PHY325: Classical Mechanics I **T Th 12:00 PM- 01:20 PM**
Room: 151 Loomis Laboratory

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Course website: `https://courses.physics.illinois.edu/phys325/fa2017/`

Textbook: *Classical Mechanics* by John R. Taylor.
Introduction to Classical Mechanics by David Morin (available online).

Prerequisites: PHYS 225; credit or concurrent registration in MATH 285.

Grade Structure: Homework will be 25% of the total grade, discussion attendance 5%, and exams will count for 70%. Two mid-term exams are worth 15% each, and the final exam is 40%.

Course Description: Kinematics and dynamics of classical systems, including a review of Newtonian kinematics and dynamics. Three dimensional motion, variable mass, and conservation laws; damped and periodically driven oscillations; gravitational potential of extended objects and motion in rotating frames of reference; Lagrangian and Hamiltonian mechanics.

Grading Policy: Partial credit will be given on homework and exams if and only if the work is coherent. A random scattering of thoughts will not be awarded points. Simple numerical errors will not be strongly punished, however students are expected to be careful about their work and will lose points for errors which give incorrect physical results. The steps to receiving partial credit are: (i) write your solution neatly and coherently using equations and words to describe what you are doing (ii) checking your answer for consistency e.g. are units correct, does the solution behave correctly in known limits? Write as though you are explaining the problem to somebody who doesn't already know the answer! Expect the exams to be challenging but to be curved accordingly.

Homework: Homework will be posted and due weekly, excepting Spring break and weeks where there are exams. Assignments will be posted on the course webpage Thursday or Friday, and will be due the following Friday at 6 PM. Assignments which are late, but handed in by Monday at 6 PM will lose 20%. No late assignments will be accepted after Monday at 6 PM. For assignments due within a week of a midterm exam, no late assignments will be accepted. Students are encouraged to work together on assignments and consult with the professor or TAs before turning it in, who will gladly check the work for errors. For this reason, students are expected to score highly on homework assignments ($\sim 95\%$).

Breakdown of topics covered: The table below lists topics covered throughout the semester and recommended reading. There may be some variation as the semester progresses, but I will attempt to adhere to this structure as closely as possible. Below, the ITEM column contains these entries for week n:

nread	READING for week n = sections from textbooks
nd	DISCUSSION = Monday
nA	LECTURE #1 = Tuesday
nB	LECTURE #2 = Thursday

The READING item gives textbook sections for each week where the letters mean:

T	Taylor = the required textbook
M	Morin = the recommended textbook (available online)

	DATE	ITEM	CONTENT
M	8/28	1read	T:1.1-4, 1.6-7; M:3.1-5
T	8/29	1A	- math: reboot
			- math: diffeq in a nutshell
			- F=ma: Cartesian coordinates
R	8/31	1B	- math: cylindrical coordinate system
			- F=ma: cylindrical coordinates
M	9/4	2read	T:2.1-5; M:3.3
		2d	-math:reboot
		1d	LABOR DAY- NO DISCUSSION #2
T	9/5	2A	- math: review of the 6 basic pieces from Phys 225
			- F=ma: position-dependent force problems
R	9/7	2B	- F=ma: spherical coordinates
			- air resistance: linear, quadratic, and range
			- air resistance: terminal velocity
M	9/11	3read	T:3.1-3, 1.5; M:5.5-6
		3d	- air resistance: intuition - linear vs quadratic
T	9/12	3A	- rockets: equation of motion (EOM)
			- rockets: solving the EOM by bypassing time
R	9/14	3B	- rockets: solution example #2

			- rockets: derivation revisited
			- multipcle sys: the center of mass (CM) position
			- multipcle sys: collective“P=MV”
			- multipcle sys: calculating the CM position
M	9/18	4read	T:3.4-5, 10.1; M:8.1-4, 2.1-2
		4d	- rockets: examples
T	9/19	4A	- multipcle sys: notational convention - capital letters
			- multipcle sys: collective Force Law
			- multipcle sys: 3rd Law violations
			- reboot: single-particle angular momentum and assoc quantities
			- reboot: reference points and associated notational convention
R	9/21	4B	- multipcle sys: “total” vs “of CM” $\rightarrow$ P is special
			- multipcle sys: collective Torque Law and valid reference points
			- multipcle sys: 3rd Law - weak and strong versions
			- multipcle sys: moment of inertia - recap
			- multipcle sys: statics - free body diagrams and F,τ balancing
M	9/25	5read	T:10.1; M:8.1, 8.4-6
		5d	- multipcle sys: spin-orbit decomposition of L
T	9/26	5A	- multipcle sys: conservation of P and L
			- multipcle sys: simplifications in uniform gravity
			- multipcle sys: reference points for I and omega
R	9/28	5B	- multipcle sys: spin-orbit decomposition of L
			- multipcle sys: general decomposition of collective motion
			- multipcle sys: d/dt for body-fixed vectors
			NO HOMEWORK #5; study for midterm
M	10/2	6read	T:4.1-10; finish discussion 6; M:3.2, 5.1-4, 5.7-8
		6d	- multipcle sys: massless connectors and string length
T	10/3	6A	- multipcle sys: $L = I\omega$ proof
			- multipcle sys: parallel-axis theorem
			- multipcle sys: kinetic energy formulae
			- multipcle sys: rolling without slipping
			- multipcle sys: rolling contact point and torque law
R	10/5	6B	MIDTERM EXAM 1 in class period
M	10/9	7read	T:4.1-10
		7d	- energy: small oscillations
			- multipcle sys: rolling on a curved surface
T	10/10	7A	- energy: potential energy recap

			- energy: conservation of T+U proof
			- energy: conservative and no-work forces
			- math: irrotational-field theorem
R	10/12	7B	- multipcle sys: potential energy → internal vs external
			- energy: when (T+U)-conservation CAN'T / MUST be used
			- energy: collisions, elastic vs inelastic
			- energy: CM(ass) frame = CM(omentum) frame
M	10/16	8read	T:4.1-10
		8d	- energy: when you can / may / must use (T+U)-conservation
T	10/17	8A	- energy: calculating U → path integral reboot
			- multipcle sys: motion of any point on a rigid body
R	10/19	8B	- energy: equilibrium analysis → methods A and B
M	10/23	9read	T:6.1-6.4; M:6.2 (sort of), 6.8 (examples)
		9d	- energy: equilibrium analysis → methods A and B
T	10/24	9A	- calcvar: Calculus of Variations → motivation and setup
			- calcvar: derivation of the Euler-Lagrange equations
R	10/26	9B	- calcvar: applications of the Euler-Lagrange equations
			- calcvar: simplifications → cyclic coords and Hamiltonian
M	10/30	10read	T:7.1-7.5; M:6.1-6.2,6.7
		10d	- calcvar: geodesics
T	10/31	10A	- lagrange: Lagrangian mechanics overview
			- lagrange: degrees of freedom and generalized coordinates
			- lagrange: example → unconstrained system
			- lagrange: example → constrained system
R	11/2	10B	- lagrange: generalized force and momentum
			- lagrange: state / configuration / phase space
			- lagrange: cyclic coordinate → conserved momentum
			- lagrange: cyclic time → conserved Hamiltonian
			- lagrange: time-dependent constraints vs natural coordinates
M	11/6	11read	T:7.5-7.8; M:6.4-6.7
		11d	- lagrange: practice, practice, practice
T	11/7	11A	- lagrange: more about the Hamiltonian
			- lagrange: small oscillations and effective potential
R	11/9	11B	- lagrange: proof part 1 → principle of least action
			- lagrange: proof part 2 → EOMs with generalized coords
			- lagrange: discussion of physical meaning
			- lagrange: other Lagrangians

			- lagrange: Noether's theorem and symmetries NO HOMEWORK #11 → study for midterm
M	11/13	12read	study for midterm
		12d	- lagrange: practice with effective potential
T	11/14	12A	
R	11/16	12B	MIDTERM EXAM 2
M	11/20	13read	T:9; M:10
		13d	- accel frames: intuition-building examples
T	11/21	13A	- accel frames: pseudo-force summary - accel frames: pseudo-force derivatio → linear - accel frames: pseudo-force derivation → rotating
R	11/23	13B	- accel frames: examples with the rotational pseudo-forces - accel frames: on earth → Coriolis shift of falling mass
M	11/27	14read	T:5.1-8; M:4.1-4
		14d	- accel frames: practice
T	11/28	14A	- accel frames: on earth → tides - math: complex numbers → techniques and traps - complex osc: equivalent forms of SHO solution
R	11/30	14B	- complex osc: damped oscillations - math: linear diff eq → superposition and complex solutions
M	5/1	15read	T:5.1-8; M:4.1-4 ... T:13 for Hamiltonian mechanics
		15d	- math: linear diff eq → superposition and complex solutions
T	5/2	15A	- complex osc: driven oscillations - complex osc: resonance - Noether's theorem in brief