



**NATIONAL UNIVERSITY OF ENGINEERING**  
**COLLEGE OF ENVIRONMENTAL ENGINEERING**  
**ENVIRONMENTAL ENGINEERING PROGRAM**

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**FS145 – THERMODYNAMICS**

**I. GENERAL INFORMATION**

<b>CODE</b>	: FS145 Thermodynamics
<b>SEMESTER</b>	: 4
<b>CREDITS</b>	: 3
<b>HOURS PER WEEK</b>	: 5 (Theory – Practice)
<b>PREREQUISITES</b>	: AA233 Physical-Chemistry
<b>CONDITION</b>	: Compulsory

**II. COURSE DESCRIPTION**

This theoretical-practical course trains students in the application of thermodynamics dealing with the following context: fundamental concepts, first law of thermodynamics, energy balance, second law of thermodynamics, third law of thermodynamics, combination of the first, second and third laws of thermodynamics, cycle of steam and gases power, refrigeration cycle.

**III. COURSE OUTCOMES**

1. Identify, understand and assess the laws of thermodynamics and their application in different industrial activities within the country.
2. Learn concepts of engine, pump, fan, compressor, boiler, turbines, heat exchanger, as well as their different applications in industrial processes.
3. Learn concepts of power, steam and gas cycles, and recommend variable solutions to solve problem in the industry.
4. Learn principles of thermal machines: refrigerator, heat pump, and their different application in the food conservation, heat and cold transfer, air conditioning, and others.

**IV. LEARNING UNITS**

**1. ENERGY AND PROPERTIES OF PURE SUBSTANCES / 20 HOURS**

Matter, mole. Thermodynamic systems and states of equilibrium / Concepts of pressure, temperature, specific volume and density / Methodology for solving thermodynamic problems / Use of pipe tables / First law of thermodynamics / Concept of energy transfer / Energy of a closed system. Internal energy. Heat and work. Efficiency / Properties of pure substances / Ideal and real gases/ Equations of state / PVT relationship. Ideal gas model. Reduced state of compressibility factor / Specific heats / Compressed air in the industry / Manometers / use of thermodynamic tables for pure substances, enthalpies, specific volume, entropy. Energy analysis. Latent vapor of vaporization. Boilers / Problems applied to the industry.

**2. ANALYSIS OF CLOSED SYSTEMS / 8 HOURS**

Energy balance of closed systems / Energy analysis of cycles / Energy transfer / Energy is like a property / Isometric, isobaric, isothermal, adiabatic and polytropic processes. Graphic application to different processes / Problems applied to the industry.

### 3. ANALYSIS OF OPEN SYSTEMS / 16 HOURS

Open systems. Steady-flow processes. Energy analysis of open system. Energy equations for open systems / Isometric, isobaric, isothermal, adiabatic and polytropic processes in open systems / Analysis of industrial processes applying thermodynamic tables and state equations. Steam boilers, turbines, compressors, nozzles, diffusers, fans, pumps, condensers, heat exchangers / Problems applied to industry.

### 4. THERMAL MACHINES, POWER AND REFRIGERATION CYCLES / 12 HOURS

Thermal machines: refrigerators, heat pumps, thermal engines, coefficient of performance, efficiency / third law of thermodynamics. Power cycles / Refrigeration cycles / problems applied to the industry.

### VI. METHODOLOGY

This course is carried out in theory and practical sessions. In theory sessions, the instructor introduces concepts and applications of the same. In practical sessions, problems are solved and their solution is analyzed in order to relate the theory with its application. The introduction and development of the course are carried out with the available multimedia resources for the presentation of slides and videos; internet access to use interactive pages (applets), online videos and pages of equipment suppliers.

### VII. EVALUATION FORMULA

The average grade PF is calculated as follows:

$$PF = 0.25 EP + 0.25 EF + 0.40 PP + 0.10 PA$$

EP: Mid-Term Exam

EF: Final Exam

PP: Quizzes average

PA: Practical work

### VIII. BIBLIOGRAPHY

1. **CENGEL, YUNUS A. AND BOLES, MICHAEL. A.**  
Thermodynamics (Spanish)  
McGraw-Hill Interamericana Editorial 2<sup>nd</sup> Edition (2006)
2. **MORAN, J. MICHAEL AND SHAPIRO, HOWARD N.**  
Fundamentals of Industrial Thermodynamics (Spanish)  
Reverte Editorial 2<sup>nd</sup> Edition, Spain (2005)
3. **PERRY, JOHN**  
Chemical Engineer's Handbook (Spanish)  
UTEHA Editorial, Mexico (2002)