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

# PURDUE UNIVERSITY

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

15-09

Print Form

Graduate Council Doc. No.10-16c

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

| | PROPOSED: | EXISTING: |
|---|---|---|
| Subject Abbreviation | ME | |
| Course Number | 54900 | |

552

Long Title: Practical Experiences in Vibrations
Short Title: Practical Expe in Vibrations

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 [X] Summer (crossed out)

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

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 | 50 | 2 | 16 | |
| Recitation | | | | |
| Presentation | | | | |
| Laboratory | 150 | 1 | 16 | |
| Lab Prep | | | | |
| Studio | | | | |
| Distance | | | | |
| Clinic | | | | |
| Experiential | | | | |
| Research | | | | |
| Ind. Study | | | | |
| Pract/Observ | | | | |

Cross-Listed Courses

2011 FEB 22 AM 9:58 RECEIVED

COURSE DESCRIPTION (INCLUDE REQUISITES/RESTRICTIONS):
ME 54900 Experimental Vibrations, Sem. 2, Class 2, lab 3, cr.3. Prerequisite: ME 37500 Theory and application of experimental structural dynamics. Experimental techniques in model analysis, impedance modeling, and basic nonlinear vibrations. Time, frequency, and spatial characteristics of vibrating systems. Virtual and real-time demonstrations and ~~experiments. Vehicl vibration in ride, machinery diagnostics, and health monitoring of~~ structural materials and components. Professor Adams.

| | | | | | |
|---|---|---|---|---|---|
| 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 2/17/11 Date Approved by Graduate Council | |
| West Lafayette Department Head | Date | West Lafayette College/School Dean | Date | Graduate Council Secretary (signed) | 2/18/11 Date |
| Graduate Area Committee Convener | Date | Graduate Dean | Date | West Lafayette Registrar (signed) | 3/4/11 Date |

OFFICE OF THE REGISTRAR

SEE ATTACHED COPY FOR SIGNATURES

3/1/11 2-2-11

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 15-09

DEPARTMENT: Mechanical Engineering
EFFECTIVE SESSION: Fall 2009

INSTRUCTIONS: Pl

- [✓] 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

**PROPOSED:**
Subject Abbreviation: ME
Course Number: ~~552~~ 54900
Long Title: Practical Experiences in Vibrations
Short Title: Exp. Vibrations
Abbreviated title will be entered by the Office of the Registrar if omitted. (22 CHARACTERS ONLY)

**EXISTING:**
Subject Abbreviation:
Course Number:

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

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

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

1. Pass/Not Pass Only [ ]
2. Satisfactory/Unsatisfactory Only [ ]
3. Repeatable [ ]
   Maximum Repeatable Credit:
4. Credit by Examination [ ]
5. ...nator Required [ ]
6. Special Fees [ ]

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

| Instructional Type | Min Per Mtg | Mtg Per Week | Wks Offered | % of Credit Allocated | Delivery Method (Asyn. Or Syn.) | Delivery Medium (Audio, Internet, Live, Text-Based, Video) |
|---|---|---|---|---|---|---|
| Lecture | 50 | 2 | 16 | | Syn | Live |
| Recitation | | | | | | |
| Presentation | | | | | | |
| Laboratory | 150 | 1 | 16 | | Syn | Live |
| Lab Prep | | | | | | |
| Studio | | | | | | |
| Distance | | | | | | |
| Clinic | | | | | | |
| Experiential | | | | | | |
| Research | | | | | | |
| Ind. Study | | | | | | |
| Pract/Observ | | | | | | |

Cross-Listed Courses

COURSE DESCRIPTION (INCLUDE REQUISITES):

**ME 552 Experimental Vibrations**, Sem. 2, Class 2, lab 3, cr. 3. Prerequisite: ME 375.

Theory and application of experimental structural dynamics. Experimental techniques in model analysis, impedance modeling, and basic nonlinear vibrations. Time, frequency, and spatial characteristics of vibrating systems. Virtual and real-time demonstrations and experiments. Vehicle vibrations in ride, machinery diagnostics, and health monitoring of structural materials and components.

| | | | | | |
|---|---|---|---|---|---|
| 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 |
| Indianapolis Department Head | Date | Indianapolis School Dean | Date | R. Cipra — Undergrad Curriculm Committee | 3/3/2010 Date |
| North Central Department Head | Date | North Central Chancellor | Date | Date Approved by Graduate Council | |
| E. Daniel Hirleman — West Lafayette Department Head | 12/12/2008 Date | [signature] — West Lafayette College/School Dean | 5/12/2010 Date | Graduate Council Secretary | Date |
| Graduate Area Committee Convener | Date | Graduate Dean | Date | West Lafayette Registrar | Date |

OFFICE OF THE REGISTRAR

Engineering Faculty Document 15-09
December 12, 2008

**TO:** The Engineering Faculty

**FROM:** The Faculty of the School of Mechanical Engineering

**RE:** New Course – ME 552 Experimental Vibrations

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.

54900

**ME ~~552~~ Experimental Vibrations**
Sem. 2, Class 2, lab 3, cr. 3
Prerequisite: ME 375

Theory and application of experimental structural dynamics. Experimental techniques in model analysis, impedance modeling, and basic nonlinear vibrations. Time, frequency, and spatial characteristics of vibrating systems. Virtual and real-time demonstrations and experiments. Vehicle vibrations in ride, machinery diagnostics, and health monitoring of structural materials and components.

**Reason:** This course has been taught six times on an experimental basis with the following enrollments: spring 02 - 14 students, spring 03 - 13 students , spring 2004 – 14 students, spring 2005 – 16 students, spring 2007 – 18 students, and spring 2008 – 17 students. This course provides students with practical hands-on experiences in vibration measurement, transducers and other issues related to experimental vibration techniques. As such, this course is a valuable complement to other analytical vibration courses.

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 ~~552~~ 54900
# EXPERIMENTAL VIBRATIONS

## Course Outcomes

1. Introduce/review the theory of *linear mechanical vibrations.*
2. Learn how to model and analyze *single/multi-degree-of-freedom (SDOF/MDOF) systems* in *free* and *forced vibration.*
3. Learn how to *plan experiments*/tests and *interpret dynamic response data* using modern technology.
4. Introduce basic *experimental methods*, *vibration hardware* and *advanced analysis techniques* like modal analysis, impedance modeling, and experimental nonlinear vibration.

### Fundamentals SDOF (review) – 2 wks

1. Assumptions and nomenclature
2. Degrees-of-freedom
3. Inertia, damping, stiffness
4. Laplace transforms
5. Transfer functions, frequency response, impulse response
6. Free/forced vibration
7. Time/freq./spatial concepts
8. Importance of SDOF systems (superpos.)
9. Matrix methods/ eigen-analysis

→

### Fundamental MDOF (review) – 3 wks

1. Free vibration
   - Poles/eigenvalues
   - Eigen-/modal vectors
   - Coord. transformation
   - Coupling (static/dyn.)
   - Modal superposition
2. Forced vibration
   - TF/FRF matrices
   - Impedance analysis
   - Fourier series and superposition
   - Relationship to modal parameters
3. General damping
   - Proportional
   - Non-proportional
   - Effects on FRF and impulse response

→

### Modal Analysis – 4 wks

1. Modal superposition
   - Single to multiple DOFs
2. Experimental methods
   - Sinusoidal I-O
   - Frequency response
   - Damped Complex Expn.
   - Mathematical I-O
3. Parameter estimation
   - Concepts (MPE process)
   - Model order
   - SDOF techniques
   - Low order techniques
   - High order techniques
   - Residue estimation
   - Modal data validation

→

### Impedance Models – 3 wks

1. Impedance models
   - Input-output models
   - Dynamic stiffness
   - Dynamic compliance
   - Compatibility and continuity constraints
   - Components and assembly
2. Perturbed boundary conditions
   - Rigid body transformation
   - Vibration absorber ex.
   - Mass, damping, stiffness
   - Nonlinear connections

→

### Intro. to Nonlinear Vibration – 3 wks

1. Qualitative methods
   - State space/geometric
   - Phase plane projection
   - Poincare maps
2. Basic phenomena
   - Fixed points/orbits
   - Nonlinear resonance
   - Modulation
   - Limit cycles
   - Bifurcation, etc.

### Laboratory Experiments - Weekly

1. Structural dynamic imedance analysis and modeling
   - FRF estimation, MIMO testing, sub-structuring
2. Structural dynamic modal analysis and modeling
   - Model order, modal parameter estimation, impact testing
3. Introduction to experimental nonlinear dynamics and vibrations
   - Periodic response, Poincare maps, harmonic distortion

### Experimental Considerations

1. Hardware
   - Transducers
   - Signal conditioners
   - Front-end
2. Signal processing
   - Time domain
   - Frequency domain
   - Fourier analysis
   - Excitation methods

**COURSE NUMBER:** ME 552

**COURSE TITLE:** Experimental Vibrations

**REQUIRED COURSE OR ELECTIVE COURSE:** Elective

**TEXTBOOK/REQUIRED MATERIAL:** Class Notes

**COORDINATING FACULTY:** D. Adams

**COURSE DESCRIPTION:** Theory and application of experimental structural dynamics. Experimental techniques in modal analysis, impedance modeling, and basic nonlinear vibrations. Time, frequency, and spatial characteristics of vibrating systems. Virtual and real-time demonstrations and experiments. Vehicle vibrations in ride, machinery diagnostics, and health monitoring of structural materials and components.

**ASSESSMENTS TOOLS:**

1. Weekly homework assignments.
2. One 1-hour exam.
3. Four laboratory reports.
1. One comprehensive final exam.

**PROFESSIONAL COMPONENT:**

1. Engineering Topics: Engineering Science – 2.5 credits (83%)
   Engineering Design – 0.5 credits (17%)

**NATURE OF DESIGN CONTENT:** Contained in the lecture material and several homework assignments are problems which relate to the design of algorithms (software) to perform specific tasks involving data characterization and parameter estimation. Also in lecture and homework are problems relating to the design of measurement systems for vibration experiments to meet specified needs for accuracy and certain kinds of input/output data.

**COMPUTER USAGE:** Students will need to use MATLAB to develop and write subroutines and make extensive use of graphics terminals and MATLAB graphics subroutines.

**COURSE STRUCTURE/SCHEDULE:**

1. Lecture – 2 days per week at 50 minutes.
2. Laboratory – 1 day per week at 150 minutes.

**TERMS OFFERED:** Spring

**PRE-REQUISITES:** ME 375 System Modeling and Analysis

**COURSE OUTCOMES:**

1. Introduce/review the theory of *linear mechanical vibrations.*
2. Learn how to model and analyze *single/multi-degree-of-freedom* (SDOF/MDOF) *systems* in *free* and *forced vibration.*
3. Learn how to *plan experiments/tests* and *interpret dynamic response data* using modern technology.
4. Introduce basic *experimental methods*, *vibration hardware* and *advanced analysis techniques* like modal analysis, impedance modeling and experimental nonlinear dynamics.

**RELATED ME PROGRAM OUTCOMES:** N/A

**PREPARED BY:** D. Adams

**REVISION DATE:** April 26, 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: Douglas E. Adams
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 55200

Course Title: Experimental Vibrations

**A. Justification for the Course:**

- This course has been taught six times on a experimental basis with the following enrollments: spring 2002 – 14 students, spring 2003 – 13 students, spring 2004 – 14 students, spring 2005 – 16 students, spring 2007 – 18 students, and spring 2008 – 17 students. This course provides students with practical hands-on experiences in vibration measurement, transducers and other issues related to experimental vibration techniques. As such, this course is a valuable complement to other analytical vibration courses.
- The purpose of ME 552 course is an advanced vibrations course that focuses both on analytical analysis methods, but also advanced experimental methods (e.g. model analysis, impedance modeling, and experimental nonlinear dynamics). As such it is designed as an entry-level graduate course. Enrollment is anticipated to run 15-20 students annually, with perhaps a few undergraduate students participating.

**B. Learning Outcomes and Methods of Evaluation or Assessment:**

- 1) Introduce/review the theory of linear mechanical vibrations, 2) Learn how to model and analyze single/multi-degree-of-freedom (SDOF/MDOF) systems in free and forced vibration, 3) Learn how to plan experiments/tests and interpret dynamic response data using modern technology, 4) Introduce basic experimental methods, vibration hardware and advanced analysis techniques like modal analysis, impedance modeling and experimental nonlinear dynamics.

- Weekly homework assignments, one 1-hour exam, four laboratory reports, and one comprehensive final exam
- Engineering Topics: Engineering Science – 2.5 credits (83% & Engineering Design – 0.5 credits (17%)
  - **Criteria:**

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

- This course is taught by lecture and lab 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 37500 – System Modeling and Analysis
- Students will need to use MatLab to develop and write subroutines and make extensive use of graphics terminals and MatLab graphics subroutines.

**D. Course Instructor(s):**

- Douglas E. Adams, 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:**

- 1. Fundamentals SDOF (review) (2 weeks), 2. Fundamental MDOF (review) (3 weeks), 3. Model Analysis (4 weeks), 4. Intro. to Nonlinear Vibration (3 weeks), 5. Laboratory Experiments (Weekly), and 6. Experimental Considerations.

**F. Reading List (include course text):**

- Class Notes
- No textbook required.

**G. Library Resources:**

- No resources needed.

**H. Example of a Course Syllabus:**

**ME 597A COURSE SYLLABUS**

| Period | Topic | Reading Assignment | Laboratory |
|---|---|---|---|
| 1 | Introduction to course and practical applications | Chap. 1 | **NO LAB** |
| 2 | Applications (continued) | Chap. 1 | |
| 3 | Modeling | Chap. 1 | **Orientation** |
| 4 | Modeling | Chap. 2 | ~All |
| 5 | Modeling | Chap. 2 | **LAB #1** |
| 6 | Modeling | Chap. 2 | ~Individual |
| 7 | Modeling | Chap. 2 | **PROJECT** |
| 8 | Analysis | Chap. 3 | ~Group |
| 9 | Analysis | Chap. 3-4 | **LAB #2** |
| 10 | Analysis | Chap. 4 | ~Individual |
| 11 | Measurement | Notes/lab | **PROJECT** |
| 12 | Measurement | Notes/lab | ~Group |
| 13 | Measurement | Notes/lab | |

| | | | |
|---|---|---|---|
| | **EXAM I, In-class exam (February 24, 2010)** | Periods 1-10 | |
| 14 | Signal processing | Notes/lab | **PROJECT** |
| 15 | Signal processing | Notes/lab | ~Group |
| 16 | Signal processing | Notes/lab | **PROJECT** |
| 17 | Data analysis | Notes/lab | ~Group |
| | *No class -- Spring vacation* | | |
| 18 | Experimental modal analysis | Notes/lab | **PROJECT** |
| 19 | Experimental modal analysis | Notes/lab | ~Group |
| 20 | Experimental modal analysis | Notes/lab | **PROJECT** |
| 21 | Experimental modal analysis | Notes/lab | ~Group |
| 22 | Experimental modal analysis | Notes/lab | **PROJECT** |
| 23 | Experimental modal analysis | Notes/lab | ~Group |
| 24 | Impedance modeling | Notes/lab | **PROJECT** |
| 25 | Impedance modeling | Notes/lab | ~Group |
| 26 | Impedance modeling | Notes/lab | **PROJECT** |
| 27 | Impedance modeling | Notes/lab | ~Group |
| | **Final Presentations (During lab period, April 19-23)** | | |
| | **Final Presentations (During lab period, April 19-23)** | | |