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Office of the Registrar
FORM 40G REV. 10/10

PURDUE UNIVERSITY
REQUEST FOR ADDITION, EXPIRATION, OR REVISION OF A GRADUATE COURSE
(50000-60000 LEVEL)

EFD 18.09

Print Form

Graduate Council Doc. No. 10-16d

DEPARTMENT Mechanical Engineering EFFECTIVE SESSION Spring 2012

INSTRUCTIONS: Please check the items below which describe the purpose of this request.

- [X] 1. New course with supporting documents (complete proposal form)
- [ ] 2. Add existing course offered at another campus
- [ ] 3. Expiration of a course
- [ ] 4. Change in course number
- [ ] 5. Change in course title
- [ ] 6. Change in course credit/type
- [ ] 7. Change in course attributes
- [ ] 8. Change in instructional hours
- [ ] 9. Change in course description
- [ ] 10. Change in course requisites
- [ ] 11. Change in semesters offered
- [ ] 12. Transfer from one department to another

304

PROPOSED:		EXISTING:	
Subject Abbreviation	ME	Subject Abbreviation	
Course Number	51100	Course Number	
Long Title	Heat Transfer in Electronic Systems		
Short Title	Heat Transfer Elec System		

Abbreviated title will be entered by the Office of the Registrar if omitted. (30 CHARACTERS ONLY)

TERMS OFFERED
Check All That Apply:
[ ] Fall [X] Spring [ ] Summer

CAMPUS(ES) INVOLVED
[ ] Calumet [ ] N. Central
[ ] Cont Ed [ ] Tech Statewide
[ ] Ft. Wayne [X] W. Lafayette
[ ] Indianapolis

CREDIT TYPE
1. Fixed Credit: Cr. Hrs. 3
2. Variable Credit Range: Minimum Cr. Hrs (Check One) To [ ] Or [ ]
Maximum Cr. Hrs.
3. Equivalent Credit: Yes [ ] No [X]
4. Thesis Credit: Yes [ ] No [X]

COURSE ATTRIBUTES: Check All That Apply
1. Pass/Not Pass Only [ ]
2. Satisfactory/Unsatisfactory Only [ ]
3. Repeatable [ ]
Maximum Repeatable Credit: [ ]
4. Credit by Examination [ ]
5. Special Fees [ ]
6. Registration Approval Type: Department [ ] Instructor [ ]
7. Variable Title [ ]
8. Honors [ ]
9. Full Time Privilege [ ]
10. Off Campus Experience [ ]

Schedule Type	Minutes Per Mtg	Meetings Per Week	Weeks Offered	% of Credit Allocated
Lecture	75	2	16	
Recitation				
Presentation				
Laboratory				
Lab Prep				
Studio				
Distance				
Clinic				
Experiential				
Research				
Ind. Study				
Pract/Observ				

Cross-Listed Courses

COURSE DESCRIPTION (INCLUDE REQUISITES/RESTRICTIONS): ME 51100 Heat Transfer in Electronic Systems, Sem. 2 (alternate years), Class 3, cr. 3. Prerequisite: ME 31500 or consent of instructor. This course covers both traditional and more innovative methods for heat extraction in electronic systems and the effectiveness and applicability of these methods over a wide range of scales. Special emphasis is given to industry-related applications with experts often attending and presenting material as part of class instruction. Professor Garimella.

Calumet Department Head	Date	Calumet School Dean	Date	Calumet Undergrad Curriculum Committee	Date
Fort Wayne Department Head	Date	Fort Wayne School Dean	Date	Fort Wayne Chancellor	Date
Indianapolis Department Head	Date	Indianapolis School Dean	Date	Undergrad Curriculum Committee	Date
North Central Department Head	Date	North Central School Dean	Date	APPROVED Date Approved by Graduate Council	2/17/11
West Lafayette Department Head	Date	West Lafayette College/School Dean	Date	Graduate Council Secretary	Date 2/18/11
Graduate Area Committee Convener	Date	Graduate Dean	Date	West Lafayette Registrar	Date 2/4/11

OFFICE OF THE REGISTRAR

SEE ATTACHED COPY FOR SIGNATURES

3/1/11

Office of the Registrar
FORM 40G REV. 1/07

PURDUE UNIVERSITY
REQUEST FOR ADDITION, EXPIRATION,
OR REVISION OF A GRADUATE COURSE
(500-600 LEVEL)

EFD 18-09

DEPARTMENT: Mechanical Engineering

EFFECTIVE SESSION: Fall 2009

INSTRUCTIONS: Ple

- [x] 1. New course with supporting documents (complete proposal form)
- [ ] 2. Add existing course offered at another campus
- [ ] 3. Expiration of a course
- [ ] 4. Change in course number
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- [ ] 8. Change in instructional hours
- [ ] 9. Change in course description
- [ ] 10. Change in course requisites
- [ ] 11. Change in semesters offered
- [ ] 12. Transfer from one department to another

PROPOSED:		EXISTING:	
Subject Abbreviation	ME	Subject Abbreviation	
Course Number	504 51100	Course Number	
Long Title			
Short Title	Heat Transfer Elec Sys		

Abbreviated title will be entered by the Office of the Registrar if omitted. (22 CHARACTERS ONLY)

TERMS OFFERED
Check All That Apply:
[ ] Summer [ ] Fall [x] Spring

CAMPUS(ES) INVOLVED
[ ] Calumet [ ] N. Central
[ ] Cont Ed [ ] Tech Statewide
[ ] Ft. Wayne [x] W. Lafayette
[ ] Indianapolis

Heat Transfer in Electronic Systems

1. Fixed Credit: Cr. Hrs
2. Variable Credit Range:
   Minimum Cr. Hrs
   (Check One) To [ ] Or [ ]
   Maximum Cr. Hrs
3. Equivalent Credit: Yes [ ] No [ ]
4. Thesis Credit: Yes [ ] 3 [ ]

2. Satisfactory/Unsatisfactory Only [ ]
3. Repeatable [ ]
   Maximum Repeatable Credit:
4. Credit by Examination [ ]
5. Designator Required [ ]
Fees [ ]

Department [ ] Instructor [ ]
8. Variable Title [ ]
9. Remedial [ ]
10. Honors [ ]
11. Full Time Privilege [ ]
12. Off Campus Experience [ ]

Instructional Type	Minutes Per	Meetings Per	Weeks	% of Credit Allocated	Delivery Method (Asyn. Or Syn.)	Delivery Medium (Audio, Internet, Live, Text-Based, Video)
Lecture	75	2	15		Syn	Live
Recitation						
Presentation						
Laboratory						
Lab Prep						
Studio						
Distance						
Clinic						
Experiential						
Research						
Ind. Study						
Pract/Observ						

Cross-Listed Courses

COURSE DESCRIPTION (INCLUDE REQUISITES):

ME 504 Heat Transfer in Electronic Systems, Sem. 2 (alternate years), Class 3, cr. 3. Prerequisite: ME 315 or consent of instructor.

This course covers both traditional and more innovative methods for heat extraction in electronic systems and the effectiveness and applicability of these methods over a wide range of scales. Special emphasis is given to industry-related applications with experts often attending and presenting material as part of class instruction.

Calumet Department Head	Date	Calumet School Dean	Date	Calumet Undergrad Curriculm Committee	Date
Fort Wayne Department Head	Date	Fort Wayne School Dean	Date	Fort Wayne Chancellor	Date
				R. Cipra	3/3/2010
Indianapolis Department Head	Date	Indianapolis School Dean	Date	Undergrad Curriculm Committee	Date
North Central Department Head	Date	North Central Chancellor	Date	Date Approved by Graduate Council	
E. Daniel Hirleman	12/12/2008				
West Lafayette Department Head	Date	West Lafayette College/School Dean	Date	Graduate Council Secretary	Date
Graduate Area Committee Convener	Date	Graduate Dean	Date	West Lafayette Registrar	Date

OFFICE OF THE REGISTRAR

TO: The Engineering Faculty

FROM: The Faculty of the School of Mechanical Engineering

RE: New Course – ME 504 Heat Transfer in Electronic Systems

The Faculty of the School of Mechanical Engineering has approved the following new course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

5/100
ME ~~504~~ Heat Transfer in Electronic Systems
Sem. 2 (alternate years), Class 3, cr. 3
Prerequisite: ME 315 or consent of instructor

This course covers both traditional and more innovative methods for heat extraction in electronic systems and the effectiveness and applicability of these methods over a wide range of scales. Special emphasis is given to industry-related applications with experts often attending and presenting material as part of class instruction.

Reason: This course has been taught three times on an experimental basis with the following enrollments: spring 2003 - 18 students, spring 2005 – 22 students, and spring 2007 - 9 students. This course introduces concepts in thermal management of electronics, demonstrates the application of first principles to electronics cooling problems, and provides students with sound tools to approach existing industrial applications while also raising awareness of emerging and novel approaches.

James D. Jones

James D. Jones, Associate Head/Professor
School of Mechanical Engineering

APPROVED FOR THE FACULTY
OF THE SCHOOLS OF ENGINEERING
BY THE ENGINEERING
CURRICULUM COMMITTEE

ECC Minutes #11

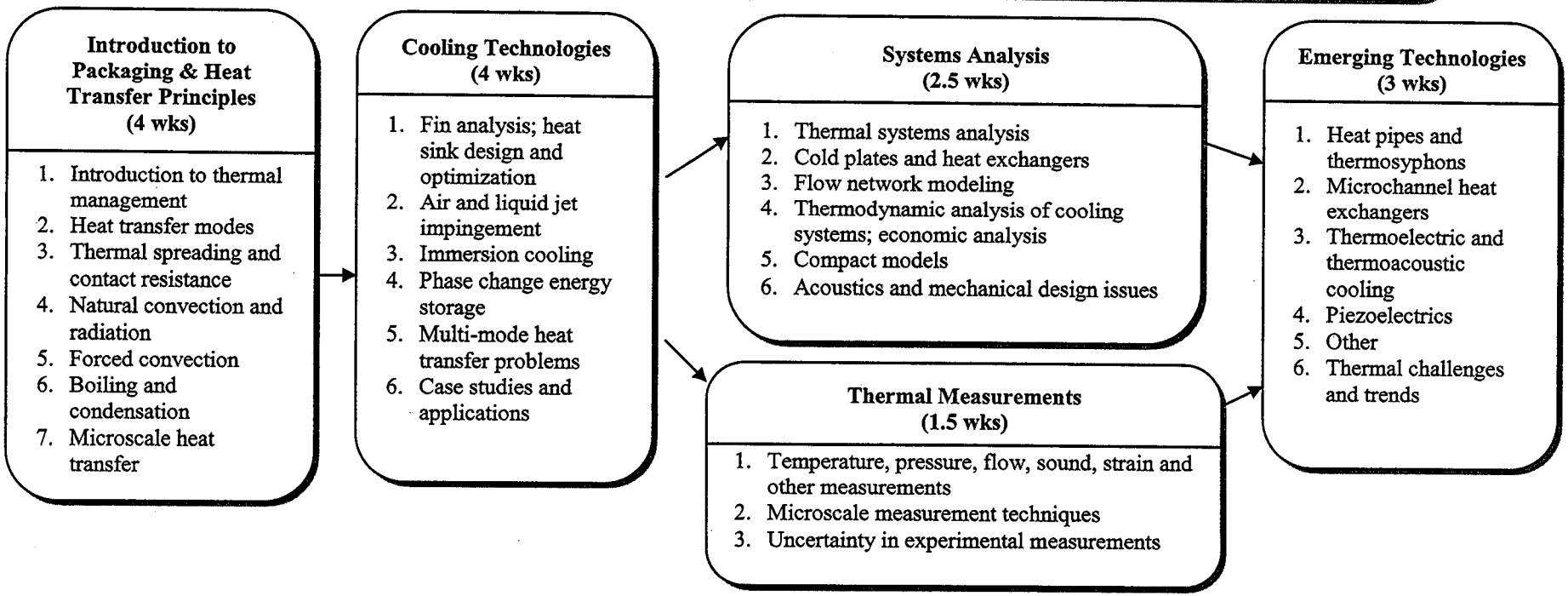
Date 12/14/09

Chairman ECC R Cipra

ME ~~504~~ 5100
HEAT TRANSFER IN ELECTRONIC SYSTEMS

Course Outcomes

1. To introduce concepts in *thermal management* of electronics to senior undergraduate and graduate students and practicing engineers.
2. To provide an appreciation for the applications of *first principles* to electronics cooling and packaging problems in industry.
3. To provide students with *sound tools to approach existing packaging and cooling applications*, while also raising awareness of *novel techniques* at the cutting edge.



COURSE NUMBER: ME 504 **COURSE TITLE:** Heat Transfer in Electronic Systems

REQUIRED COURSE OR ELECTIVE COURSE: Elective

TERMS OFFERED: Spring (Odd numbered years)

TEXTBOOK/REQUIRED MATERIAL: None

PRE-REQUISITES: ME 315 Heat and Mass Transfer

COORDINATING FACULTY: S. V. Garimella

COURSE DESCRIPTION: This course covers both traditional and more innovative methods for heat extraction in electronic systems and the effectiveness and applicability of these methods over a wide range of scales. Special emphasis is given to industry-related applications with experts often attending and presenting material as part of class instruction.

COURSE OUTCOMES:

1. To introduce concepts in thermal management of electronics to senior undergraduate and graduate students and practicing engineers.
2. To provide an appreciation for the applications of first principles to electronics cooling and packaging problems in industry.
3. To provide students with sound tools to approach existing packaging and cooling applications, while also raising awareness of novel techniques at the cutting edge.

ASSESSMENTS TOOLS:

1. Homework assignments.
2. Exams.
3. Projects to be done both individually and in group settings.

RELATED ME PROGRAM OUTCOMES: N/A

PROFESSIONAL COMPONENT:

1. Engineering Topics: Engineering Science – 1 credit (67%)
   Engineering Design – 2 credits (33%)

NATURE OF DESIGN CONTENT: Several short-term design projects involving open-ended problems and case studies, needing computational analysis, using commercial codes and solvers.

COMPUTER USAGE: Required for analysis needed in homework assignments and class projects.

COURSE STRUCTURE/SCHEDULE:

1. Lecture – 2 days per week at 75 minutes each.

PREPARED BY: S. V. Garimella **REVISION DATE:** June 13, 2007

Supporting Document for a New Graduate Course

Purdue University Graduate Council

For Reviewer's comments only (Select One)
Choose an item.
Reviewer:
Click here to enter text.
Comments:
Click here to enter text.

From: Faculty Member: Suresh V. Garimella
Department: Mechanical Engineering
Campus: West Lafayette

Date: 3/15/2010

Subject: Proposal for New Graduate Course- Documentation Required by the Graduate Council to Accompany Registrar's Form 40G

Contact for information if questions arise:

Name:	James D. Jones
Phone Number:	494-5691
E-mail:	jonesjd@purdue.edu
Campus Address:	1288 ME/ ME room 222

Course Subject Abbreviation and Number: ME 50400

Course Title: Heat Transfer in Electronic Systems

A. Justification for the Course:

- This course has been taught three times on an experimental basis with the following enrollments: spring 2003 – 18 students, spring 2005 – 22 students, and spring 2007 – 9 students. This course introduces concepts in thermal management of electronics, demonstrates the application of first principles to electronics cooling problems, and provides students with sound tools to approach existing industrial applications while also raising awareness of emerging and novel approaches.
- The proposed ME 50400 course covers advanced topics in heat extraction in electronic systems. This course builds off the fundamental principles in ME 31500 and is intended for entry-level graduate students, although some undergraduates may take the course. The course will be taught in alternate years with an anticipated enrollment of 15-20 students, mostly graduate students.

B. Learning Outcomes and Methods of Evaluation or Assessment:

- 1) To introduce concepts in thermal management of electronics to senior undergraduate and graduate students and practicing engineers, 2) To provide an appreciation for the applications of first principles to electronics cooling and packaging problems in industry, and 3) To provide students with sound tools to approach existing packaging and cooling applications, while also raising awareness of novel techniques at the cutting edge.

- Homework assignments, exams, and projects to be done both individually and in group settings.
- 1. Engineering Topics: Engineering Science – 1 credit (67%) & Engineering Design – 2 credits (33%)
    - **Criteria:**

☒	Exams and Quizzes	☒	Papers and Projects
☒	Homework	☐	Laboratory Exercises
☐	Attendance and Class Participation	☐	Extra Credit Policies

- This course is taught by lecture and the program outcomes are described in the program map.
    - **Method of Instruction:**

☒	Lecture	☐	Recitation
☐	Presentation	☐	Laboratory
☐	Lab Prep	☐	Studio
☐	Distance	☐	Clinic
☐	Experimental	☐	Research
☐	Ind. Study	☐	Pract/Observe
☐	Seminar		

C. Prerequisite(s):

- ME 31500 – Heat and Mass Transfer
- Required for analysis needed in homework assignments and class projects.

D. Course Instructor(s):

- Suresh Garimella, R. Eugene and Susie E. Goodson Distinguished Professor of Mechanical Engineering
- Is the instructor currently a member of the Graduate Faculty? ☒ Yes ☐ No Click here to enter text.
  (If the answer is no, indicate when it is expected that a request will be submitted.)

E. Course Outline:

- Introduction to Packaging & Heat Transfer Principles (4 weeks), Cooling Technologies (4 weeks), System Analysis (2.5 weeks), Thermal Measurements (1.5 weeks), and Emerging Technologies (3 weeks)

F. Reading List (include course text):

- No textbook required.

- No textbook required.

Library Resources:

- No resources needed.

H. Example of a Course Syllabus:

Tentative Schedule - Spring 2009

[1] Some of the lectures will be delivered by invited guest speakers who are experts in the field.

Period	Date	Topic[1]	Important Due Date
	January		
1	T 13	Heat transfer fundamentals – review of conduction, convection and radiation	
2	Th 15	"Thermal management of electronic systems: Challenges and opportunities," Guest Lecutre, Dr. Ravi Mahajan, Intel Corp.	
3	T 20	Contact resistance	
4	Th 22	Conjugate conduction and thermal spreading	HW 1
5	T 27	Fin analysis, heat sink design	
6	Th 29	Natural convection in electronics packaging	Design Project 1
	February		
7	T 3	"Sources of self-heating in electronics," Guest Lecture, Dr. Shankar Krishnan, Pacific Northwest Labs	
8	Th 5	Radiation in electronic packages	
9	T 10	Forced convection in electronics	HW 2
10	Th 12	Boiling and condensation	
11	T 17	Phase change energy storage with PCMs	
12	Th 19	"Liquid cold plates for electronics cooling," Guest Lecture, Dr. Sukhvinder Kang, Aavid Thermalloy	
13	T 24	"Immersion cooling of electronics," Guest Lecture, Dr. Phil Tuma, 3M Corp.	HW 3
14	Th 26	"Introduction to heat pipes," Guest Lecture, Dr. Mark North, Thermacore	Design Project 2
	March		
15	T 3	"Acoustics and mechanical design issues," Guest Lecture, Mark Juds, Eaton Corp.	
16	Th 5	Jet Impingement	

17	T 10	Microchannel heat exchangers	
18	Th 12	"Design of fan heat sinks," Guest Lecture, Dr. Ioan Sauciuc, Intel Corp.	HW 4
	16-21	**Spring Break**	
19	T 24	Piezoelectric fans	
20	Th 26	"Thermal management of consumer electronics," Guest Lecture, Dr. Kazuaki Yazawa, Sony Corp.	
21	T 31	**Midterm Exam**	
	April		
22	Th 2	"Thermal management of information technology data centers," Guest Lecture, Dr. Madhu Iyengar, IBM	
23	T 7	Design Proposal Presentations	HW 5, Project Strategy
24	Th 9	"Miniature-scale refrigeration systems for electronics cooling," Guest Lecture, Dr. Eckhard Groll	
25	T 14	"Thermoelectric modules," Guest Lecture, Dr. Marc Hodes, Tufts University	
26	Th 16	"Small-scale waste heat recovery," Guest Lecture, Dr. Srinivas Garimella, Georgia Tech	
27	T 21	Thermal design of automotive electronics	HW 6
28	Th 23	Novel microscale diagnostics	
29	T 28	**Final Project Presentations**	
30	Th 30	**Final Project Presentations**	
-	May 7	**Final Project Report**	