Course information: Undergraduate Dynamics (Engr 15) (4 units)

Instructor	Paul Mitiguy	Shannon Edd	Jenny Yong	Ying Zhao
E-mail	Phone or meet	snedd@stanford.edu	jryong@stanford.edu	xyz13@stanford.edu
Cell phone	**650-346-9595**	864-650-6564	312-961-3980	609-937-4638

Office location	113 Peterson (Bldg. 550 - D.School), 416 Escondido Mall, Stanford CA 94305-4021
Classroom/time	Bldg. 530, Room 127. Tues/Thurs 12:35-2:05
Web site	https://coursework.stanford.edu and http://www.stanford.edu/class/engr15
Holidays	Saturday Nov. 17 to Sunday Nov. 25, 2012
Software	MATLAB®, **M**otion**G**enesis, ... (**M**otion**G**enesis™ is a MATLAB® connections partner)
Course elements	Lecture, **computation/office hours**, colleagues, homework, MIPSI, book.
Reading	***Dynamics of Mechanical, Aerospace, and Biomechanical Systems. 3D Computational Guided. By Mitiguy.*** Distributed in class, **$97**. Purchase includes 1-year license of **M**otion**G**enesis™ Kane

$\vec{\mathbf{F}} = m\vec{\mathbf{a}}$ computation/simulation office hours

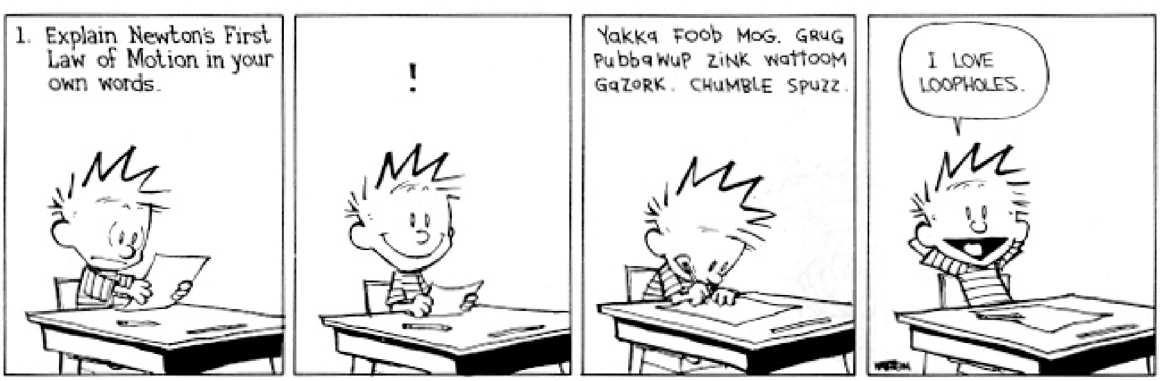
Day	Time	Location	Instructor
Sun	7:00-8:45$^+$	Peterson 550-200	Shannon/Ying
Mon	4:00-6:15$^+$	Peterson 550-126/Atrium	Jenny, ...
Mon	6:00-8:15$^+$	Peterson 550-126/Atrium	Paul, ...
Mon	7:30-8:45$^+$	Peterson 550-126/Atrium	Ying, ...
Tues	8:45-10:00$^+$	Peterson 550-126/Atrium	Jenny, ...
Tues	10:00-12:00	Peterson 550-126/Atrium	Shannon, ...
Tues	5:15-6:30$^+$	Peterson 550-126/Atrium	Paul (share with ME161)
Thurs	5:15-6:30$^+$	Peterson 550-126/Atrium	Paul (share with ME161)

Office hours start Sun. Sept. 30 and restart Sun. Nov. 25

Note: CAs facilitate computational exercises, interactive classroom participation, and peer-networking.
Note: CAs comprehensively support MIPSI computation/simulation projects (may relate to job/Ph.D. research).
Note: CAs help bring computer & demo equipment to/from class and clear board before/during/after lecture.
Note: Instructor meetings and/or student appointments (as needed) Thursday 6:15-7:15 in Peterson 550-126.
Note: Students are expected to help each other. **Cookies provided on occasion**.

Dynamics course description (2D and 3D forces and motion for particles and rigid bodies)

Vectors: Geometry and differentiation. **Kinematics**: Position, rotation matrices, linear/angular velocity, linear/angular acceleration. **Mass distribution**: Mass, center of mass, moment and products of inertia, inertia dyadics. **Forces**: Resultant, moments, torques, force models (friction, gravity, springs, dampers, air-resistance, etc). **Laws of motion**: $\vec{\mathbf{F}} = m\vec{\mathbf{a}}$ and angular momentum principle. Power, work, potential energy, and conservation of energy. **Computation**: Symbolic and numerical solutions of nonlinear algebraic and differential equations governing static and dynamic systems. Demonstrations and physical examples.
Prerequisites: Calculus, physics, and statics.



[6] 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).

Course objectives

Dynamics is a required ME undergraduate course and is a prerequisite for many mechanical, aerospace, and biomechanical, courses e.g., ME161 (dynamic systems), ME227 (vehicle dynamics), ME281 (biomechanics of human movement), and AA242/ME331 (advanced dynamics). The course objectives are to:

- Model, introduce mathematical identifiers, analyze, and interpret dynamic systems
- Employ analytical and numerical methods to investigate real physical systems
- Gain physical insights into basic principles with physical demonstrations, in-class laboratories, and computer experiments (e.g., **M**otion**G**enesis, MATLAB®, and Working Model)
- Develop intuition about the time-dependent nature of dynamic systems
- Develop a hands-on, minds-on, can-do attitude

ABET (Accreditation Board of Engineering & Technology) outcomes – in order of relevance

- Ability to identify, formulate, and solve engineering problems
- Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
- Graduates have the ability to apply knowledge of mathematics, science, and engineering
- Ability to design and conduct computer experiments, as well as to analyze and interpret data

School-to-work skills for graduate school and professional careers F=ma

This dynamics course focuses on formulation and solution of equations of motion for 3D dynamic systems. The course facilitates graduate and professional work in advanced dynamics & simulation. The "big picture" is $\vec{\mathbf{F}} = m\vec{\mathbf{a}}$. This course is ***detail-oriented*** with focus on details of $\vec{\mathbf{F}}$, m, $\vec{\mathbf{a}}$, the equals (=) sign, definitions, equations, words, precise notation, descriptive language, negative signs, computational solution, interpretation, MATLAB®, **M**otion**G**enesis, etc.

Topics covered

History of math & mechanics	Computational tools and ODEs	Computation & algebraic equations
Math review	Vectors and dyadics	Vector bases
Rotation matrices	Vector differentiation	Angular velocity
Angular acceleration	Position vectors/geometry	Velocity & acceleration
Rolling/gears*	Linear/angular momentum	Kinetic energy
Mass	Center of mass	Inertia dyadics
Inertia matrices	Moments/products of inertia	Shift/parallel axes theorems*
Force and impulse*	Moment vs. torque*	Replacement of forces*
Power	Work	Potential energy
$\vec{\mathbf{F}} = m\vec{\mathbf{a}}$ for particles/systems	Euler's equations for a rigid body	Angular momentum principle
Impulse-momentum principle*	Inelastic collisions*	Coefficient of restitution*

Grading

- **Graded material:** Student → **Box** → Ying Zhao (alphabetize) → Graders → Ying Zhao (Coursework/Excel) → Ying Zhao (Photocopy, ABET) → Student (in class).

  Ying Zhao is the grader intermediary. Consult **Ying** 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®, 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***.
- **Homework: 35%** 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 (not by instructors or under office doors)
  - Homework submitted one lecture day late is penalized **15 points**. Homework submitted two lecture days late is penalized **35^+ points**, and is not thoroughly examined. Homework submitted 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, ***one class*** homework extensions are permitted during the quarter. For example, a homework due Tuesday may be submitted on Thursday 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.
- Use detailed **notation** e.g., ${}^{N}\vec{\mathbf{v}}^{P}$. Use $\triangleq$ for **definitions**, e.g., ${}^{N}\vec{\mathbf{a}}^{P} \triangleq \frac{{}^{N}d\,{}^{N}\vec{\mathbf{v}}^{P}}{dt}$
- Homework marked **optional** does not need to be submitted (no extra credit).
- Homework must be **stapled** (not paper clipped, dog-eared, origami, or bubble-gummed)

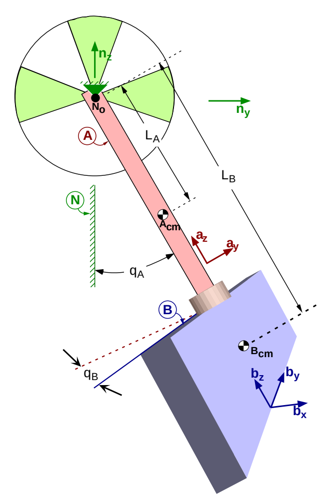
Homework solutions are not posted. Ask your friends and instructors for help. Homework is practice, not a trade secret, and you are ***encouraged*** to work with your classmates and instructors. There is a strong correlation between high homework scores and high exam scores - and few reasons to do poorly on homework.

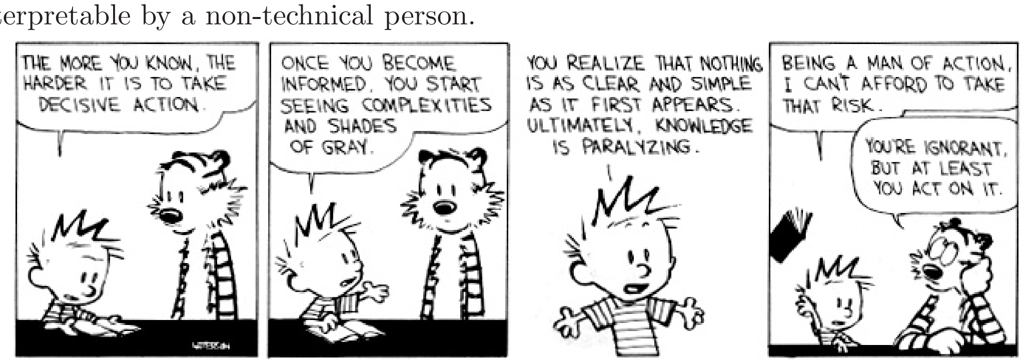
- **Midterm: 25%** The midterm exam is in-class, open-book, and open-note. No calculators, computers, cell phones, or other electronic devices are allowed. The midterm exam time and location will be announced. No midterm makeup exam will be given.
- **Final: 35%** The final exam is in-class, open-book, and open-note. No calculators, computers, cell phones, or other electronic devices are allowed. Exam time and location will be announced. No final makeup exam will be given without university authorization.
- **MIPSI: 5%** The motion simulation exercise is done in groups of two students, submitted weekly, and presented near the end of the course. Instructions are included with the 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

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., $\vec{\mathbf{F}} = m\vec{\mathbf{a}}$) 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.





Interactive participation and peer instruction

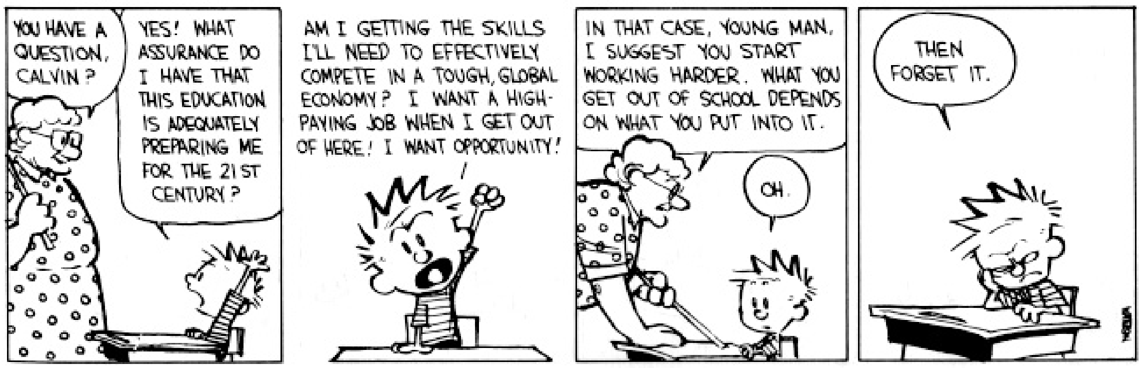
Class participation is facilitated by the instructor team who will ask students to engage in peer instruction, participate in demos, answer questions, and work out problems on the board. In-class music and videos are played by **Jenny Yong** (send her music and video/YouTube requests).

Computation and visualization tools (MATLAB®, MotionGenesis, Working Model, ...)

This course provides training for computational tools for **generating** and **solving** equilibrium equations. Plotting capabilities in MATLAB®, MotionGenesis or Excel are useful for generating graphs.

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, criticism, content, images, and creative brainstorming about lectures, labs, computation, homework, demos, 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.



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. 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.

No electronics policy: Please be courteous to your classmates by turning off all electronics during lecture (e.g., no laptops, phones, texting, etc.) For more information, Google "Mitiguy, old school, NY Times, Andrew Luck".

Students with documented disabilities

Students who need academic accommodation based on impact of a disability must initiate a request with the Student Disability Resource Center (SDRC) located within the Office of Accessible Education (OAE) 563 Salvatierra Walk (phone: 723-1066). SDRC staff evaluate the request with required documentation, recommend accommodations, and prepare an Accommodation Letter for faculty dated in the current quarter in which the request is being made. Students should contact the SDRC as soon as possible since timely notice is needed to coordinate accommodations.

Schedule: Lectures, homeworks, exams, MIPSI (tentative)

Week	1^{st} meeting of week	2^{nd} meeting of week
09/24	MIPSI. Computation with babyboot.	Vector +, $*$, -, $\cdot$, $\times$, $\vec{\mathbf{v}}^2$, angles
10/01	Hw 1. Basis independent vectors Hw 2. Vector computation + - $\cdot$ $\times$	**Computation:** Mathematics, evaluating expressions, matrices, solving linear/nonlinear algebraic equations. 3D microphone problem. Saving/running .m and .al files.
10/08	Hw 4. Vector bases: Rotation matrices I Hw 5. Vector differentiation	**Computation:** Vector computation (+ - $\cdot$ $\times$, magnitude), position vectors, rotation matrices, vector geometry (measurements of distance, area, volume, angles). Inverse/forward kinematics for neuromuscular biomechanics.
10/15	Hw 6. Angular velocity/acceleration **Direct feedback** homework grading - sign up for in-class time-slot to meet with an instructor.	**Computation:** Symbolic differentiation, computer solutions to nonlinear ODEs, SI/US unit conversions. ODEs, simulation, plotting for precessing gyro and torque-free satellite. Automating .m files.
10/21	**Midterm exam review by TAs, 8:00-8:50. Bldg. 550 (Peterson), room 200.**	
10/22	Hw 7. Points: Velocity/acceleration I	**Midterm**
10/29	Hw 9. Particles: Momentum, energy, $\vec{\mathbf{F}} = m\vec{\mathbf{a}}$ Projectile motion of baseball (with/without air-resistance). Vibration/damping/resonance of mass/spring/damper rocket-slide ride.	**Computation:** Computer-generated equations of motion ($\vec{\mathbf{F}} = m\vec{\mathbf{a}}$). Accuracy (closed form vs numerical solution) of ODEs. Simulation, plotting, and visualization of projectile motion and rocket-sled.
11/05	Hw 10. Mass/inertia I	**Dynamic Celt Lab**
11/12	Hw 11. Rigid bodies: Momentum, energy, motion	**Simulation Project: MIPSI** Consulting – submit question, model, system picture, identifier table.
11/19	**Thanksgiving Week** (Complete homework and continue MIPSI)	
11/26	Hw 14. Translation: Laws of motion **Computation:** Coast-guard helicopter rescue	**Computation:** Kinematics, angular velocity/acceleration, velocity/acceleration. Trim solution of aircraft. Phugoid mode simulation.
12/03	Hw 15. Systems: Road maps/DAlembert's method Road maps and cyber-knife surgical robot	**Simulation Project: MIPSI** Presentation - submit 1 power-point slide with: (a) question, (b) picture of system, (c) picture of team, (d) results (answer to question).
12/09	**Final exam review by TAs, 8:00-9:00. Bldg. 550 (Peterson), room 200.**	
12/10	**MIPSI Project - Team Simulation Report**. Course evaluations.	
12/12	**Final exam Wed 7:00-10:00. Room to be announced.** Grades in Axess.	
	Dec. 15-Jan. 6 Winter break