	BSc in MECHANICAL ENGINEERING		
EPS	**COURSE: THERMAL ENGINEERING**		
	TEACHING STAFF: LLUÏSA F. CABEZA		
	YEAR: 2nd	**CREDITS: 9**	**TYPE: COMPULSORY**

1. OBJECTIVES

The objective for this course is to acquire the basic knowledge on heat transfer and applied thermodynamics. These concepts are necessary to understand how the typical thermal devices work (refrigerators, air conditioning devices, car engines or steam or steam engines).

2. STRUCTURE

The course is divided in two semesters, during the first one we will study heat transfer and during the second one thermodynamics.

The credits of the course are set up follows:
4,5 credits per semester:
- 2 theory credits
- 1,5 exercise work credits
- 1 practical work credit

3. PROGRAMME

Heat transfer:

1. BASIC CONCEPTS ON HEAT TRANSFER
1.1. Introduction to heat transfer
1.2. Heat transfer mechanisms
1.3 Simultaneity on heat transfer mechanisms
1.4. Problems on basic concepts of heat transfer.

2. STEADY STATE HEAT CONDUCTION
2.1. Steady state heat conduction in walls
2.2. Contact heat transfer resistance
2.3. Heat transfer resistance networks
2.4. Heat conduction in cylinders and spheres
2.5. Critic insulation ratio
2.6. Heat conduction from finned surfaces
2.7. Heat transfer in common configurations
2.8. Steady state heat condition problems

3. TRANSIENT STATE HEAT CONDUCTION
3.1. Capacity systems

3.2. Transient state heat conduction in large walls, long cylinders and spheres
3.3. Transient state heat conduction in semi-infinite solids
3.4. Transient state heat conduction in multidimensional systems
3.5. Transient state heat conduction problems

4. NUMERICAL METHODS IN HEAT CONDUCTION
4.1. Numerical formulation of heat conduction problems
4.2. Steady state heat conduction in one dimension
4.3. Steady state heat conduction in two dimensions
4.4. Transient state heat conduction
4.5. Numerical methods in heat conduction problems

5. FORCED CONVECTION
5.1. Physical mechanism of forced convection
5.2. Flow on plane surfaces
5.3. Flow around cylinders and spheres
5.4. Flow in pipes and ducts
5.5. Flow around cylinders and spheres
5.6. Flow in pipes
5.7. Forced convection problems

6. NATURAL CONVECTION
6.1. Physical mechanism of natural convection
6.2. Natural convection on surfaces
6.3. Natural convection within closed volumes
6.4. Natural convection in finned surfaces
6.5. Combined natural and forced convection
6.6. Natural convection problems

7. HEAT EXCHANGERS
7.1. Types of heat exchangers
7.2. Heat transfer global coefficient
7.3. Heat exchangers analysis
7.4. LTMD method
7.5. NTU method
7.6. Heat exchangers problems

Thermodynamics:

8. PURE SUBSTANCES PROPERTIES
8.1. Pure substances
8.2. Phases of a pure substance
8.3. Phase change processes in a pure substance
8.4. Property diagrams for phase change properties
8.5. Property tables
8.6. State equation for ideal gases
8.7. Compressibility factor
8.8. Specific heat
8.9. Internal energy, enthalpy and specific heat of ideal gases
8.10. Internal energy, enthalpy and specific heat of solids and liquids
8.11. Pure substances properties problems

9. FIRST PRINCIPLE OF THERMODYNAMICS
9.1. The first principle of thermodynamics
9.2. Energy balance for closes systems
9.3. Energy balance for steady state systems
9.4. Energy balance of non-steady state systems

9.5. Energy balance for transient state processes
9.6. First principle of thermodynamics problems

10. SECOND PRINCIPLE OF THERMODYNAMICS
10.1. Introduction to the second principle of thermodynamics
10.2. Thermal energy storage
10.3. Heat engines
10.4. Efficiencies in energy conversion
10.5. Refrigerators and heat pumps
10.6. Carnot cycle
10.7. Carnot's thermal engine
10.8. The refrigerator and Carnot's heat pump
10.9. Second principle of thermodynamics problems

11. ENTROPY
11.1. Entropy
11.2. Principle of entropy increase
11.3. Entropy change on pure substances
11.4. Isentropic processes
11.5. Entropy change of liquids and solids
11.6. Entropy change of ideal gases
11.7. Isentropic efficiency of steady state devices
11.8. Entropy balance
11.9. Entropy problems

12. GAS POWER CYCLES
12.1. Basic considerations on power cycles analysis
12.2. Carnot cycle and its value to engineering
12.3. Standard air assumptions
12.4. Inverse motors
12.5. Otto's Cycle : ideal cycle for spark-ignition engines
12.6. Diesel Cycle: ideal cycle for compression-ignition engines
12.7. Stirling and Ericsson cycles
12.8. Brayton cycle: the ideal cycle for gas turbines
12.9. Gas power cycles problems

13. STEAM POWER CYCLES AND COMBINED CYCLES
13.1. The steam Carnot cycle
13.2. Rankine's cycle: the ideal cycle for the steam power cycles
13.3. Real steam power cycles diversions of the ideals
13.4. How to improve the efficiency of the Rankine cycle
13.5. 13.7. The gas-steam combined cycle
13.8. Steam power cycles and combined cycles problems

14. REFRIGERATION CYCLES
14.1. Refrigerators and heat pumps
14.2. The reverse Carnot cycle
14.3. The ideal reverse compression cycle
14.4. The real reverse compression cycle
14.5. Refrigeration cycles problems

4. COURSE MATERIAL

Notes on Heat transfer – Thermal Engineering
EPS Notebook

5. READING

Basic reading:

- Y. A. Çengel, "Heat Transfer. A practical approach", McGrawHill, 1998. ISBN: 0-07-011505-2.
- Y. A. Çengel, M. A. Boles, "Thermodynamics. An engineering approach", McGrawHill, 2002. ISBN: 0-07-112177-3.

Complementary reading:

- F. P. Incropera, D. P. De Witt, "Fundamentos de transferencia de calor", Prentice Hall Hispanoamericana, 1999. ISBN: 970-17-0170-4.
- J. P. Holman, "Transferencia de calor", McGrawHill, 1998. ISBN: 84-481-2040-X.
- F. Kreith, M. S. Bohn, "Principios de transferencia de calor", Paraninfo Thompson, 2001. ISBN: 970-686-063-0.
- J. M. Marín, C. Monné, "Transferencia de calor", Kronos, 1998. ISBN: 84-88502-72-9.
- J. Illa, J. C. Cuchí "Problemes de termotència", Eumo, 1991. ISBN: 84-7602-558-0.
- M. J. Moran, H. N. Shapiro, "Fundamentos de termodinámica técnica", Ed. Reverté, 1994. ISBN: 84-291-4169-3.
- D. C. Look, H. J. Sauer, "Engineering Thermodynamics", Ed. Van Nostrand Reinhold, 1988. ISBN: 0-278-00052-5.

6. ASSESSMENT

The course assessment includes one theoretical and one practical part.

The theoretical part will be assessed individually for each semester. During the two mid-semesters there will be a partial exam, i.e. PQ1 and PQ2, and a final exam for each semester, i.e. FQ1 and FQ2.

The mark for each semester will be calculated as follows:

Q1=max(0,10·PQ1+0,90·FQ1, FQ1)
Q2=max(0,10·PQ2+0,90·FQ2, FQ2)

The mark for the theoretical part for the first examination session will be calculated as follows:

NT(1)=(Q1+Q2)/2 if: Qi ☐ 3
NT(1)=min[(Q1+Q2)/2, 2,5] otherwise

The September exam is divided into two parts, one for each semester (QE1, QE2). The student has the option to do each individual parts. If the student does not sit the exam, he will keep the mark from the first examination session.

The mark of the theoretical part for the second examination session will be calculated as follows:

NT(2)=(QE1+QE2)/2 if: Qi ☐ 4
NT(2)=min[(QE1+QE2)/2, 2,5] otherwise

The practical part (NP) will be evaluated from the practical laboratory work reports and other projects that could be asked for submission during the year (NM) and from the active participation of the student in class (NA).

Mark of the practical part:

NM: reports mark from practical work and projects
NA: evaluation of the students participation in class during the year.

Course mark:

N=0,7xNT+0,3xNP if: NT ☐ 4 and NP ☐ 4
N=min[(0,7xNT+0,3xNP), 2,5] otherwise