually or in groups, the exercises that are indicated. The student will have in advance in the section of the Digital Campus enabled for the subject of the set of problems to be performed.
- DELIVERY OF EXERCISES: Delivery of problems solved by students. The deliveries will consist of the individual or group resolution, to be carried out in class or outside of class, of any problem/s from the list, or similar to those of the list, that the student will have in the Digital Campus. This activity will have evaluative weight and for its realization a rubric will be available. The student can "feed-back" from the delivery of the corrected problems.
- LEARNING FROM EXPERIMENTATION: Practical laboratory sessions, carried out directly by the students, guided by the teacher, which will allow them to directly observe relevant aspects of the developed theory. The scripts of the practices to be developed will be available, in advance of their realization, in the section of the Digital Campus enabled for the subject. The students will give the teacher a copy of the experimental data obtained. Subsequently, the students must make a report of the practice carried out. For its realization the student will have a rubric in the Digital Campus about the preparation of the internship reports. These reports will have an evaluative weight and must be submitted before the date indicated by the professor.
- GUIDES OF SELF-DIRECTED LEARNING: Preparation and presentation of a subject of the course. It will be necessary to work in groups of 5 - 7 students on a subject of the syllabus of the course assigned by the teacher. They will have the objectives, the sections to develop and the tasks to be carried out. The group must be able to decide how it should be organized and know how to identify the sources of information. They must also decide how much time to devote to learning the content and doing the tasks. These must be as professional as possible. The presentation of the activity will be done in writing and orally and will have an evaluative weight.
- TUTORIALS: The collective or individual tutorials will allow the student to solve any doubts that may have on the subject for an effective follow-up of the subject.
- INDIVIDUAL WRITTEN TESTS: The students will perform two partial tests (individual written tests) of the theory and problems developed in the subject. The first partial control (CP1) will be carried out in the middle of the semester and the second partial control (CP2) will be carried out at the end of the semester period (Final Evaluation period). There will be a Final Control of the subject (CFinal) in the Final Evaluation period. Students with a grade of CP1 less than 3.5 can be presented optionally to the Final Control, which will replace CP2. There will also be a Global Control (CGlobal) of Re-evaluation of all knowledge of theory and problems developed in the subject (Re-evaluation period).

Learning objectives of the subject

At the end of the course students should be able to :

Study load

Total learning time: 150h	Hours large group:	52h 30m	35.00%
	Hours medium group:	0h	0.00%
	Hours small group:	7h 30m	5.00%
	Guided activities:	0h	0.00%
	Self study:	90h	60.00%

Content

TOPIC 1. MOIST AIR. AIR CONDITIONING PROCESSES.	Learning time: 30h Theory classes: 13h Self study : 17h

Description:

1.1.- P-V-T relations and thermodynamic properties of ideal gas mixtures.
1.2.- Concept of moist air. Basic properties of moist air: Specific humidity, relative humidity and degree of saturation. Specific enthalpy and specific volume of moist air. Dew temperature.
1.3.- Adiabatic saturation temperature and wet thermometer temperature.
1.4.- Psychrometric diagram.
1.5.- Air conditioning processes: Dehumidification with heating. Evaporative cooling. Humidification with or without previous heating. Adiabatic mixture of two humid air streams. Application to the calculation of air conditioning systems.

Related activities:

A1. Problems of moist air and air conditioning processes.
A5. First individual written test.

Specific objectives:

At the end of this teaching unit, the student must be able to:
- Define and perform calculations with the models to describe the P-V-T behavior of ideal gas mixtures (Dalton and Amagat).
- Calculate the thermodynamic properties of ideal gas mixtures (enthalpy and heat capacities).
- Define and perform calculations with concepts related to moist air (specific humidity, relative humidity, degree of saturation, dew temperature, specific enthalpy, specific volume, adiabatic saturation temperature and wet thermometer temperature).
- Use the psychrometric diagram to graphically determine the properties of moist air.
- Calculate analytically the basic processes of moist air conditioning (heating and sensitive cooling, cooling with dehumidification, humidification with liquid water or water vapor and adiabatic mixing of two moist air streams).
- Represent and graphically calculate the previous air conditioning processes based on the psychrometric diagram.
- Calculate air conditioning systems in summer and winter conditions.

TOPIC 2. STEADY-STATE HEAT CONDUCTION	Learning time: 28h Theory classes: 11h Laboratory classes: 0h Self study : 17h

Description:
2.1.- General equation of heat conduction: Equation in cartesian coordinates and equation in cylindrical coordinates.
2.2.- One-dimensional conduction in steady state: Temperature profile, heat flow and thermal resistance in a flat, cylindrical and spherical wall. Global coefficient of heat transmission (U). Critical insulation thickness for a cylinder. Variable thermal conductivity of the material. Thermal insulation of pipes (regulation and calculation).
2.3.- Heat transfer by fins: Profile of temperature and heat flow in a straight fin of uniform thickness and in a needle of constant cross section. Efficiency concept of a fin. Efficiency graphs of fins of different geometries. Total surface effectiveness of a surface with a set of fins.
2.4.- Bi- and three-dimensional conduction in steady state: Analytical methods. Method of Shape Factor for conduction in different geometries. Numerical methods.

Related activities:
A2. Problems of heat transmission by conduction in steady state.
A5. First individual written test.

Specific objectives:
At the end of this teaching unit, the student should be able to:
- Apply the method of thermal resistances to solve several problems of heat transmission that can be found in practice (with flat, cylindrical and spherical geometries), in the case of individual mechanisms or combined mechanisms.
- Interpret and solve the problem of the criticality of the thermal insulation of cylinders (and pipes).
- Solve problems of heat conduction in several geometries with thermal conductivity of the material variable with temperature.
- Choose the thickness of the insulation of a pipe that transports hot or cold fluids based on the simplified method of RITE 2013 (Consolidated version).
- Calculate and select the insulation thickness of a pipe that transports hot or cold fluids based on technical criteria (reduction in thermal losses or maximum surface temperature of the insulation). You must also know how to solve these problems with the AISLAM software.
- Use efficiencies graphs of fins of different geometries.
- Calculate the total heat flow on a flapped surface and apply it to practical problems.
- Use the Shape Factor method to calculate the heat flow in various geometries (1D, 2D and 3D) and apply it to real engineering problems.
- Apply the numerical method of finite differences to solve 2D stationary heat conduction problems in Cartesian coordinates.

340056 - ETER-M6O29 - Thermal Engineering

TOPIC 3. UNSTEADY-STATE HEAT CONDUCTION	Learning time: 16h 30m Theory classes: 6h Laboratory classes: 1h 30m Self study : 9h

Description:
3.1. Equation of heat conduction in transient state.
3.2. Transient heat conduction: Solid with negligible internal resistance.
3.3. Analytical and graphical solution (Graphics by Heisler and Gröber) of transient conduction problems: One-dimensional transient conduction (large flat plate, long cylinder and sphere). Bi- and three-dimensional transient conduction.
3.4. Introduction to the numerical solutions to the problems of conduction in transitory regime: Explicit and implicit formulation by finite differences of the method of the heat balance.

Related activities:
A12. Heat transfer problems by conduction in transient state.
A4. Laboratory practice: Transmission of heat by conduction in transient state in a cylinder.
A11. Second individual written test.

Specific objectives:
At the end of this teaching unit, the student should be able to:
- Know the equation of heat conduction in transient state, its different forms and simplifications.
- Identify and calculate heat conduction problems in transient state when the internal resistance to conduction inside the solid is negligible.
- Use the graphics of Heisler and Gröber and the analytical solution of a single term in the series to solve problems of transient heat conduction 1D, 2D and 3D and apply it to real engineering problems.
- Apply the numerical method of finite differences to solve 1D and 2D transient heat conduction problems in Cartesian coordinates.

TOPIC 4. CONVECTION HEAT TRANSFER: EMPIRICAL CORRELATIONS	Learning time: 24h 15m Theory classes: 8h Laboratory classes: 2h 15m Self study : 14h

Description:
4.1.- Dimensionless parameters relevant to the characterization of forced convection.
4.2.- Heat Transmission by Forced Convection in Internal Flow in pipes and non-circular ducts: Correlations for turbulent flow, laminar flow and transition flow in pipes. Correlations by the flow inside non-circular ducts.
4.3.- Heat Transmission by Forced Convection in External Flow: Correlations for laminar and turbulent flow on a flat plate. Correlations for the flow around a circular and non-circular cylinder. Correlations by the flow around tube batteries.
4.4.- Heat Convection by Natural Convection: Relevant dimensionless parameters in natural convection. Correlations for natural convection in plates, cylinders and spheres.
4.5.- Study of the transmission of heat in the condensation of vapors and the boiling of liquids.

Related activities:
A6. Heat transfer problems by Convection: Empirical correlations.
A9. Laboratory practice: Transmission of heat by natural convection and radiation in a black flat plate.
A10. Laboratory practice: Transmission of heat by natural convection and radiation in a flat plate with shiny aluminum coating and determination of its emisivitat.
A11. Second individual written test.

Specific objectives:
At the end of this teaching unit, the student must be able to:
- Identify the dimensionless parameters that characterize the transmission of heat by forced convection, by natural convection and by convection with phase change.
- Calculate the coefficients of heat transmission by forced convection in internal flow in pipes and non-circular ducts in turbulent, laminar and transition conditions.
- Calculate the coefficients of heat transmission by forced convection in external flow in a flat plate, a cylinder and a sphere, as well as around a bundle of tubes.
- Calculate the coefficients of heat transmission by natural convection in external flow in plates, cylinders and spheres in laminar and turbulent regime.
- Calculate the heat transfer coefficients by convection in the condensation of vapors and the boiling of liquids.

TOPIC 5. THERMAL EQUIPMENT AND GENERATORS	Learning time: 33h 15m Theory classes: 12h Laboratory classes: 2h 15m Self study : 19h

Description:

5.1. Heat exchangers: Classification. Overall heat transfer coefficient (U). Energy balance equations. Logarithmic mean temperature difference (LMTD). F graphics for various types of heat exchangers. Calculation Method F-DTML. Effectiveness (E) and number of transfer units (NUT) exchanger. E-NUT graphics and formulas E = f (Rc, NUT) and NUT = f (Rc, E) for exchangers of various configurations. Solving the problem of thermal behavior analysis and the problem of a heat exchanger design.
5.2. Water cooling towers or cooling towers: Classification and applications of cooling towers. Mathematical model of a cooling tower and cooling power.
5.3. Boilers or steam generators: Classification. Use of boilers. Balance of mass and energy applied to a boiler. Performance of a boiler.

Related activities:

A3. Laboratory: Experimental study of the thermal behavior of heat exchangers: double pipe, shell and tube, and plate.
A7. Problems of equipment and thermal generators.
A11. Second individual written test.

Specific objectives:

At the end of this teaching unit, the student must be able to:
- Identify and classify the different types of heat exchangers.
- Set the equation for the calculation of the global coefficient of heat transmission (U).
- Make a general energy balance to the heat exchangers.
- Use the graphs for the calculation of F in several types of exchangers.
- Use the E-NUT graphs and the formulas E = f (Rc, NUT) and NUT = f (Rc, E) for exchangers of various configurations.
- Analyze the thermal behavior and design a heat exchanger based on the F-DTML and E-NUT methods.
- Establish the applications of the cooling towers and make their classification.
- Calculate a cooling tower and establish its cooling power.
- Classify the different types of boilers and make balance of mass and energy to them.
- Determine the thermal performance of a boiler.

TOPIC 6. INDUSTRIAL HEAT AND COLD	Learning time: 18h Theory classes: 4h Self study : 14h

Description:
6.1. Fuels and combustion: Classification of fuels. Calorific value of fuels. Mass balance and chemical equations of combustion (stoichiometric combustion, combustion with air excess and defect). Energy balance in combustion. Adiabatic flame temperature. Numeric example(s) of application.

Related activities:
A8. Preparation, delivery in writing and oral presentation of Topic 6: Industrial heat and cold.

Specific objectives:
At the end of this teaching unit, the student must be able to:
- Interpret concepts related to fuels and combustion.
- Apply the principle of conservation of the mass to reactive systems to perform calculations and determine the adjusted combustion equations.
- Apply the energy balance to a combustion and look for the adiabatic flame temperature.

340056 - ETER-M6O29 - Thermal Engineering

Qualification system

The evaluation weight of the various concepts involved in the qualification of the subject are:
- INDIVIDUAL WRITTEN TESTS: 68 %
- DELIVERY OF SOLVED EXERCISES: 10 %
- REPORTS OF LABORATORY PRACTICES: 10 %
- PREPARATION, DELIVERY IN WRITING AND ORAL PRESENTATION OF A TOPIC: 12 %

To obtain the final ETER grade, you will apply the following evaluation equation:

[1] Final Note of ETER = Note CP1*0.34 + Note CP2*0.34 + Note Delivery Problems*0.10 + Note Practices*0.10 + Note Work and Exposition of a Topic*0.12

Students who have obtained a grade lower than 3.5 in the Note of CP1, may be presented as an optional to a Final Control (CFinal) instead of CP2. This CFinal will be held on the same day and time as the CP2, within the Final Evaluation Period. The equation of the evaluation, to obtain the Final Note of ETER, in this case is:

[2] Final Note of ETER = Note CFinal*0.68 + Note Delivery Problems*0.10 + Note Practices*0.10 + Note Work and Exposition of a Topic*0.12

There are no minimum notes in any of the previous evaluative acts at the time of applying equations [1] or [2].

RE-EVALUATION:
The student who has: 3.0 <= Final Note of ETER <= 4.9, has the right to take the re-evaluation of the ETER subject.
The re-evaluation will consist of a Global Control of theory and problems of the subject that will weigh 68%.
Once the Global Control (CGlobal) of re-evaluation is done, the final grade of Re-evaluation will be obtained following the following expression:

Final Note Re-evaluation = Note CGlobal*0.68 + Note Delivery Problems*0.10 + Note Practices*0.10 + Note Work and Exposition of a Topic*0.12

The Final Note of ETER after the re-evaluation will be:
a) If the Final Note Re-evaluation is equal to or greater than 5.0: The Final Note of ETER = 5.0
b) If the Final Note Re-evaluation is lower than 5.0: the highest grade between the Final Note Re-evaluation and the Final Note of ETER prior to the re-evaluation will be taken as the Final Note of ETER.

Regulations for carrying out activities

- Each of the two individual written tests (Partial Controls), will consist of two parts: a theory test (which may constitute up to 30% of the test score) and a certain number of problems (to complite the 100% of the test score). Both tests have the same evaluative weight (34%). A minimum note of the Partial Controls is not required.

- The Final Control (CFinal) will consist of two parts: a theory test (which may constitute up to 30% of the test score) and a certain number of problems (to complite the 100% of the test score). This test has an evaluative weight of 68%. A minimum grade of the Final Control is not required.

- Deliveries of problems solved individually will be evaluated following the rubric for the realization of the delivery of problems, which the student will have in advance. The problems solved must be delivered personally to the teacher or through the Campus Athena, and within the allotted time period.

- The reports of laboratory practices will be evaluated according to the rubric established for the realization of the same and that the students will have previously. In order to take note of the laboratory practices, it is essential to have done the practices in person and present the reports with the group with which the laboratory practice was carried out.

- The realization, by groups, of the delivery in writing and the oral presentation of a subject of the subject will have a deadline that will establish the teacher. Your qualification will be made according to the corresponding rubric that the students will know in advance. If a student does not show up at the oral presentation of the topic he will have a zero of this part.

- If a student submits problems and/or practices, at the end he/she will have a grade of the subject even if he/she has not been submitted to the individual written tests (Partial Controls or Final Control).

RE-EVALUATION:

- When the Final Score of ETER is lower than 5.0 but equal to or higher than 3.0, the Re-evaluation is eligible. In this case, the theory and problems contents of CP1 and CP2 are reappraised. In the Re-evaluation there will be a Global Control of the subject (CGlobal) and this will have a weight of 68%.

- The Global Control (CGlobal) of the Re-evaluation will consist of two parts: a theory test (which may constitute up to 30% of the test score) and a certain number of problems (to complite the 100% of the test score).

340056 - ETER-M6O29 - Thermal Engineering

Bibliography

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