Course information: Advanced Dynamics & Simulation - ME331B

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Instructors	Jeffrey Schlosser	Diana Gentry	Linus Park
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Cell phone	336-558-4929		650-906-4908
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
Distributed in class

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

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

Day	Time	Location	Instructor
Sun	7:00-9:00$^+$	Peterson 550-126	Diana Gentry, ...
Mon	4:00-5:30$^+$	Peterson 550-126	Diana Gentry (when Mon. class)
Mon	7:30-9:00$^+$	Peterson 550-126	Apoorva Rajagopal, ...
Mon	8:00-10:00$^+$	Peterson 550-126	Jeffrey Schlooser, ...
Tues	5:30-7:00$^+$	Peterson 550-126	Barrett Heyneman, ...
Tues	7:00-9:00$^+$	Peterson 550-126	Linus Park, ...
Wed	4:00-6:00$^+$	Peterson 550-126	Paul Mitiguy, ...
Fri	4:00-6:00$^+$	Peterson 550-126	Paul Mitiguy, ...

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 $\mathbf{F} = m\mathbf{a}$. This course is a ***detail-oriented*** course concerned with details of $\mathbf{F}$, m, $\mathbf{a}$, the equals (=) sign, definitions, equations, words, precise notation, descriptive language, negative signs, efficiency of formulation, computational solution, MATLAB®, **M**otion**G**enesis, etc.

[7] Paul 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).

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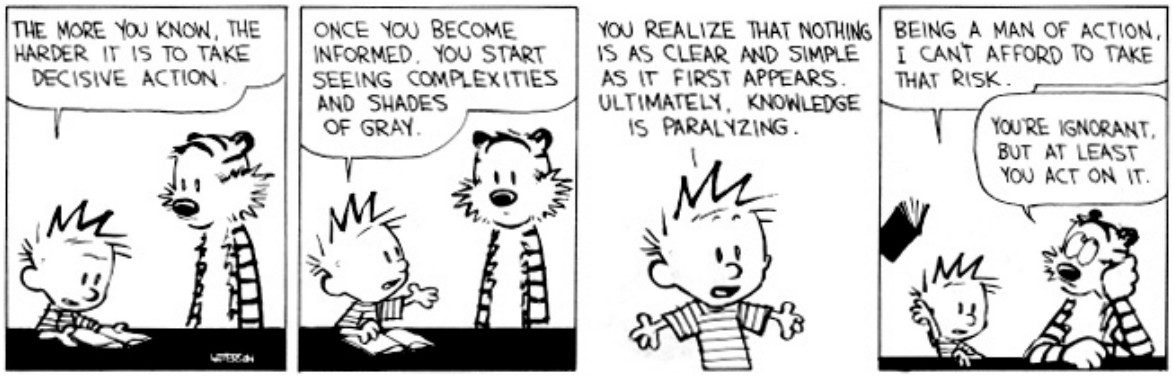
Learning by design - we appreciate your feedback.

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 $\surd^{++}$ (100), $\surd^{+}$ (93), $\surd$ (85), $\surd^{-}$ (78), $\surd^{--}$ (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 (<u>not</u> by instructors or under office doors)
  - Homework passed in one lecture day late is penalized **15 points**. Homework passed in two lecture days late is penalized **35^+ points**, and is not thoroughly examined. 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).
  - Write neatly and use only one side of the paper.
  - Communicate clearly, write neatly, and use only one side of the paper.
  - Use detailed **notation** e.g., ${}^N\mathbf{v}^P$. Use $\triangleq$ for **definitions**, e..g., ${}^N\mathbf{a}^P \triangleq \dfrac{{}^N d\,{}^N\mathbf{v}^P}{dt}$
  - 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

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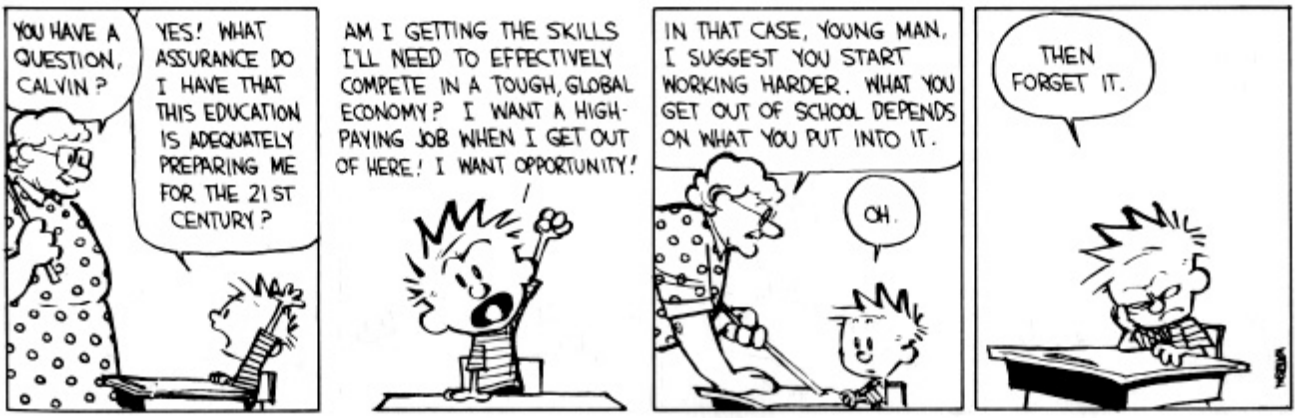
- **Graded material:** Student → Box → Linus Park (alphabetize) → Graders → Linus Park (Coursework/Excel) → Student (in class or outside Paul's office).

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

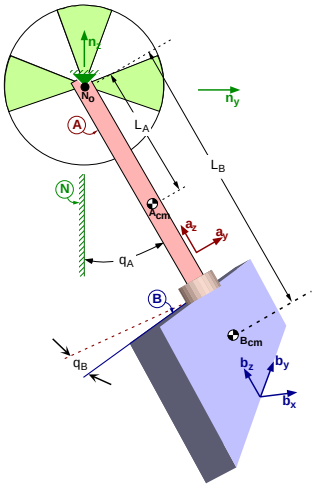
  When **you** choose to use computational tools (e.g., **M**otion**G**enesis, MATLAB®, C, etc.) to **avoid tedious calculations**, make sure **you** know what the computer is doing (it is not magic). Print out and submit the appropriate computational files (e.g., `.all` files) and include both input and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



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.

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, θ. 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., $\mathbf{F} = m\mathbf{a}$) 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 **M**otion**G**enesis.
- **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).

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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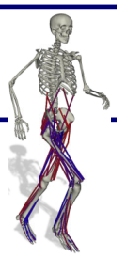
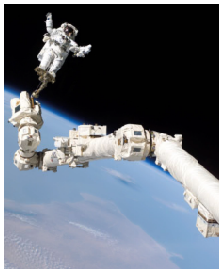
Computational/Simulation Labs and Homework Schedule

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

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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