NEW COURSE PROPOSAL

College: [Engineering and Computer Science] **Department: [Mechanical Engineering]**

Note: Use this form to request a single course that can be offered independently of any other course, lab or activity.

1. **Course information for Catalog Entry**

   Subject Abbreviation and Number: **[ME 376]**

   Course Title: **[Heat Transfer in Electrical and Electronic Systems]**

   Units: **[3]** units

   Course Prerequisites: **[Math 280, Phys 220A/L]** *(if any)*

   Course Corequisites: **[ ]** *(if any)*

   Recommended Preparatory Courses: **[ ]** *(if any)*

2. **Course Description for Printed Catalog:** *Notes:* If grading is NC/CR only, please state in course description. If a course numbered less than 500 is available for graduate credit, please state "Available for graduate credit in the catalog description."

   [Prerequisites: MATH 280, PHYS 220A/L. Basic principles of thermodynamics and heat transfer applicable to electrical and electronic systems. Introduction of conductive, convective, and radiative modes of heat transfer. Analysis of a finned heat sink. Not available for credit for Mechanical Engineering majors. **]**

3. **Date of Proposed Implementation: (Semester/Year): [Fall] / [2016]** *Comments*

4. **Course Level**

   [X]Undergraduate Only **[]**Graduate Only **[]**Graduate/Undergraduate

5. **Course Abbreviation "Short title" (maximum of 17 characters and spaces)**

   Short Title: **[H•E•A•T• •T•R•A•N•S•F•E•R• •E•E•S]**

6. **Basis of Grading:**

   []Credit/No Credit Only **[X]Letter Grade Only** **[]CR/NC or Letter Grade**

7. **Number of times a course may be taken:**

   [X] May be taken for credit for a total of **[1]** times, or for a maximum of **[3]** units

   [ ] Multiple enrollments are allowed within a semester

8. **C-Classification:** *(e.g., Lecture-discussion (C-4).)*

   [3] units @ **[C] [4]**

9. **Replaces Current Experimental Course?**

   [X] YES **[ ]** NO

   Replaces Course Number/Suffix:**[ME 396 HT]**

   Previously offered **[1]** times.

10. Proposed Course Uses: *(Check all that apply)*

[ ]Own Program: [ ]Major [ ]Minor [ ]Masters [ ]Credential [X]Other

[X] Requirement or Elective in another Program
[ ] General Elective
[ ] General Education, Section [ ]
[ ] Meets GE Information Competence (IC) Requirement
[ ] Meets GE Writing Intensive (WI) Requirement
[ ] Community Service Learning (CS)
[ ] Cross-listed with: *(List courses)* [ ]

11. Justification for Request: *Course use in program, level, use in General Education, Credential, or other. Include information on overlap/duplication of courses within and outside of department or program. (Attach)*

12. Estimate of Impact on Resources within the Department, for other Departments and the University. *(Attach)*
(See Resource List)

13. Course Outline and Syllabus *(Attach) Include methods of evaluation, suggested texts, and selected bibliography.* Describe the difference in expectations of graduates and undergraduates for all 400 level courses that are offered to both.

14. Indicate which of the PROGRAM'S measurable Student Learning Outcomes are addressed in this course. *(Attach)*

15. Assessment of COURSE objectives *(Attach)*

A. Identify each of the course objectives and describe how the student performance will be assessed

(For numbers 14 and 15, see Course Alignment Matrix and the Course Objectives Chart)

16. If this is a General Education course, indicate how the General Education Measurable Student Learning Outcomes (from the appropriate section) are addressed in this course. *(Attach)*

17. Methods of Assessment for Measurable Student Learning Outcomes *(Attach)*

A. Assessment tools
B. Describe the procedure dept/program will use to ensure the faculty teaching the course will be involved in the assessment process (refer to the university's policy on assessment.)

18. Record of Consultation: *(Normally all consultation should be with a department chair or program coordinator.) If more space is needed attach statement and supporting memoranda.*

Date:	Dept/College:	Department Chair/ Program Coordinator	Concur (Y/N)
[3/5/2015]	[CECM/ECS]	[N. Dermendjian]	[Y]
[3/5/2015]	[CS/ECS]	[R. Covington]	[Y]
[3/5/2015]	[ECE/ECS]	[A. Amini]	[Y]
[3/5/2015]	[ME/ECS]	[H. Johari]	[Y]

[3/5/2015]	[MSEM/ECS]	[K. Chang]	[Y]
[ ]	[ ]	[ ]	[ ]

Consultation with the Oviatt Library is needed to ensure the availability of appropriate resources to support proposed course curriculum.

Collection Development Coordinator **Date**

Please send an email to: collection.development@csun.edu [3/5/2015]

19. Approvals:

Department Chair/Program Coordinator:	Hamid Johari	Date:	[3/5/2015]
College (Dean or Associate Dean):	Robert Ryan	Date:	[3/25/2015]
Educational Policies Committee:		Date:	[ ]
Graduate Studies Committee:		Date:	[ ]
Provost:		Date:	[ ]

11. Justification for Request:

The proposed course is designed specifically for students majoring in Electrical Engineering (EE). Currently, these students take either ME 370 Thermodynamics or ME 375 Heat Transfer, both of which are geared toward mechanical engineering applications. For example, large scale power plant design and analysis is prominently showcased in the thermodynamics courses. However, EE students will typically encounter much different design and analysis issues and at different scales in their professional careers. Thus, this course will fill the needs of EE students in the area of heat transfer as applied to electrical and electronic systems. The addition of this course will enable EE students gain the appropriate knowledge and analysis tools and help them to prepare for their industry careers.

12. Estimated Impact on Resources within the Department, for other Departments and the University:

Minimal impact is expected on the current departmental resources because the faculty member assigned to teaching one section of ME 375 will be assigned to teach this new course. Moreover, EE students who are required to take either ME 370 or ME 375 will have to take this course in place of one of the former classes. A new instructor or position will not be needed, and the total number of students enrolled in ME 370, 375, and the proposed ME 376 will remain the same.

13. Course Outline and Syllabus:

ME 376 Heat Transfer in Electrical and Electronic Systems

Prerequisite: MATH 280, Phys 220A/L

Textbook: Required: **Heat and Mass Transfer-Fundamentals and Applications -** Y. A. Cengel and A. J. Ghajar; McGraw Hill, 5th Edition, 2014

References:

Thermal Measurements in Electronics Cooling – K. Azar; CRC Press, 1st edition, 1997
Cooling Techniques for Electronic Equipment – D. Steinberg; Wiley-Interscience; 2nd ed., 1991

Course Content: The topics to be covered is listed below along with the time allotted to each topic.

A. Introduction to Thermodynamics (Time Allotted: 2 weeks)

1. Thermodynamic definitions
   a. Brief discussion about the definition of a system, its boundaries and how the thermodynamic properties of that system define its state or condition.
   b. Introduce the concepts of energy in the form of work, internal energy and heat.
2. First Law of Thermodynamics for a closed system
   a. Discuss the concept of the First Law of Thermodynamics and how it applies to a closed system such as a gas enclosed by a rigid cylinder wall and bottom with a moveable piston as the upper boundary.
   b. Review the various forms of energy and how they relate to the above example.
3. First Law of Thermodynamics for an open system
   a. The First Law can be explained with a simple example such as the heating of a fluid that is flowing through a tube.
   b. The concept of the thermal transport of energy by a moving fluid can be introduced here along with the meaning of the mass flow rate of a fluid.

B. Introduction to Heat Transfer (Time Allotted: 1.5 weeks)

1. Overview of the three modes of heat transfer
2. Discussion of heat is physically transferred with each of the modes
3. Provide a simple physical example of each mode along with a simple equation to demonstrate how the rate of heat transfer in each case can calculated.

C. Steady State Heat Transfer (Time Allotted: 3 weeks)

1. Plane walls and cylinders
   a. Emphasize the application of the conservation of energy combined with the Fourier conduction law to calculate the rate of heat transfer through a wall.
   b. Introduce thermal resistance and its applicability in solving 1D steady state conduction problems for plates and hollow cylinders.
2. Fins
   a. Introduce fins by emphasizing the physical aspects of fin heat transfer along with the concept of fin efficiency and the increased area offered by fins.
   b. Use the thermal resistance approach to deal with multiple parallel fins or an array of fins.
3. Derivations

    a. Brief demonstrations of the analyses of the temperature distributions and the rate of heat transfer for each of the above geometries

4. Use of electronic cooling examples
    a. Use examples of pin fin arrays and/or parallel plate fins to remove heat form devices such as circuit boards or power transistors.
    b. Cover examples of commercially designed fins for use in cooling electronic devices
    c. Discussion of 1D internal heat generation with respect to heat generating devices.

D. Transient Heat Transfer (Time Allotted: 2 weeks)

1. Physical description of the conduction and thermal storage mechanisms in transient heat transfer.
    a. Discuss how physical properties can influence the lumped versus distributed mass models of transient heat transfer.
2. Develop the Biot number for distinguishing between the two different transient thermal models.
3. Derive the “quenching solution” as a lumped mass solution for low Biot numbers.
4. Solve the lumped mass case where heat is generated uniformly within the body.

E. Forced Convection-External and Internal (Allotted Time: 2.0 weeks)

1. Introduction into fluid flow over a solid surface (external)
    a. Physical discussion of thermal and hydrodynamic boundary layer.
    b. Introduction of temperature and velocity profiles within boundary layers.
    c. Introduce rough approximation regarding film coefficient and its relationship to boundary layer thickness in laminar flow and the sub layer thickness in turbulent flow.
2. Nusselt number correlations (external)
    a. Introduce dimensionless parameters such as the Reynolds and Nusselt numbers
    b. Correlations for flat plate in both laminar and turbulent flow cases
    c. Correlations for flow over circular, rectangular and other tubular cross-sections
3. Electronic cooling examples (external)
    a. Calculate heat removal rate for flat surfaces that are fan cooled.
    b. Revisit finned heat sinks using a pin fin array or a number of parallel flat fins
4. Brief discussion on internal convection

a. Utilize similarities to external flow along with the differences with respect to internal flow that lead to an entrance region where the film coefficient is larger than that of the fully developed region.

b. Introduce correlation equations for laminar and turbulent internal flow.

F. **Natural Convection Heat Transfer (**Allotted time: 1 week)

1. Physical description of a buoyancy driven boundary layer
   a. Utilize the physical discussion of forced convection but emphasizing the buoyancy force involvement.
   b. Briefly discuss the addition of a dimensionless Grashof number and how it replaces the Reynolds number in the Nusselt number correlations when forced convection is negligible.
2. Natural convection heat transfer correlations
   a. Show how external flow natural convection correlation on flat surfaces exhibit many similarities to forced convection correlations.
   b. Discuss the utilization of natural convection equations in electronic cooling.
   c. Briefly touch upon the fact that correlations exist for an array of finned surfaces where the spacing between fins needs to be taken into account.

G. **Radiation Heat Transfer (**Allotted Time: 2 weeks)

1. Radiation Physics
   a. Introduce concept of electromagnetic radiation and its relationship to both waves and photons with regards to the electromagnetic spectrum.
   b. Introduce the concept of a blackbody along with the Stefan-Boltzmann law where the blackbody emissive power is related to the body's temperature.
   c. Discuss the radiative properties including emissivity (for emission) and absorptivity, reflectivity, and transmissivity (for irradiation).
2. Radiation heat transfer
   a. Introduction of view factors
   b. Heat transfer by radiation between two diffuse gray bodies

Course Objectives:

A. Obtain a thorough understanding of the first law of thermodynamics and basic principles of heat transfer.
B. Learn the various modes of heat transfer and how they can be used in various applications.
C. Apply the principles of heat transfer to analyze an electronic cooling device.

Grading: There will be two midterm exams and one final exam in addition to the homework assignments and one project. The breakdown of the final grade is as follows:

Assignment	% of final grade
Homework	10%
Project	15%
Midterm 1	20%
Midterm 2	25%
Final	30%

Homework: Homework problems will be assigned once a week approximately and they are due in the class the following week. No late homework will be accepted.

Project: The project will address the use of a commercially available finned heat sink for electronic cooling. The students will be asked to use the analytical tools covered in the class to compare the predicted performance of the heat sink to specifications provided by the heat sink manufacturer.

Course Policies: Attendance is mandatory for all classes. Please bring your textbook to class. For help on homework problems, you should have tried the problem on your own first.

14. Indicate which of the Program's Measurable Student Learning Outcomes are addressed in this course:

Demonstration of Program Outcomes in course
a. an ability to apply knowledge of mathematics, science, and engineering
e. an ability to identify, formulate, and solve engineering problems

15. Assessment of COURSE objectives

The three course objectives listed in the course outline are assessed through the homework and examinations in addition to the project. The alignment of the course objectives and the student assessment tools is shown in the table below.

Course Objectives	Assessments of Student Performance
1. Obtain a thorough understanding of the first law of thermodynamics and basic principles of heat transfer.	Examinations and Homework
2. Learn the various modes of heat transfer and how they can be used in various applications.	Examinations and Homework
3. Apply the principles of heat transfer to analyze an electronic cooling device.	Project

16. Not Applicable

17. Methods of Assessment for Measurable Student Learning Outcomes:
A. Assessment Tools

Homework, Project, Examinations

COURSE ALIGNMENT MATRIX

Assess how well ____ME 376____ contributes to the program's student learning outcomes by rating each course objective for that course with an I, P or D.

I=introduced (basic level of proficiency is expected)
P=practiced (proficient/intermediate level of proficiency is expected)
D=demonstrated (highest level/most advanced level of proficiency is expected)

Course Objectives	Student Learning Outcome a	Student Learning Outcome e	
1. Obtain a thorough understanding of the first law of thermodynamics and basic principles of heat transfer.	D	D	
2. Learn the various modes of heat transfer and how they can be used in various applications.	D	D	
3. Apply the principles of heat transfer to analyze an electronic cooling device.	P	P	

B) Describe the procedure dept/program will use to ensure the faculty teaching the course will be involved in the assessment process

The ME Department has developed a Course Evaluation Form which is used by all full-time and part-time faculty members to evaluate program outcomes and course objectives. All mechanical engineering courses are evaluated according to a defined schedule. The form template is attached.

Mechanical Engineering - Course Evaluation Form

Course Number: **Instructor:** **Semester/year:**

The purpose of this is form is to document the achievement of course objectives and program outcomes in the courses that you instruct. Answers to the questions below should cite supporting evidence from your own observations, student performance on assignments and examinations, and other feedback.

☐ **First time course taught by this instructor** ☐ **Course taught previously**

Course prerequisite(s) ____________________ ____________________ ____________________

- **Were the students adequately prepared by prerequisite courses?** **Yes** ☐ **No** ☐

- Were changes implemented since the last time this course was taught? **Yes** ☐ **No** ☐

If Yes, what changes were made since the last time this course was taught? Did these changes improve the course?

Changes made since last time	*Effects of change*

- Are changes called for the next time this course is taught? **Yes** ☐ **No** ☐

If Yes, what changes should be made the next time this course is taught?

Changes recommended for next time	*Purpose of changes*

Most useful comments from students:

Achievement of Course Objectives/Demonstration of Program Outcomes

Did the students demonstrate achievement of the course objectives and program outcomes specific to this course? In the table below, rate achievement of objectives/outcomes using evidence from direct assessment of student work, student surveys, etc.

If sampling, please indicate the approximate percent of the class sampled:
Use assessment rubrics for determining program outcome assessment

Course Objectives/Program Outcomes List Course Objectives first, followed by Program Outcomes	*Means of Direct Assessment by Instructor—what evidence was used for your assessment?*	*Instructor's Direct Outcome Assessment 4=Excellent to 0=Poor*	*Improved (yes/no/??) compared to last year*