Universidad Carlos III de Madrid
www.uc3m.es

COURSE: Turbomachinery Design		
DEGREE: Aerospace Engineering	**YEAR: 4th**	**TERM: 1st**

La asignatura tiene 29 sesiones que se distribuyen a lo largo de 14 semanas. Los laboratorios pueden situarse en cualquiera de ellas. Semanalmente el alumnos tendrá dos sesiones, excepto en un caso que serán tres

WEEKLY PLANNING

WEEK	SESSION	DESCRIPTION	GROUPS (mark X)		SPECIAL ROOM FOR SESSION (Computer class room, audio-visual class room)	Indicate YES/NO If the session needs 2 teachers	WEEKLY PROGRAMMING FOR STUDENT		
			LECTURES	SEMINARS			DESCRIPTION	CLASS HOURS	HOMEWORK HOURS (Max. 7h week)
1	1	**Introduction and dimensional analysis 1** Introduction to the subject. Course scheduling. Definition of a turbomachine. Different kinds and applications. Main defining variables, dimensions and fluid properties. Units. Dimensional analysis: incompressible flow. Specific Speed: machine selection.	X			NO	Reading the corresponding book chapters Study and personal work	1,6	5
1	2	**Dimensional analysis 2** Compressible gas flow relations. Dimensional analysis: compressible flow. Exercises on dimensional analysis		X		NO	Reading the corresponding book chapters Study and personal work Solve the proposed exercises	1,6	

		Turbomachinery Basic Equations 1 Fluid mechanics and thermodynamics equations in integral and differential form. Euler equations for turbomachines. Definition of Rothalpy.							
2	3	**Turbomachinery Basic Equations 2** Second law of thermodynamics: entropy. Definition of adiabatic / polytropic efficiency. Enthalpy-entropy diagrams. Exercises on Turbomachinery Basic Equations	X	X		NO	Reading the corresponding book chapters Study and personal work Solve the proposed exercises	1,6	5
2	4	**Axial flow turbines: two-dimensional stage theory 1** Dimensional analysis of a single turbine stage. Thermodynamics of a turbine stage. Total-to-total stage efficiency. Row loss-stage efficiency relation. Velocity triangles, loading and flow parameters, reaction: Repeating stage hypothesis.	X			NO	Reading the corresponding book chapters Study and personal work	1,6	
3	5	**Axial flow turbines: two-dimensional stage theory 2** Reaction. Effect on efficiency. Optimum reaction. Smith chart. Empirical versus reversible.	X			NO	Reading the corresponding book chapters Study and personal work	1,6	7
3	6	**Axial flow turbines: two-dimensional stage theory 3** Estimation of turbine stage performance. Flow characteristics of a multistage turbine. Stresses in turbine rotor blades. Turbine blade cooling. Detailed design & Design criteria	X			NO	Reading the corresponding book chapters Study and personal work	1,6	
4	7	**Axial flow turbines: two-dimensional stage theory 4** Exercises on axial flow turbines		X		NO	Solve the proposed exercises	1,6	7
4	8	**Axial flow compressors and fans: 2D stage theory 1** Dimensional analysis of a single compressor stage. Thermodynamics of a compressor stage. Total-to-total stage efficiency. Row loss-stage efficiency relation. Velocity triangles, loading and flow parameters, reaction. Repeating stage hypothesis.	X			NO	Reading the corresponding book chapters Study and personal work	1,6	
5	9	**Axial flow compressors and fans: 2D stage theory 2** Loading-Flow coefficient chart. Reaction choice. Lift and Drag in terms of ϕ and ψ. Diffusion Factor and solidity selection.	X			NO	Reading the corresponding book chapters Study and personal work	1,6	7

		Estimation of compressor pressure ratio and efficiency.							
5	10	**Axial flow compressors and fans: 2D stage theory 3** Simplify off-design performance. Compressor characteristic maps. Stall and surge phenomena.	X			NO	Reading the corresponding book chapters Study and personal work	1,6	
6	11	**Axial flow compressors and fans: 2D stage theory 4** Exercises on Axial Flow Compressors		X		NO	Solve the proposed exercises	1,6	7
6	12	**Lab Session 1** Smith chart		X	Computer room	NO	Solve the proposed exercises	1,6	
7	13	**Two-Dimensional Cascades 1** Introduction. Definition of streamsurface, m'-θ plane, blade-to-blade analysis. Cascade nomenclature for compressors and turbines. Cascade kinematics: velocity triangles. Cascade dynamics: forces, momentum. Cascade entalphy and entropy change: loss definitions.	X			NO	Reading the corresponding book chapters Study and personal work	1,6	7
7	14	**Two-Dimensional Cascades 2. Compressor** Compressor cascade performance. Compressor characteristics: enthalpy rise, pressure recovery, deflection, deviation and loss. Blade loading: surface velocity distribution, diffusion factor. Compressor cascade correlations: optimum solidity, polar curve. Diffusor efficiency	X			NO	Reading the corresponding book chapters Study and personal work	1,6	
8	15	**Two-Dimensional Cascades 3. Turbine** Turbine cascade performance. Turbine characteristics: turning angle, Zweifel coefficient. Surface velocity distribution: Back Surface Diffusion parameter. Turbine cascade correlations: loss, optimum pitch-chord ratio	X			NO	Reading the corresponding book chapters Study and personal work	1,6	7
8	16	**Two-Dimensional Cascades 4** Exercises on Two-Dimensional Cascades		X		NO	Solve the proposed exercises	1,6	
9	17	**Lab session 2** Airfoil design and introduction to MISES		X	Computer room		Solve the proposed exercises	1,6	6

9	18	**Three-dimensional flow in Axial Turbomachines 1** Theory of radial equilibrium. The indirect problem: free-vortex flow, forced-vortex flow, general whirl distribution. The direct problem.	X			NO	Reading the corresponding book chapters Study and personal work	1,6	
10	19	**Lab Session 3** Cascade analysis with MISES		X	Computer room	NO	Solve the proposed exercises	1,6	7
10	20	**Three-dimensional flow in Axial Turbomachines 2** Compressible flow through a blade-row. Constant specific mass flow. Actuator disc approach. Blade-row interactions. Computer methods solving through-flow problem.	X			NO	Reading the corresponding book chapters Study and personal work	1,6	
11	21	**Three-dimensional flow in Axial Turbomachines 3** Secondary flows. Loss, angles and helicity. Three-dimensional losses. Types and models. CFD analysis. Exercises on Three-Dimensional Flow		X		NO	Reading the corresponding book chapters Study and personal work Solve the proposed exercises	1,6	5
11	22	**Centrifugal compressors, fans and pumps 1** Introduction, definitions and parts. Theoretical analysis of a centrifugal compressor: Inlet, impeller and diffuser equations. Optimum design of a centrifugal compressor inlet. Slip factor. Correlations.	X			NO	Reading the corresponding book chapters Study and personal work	1,6	
12	23	**Centrifugal compressors, fans and pumps 2** Performance of centrifugal compressors. Diffuser system. Vane and vane-less diffusers. Chocking in a compressor stage		X		NO	Reading the corresponding book chapters Study and personal work	1,6	5
12	24	**Centrifugal compressors, fans and pumps 3** **Exercises**		X		NO	Solve the proposed exercises	1,6	
13	25	**Radial turbines 1** Introduction. Types of inward flow radial turbine. Thermodynamics of the 90 degrees IFR turbine Basic rotor design. Rotor efficiency definition. Mach number relations. Loss coefficients.	X			NO	Reading the corresponding book chapters Study and personal work	1,6	5
13	26	**Radial turbines 2** Optimum efficiency considerations. Minimum number of blades. Design considerations for rotor exit.	X			NO	Reading the corresponding book chapters Study and personal work	1,6	

		Incidence, clearance and windage losses. Pressure ratio limits.							
14	27	**Exercises on radial turbines** **Examples of exam exercises**		X		NO	Solve the proposed exercises	1,6	6
14	28	**Presentation of blade design**		X		SI	Report lab activities	1,6	
	29	**Lab session 3** Experimental calculation of a compressor map		X	LAB 7.0.H.06	NO	Solve the proposed exercises	1,6	2
							Subtotal 1	**48.3**	**88**
							Total 1 *(Hours of class plus student homework hours between weeks 1-14)*	136.3	

15		Tutorials, handing in, etc							5
16		Assessment						3	15
17									
18									
							Subtotal 2	**3**	**20**
							Total 2 *(Hours of class plus student homework hours between weeks 15-18)*	23	

TOTAL *(Total 1 + Total 2. Maximum 180 hours)*	**159.3**