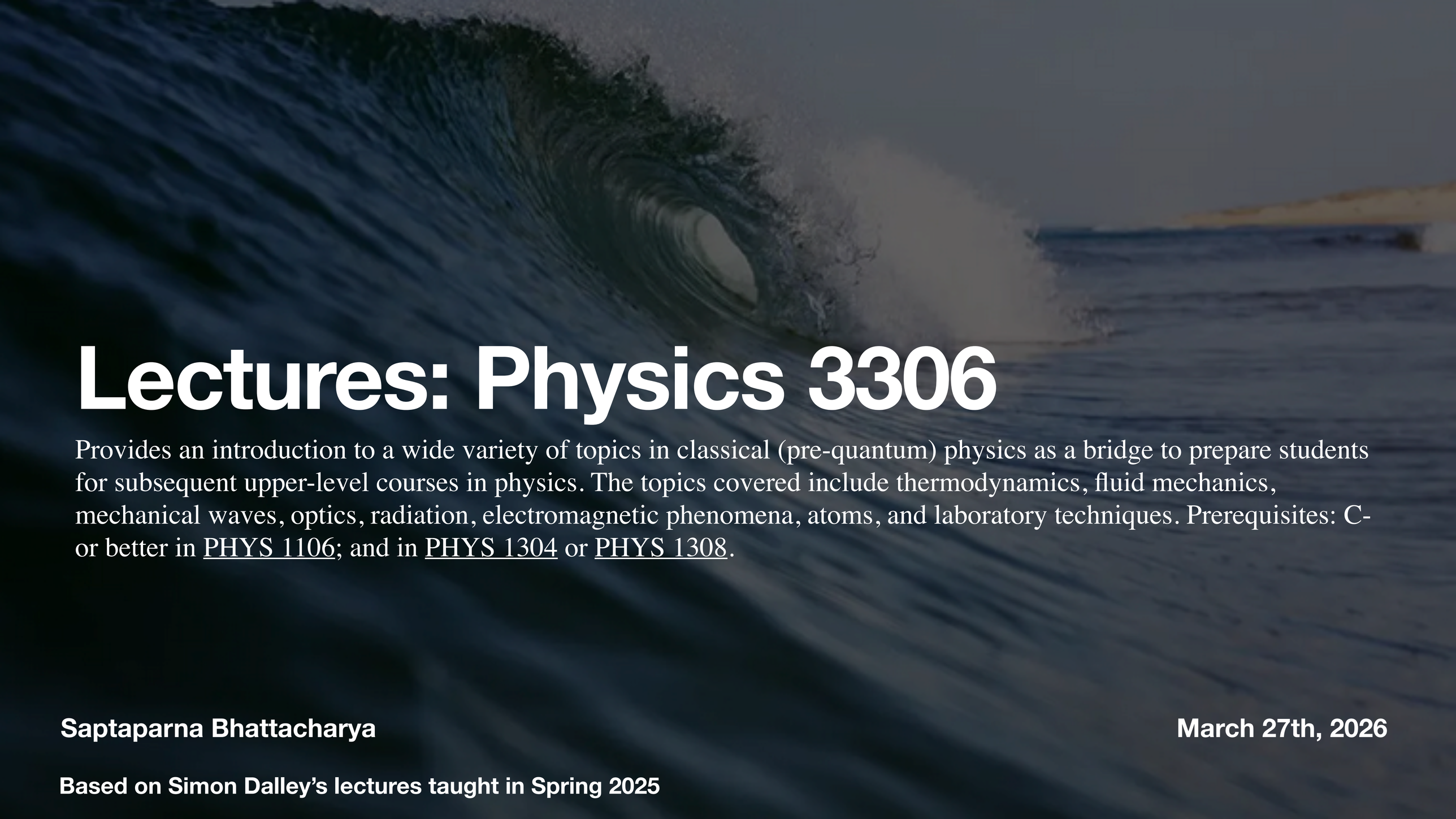


Lectures: Physics 3306

Provides an introduction to a wide variety of topics in classical (pre-quantum) physics as a bridge to prepare students for subsequent upper-level courses in physics. The topics covered include thermodynamics, fluid mechanics, mechanical waves, optics, radiation, electromagnetic phenomena, atoms, and laboratory techniques. Prerequisites: C- or better in PHYS 1106; and in PHYS 1304 or PHYS 1308.

Saptaparna Bhattacharya

March 27th, 2026

Based on Simon Dalley's lectures taught in Spring 2025

Labs

Lectures

Schedule

No class

Month	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
January	19	20	21 ✅	22	23 ✅	24	25
	26 ❄️🌨️❄️❄️❄️	27	28 ❄️🌨️❄️❄️❄️	29	30 ✅	31	1
February	2 ✅	3	4 ✅	5	6 ✅	7	8
	9 ✅	10	11 HWB due ✅	12	13 ✅	14	15
	16 ✅	17	18 ✅	19	20 HWC due ✅	21	22
	23 Hegi Center ✅	24	25 HWD due ✅	26	27 ✅	28	1
March	2 ✅	3	4 HWE due	5	6 ✅	7	8
	9 ✅	10	11	12	13 Midterm	14	15
	16	17	18	19	20	21	22
	23 ✅	24	25	26	27 ✅	28	29
April	30 Lecture 11	31	1 HWF due	2	3	4	5

Labs

Lectures

Schedule

No class

Month	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
April	6 Midterm 2	7	8 HWG due	9	10 Lecture 13	11	12
	13 Lecture 14	14	15 HWH due	16	17 Lecture 15	18	19
	20 Lecture 16	21	22 HWI due	23	24 Lecture 17	25	26
May	27 Lecture 18	28	29 HWJ due	30	1 Lecture 19	2	3
	4 Lecture 20	5	6	7	8	9	10

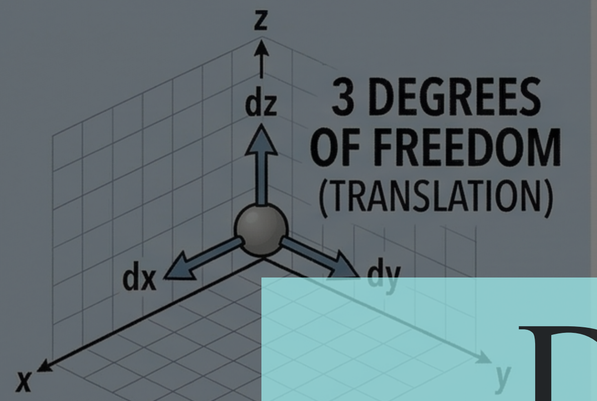
Exam discussion

Degrees of Freedom
Halliday 19.6-19.9

DEGREES OF FREEDOM: THE WAYS A SYSTEM CAN MOVE AND STORE ENERGY.

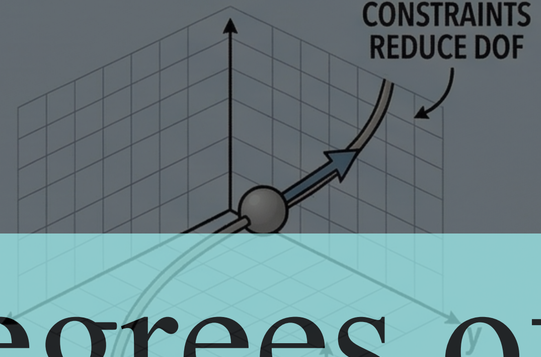
1. MECHANICAL SYSTEMS: INDEPENDENT WAYS TO MOVE (MOBILITY)

1.1. SINGLE PARTICLE IN 3D SPACE

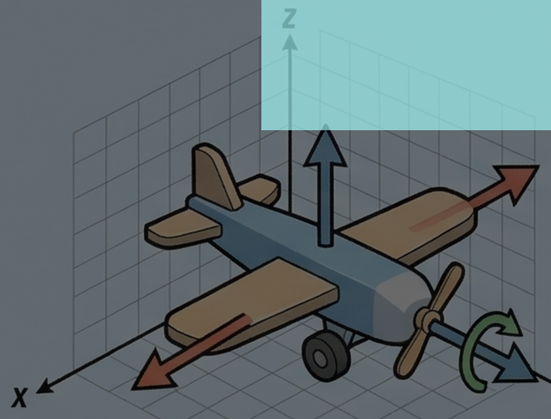


3 DEGREES OF FREEDOM (TRANSLATION)

1.2. CONSTRAINED PARTICLE (BEAD ON A WIRE)



1.3. RIGID BODY IN 3D SPACE



3 TRANSLATIONS (FORE/AFT, LEFT/RIGHT, UP/DOWN)

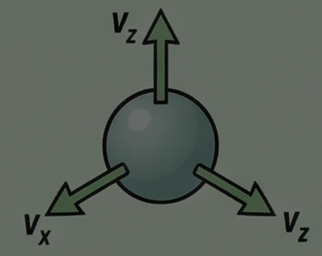
3 ROTATIONS (ROLL, PITCH, YAW)

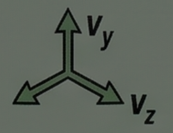
3 TRANSLATIONS (FORE/AFT, LEFT/RIGHT, UP/DOWN)

6 DEGREES OF FREEDOM (TRANSLATION + ROTATION)

2. MOLECULAR SYSTEMS: INDEPENDENT WAYS TO STORE ENERGY (EQUIPARTITION)

2.1. MONATOMIC GAS (e.g., HELIUM)





3 TRANSLATIONAL DOF

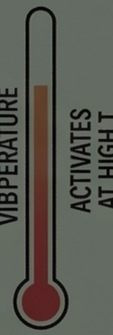
TOTAL 3 DOF

$$U = \frac{3}{2} N k_B T$$

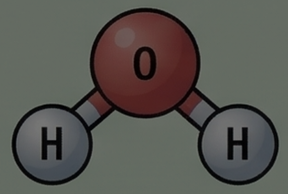
2.2. DIATOMIC GAS (e.g., NITROGEN)

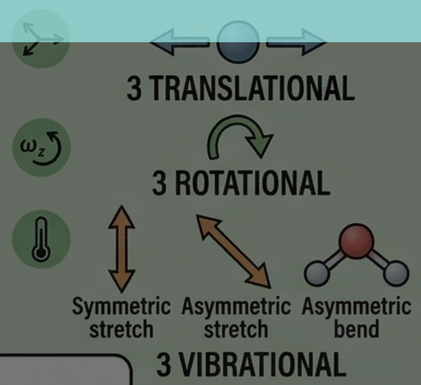
TOTAL 6 DOF

$$U = \frac{6}{2} N k_B T$$



2.3. POLYATOMIC GAS (e.g., WATER)





TOTAL 9 DOF (at high T)

$$U = \frac{3}{2} N k_B T$$

DOF = TOTAL POSSIBLE INDEPENDENT MODES
(TRANSLATION, ROTATION, VIBRATION) **MINUS** INDEPENDENT CONSTRAINTS.

Key concepts: Adiabatic Expansion

- Derive an expression for internal energy (E_{int}) of an ideal gas from molecular considerations
- The average translational kinetic energy of a single atom depends only on the gas temperature and is given by $K_{\text{avg}} = \frac{3}{2}kT$
- A sample of n moles of such a gas contains nN_A atoms. The internal energy E_{int} is then:
  - $E_{\text{int}} = (nN_A)k_{\text{avg}} = (nN_A)\left(\frac{3}{2}kT\right)$
  - $k = R/N_A$
  - $E_{\text{int}} = \frac{3}{2}nRT$ (monoatomic ideal gas)

Key concepts: Adiabatic Expansion

- The gas temperature rises from T to $T + \Delta T$
- The pressure changes from p to $p + \Delta p$
- Heat:
  - $Q = nC_V\Delta T$ (constant volume)
  - C_V: molar specific heat at constant volume
- Using the first law:
  - $\Delta E_{\text{int}} = nC_V\Delta T - W$
  - If $W = 0$, $C_V = \dfrac{\Delta E_{\text{int}}}{n\Delta T}$
  - Change in internal energy: $\Delta E_{\text{int}} = \dfrac{3}{2}nR\Delta T$
  - $C_V = \dfrac{3}{2}R = 12.5\ \text{J/mol}\,.\,\text{K}$

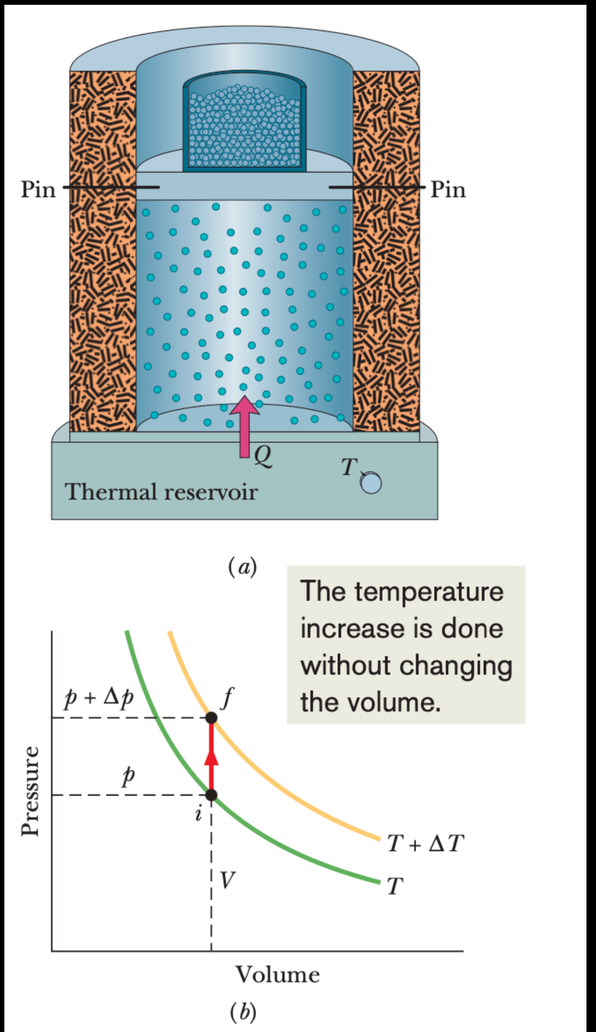


Figure 19-9 (*a*) The temperature of an ideal gas is raised from T to $T + \Delta T$ in a constant-volume process. Heat is added, but no work is done. (*b*) The process on a p-V diagram.