Engineering Technology –MET Option

Course Number and Name: ET 396, Heat Transfer and Applications

Credits & Contact Hours: 3cr., two weekly lectures of 50 min. each, and one weekly 2.5-hour laboratory session. Total semester contact hours are approximately 55.

Instructor's name: Craig Ricketts
Textbook *title*, author, and year: *Heat and Mass Transfer – Fundamentals and Applications,* Çengel, Y. A. and Ghajar, A. J., 2011.
Supplemental materials: *Virtual Experiments in Food Processing*, Singh, R. P. and Erdogdu, 2009; *CyclePad*, a shareware application for simple heat exchanger analysis; and *Engineering Equation Solver, (EES)* of F-Chart Software.

Specific Course Information:

a. **Course Catalog Description -** Fundamentals of conduction, convection, and radiation heat transfer. Application of heat transfer, thermodynamics, and fluid mechanics principles to thermal system analysis and design.
b. **Prerequisites** – ET 306 Applied Thermodynamics and ET 308 Fluid Technology.
c. **Laboratory** – See information below.
d. **Augmenting** – This is a required course in the MET curriculum.

Course Goals and Objectives:

Student understands the physical concepts and basic principles of the three heat transfer modes and becomes better proficient in applying relevant problem solving methods and tools of good practice. Student also becomes more familiar with the development and exercise of laboratory procedures and the processing, evaluation, and professional presentation of experimental data. Through all of the above, student gains additional experience in the application of the fundamentals that underlie the design, testing, and performance evaluation of thermal systems.

Related ABET Outcomes:

The **following** are the MET (x.) and ABET student outcomes that directly relate to Criterion 3. *An ability to select and apply the knowledge, techniques, skills, and modern tools of the discipline;* to include:

(1.) **Algebra**, trigonometry, Boolean mathematics, **calculus**, statistics and probability, **fundamental principles and concepts of science and engineering technology**, **good practice in problem solving**, and **methods of standard practice in the analysis** and applied design **of mechanical systems**.
Also ABET 3.a., 3.b., 3.c., 3.d., 3.e., 3.f., and 3.k.

(2) **Fundamental aspects** of AC and DC circuits, **electrical components**, computer programming logic, instrumentation principles, **experimental techniques**, and **methods of standard practice, safety consciousness**, **critical thinking skills** and **codes and standards** in the **testing** and **evaluation** of **mechanical systems**.
Also ABET 3.a., 3.b., 3.c., 3.d., 3.e., 3.f., and 3.k.

(4.) **Current software corresponding to good practice in the application of mechanical engineering technologies. Software application functions to include:** word processing, **spreadsheet calculations**, **graphing**, presentation media, computer assisted drafting and manufacturing, manufacturing processes, statistics, data acquisition, project management, and **the analysis** and applied design **of systems involving** mechanisms, machines, or **fluid and thermal processes**.

Also ABET 3.a., 3.b., 3.c., 3.d., 3.e., 3.f., and 3.k.

Course topics and class hours devoted to each topic:

Topics	**Class Hours**
· Introduction: field overview and significance, historical perspectives	1
· Units and basic definitions, heat transfer modes	1
· Forms of the heat conduction equation; boundary and initial conditions	2
· Steady-state heat conduction	3
· Transient heat conduction	2
· Numerical methods for analysis of heat conduction	2
· Fundamentals of convection heat transfer	2
· External forced convection heat transfer	1
· Internal forced convection heat transfer	1
· Natural convection heat transfer	2
· Boiling and condensation	2
· Fundamental of thermal radiation	2
· Radiation heat transfer	2
· Heat exchangers	4
· Examinations	0
· Topic Reviews	3

Laboratory topics and lab session hours devoted to each topic:

Topics	**Lab Hours**
· Introduction: laboratory overview, relevance, and significance	1
· Safety in laboratory practice	1
· Professional ethics: a contemporary case study	1
· Use of codes and standards in practice	1
· Good practice in the graphing of experimental data for technical reports	1
· Application of sample statistics in the evaluation of experimental data	1
· Application of error analysis in the planning of an experiment	1
· Thermal properties, units and basic definitions; review of in practice	2
· Data acquisition techniques using a microcomputer	1
· Heat and mass transfer processes in the cooling and drying of a food crop	2
· Fundamental principles underlying the calculation of solar collector efficiency	2
· Performance evaluation of a double-pipe heat exchanger	2
· Evaluation of a lab-scale apparatus for measurement of thermal conductivity	2
· Concept of apparent thermal conductivity of a bulk insulation material	1
· Experimental determination of the convection heat transfer coefficient	2
· Technical and economic analysis of a heat exchanger	2
· Survey and qualitative performance evaluation of typical cooling fin designs	2
· Software applications in heat transfer analysis	3
· Examinations	4
· Exposure to industrial-scale thermal processing or HVAC systems having hardware components such as heat exchangers, pipe and pipe fittings, vapor compression chillers, ductwork, vacuum drying towers, furnaces, or measurement and control equipment ; via a field trip to a local food processing plant. Or a large-scale commercial building during the stage which commissioning of its mechanical systems is being undertaken.	2

Laboratory Exercises: typical topics for four cycles, each of two consecutive lab periods (prelab exercise and laboratory report required):

Lumped system analysis of a temperature sensor to include determination of the convection heat transfer coefficient
(with microcomputer-based DAQ system, thermocouple, and bath of ice, or boiling water).

Evaluation of the performance of a solar collector
(with solar collector test apparatus and instrumentation for temperature and flow measurements).

Performance evaluation of a double-pipe heat exchanger
(with microcomputer-based data acquisition system, variable-area flow meter and thermocouple probes).

Determination of the thermal conductivity of several metals
(with microcomputer-based DAQ system, digital ammeter and voltmeter, and thermistor temperature sensors).

Other Typical Lab Assignments and Topics (1 lab period each):

Discussion of laboratory safety and requirements for prelab exercises and lab reports.

An exercise in professional ethics toward further development of professional ethics in the workplace (via a contemporary case study). Concept worksheet required.

Exercise in the good practice of graphing experimental data (with microcomputer and graphing software package). Table of data and professional-quality graph required. Concept worksheet required.

Survey and qualitative performance evaluation of a multitude of cooling fin designs utilized in contemporary electronic packaging applications.

Evaluation of a laboratory-scale apparatus for suitability in measuring the thermal conductivity of a fibrous bulk insulating material. Concept worksheet required.

Exercise on the distinction between the apparent thermal conductivity of a bulk insulating material and the thermal conductivity of its solid constituent as a simple substance. Concept worksheet required.

Conceptual design of a hardware component via analysis of heat and mass transfer processes in the cooling and drying of a food crop. Concept worksheet required.

Technical and economic evaluation of the feasibility of a proposed heat exchanger installation for energy and cost savings (with software package for thermodynamic system analysis, *CyclePad*). Concept worksheet required.

Field trip to local food processing plant, large office building, or on-campus solar furnace. Concept worksheet required.

Oral and Written Communication Requirements:

Students engage in discussions (led by instructor) during pre-lab and lab exercise sessions to share insights and recommended techniques and procedures for relevant lab exercise. All lab exercises require a laboratory exercise documentation sheet and a memorandum report.

Prepared by: Craig Ricketts **Date**: 12/28/10