Summary on unit 2 (update: 10/5/10)

Sec 3.6-3.13. Electric force: $\mathbf{F} = k_e \frac{q_1 q_2}{r^2}\hat{\mathbf{r}}$, where $k_e = \frac{1}{4\pi\epsilon_0} = 9 \times 10^9 Nm^2/C^2$.

Reciprocity: Applicable for $\frac{1}{r^2}$ forces, e.g. grav. and elec. forces. Here each object may have a finite size. But it must be uniformly spherically symmetric. r is the distance from center to center.

Momentum principle implies conservation of momentum, i.e. $\Delta p_{sys} + \Delta p_{env} = 0$.

Many body system

- $\mathbf{P}_{sys} = m_1\mathbf{p}_1 + m_2\mathbf{p}_2 + \cdots$ and $\mathbf{F}_{net} = \mathbf{F}_1 + \mathbf{F}_2 + \cdots$. If the internal forces satisfy the principle of reciprocity, then $\mathbf{F}_1$, $\mathbf{F}_2$, $\cdots$ will only include external forces.
- Center of mass an effective one body system. For NR, $\mathbf{P}_{cm} = M_{cm}\mathbf{v}_{cm}$, where $M_{cm} = m_1 + m2 + \cdots$
- Or $\mathbf{v}_{cm} = \mathbf{P}_{cm}/M_{cm} = (m_1\mathbf{v}_2 + m_1\mathbf{v}_2 + \cdots)/M_{cm}$ and $\mathbf{r}_{cm} = (m_1\mathbf{r}_2 + m_2\mathbf{r}_2 + \cdots)/M_{cm}$.

Sec. 4.1-4.17. Ball-spring model. 1 mole: $N_A = 6 \times 10^{23}$ atoms. M: molar mass, V: molar volume.

- Mass density: $\rho = M/V = m/d^3$, where d^3 is the atomic volume, and m the atomic mass.
- One interatomic bound: $F = k_1 s$. One cable: $L = nd$, $A = md^2$: $F = k_{mn}\Delta L$. Solve $k_{nm} = \frac{m}{n}k_1$.
- Young's modulus $= (F/A)/(\Delta L/L) = (F/\Delta L) \times (L/A) = (k_{mn}) \times (nd/md^2) = k_1/d$.

Derivative form of Mom-Principle: $d\mathbf{p}/dt = \mathbf{F}_{net}$. Conventional equation of motion (NR case): "$\mathbf{F} = m\mathbf{a}$".

Frequency of oscillations and speed of sound

- Equation of motion: $dmv/dt = mdv/dt = md^2x/dt = -kx$.
- Analytic solution: $x = Acos\omega t$, $\omega = \sqrt{k/m}$.
- Speed of sound: $v = \sqrt{Y/\rho} \rightarrow \sqrt{(k_1/d)/(m/d^3)} = \sqrt{k_1/m}d$.
- Chemical bounds of a nucleus with length and stiffness: [d, k] and of its isotope with: [d', k'], are essentially the same, i.e. $d \approx d'$ and $k \approx k'$, since both have practically the same charge content.

Sec 5.1 to 5.7 Rate of chamge of momentum.

- Statics (equilibrium): $d\mathbf{p}/dt = 0 = \mathbf{F}_{net} = \Sigma_i \mathbf{F}_i$.
- Motion along a curved path:: $\mathbf{p} = p\hat{\mathbf{p}}$, $d\mathbf{p}/dt = \mathbf{F}$, $\mathbf{F}_{||} = dp/dt\hat{\mathbf{p}}$, $\mathbf{F}\perp$=pd$\hat{\mathbf{p}}/dt = (pv/R)\hat{\mathbf{n}}$
- Local circle defines R, $\mathbf{v}$ and $\hat{\mathbf{n}}$(Fig 4.38, 4.39). $\theta = |\Delta\hat{\mathbf{p}}|/|\hat{\mathbf{p}}| = |\mathbf{v}|\Delta t/R$, or $|\Delta\hat{\mathbf{p}}|/\Delta t = v/R$.

Sec. 6.1-6.7. Introduction to Energy Principle.

- Energy of a single particle: $E = \gamma mc^2 \equiv mc^2 + K$. NR case: $K \approx (1/2)mv^2 = p^2/2m$, in Joules.
  R case: $E^2 = (pc)^2 + (mc^2)^2$. $1eV = 1.6 \times 10^{-19}J$, $1MeV = 10^6 eV$.
- Energy principle: $\Delta E_{system} = (W + Q)_{surr}$.
- $W = F_x\Delta x + \cdots = \mathbf{F} \cdot \Delta\mathbf{r} = F\Delta rcos\theta = F_{||}\Delta r = F\Delta r_{||}$.
- Near earth surface: $F = -mg$, $W = -mg(y_f - y_i)$.
- For $\mathbf{r}$-dependent force: $W = \Sigma\mathbf{F} \cdot \Delta\mathbf{r} = \int_i^f \mathbf{F} \cdot d\mathbf{r}$.
- Example: Spring force $F = -kx$. Work by spring in slowing the ball: $W = -k(x_f^2 - x_i^2)/2$.