Homework Problem Set 5 – Due Thursday, 10/13

Problem 1

The individual fish in a swarm are moving with various (non-zero) velocities in various directions. Is it possible that the entire swarm has zero net momentum?

Problem 2

A pitcher is going through the motions of throwing a fastball, but at the last moment holds on to the ball so that it comes back to rest. What is the net impulse imparted on the pitcher? Will the pitcher experience any recoil?

Problem 3

A 1500 kg Fiat collides with a 4,000 kg Hummer. Which of the following quantities have the SAME MAGNITUDE for both during impact, and which don't: Force, impulse, change in momentum, acceleration?

Problem 4

Calculate the momentum for each of the following objects (show your math):

a) a 20,000 kg whale moving at 2.5 m/s
b) a 5,000 kg truck moving at 10 m/s
c) a 2,000 kg car moving at 25 m/s
d) a 500 kg rock after being in free fall for 10 s
e) a 25 kg projectile moving with a speed of 2,000 m/s
f) a 50,000 kg meteorite moving with a speed of 2,000 m/s
g) a 50,000 kg meteorite at rest (after impact)

Problem 5

For the meteorite in 4f)-g), how much impulse does it impart on the spot on Earth where it impacts?

Problem 6

During a crash, a car comes to a sudden halt. Explain how an airbag can reduce the amount of **force** felt by the driver compared to just having the dashboard to stop them?

Problem 7

A tennis training machine spits out a tennis ball of 0.2 kg at a speed of 12 m/s. The machine is rigidly anchored in the ground and hence ultimately to the entire planet Earth. Why do we not observe a change in velocity of Earth after the machine fires, given that it must absorb a recoil impulse equal to the momentum of the launched ball?

Problem 8

A 5 kg fish swallows a smaller 1 kg fish for lunch. The big fish is initially moving with 6 m/s to the right, while the small fish is at rest. What is the big fish's velocity immediately after this "inelastic collision"?

Problem 9

Consider a 5 kg rock in free fall. It starts out from a height of 180 m with zero velocity, and hits the ground 6 s later, stopping abruptly. Since the fall is due to its interaction with Planet Earth, we consider as our "system" BOTH of these objects – Earth and the rock. For simplicity, assume Earth is also at rest at the beginning. Furthermore, assume "up" is in the direction away from the center of Earth, and counted as positive from here on. Now calculate the momentum (including sign!) of BOTH the rock AND Earth at each of the following points in time:

a) Right at the moment the rock is released at 180 m height.

b) Right before the rock hits the ground

c) Right after the rock hits the ground.

d) What is the impulse imparted on Earth from before the Fall to the moment right before impact?

e) What is the impulse imparted on Earth from right before impact to the moment right AFTER impact?

f) What is the TOTAL (net) momentum of the entire system at each moment?

Problem 10 - XC

Why did the "bouncy" ball in lecture manage to knock over the wooden block upon impact while the "lazy" ball did not? (Assume they both have the same mass and the same speed when they hit the wooden block).