Workshop Tutorials for Introductory Physics

MI9: **Collisions**

A. Review of Basic Ideas:

Use the following words to fill in the blanks:
push, kinetic, inelastic, conservation, larger, short, friction, conservative, elastic, momentum

Collisions

A .22 rifle bullet and a pitched baseball have roughly the same ________ energy - a hundred or so joules. Which would you rather catch? How can a rocket engine accelerate a space shuttle in outer space where there's nothing to _______ against? To answer these and similar questions we need two new concepts, momentum and impulse, and a new conservation law, conservation of momentum. The validity of this ________ principle extends far beyond the bounds of classical mechanics to include relativistic mechanics (the mechanics of the very fast) and quantum mechanics (the mechanics of the very small).

To most people the term 'collision' is likely to mean some sort of automotive disaster. We'll use it in that sense, but we'll also broaden the meaning to include any strong interaction between two bodies that lasts a relatively ________ time. So we include not only car accidents but also balls hitting on a billiard table, the slowing down of neutrons in a nuclear reactor, a bowling ball striking the pins, and the impact of a meteor on the surface of the Earth.

Conservation of momentum is true for any isolated system. If the interaction forces are much ________ than the net external force, we can model the system as an isolated system, neglecting the external forces entirely. Two cars colliding at an icy intersection provides a good example. Even two cars colliding on dry pavement can be treated as an isolated system during the collision if, as happens all too often, the interaction forces between the cars are much larger than the ________ forces of pavement against tyres.

If the interaction forces between the bodies are ________, the total kinetic energy of the system is the same after the collision as before. Such a collision is called an elastic collision. A collision between two hard steel balls or two billiard balls is almost completely ________, and collisions between subatomic particles are often, though not always, elastic. A collision in which the total kinetic energy after the collision is less than that before the collision is called an ________collision. If the colliding bodies stick together and move as one body after the collision, for example the fenders of two colliding cars lock together, then kinetic energy is not conserved and these collisions are often referred to as completely inelastic. In an isolated system the ________, unlike the mechanical energy, is conserved regardless of whether the collision is elastic or inelastic.

Discussion question
Do you think a collision between cars is usually elastic or inelastic?

B. Activity Questions:

1. Newton's cradle – different balls

Examine the two sets of Newton's cradle on display. Explain the difference between the two types (one with steel balls and one with lead balls) of apparatus on display.
Can you explain the behaviour of the balls with only energy conservation or do you need conservation of momentum as well? Discuss your answer.

2. Air track
What happens when a moving object collides with an identical stationary one? Why does this happen?
What if they have different masses?
What purpose do the metal loops serve?

3. Bouncing balls II
Hold a little ball in contact with and directly above a big ball. Drop the balls together.
Describe what happens. Why does this happen?
Do you get the same behavior if the big ball is above the little ball?

C. Qualitative Questions:

1. One of the first things that physicists do when approaching a problem is identify the system that they are investigating, and determine whether it is isolated or not.
a. Why is the collision between two cars on an icy intersection a better approximation to an isolated system than a collision on a dry intersection?
b. What are the forces on each car during the collision? Are these external or internal forces? Draw a diagram showing these forces.
c. Which of the forces are conservative and which are non-conservative?
d. What is the net force on each car during the collision?

2. Why is it easier and less painful to catch a fast moving ball by moving your hand back with the ball, rather than keeping your hand still?

D. Quantitative Question:

A steel wrecking ball of mass 200 kg is fastened to a 10 m long chain which is fixed at the far end to a crane. The ball is released when the chain is horizontal as shown. At the bottom of its path, the ball strikes a 1000 kg car initially at rest on a frictionless surface. The collision is completely inelastic so that the ball and car move together just after the collision.
What is the speed of the ball and car just after the collision?
Hint: First find the velocity v of the ball at the bottom using conservation of mechanical energy, then use conservation of linear momentum to solve the problem.