Course information: Advanced Dynamics & Simulation - ME331B

Instructors
Paul Mitiguy      Barrett Heyneman      Apoorva Rajagopal
E-mail
Phone preferred  Heyneman@stanford.edu apoorvar@stanford.edu
Cell phone
650-346-9595     650-804-4159     650-799-4061
Office location
Peterson 113
Instructors
Jeffrey Schlosser      Diana Gentry      Linus Park
E-mail
JSchlosser@stanford.edu dgentry@stanford.edu ljpark@stanford.edu
Cell phone
336-558-4929      650-906-4988
Class location/time
Bldg. 530-127      MWF 2:15-3:45
Web site
www.stanford.edu/class/me331b  (Webmaster: Jeffrey Schlosser)
Holidays
Monday May 30 (memorial day)

Course material
Advanced Dynamics & Motion Simulation
For Professional Mechanical, Aerospace, and Biomechanical Engineers

Office hours - start Friday April 1 (cookies provided on occasion)

<table>
<thead>
<tr>
<th>Day</th>
<th>Time</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun</td>
<td>7:00-9:00+</td>
<td>Peterson 550-126</td>
<td>Diana Gentry, ...</td>
</tr>
<tr>
<td>Mon</td>
<td>4:00-5:30+</td>
<td>Peterson 550-126</td>
<td>Diana Gentry (when Mon. class)</td>
</tr>
<tr>
<td>Mon</td>
<td>7:30-9:00+</td>
<td>Peterson 550-126</td>
<td>Apoorva Rajagopal, ...</td>
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<tr>
<td>Mon</td>
<td>8:00-10:00+</td>
<td>Peterson 550-126</td>
<td>Jeffrey Schlosser, ...</td>
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<tr>
<td>Tues</td>
<td>5:30-7:00+</td>
<td>Peterson 550-126</td>
<td>Barrett Heyneman, ...</td>
</tr>
<tr>
<td>Tues</td>
<td>7:00-9:00+</td>
<td>Peterson 550-126</td>
<td>Linus Park, ...</td>
</tr>
<tr>
<td>Wed</td>
<td>4:00-6:00+</td>
<td>Peterson 550-126</td>
<td>Paul Mitiguy, ...</td>
</tr>
<tr>
<td>Fri</td>
<td>4:00-6:00+</td>
<td>Peterson 550-126</td>
<td>Paul Mitiguy, ...</td>
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</tbody>
</table>

Course description
Formulation of equations of motion for constrained systems with: Newton/Euler equations; angular momentum principle; D’Alembert principle (Dynamics road maps); power, work, and energy; Kane’s method; and Lagrange’s equations. Numerical solutions of nonlinear algebraic and differential equations governing the behavior of multiple degree of freedom systems. Symbolic and numerical computational methods. Computer simulation of multi-body dynamic systems. 3 units, (Mitiguy)

Training and skills for professional research and careers
Advanced Dynamics focuses on efficient formulation and solution of equations of motion for complex 3D multibody dynamic systems. The course facilitates advanced graduate research and professional work. The "big picture" is \( \mathbf{F} = \mathbf{m} \mathbf{a} \). This course is a detail-oriented course concerned with details of \( \mathbf{F} \), \( \mathbf{m} \), \( \mathbf{a} \), the equals (=) sign, definitions, equations, words, precise notation, descriptive language, negative signs, efficiency of formulation, computational solution, MATLAB®, MotionGenesis, etc.

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Footnote:
1Paul prefers meeting students in office hours, scheduling a weekend or evening appointment, or talking on the telephone rather than corresponding by e-mail (particularly on technical matters).
Learning by design - we appreciate your feedback.
The word educate is from the Latin educare - “to draw out” (not “to stuff in”). Please provide suggestions, comments, criticism, ideas, content, images, video, and creative brainstorming about lectures, labs, homeworks, classroom interaction, office hours, software, hardware, etc. With 150+ classes of experience and a significant financial investment in your education, you are both learning experts and customers.

Grading

- **Homework: 30%**  
  Homework is graded with √+++ (100), √+ (93), √ (85), √− (78), √−− (70), or no credit (0), and is due in the box at the start of class.
  - Homework is only accepted in the box at the front of class (not by instructors or under office doors)
  - Homework passed in one lecture day late is penalized 15 points. Homework passed in more than two lecture days is penalized 55+ points and is not thoroughly examined.
  - Homework is not accepted after the last day of class.
  - To accommodate ill or overtired students, or students who need an extension for any other reason, two class homework extensions are permitted during the quarter. For example, a homework due Wednesday may be passed in on Friday without penalty.
  - Submit your work and answers on separate sheets of paper (not on homework assignments).
  - Communicate clearly, write neatly, and use only one side of the paper.
  - Homework must be stapled (not paper clipped, dog-eared, origami, or bubble-gummed)
  - Homework solutions are not posted. Ask your friends and instructors for help. Homework is practice, not a trade secret, and you are encouraged to work with your classmates and instructors. There is a strong correlation between high homework scores and high exam scores - and few reasons to do poorly on homework.

- **Midterm: 25%**  
The in-class portion is open-book and open-note. No electronic devices are permitted (i.e., no blackberry, cell phone, computer, calculator, etc.) No makeup exam will be given.

- **Final: 35%**  
The in-class portion is open-book and open-note. No electronic devices are permitted (i.e., no blackberry, cell phone, computer, calculator, etc.) No makeup exam will be given.

- **MIPSI: 15%**  
Your motion simulation exercise is submitted weekly and presented to an instructor during finals week. Instructions are included with homework.

  - 5% Asking and answering a sensible question.
  - 5% Comprehensible schematics (possibly with photo)
  - 10% Complete description of modeling assumptions.
  - 10% Precise description of all physical objects and unit vectors.
  - 10% Concise accurate tabular description of all scalar symbols.
  - 45% Correctness of analysis. Short (2-3 pg.), solid report.
  - 5% Relevant text interspersed with relevant plots.
  - 10% Technical difficulty, physical demonstration, or interesting problem
• **Graded material:** Student → Box → Linus Park (alphabetize) → Graders → Linus Park (Coursework/Excel) → Student (in class or outside Paul’s office).

**Linus Park** is the grader intermediary. Consult Linus for questions about homework/test scores. Verify your scores at [https://coursework.stanford.edu](https://coursework.stanford.edu) each week to ensure no grades were overlooked.

When you choose to use computational tools (e.g., MotionGenesis, MATLAB®, C, etc.) to avoid tedious calculations, make sure you know what the computer is doing (it is not magic). Print out and submit the appropriate computational files (e.g., .all files) and include both input and output.

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**Class participation (and student/instructor provided videos, music, and related content)**

Class participation is facilitated by **Linus Park** and **Jeff Schlosser** who will provide music, images, YouTube, call on students to participate in demos, answer questions, and work out problems on the board.

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**MIPSI**

- **Model physical system.** Capture the essential components of the physical system being analyzed and draw a simple sketch of the model.

- **Identifiers, symbols and values,** e.g., \( m, g, L, \theta \). Name and label relevant parts, e.g., bodies, lengths, angles, etc. Introduce unit vectors. Analytically or empirically determine physical constants.

- **Physics:** Using physical principles, (e.g., \( F = ma \)) formulate equations which relate the identifiers and govern the behavior of the system.

- **Simplify and solve.** Produce numerical or closed form solutions for the unknown identifiers, e.g., with MATLAB® and MotionGenesis.

- **Interpret, design, and control physical system:** Generate and communicate results (numbers, plots, animation, virtual-reality, etc.) that are easily interpretable by a non-technical person (perhaps your boss).

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**Course conduct and the Stanford University Honor Code and Fundamental Standard**

Students are required to uphold Stanford University’s Honor Code and Fundamental Standard. Makeup exams are not given without university authorization. Exam grades are non-negotiable and exams will not be regraded. Exams, homework, labs, and other submitted material may be photo-copied by an instructor. Other than with an instructor, there is to be no class-related communication (no exchange of electronic devices, notes, homework, written material, or other information) during exams. Although you are encouraged to work with other students on homework and lab problems, it is expected that each student pass in his/her own homework and lab. Copying other students’ homeworks or labs is a violation of the Honor Code.

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## Computational/Simulation Labs and Homework Schedule

<table>
<thead>
<tr>
<th>Sunday</th>
<th>Monday (computational)</th>
<th>Wednesday (lecture)</th>
<th>Friday (lecture)</th>
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<tbody>
<tr>
<td>March 27</td>
<td>Hw 1 &amp; 2 assigned</td>
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<tr>
<td>April 3</td>
<td>Hw 1 &amp; 2 due</td>
<td>Hw 3 due</td>
<td>Hw 4 &amp; 5 assigned</td>
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<tr>
<td></td>
<td>Computation/Simulation Lab: Vector geometry.  (Paul Mitiguy)</td>
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<tr>
<td>April 10</td>
<td>Computation/Simulation Lab: Rotational kinematics, vector geometry, neuromuscular biomechanics.  (Apoorva Rajagopal)</td>
<td>Hw 4 &amp; 5 due</td>
<td>Hw 6 assigned</td>
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<tr>
<td>April 17</td>
<td>No computational lab.</td>
<td>Hw 6 due</td>
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<td></td>
<td>Extra time for Hw 6.</td>
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<tr>
<td>April 24</td>
<td>Computation/Simulation Lab: Trim solution of aircraft, static equilibrium, nonlinear algebraic equations. Simulation of aircraft Flugge mode and affect of center of mass location on stability.  (Kyle Washabaugh)</td>
<td>Hw 7 due</td>
<td>Hw 8 assigned</td>
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<tr>
<td>May 1</td>
<td>No computational lab.</td>
<td>Hw 8 due</td>
<td>MIDTERM</td>
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<td>Extra time for Hw 8.</td>
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<td>Prepare for Midterm.</td>
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<tr>
<td>May 8</td>
<td>Computation/Simulation Lab: Simulation tips for friction and event detection.  (Linus Park)</td>
<td>Hw 9 due</td>
<td>Hw 10 &amp; 12 assigned</td>
</tr>
<tr>
<td>May 22</td>
<td>Optional: Computation/Simulation Lab: Dynamics road maps. Robotic surgery. MIPSi.  (JeffSchlosser)</td>
<td>Hw 15.13, 15.16, 16, 17 due.</td>
<td>Hw 18 assigned</td>
</tr>
<tr>
<td>May 29</td>
<td>Memorial day.  No class.</td>
<td>Hw 18 due.</td>
<td>Become Exam period.  No class.</td>
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<tr>
<td>June 5</td>
<td><strong>FINAL EXAM 12:15 - 3:15 pm</strong></td>
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**June 12 -- Graduation Sunday**

### Advanced Computation/Simulation Labs:
1. Feed-back control of dynamic systems.
2. Feed-forward control techniques.
3. Euler Parameters/Quaternions and orientation.
4. Constraints and constraint stabilization
5. Inequality constraints and event-handling.

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