Oct 23  (CRN 34621 for lecture, 34622 for recitation)
Get whiteboards.
Molecular binding

Draw potential energy curve: $F_{\text{diatomic molecule}}$
1. Where is equilibrium position?
2. What happens to the potential energy/force if you push them together? (Just a little, and as much as possible)
3. What happens if you pull them apart? (Just a little, and an infinite amount)
\[ F_r = -\frac{dU}{dr} \]

\[ V = \frac{1}{2} kx^2 \]

- \( K+U \) unbound
- \( K+U \) bound
- \( K+V > 0 \) unbound
- \( K+V < 0 \) bound

Equilibrium point

\[ E = K+U \]
Review for Midterm 2

Chapter Ch 4 + 5

Ch 4

Young’s Modulus
\[ Y = \frac{\text{stress}}{\text{strain}} = \frac{(F/A)}{(\Delta L/L)} \]

Micro/macro
\[ Y = \frac{k_{si}}{d} \text{, where } d \text{ is diameter} \]

Speed of Sound
\[ v = \sqrt{\frac{k_{si}}{m_a}} \]
More on momentum principle
\[
\frac{d\vec{p}}{dt} = \vec{F}_{\text{net}}, \quad (\frac{d(|\vec{p}|)}{dt}) \hat{p} = \vec{F}_{\text{ill}} \quad \text{and} \quad |\vec{p}| \frac{d\hat{p}}{dt} = \vec{F}_I
\]

Analytic solution to harmonic oscillator

\[X = A \cos(\omega t) \quad \omega = \sqrt{\frac{k}{m}}\]

Amplitude

Assuming no friction, spring mass negligible

Period\[T = \frac{1}{f} = \frac{2\pi}{\omega}\]
Chapter 5

Energy of particle: \[ E_{\text{particle}} = \gamma mc^2 = \frac{mc^2}{\sqrt{1 - v^2/c^2}} \]

\[ = mc^2 + K \]

\[ \gamma \rightarrow \text{kinetic} \]

Kinetic energy
\[ K = \gamma mc^2 - mc^2 \]
\[ K \approx \frac{1}{2} mv^2 = \frac{p^2}{2m} \quad \frac{1}{2} \quad V \ll c \]

Connection between energy and momentum
\[ E^2 - (pc)^2 = (mc^2)^2 \]

So for massless particles \( \Rightarrow E = pc \)
Energy principle \( \Delta E_{\text{system}} = W_{\text{surroundings}} \)

Work \( W = \mathbf{F} \cdot \Delta \mathbf{r} = F_x \Delta x + F_y \Delta y + F_z \Delta z \)
\[ = \mathbf{F} \cdot \Delta \mathbf{r} \text{ cgs} \]
\[ W = \mathbf{F} \cdot \Delta \mathbf{r} \quad \text{or} \quad W = \int \mathbf{F} \cdot d\mathbf{r} \]

Conservation of energy \( \Delta E_{\text{system}} + \Delta E_{\text{surroundings}} = 0 \)

Potential energy (energy of interacting pair of particles) \( \Delta U = -W_{\text{internal}} \)

Force + potential energy \( F_x = -\frac{dU}{dx} \)
\[ F_x = -\frac{\partial U}{\partial x}, \quad F_y = -\frac{\partial U}{\partial y}, \quad F_z = \frac{\partial U}{\partial z} \]

\( \text{partial derivative} \)

\[ \vec{F} = \langle -\frac{\partial U}{\partial x}, -\frac{\partial U}{\partial y}, -\frac{\partial U}{\partial z} \rangle \]

\[ = -\nabla U \]

\[ -\frac{\partial U}{\partial x} = F_x \]
Know how to plot potential & kinetic energy

\[ U_{\text{gravity}} = -G \frac{m_1 m_2}{r}, \quad G = 6.7 \times 10^{-11} \frac{\text{Nm}^2}{\text{kg}^2} \]

Near the surface of Earth, \( \Delta U \propto \Delta (mg) \)

\[ U_{\text{electric}} = -\frac{1}{4\pi \varepsilon_0} \frac{q_1 q_2}{r}, \quad \frac{1}{4\pi \varepsilon_0} = 9 \times 10^9 \frac{\text{N} \cdot \text{m}^2}{\text{C}^2} \]
\[ p_{\text{macro}} = \frac{M}{V} = \frac{\text{Nanomolar} \times \text{Mass}}{\text{Nanomolar} \times \text{Volume}} = p_{\text{micro}} \]

\[ d_{\text{macro}} = \frac{\text{Mass}}{\rho} \]

\[ d = \sqrt[3]{\frac{\text{Mass}}{\rho}} \]

\[ \text{Molar} = \frac{\text{Mass per mol}}{\text{Mol} \cdot \text{mol}^{-1}} \]