Summary on unit 2 (update: 10/7/10)

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

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
- $P_{sys} = m_1 \mathbf{p}_1 + m_2 \mathbf{p}_2 + \cdots$ 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 as an effective one body system. For NR, $P_{cm} = M_{cm} \mathbf{v}_{cm}$, where $M_{cm} = m_1 + m_2 + \cdots$
- Or $\mathbf{v}_{cm} = P_{cm}/M_{cm} = (m_1 \mathbf{v}_2 + m_1 \mathbf{v}_2 + \cdots)/M_{cm}$ 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
  - Mass density: $\rho = M/V = m/d^3$, where $d^3$ is the atomic volume, and in the atomic mass.
  - One interatomic bound: $F = k_1 \delta$. 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: $dp/dt = \mathbf{F}_{net}$. Conventional equation of motion (NR case): “$\mathbf{F} = ma$”.

Frequency of oscillations and speed of sound
- Analytic solution: $x = A \cos \omega t, \omega = \sqrt{k/m}$.
- Speed of sound: $v = \sqrt{Y/\rho} \rightarrow \sqrt{(k_1/d)/(m/d^2)} = \sqrt{k_1/md}$.
- 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 change of momentum.
- Statics (equilibrium): $d\mathbf{p}/dt = 0 = \mathbf{F}_{net} = \Sigma_i \mathbf{F}_i$.
- Motion along a curved path: $\mathbf{p} = p\hat{r}, d\mathbf{p}/dt = \mathbf{F}, \mathbf{F}_\parallel = dp/dt \hat{r}, \mathbf{F}_\perp = pd\hat{r}/dt = (pv/R)\hat{n} = (\gamma mv^2/R)\hat{n}$
- Local circle defines $R, \mathbf{v}$ and $\hat{n}$ (Fig 5.26, 5.37). $\theta = |\Delta \hat{p}|/|\hat{p}| = |\mathbf{v}|\Delta t/R$, or $|\Delta \hat{p}|/\Delta t = v/R$.

- 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: $\Delta E_{system} = (W + Q)_{surr}$.
- $W = F_x \Delta x + \cdots = \mathbf{F} \cdot \Delta \mathbf{r} = F\Delta \cos \theta = F_{\parallel} \Delta r = F_{\parallel} \Delta r_{\parallel}$.
- Near earth surface: $F = -mg, W = -mg(y_f - y_0)$.
- For $\mathbf{r}$-dependent force: $W = \Sigma \mathbf{F} \cdot \Delta \mathbf{r} = \int F \cdot dr$.
- Example: Spring force $F = -kx$. Work by spring in slowing the ball: $W = -k(x_f^2 - x_i^2)/2$. 

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