ME 592 Fundamentals of Particle Image Velocimetry, Sem. 2, Class 1, cr. 1. Prerequisite: ME 30900

Measurement of fluids in motion using the particle image velocimetry technique and related techniques through computer programming, laboratory experiments, and independent research in experimental fluids journals.

Professor Wereley.
ME 592 Fundamentals of Particle Image Velocimetry, Sem. 2, Class 1, cr. 1. Prerequisite: ME 309

Measurement of fluids in motion using the particle image velocimetry technique and related techniques through computer programming, laboratory experiments, and independent research in experimental fluids journals.
TO: The Engineering Faculty

FROM: The Faculty of the School of Mechanical Engineering

RE: New Course – ME 592 Fundamentals of Particle Image Velocimetry

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.

ME 592 Fundamentals of Particle Image Velocimetry
Sem. 2, Class 1, cr. 1
Prerequisite: ME 309

Measurement of fluids in motion using the particle image velocimetry technique and related techniques through computer programming, laboratory experiments, and independent reading of experimental fluids journals.

Reason: This course has been taught three times on an experimental basis with the following enrollments: spring 2002 - 25 students, spring 2005 - 22 students, and spring 2008 - 17 students. This course provides students with fundamental knowledge and experience on how to measure fluid motion using the particle image velocimetry (PIV) technique. As such this course is a valuable source for developing skills in this technique for students utilizing PIV in their research.

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 592
FUNDAMENTALS OF PARTICLE IMAGE VELOCIMETRY

## Course Outcomes
1. To learn the principles of quantitative flow visualization.
2. To study the physical phenomena underlying particle image velocimetry.
3. To understand the limitations of this flow measurement technique.
4. To explore advanced topics in particle image velocimetry.

## Outline

<table>
<thead>
<tr>
<th>Introduction (2 wks)</th>
<th>Tracer particles (2 wks)</th>
<th>Light sources (1 wk)</th>
<th>Image Recording (2 wks)</th>
<th>Mathematical Background (3 wks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Historical background</td>
<td>1. Fluid/Particle dynamics</td>
<td>1. lasers</td>
<td>1. Photographic recording</td>
<td>1. Particle image locations</td>
</tr>
<tr>
<td>2. Principles of operation</td>
<td>2. Light scattering behavior</td>
<td>2. white light sources</td>
<td>2. Digital imaging</td>
<td>2. Image intensity field</td>
</tr>
<tr>
<td>3. Recent developments</td>
<td>3. particle generation and supply</td>
<td></td>
<td>3. Sources of error in imaging</td>
<td>3. auto/cross correlation</td>
</tr>
</tbody>
</table>

## Advanced Topics (5 wks)
1. Adaptive window shifting
2. image correction
3. simultaneous temperature/velocity measurements
4. holographic and other 3D techniques
5. bio applications
6. micro applications
**COURSE NUMBER:** ME 592

**COURSE TITLE:** Fundamentals of Particle Image Velocimetry

**REQUIRED COURSE OR ELECTIVE COURSE:** Elective


**COORDINATING FACULTY:** S. Wereley

**COURSE DESCRIPTION:** Measurement of fluids in motion using the particle image velocimetry technique and related techniques through computer programming, laboratory experiments, and independent reading of experimental fluids journals.

**ASSESSMENTS TOOLS:**
1. Weekly homework assignments.
2. One laboratory report.
3. One final oral report.

**PROFESSIONAL COMPONENT:**
1. Engineering Topics: Engineering Science – ___ credit (80%)
   Engineering Design – ___ credit (20%)

**NATURE OF DESIGN CONTENT:** The class has a project for the final deliverable. Students must design the experiment necessary for this project. The design can be either a computational design or actual hardware.

**COMPUTER USAGE:** The students will need to use Matlab or a programming language (C/C++, VisualBasic, Fortran, etc.) to write basic particle image velocimetry computer programs.

**COURSE STRUCTURE/SCHEDULE:**
1. Lecture – 1 day per week at 50 minutes.

**PREPARED BY:** S. Wereley

**TERMS OFFERED:** Spring

**PRE-REQUISITES:** ME 309 Fluid Mechanics

**COURSE OUTCOMES:**
1. Understand the various scientific principles underlying the particle image velocimetry technique – fluid dynamics, particle dynamics, optics, etc.
2. Gain an in dept understanding of the PIV technique including its advantages over competing techniques, its limitations, and its future potential.
3. An ability to analyze a particular flow and determine the optimal parameter space for investigating that flow: particle size, time between exposures, imaging format, magnification, etc.
4. Exposure to several of the commercial particle image velocimetry packages in addition to writing their own basic software.

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

**DATE:** March 26, 2007
Supporting Document for a New Graduate Course

Purdue University Graduate Council

From: Faculty Member: Steven T. Weneley
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: 494-6691
E-mail: jonesjd@purdue.edu
Campus Address: 1288 ME/ME room 222

Course Subject Abbreviation and Number: ME59200
Course Title: Fundamentals of Particle Image Velocimetry

A. Justification for the Course:

- This course has been taught three times on an experimental basis with the following enrollments: spring 2002 – 25 students, spring 2005 – 22 students, and spring 2008 – 17 students. This course provides students with fundamental knowledge and experience on how to measure fluid motion using the particle image velocimetry (PIV) technique. As such this course is a valuable source for developing skills in this technique for students utilizing PIV in their research.

- The proposed ME 59200 is a one-credit course on the fundamentals of particle image velocimetry (PIV). Because of the advanced nature of this measurement technique, this course is designed for entry-level graduate students, although some undergraduate students may take the course. Enrollment is anticipated to be 15-20 students per year, mostly graduate students.

B. Learning Outcomes and Methods of Evaluation or Assessment:

- 1) Understand the various scientific principles underlying the particle image velocimetry technique – fluid dynamics, particle dynamics, optics, etc. 2) Gain an in-depth understanding of the PIV technique including its advantages over competing techniques, its limitations, and its future potential. 3) An ability to analyze a particular flow and determine the optimal parameter space for investigating that
flow: particle size, time between exposures, imaging format, magnification, etc. 4) Exposure to several of the commercial particle image velocimetry packages in addition to writing their own basic software.

- Weekly homework assignments, one laboratory report and one final oral report.
- Engineering Topics: Engineering Science - ___ credit (80%) & Engineering Design - ___ credit (20%)
  - **Criteria:**
    - [ ] Exams and Quizzes
    - [x] Papers and Projects
    - [x] Homework
    - [x] Laboratory Exercises
    - [ ] Attendance and Class Participation
    - [ ] Extra Credit Policies

- This course is taught by lecture and covers the program outcomes described in the program map.
  - **Method of Instruction:**
    - [x] Lecture
    - [ ] Recitation
    - [ ] Presentation
    - [ ] Laboratory
    - [ ] Lab Prep
    - [ ] Studio
    - [ ] Distance
    - [ ] Clinic
    - [ ] Experimental
    - [ ] Research
    - [ ] Ind. Study
    - [ ] Pract/Obsrve
    - [ ] Seminar

C. Prerequisite(s):

- ME 30900 – Fluid Mechanics
- The students will need to use Matlab or a programming language (C/C++, Visual Basic, Fortran, etc.) to write basic particle image velocimetry computer programs.

D. Course Instructor(s):

- Steven T. Wereley, Associate Professor of Mechanical Engineering
- Is the instructor currently a member of the Graduate Faculty?  [x] 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 (2 weeks), Tracer particles (2 weeks). Light sources (1 week), Image recording (2 weeks), Mathematical background (3 weeks), and Advanced topics (5 weeks).
F. Reading List (include course text):
   
   - No textbook required.

G. Library Resources:

   - No resources needed.

H. Example of a Course Syllabus:

<table>
<thead>
<tr>
<th>Date</th>
<th>Class #</th>
<th>Subject</th>
<th>Reading</th>
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</thead>
<tbody>
<tr>
<td>11-Jan</td>
<td>1</td>
<td>Introduction</td>
<td>Chapter 1</td>
</tr>
<tr>
<td>18-Jan</td>
<td>2</td>
<td>Demonstrations</td>
<td></td>
</tr>
<tr>
<td>25-Jan</td>
<td>3</td>
<td>Tracer particles, illumination</td>
<td>Chapter 2</td>
</tr>
<tr>
<td>1-Feb</td>
<td>4</td>
<td>Particle imaging</td>
<td>Chapter 2</td>
</tr>
<tr>
<td>8-Feb</td>
<td>5</td>
<td>Statistics of PIV</td>
<td>Chapter 3</td>
</tr>
<tr>
<td>15-Feb</td>
<td>6</td>
<td>Recording techniques</td>
<td>Chapter 4</td>
</tr>
<tr>
<td>22-Feb</td>
<td>7</td>
<td>Eval Techniques I, corr, peak fitting</td>
<td>Chapter 5, papers</td>
</tr>
<tr>
<td>1-Mar</td>
<td>8</td>
<td>Eval Techniques II, corr tracking, padding</td>
<td>Chapter 5, papers</td>
</tr>
<tr>
<td>8-Mar</td>
<td>9</td>
<td>Eval Techniques III, corr avg, CDIC</td>
<td>Chapter 5, papers</td>
</tr>
<tr>
<td>22-Mar</td>
<td>10</td>
<td>Image processing, particle ident, part tracking</td>
<td>papers</td>
</tr>
<tr>
<td>29-Mar</td>
<td>11</td>
<td>Data validation, correction, statistics</td>
<td>papers</td>
</tr>
<tr>
<td>5-Apr</td>
<td>12</td>
<td>Resolution, uncertainty</td>
<td>papers</td>
</tr>
<tr>
<td>12-Apr</td>
<td>13</td>
<td>Advanced Topics, stereo, holo, temp</td>
<td>papers</td>
</tr>
<tr>
<td>19-Apr</td>
<td>14</td>
<td>Applications</td>
<td></td>
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<tr>
<td>26-Apr</td>
<td>15</td>
<td>Reports</td>
<td></td>
</tr>
<tr>
<td>Final</td>
<td>16</td>
<td>Reports</td>
<td></td>
</tr>
</tbody>
</table>
# Supporting Document for a New Graduate Course

**To:** Purdue University Graduate Council  
**From:** Faculty Member: Anilk Bajaj  
**Department:** Mechanical Engineering  
**Campus:** Mechanical Engineering  
**Date:** 3/16/2010  
**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 69100  
**Course Title:** Mechanical Engineering Graduate Seminar

## A. Justification for the Course:

- This course has been taught four times on an experimental basis with the following enrollments: fall 2004 – 63 students, fall 2005 – 110 students, fall 2006 – 140 students, and fall 2007 – 163 students. This course provides new graduate students with a broad understanding of the field of Mechanical Engineering and an appreciation of various interdisciplinary research efforts.

- ME 69100 is a new Mechanical Engineering Graduate Seminar course. As such it is designed exclusively for new graduate students. No undergraduates will be taking this course. Anticipated enrollment will typically be 100-150 graduate students.

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

- 1) Develop an understanding of the field of Mechanical Engineering in its widest possible applications.  
2) Develop an appreciation of the various interdisciplinary research efforts being pursued where Mechanical Engineering has the potential to provide leadership.

- 1. Attendance 2. Every student is required to attend at least 10 of the seminars of the fourteen scheduled during a semester. 3. Some substitution of seminars in the series by high-level technical seminars across campus is permitted.
• Engineering Topics: Engineering Science – 0 credits (0%)
  
  o Criteria:

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

• This course is taught by lecture and covers the program outcomes described in the program map.
  
  o Method of instruction:

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

• Prerequisite(s):

  • Graduate standing, MS or PhD student in Mechanical Engineering
  
  • None

D. Course Instructor(s):

• Anil K. Bajaj, Associate Head for Graduate Education & Research and 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:

• Typical Schedule (15 weeks)

F. Reading List (include course text):

• No textbook required.

• No textbook required.
G. Library Resources:

- No resources needed.

H. Example of a Course Syllabus:

- The course syllabus changes from semester to semester depending on guest speakers. The guest speakers range from industry to faculty from around the country to talk about their research and experiences. The graduate students must attend 10 seminars during the semester and this is tracked by swiping their PUID card at the beginning of the seminar.