

MEAM 110 – Introduction to Mechanics (1 CU)

This lecture course and a companion laboratory course (MEAM 147) build upon the concepts of Newtonian (classical) mechanics and their application to engineered systems. This course introduces students to mechanical principles that are the foundation of upper-level engineering courses including MEAM 210 and 211. Co-requisites: Math 104 and MEAM 147.

MEAM 110 encompasses three major parts: I. Kinematics of Motion and Vector Mechanics; II. Static Equilibrium and Structures; and III. Dynamics. The lectures and laboratories (MEAM 147) will be integrated. Topics include: vector analysis, statics of rigid bodies, introduction to deformable bodies, friction, kinematics of motion, work and energy, conservation laws, and dynamics of particles. Case studies will be introduced, and the role of Newtonian mechanics in emerging applications including bio- and nano- technologies will be discussed.

Blackboard: <https://courseweb.library.upenn.edu>

Instructors: Dr. John L. Bassani – 231 Towne; bassani@seas.upenn.edu; 215-898-5632
Dr. Michael Carchidi – 208 Towne; carchidi@seas.upenn.edu; 215-898-8342

Teaching Assistants: Spring Berman – 403 Levine (GRASP Lab); spring@seas.upenn.edu
Jason Thompson – 216 Towne; thompsja@seas.upenn.edu

Office hours will be posted on Blackboard. Email is probably the best way to contact anyone of us.

Required textbook: *Essential University Physics Vol. 1*, Richard Wolfson, Pearson Addison Wesley, 2007.

Recommended reading: *The Character of Physical Law*, Richard Feynman, MIT Press, 1965 and 1967 (from the 1964 *Messenger Lectures* at Cornell University).

Handouts throughout the semester will supplement the textbook and will be placed on the Blackboard site under “Course Documents.” Some of the handouts are already noted in the Schedule.

Syllabus and Schedule: 3 hours of lecture (MWF) and a one-hour recitation (Tu) each week. There will be three in-class exams during the semester and a final exam. Exams will be closed book and notes, although selected equations will be provided. Due dates for homework are listed in the Weekly Schedule (*refer to the Blackboard site for the updated version of the Schedule*). Some of the problems in a given assignment may be addressed in recitation and, in that case, you will not have to hand in those problems. Weekly labs (Th) are noted in the MEAM 110 schedule, but students must refer to the MEAM 147 Blackboard site for detailed up-to-date information about the labs.

Peer Instruction (PI): Periodically, students will break up into small groups in lecture to solve a problem, and each group will have an opportunity to report its finding to the class – “peer instruction” (denoted PI in Schedule).

Grading: Homework – 25%; Peer Instruction – 5%; 3 In-Class Exams – 45%, Final Exam – 25%

Late homeworks will have 20% deducted for each day late and will not be accepted after solutions are posted. Make-up exams are possible only with an approved excuse.

MEAM 110 Syllabus and Weekly Schedule (updated Nov. 7)

Week	Date	Topic (Chapter or Section *)	Homework	Due
1	9/5 (Lec)	Introduction to mechanics ^{CD} (W – Ch. 1); Gravitation (W – Sec. 8.1, 8.2, 8.5; F – Ch. 1)	<u>Ch. 1</u> : 17, 20, 23, 41 [†] , 48 <u>Ch. 8</u> : 12, 16 ($\mu=10^{-6}$)	9/12
	9/6 (Lab)	<i>Introduction</i>		
	9/7 (Lec)	Overview of math requirements: some vector algebra, trigonometry, and a little calculus; Maple and Matlab are useful but not required; Units, accuracy, estimation; IDEA strategy of problem solving ^{CD} (F – Ch. 2); Safe design		
2	9/10 (Lec)	Motion in a straight line: displacement, time, velocity and acceleration (W – Ch. 2)	<u>Ch. 2</u> : 20, 22, 23, 24, 28, 36, 41, 52, 73	9/19
	9/11 (Rec)	Unit conversion, average speed, radius of the earth - see recitation problems on Blackboard		
	9/12 (Lec)	Constant acceleration (1D), e.g. tossing a ball vertically; Preview of energy conservation (handout ^{CD}); Matlab simulation ^{CD} ; PI-1 : dropping versus tossing [‡]		
	9/13 (Lab)	<i>One-dimensional motion</i>		
	9/14 (Lec)	Motion in 2D and 3 D; Vectors (W – Ch. 3)		
3	9/17 (Lec)	Vectors, coordinate systems, components of vectors ^{CD} ; Constant acceleration (2D)	<u>Ch. 3</u> : 17, 21, 31, 34, 42, 45, 60, 73, 78	9/26
	9/18 (Rec)	One and two-dimensional motion with uniform acceleration - recitation problems on Blackboard		
	9/19 (Lec)	2D Projectile motions; Matlab simulation ^{CD} ; PI-2 : optimum launch angle		
	9/20 (Lab)	<i>Manufacturing and metrology</i>		
	9/21 (Lec)	Forces and motion; Newton's 1 st and 2 nd Laws and equations of motion; Inertial and non-inertial frames of reference (handout ^{CD}) (W – Ch. 4)		
4	9/24 (Lec)	Circular motion (handout ^{CD}); Newton's 3 rd law; Atwood's machine (handout ^{CD})	<u>Ch. 4</u> : 32, 45, 47, 51, 55, 69	10/3
	9/25 (Rec)	Relative motion - see recitation problems on Blackboard		
	9/26 (Lec)	Harmonic oscillations (handout ^{CD}): spring-mass system (W – Sec. 13.1, 13.2); Inertial effects and when they are negligible		
	9/27 (Lab)	<i>Force and motion</i>		
	9/28 (Lec)	Static equilibrium (W – Ch. 12); Free-body diagrams and problem solving strategies (handout ^{CD}); PI-3 : squashing a cockroach		

* W=Wolfson and F=Feynman. Note: (a) Chapters and sections are only listed on the day of the first lecture that the topics arise. (b) Unless specific sections are listed, you should read the entire chapter.

^{CD} Denotes "Course Document" on Blackboard. Documents handed out in class are also noted.

[†] At standard temperature and pressure, one "mole of air" contains Avogadro's number of molecules, about 6.02×10^{23} , and occupies a volume of 22.4 liters.

[‡] Peer instruction – Students will break up into small groups and discuss the solution to a problem posed in class. Problems and solutions on Blackboard.

5	10/1 (Lec)	Static equilibrium and stability (W – Ex. 5.2 and 5.3, pp. 69 and 70; Ch. 12)	<u>Ch. 12</u> : 21, 24, 28, 29	10/12
	10/2 (Rec)	Newton's laws of motion – see recitation problems on blackboard		
	10/3 (Lec)	Rotational motion and moments (handout ^{CD}); Systems of forces and moments acting on bodies – we will primarily consider 2D systems; Snap-through buckling (handout ^{CD})		
	10/4 (Lab)	<i>Force equilibrium and translational stability: Snap through buckling</i>		
	10/5 (Lec)	Exam 1		
6	10/8 (Lec)	Moments (torques): Secs. (10.2 and 11.2; Ch. 12)		
	10/9 (Rec)	Newton's laws of motion and circular motion – see recitation problems on blackboard		
	10/10 (Lec)	More on static equilibrium; Moment-induced buckling (handout)		
	10/11 (Lab)	<i>Moment equilibrium and rotational stability: Tipping and Moment-Induced Buckling</i>		
	10/12 (Lec)	Moments peddling a bicycle (handout ^{CD}); PI 4 : Hanging a sign	<u>Ch. 12</u> : 31, 33, 37, 56, problem on buckling (see Blackboard)	10/24
7	10/15 (Lec)	Fall Break		
	10/16 (Rec)	Fall Break		
	10/17 (Lec)	Introduction to axial stress and strain; Hooke's law (handout)		
	10/18 (Lab)	<i>Stress and strain: Hooke's law</i>		
	10/19 (Lec)	Work (W – Ch. 6)	<u>Ch. 6</u> : 14, 15, 20	10/24
8	10/22 (Lec)	Work, energy and power		
	10/23 (Rec)	Forces and Circular Motion		
	10/24 (Lec)	Conservation of energy (W – Ch. 7; F – Ch. 3)	<u>Ch. 6</u> : 28, 33, 44, 54, 63, 74, 81; <u>Ch. 7</u> : 21, 24	10/31
	10/25 (Lab)	<i>Interaction forces at a distance: Model AFM Lab</i>		
	10/26 (Lec)	Conservation of energy: minimum potential energy (handout). PI 5 : Climbing a ladder.	<u>Ch. 7</u> : 28, 39, 45, 58, 59, 62	11/7
9	10/29 (Lec)	Friction, Tribology, Adhesion (W – 5.4, 5.5) (handout ^{CD})	<u>Ch. 5</u> : 29; <u>Ch. 12</u> : 39	11/7
	10/30 (Rec)	Forces and Moments		
	10/31 (Lec)	Review		
	11/1 (Lab)	<i>Static and kinetic friction</i>		
	11/2 (Lec)	Exam 2		
10	11/5 (Lec)	More on conservation of energy, e.g. pendulum, pin ball. Bouncing ball.		
	11/6 (Rec)	Friction and Energy Methods		
	11/7 (Lec)	Energy loss (dissipation) due to friction: non-conservative forces. PI 6 : Skateboarding bowl.	<u>Ch. 9</u> : 18, 24, 27, 31, 32, 37, 42, 56	11/16
	11/8 (Lab)	<i>Ballistic Motion and Energy</i>		

	11/9 (Lec)	Dynamics: systems of particles; center of mass (W – Ch. 9).		
11	11/12 (Lec)	Internal and external forces; Conservation of momentum of system when net external force vanishes.		
	11/13 (Rec)	Impulse Force and Center of Mass		
	11/14 (Lec)	Recoil – e.g. shooting a gun; Collisions in 1D and coefficient of restitution; Impulse forces. (W – Sec. 9.4 – 9.6)		
	11/15 (Lab)	<i>Energy, Momentum and Coefficient of Restitution</i>		
	11/16 (Lec)	Kinetic energy for collisions in 1D and coefficient of restitution; Crash safety.	<u>Ch. 9</u> : 62, 66, 71, 78	11/28
12	11/19 (Lec)	Collisions in 2D; Rotational motion: angular velocity and acceleration; Moments (torques), rotational inertia, and rotational analog of Newton's law of motion. (W – Ch. 10)	<u>Ch. 10</u> : 15, 30, 37, 38, 47, 53, 57, 68 (use Table 10.2 for problems 37 and 53)	12/3
	11/20 (Rec)			
	11/21 (Lec)	Review		
	11/22	Thanksgiving Break		
	11/23	Thanksgiving Break		
13	11/26 (Lec)	Rotational energy and rolling motion. Parallel axis theorem. PI 7 – Loop de loop roller coaster: problem 10.68;		
	11/27 (Rec)			
	11/28 (Lec)	Rotational vectors and angular momentum (W – Ch. 11)	<u>Ch. 11</u> : 21, 24, 28, 47 (use Table 10.2 for problem 24)	12/7
	11/29 (Lab)	<i>Kinematics and dynamics of rolling</i>		
	11/30 (Lec)	Exam 3		
14	12/3 (Lec)	Conservation of angular momentum.		
	12/4 (Rec)			
	12/5 (Lec)	Gyroscopes and precession.		
	12/6 (Lab)			
	12/7 (Lec)	Review		
15	12/10	Reading Days		
	12/11	Reading Days		
	12/13	Final Exam 9-11am		