Sec 10.1-7 Collisions: Interaction over a short time. $ΔP = FΔt ≈ 0$, $ΔE = Δ(K + E_{int}) = W + Q ≈ 0$. 3 types: Elastic: $ΔK = 0$. Inelastic: $ΔK < 0$. Maximally inelastic: stuck together, or $K_{rel} = 0$. 
Change of internal energy: $E = K + E_{int}$. $ΔE = 0$ implies $ΔE_{int} = −ΔK = −ΔK_{rel}$ (Verify last step) 
Changing reference frames. Notations: $p_1 + p_2 = p_1' + p_2'$, where $p_1' ≡ p_{1f}$ and $p_2' ≡ p_{2f}$.
- Bowling ball (Bb) hits pingpong ball(Pb) at rest. In lab frame: $Mv_1 + mv_2(0) = Mv_1' + mv_2'$. 
- Bb-frame is where Bb at rest. Velocities in Bb-frame and in lab-frame are related by $V^* = V − v_{Bb}$, Pb in Bb-frame $v_2' = v_2 − v_{Bb} = −v_{Bb}$.
- After elastic bounce, the Bb-frame velocity is: $v_2^* = −v_2^* = v_{Bb}$.
- In lab frame: Since in general $V = V^* + v_{Bb}$, final lab-frame Pb velocity is $v_2' = v_2^* + v_{Bb} = 2v_{Bb}$.

What is the sign of $v_i'$ in elastic collisions where $v_2 = 0$ in 3 cases: $m_1 < m_2$, $m_1 = m_2$, and $m_1 > m_2$?
Elastic headon collisions for arbitrary $m_1$, $m_2$, $v_1$, $v_2$: $v_1' = 2v_{cm} − v_1$ and $v_2' = 2v_{cm} − v_2$. Derive.
Ballistic Pendulum 1d collision: (i) Initial: (A) after collision $m+M$ stuck together $m+M$; (B) block reached final height. Steps to determine $v_1$. Geometry: From L, $θ$ to h. From h to $K_A$. From $K_A$ to $v_1$.
(i) to (A): $ΔP = P_A − P$, $P_1 = mv_1$, $P_A = (m + M)v_A$. (A) to (B): $ΔE = ΔK + ΔU = 0$. $ΔE_{int} = 0$, why?
Beyond 1d collisions:
Impact parameter b: b decreases, scattering angle increases.
Rutherford scattering: It led to the discovery of nuclei in atoms.

Sec 11.1-9 Angular momentum in rotational motion

Translational rotation: $L = L_{O} = r × p = rpsinθ $, $r_{\perp}p\hat{n} = r_{\perp}p\hat{n}$
Angular momentum Principle (AMP) about O (subscript suppressed): $dL/dt = \vec{\tau}$, $\vec{\tau} = d(r × p)/dt = r_{\perp}F\hat{n}$.
Planetary motion: $dL_{O}/dt = r × F = 0$, since $F = −GMm\dot{r}/r^2$. This implies that $L_{O} = const$.
Kepler’s 2nd law: $\Delta A/\Delta t = const$. $ΔA = \frac{1}{2}r_{\perp}v_{\Delta t}$. $\Delta A/\Delta t = \frac{r_{\perp}p}{2m}$ = $\frac{\dot{L}}{2m}$.
Angular momentum of multiparticle system: $L_{tot} = L_{trans} + L_{rot}$.
Example: A dumbbell has masses $m_1 = m_2 = m$, separated by 2a. Rotational angular velocity: $\omega_1\hat{n}$.
Assume its cm rotates along $\hat{n}$, with a uniform velocity along a cicular arc, where $v_{cm} = r_{cm}\omega_2$.
The two angular momenta vectors are $L_{rot} = 2ma^2\omega_1\hat{n}$ and $L_{cm} = 2mr^2_{cm}\omega_2\hat{n}$.
Angular momentum of rotation of a rigid body. $L_{tot,A\hat{n}} = (L_{cm,A} + L_{rot})\hat{n}$.
AMP for rigid body rotation about A. $\frac{dL}{dt} = \frac{dL_{rot,A\hat{n}}}{dt} + \frac{dL_{cm}}{dt} = r_{cm,A} × F_{cm} + \tau_{rot}\hat{n}$.
Boy+MGR: Torque, negligible: $\frac{dL}{dt} ≈ 0$. $L_1 = av_1$, $L_f = ma^2\omega_f + I_{MGR} × \omega_f$.
Meteorite hits a satellite. Collisions: $ΔP = 0$, $ΔL = ΔL\hat{n} = 0$. Use $ΔE = 0$ to find $ΔE_{int}$.
Prediction on $θ$. Linear to rotation: $v = \frac{d\theta}{dt}$ to $ω = \frac{dθ}{dt}$, $p = mv$ to $L = I\omega$, $F$ to $τ$.
AMP for Rigid body rotation: $ΔL = τΔt$ leads to $L_f − L_1 = τL_1$, or $ω_f − ω_i = \frac{τL_1}{I}$.
Position update: $θ_f = θ_i + \omega_{avg}Δt$, where for constant $F$, $ω_{avg} = \frac{ω_f + ω_i}{2}$.