Preparation Notes for Chapter 9 (Linear Momentum; two-three classes)

Momentum and Impulse
Reading 9.1-9.2; Problems 9.5, 9.10

(1) Review by instructor: momentum p=mv; vector, kg m/s; F_{net} = m a = m dv/dt = d(mv)/dt = dp/dt
(2) Impulse $\Delta p = \int_{t_1}^{t_2} F dt = I$ $I = \overline{F}\Delta t$ where $\overline{F} = \int_{t_1}^{t_2} F dt/\Delta t$
(3) Discussion: the movie “Speed”; in the scene at the end, when the subway car jumps the rails to avoid crashing into the end of the tunnel; why is this a good strategy? (many little collisions are better than one big collision; smaller force over longer time)
(Alternatively, if class hasn't seen the movie, discuss a truck hitting sand cans versus a bridge pillar)
(4) Problem 10

Collisions
Reading 9.3-9.4; Problems 57, 61

(1) What is a collision? two particles exert large impulsive force on each other. Assume $I >>$ other forces
$p = p_1 + p_2$; dp/dt = dp_1/dt + dp_2/dt = F_{21} + F_{12} = 0
p = constant; $p_{1i} + p_{2i} = p_{1f} + p_{2f}$
(2) Discussion topic: can you come up with an example of a collision where momentum is NOT conserved?
(3) Elastic collisions –> ΔK = 0; inelastic collisions –> Δ K $\neq$ 0; Perfectly inelastic –> objects stick together; discuss everyday examples of collisions; what type are they?
(4) Demo: drop a small ball above a big ball; small ball shoots off very fast; students discuss why this happened. (Note: this is a good demo but the mathematical discussion is long if you try to derive it from the formulae below; if you want to derive the speed of the lighter ball, I find it good to have an overhead with the formula for the speed of m_1 and m_2 written down as a starting point.)
(5) review some formulas with them (perhaps as part of doing the problems?):
perfectly inelastic: $m_1v_{1i} + m_2v_{2i} = (m_1+m_2)v_f$
elastic: $m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$
$\frac{1}{2}m_1v_{1i}^2 + \frac{1}{2}m_2v_{2i}^2 = \frac{1}{2}m_1v_{1f}^2 + \frac{1}{2}m_2v_{2f}^2$
(6) Problem 61

Suggested Presentation Topics

Airbags, Sand Cans, and other Highway Lifesavers

Baseball Bat Weight and Momentum Exchange with the Ball

Why it *is* Important to Follow-through on that Swing

Car collisions: Damage as a Function of Car Velocity

Desirable Properties of Highway Medians

Properties of Survivable Falls

Note: these presentations can be difficult, particularly if they are trying to measure impulse. The trick is to try to make the collision occur over as long a time as possible. Some of these presentations topics are less amenable to quantitative analysis, so some of the experiments may have to be qualitative or comparisons between one setup and another.

Content of Chapter 9

momentum and relation to force
impulse
conservation of momentum in isolated systems
collisions: elastic, inelastic, perfectly inelastic

(Concept Map for Chapter 9 is also available)