Momentum, Impulse and Momentum Change

Read from Lesson 1 of the Momentum and Collisions chapter at The Physics Classroom:
http://www.physicsclassroom.com/Class/momentum/u4l1a.html
http://www.physicsclassroom.com/Class/momentum/u4l1b.html

MOP Connection: Momentum and Collisions: sublevels 1 and 2

Momentum
1. The momentum of an object depends upon the object’s ________. Pick two quantities.
   a. mass - how much stuff it has
   b. acceleration - the rate at which the stuff changes its velocity
   c. weight - the force by which gravity attracts the stuff to Earth
   d. velocity - how fast and in what direction it’s stuff is moving
   e. position - where the stuff is at

2. Momentum is a ____________ quantity.
   a. scalar  b. vector

3. Which are complete descriptions of the momentum of an object? Circle all that apply.
   a. 2.0 kg/s  b. 7.2 kg•m/s, right  c. 6.1 kg•m/s², down
   d. 4.2 m/s, east  e. 1.9 kg•m/s, west  f. 2.3 kg•m/s

4. The two quantities needed to calculate an object’s momentum are __________ and __________.

5. Consider the mass and velocity values of Objects A and B below. Compared to Object B, Object A has ____ momentum.
   a. two times the  b. four times the
   c. eight times the  d. the same
   e. one-half the  f. one-fourth the
   g. ... impossible to tell without knowledge of the F and a.

6. Calculate the momentum value of ... (Include appropriate units on your answers.)
   a. ... a 2.0-kg brick moving through the air at 12 m/s.
   b. ... a 3.5-kg wagon moving along the sidewalk at 1.2 m/s.

7. With what velocity must a 0.53-kg softball be moving to equal the momentum of a 0.31-kg baseball moving at 21 m/s?

Impulse and Momentum Change
8. Insert these words into the four blanks of the sentence: mass, momentum, acceleration, time, impact, weight, impulse, and force. (Not every word will be used.)
   In a collision, an object experiences an (n) __________________ acting for a certain amount of ________________ and which is known as an (n) ________________ ; it serves to change the ________________ of the object.
Momentum and Collisions

9. A(n) _________________ causes and is equal to a change in momentum.
   a.   force    b.  impact    c.  impulse    d.  collision

10. Calculate the impulse experienced by .... .   (Show appropriate units on your answer.)
    a. ... a 65.8-kg halfback encountering a force of 1025 N for 0.350 seconds.
    b. ... a 0.168-kg tennis ball encountering a force of 126 N that changes its velocity by 61.8 m/s.

11. Determine the impulse (I), momentum change (Δp), momentum (p) and other values.
    A 7-ball collides with the 8-ball.  A moving medicine ball is caught by a girl on ice skates.

A car is at rest when it experiences a forward propulsion force to set it in motion. It then experiences a second forward propulsion force to speed it up even more. Finally, it brakes to a stop.

A tennis ball is at rest when it experiences a forward force to set it in motion. It then strikes a wall where it encounters a force that slows it down and finally turns it around and sends it backwards.
Controlling a Collision

Read from Lesson 1 of the Momentum and Collisions chapter at The Physics Classroom:
http://www.physicsclassroom.com/Class/momentum/u4l1a.html
http://www.physicsclassroom.com/Class/momentum/u4l1b.html

MOP Connection: Momentum and Collisions: sublevel 3

Review:
1. A halfback (m = 80 kg), a tight end (m = 100 kg), and a lineman (m = 120 kg) are running down the football field. Consider their ticker tape patterns below.
   - Lineman → · · · · · · · · · · · · · · · · · · · · · · · · · · · · ·
   - Tight End → · · · · · · · · · · · · · · · · · · · · · · · · · · · · ·
   - Halfback → · · · · · · · · · · · · · · · · · · · · · · · · · · · · ·

The lineman’s velocity is 3 m/s (right). The tight end’s velocity is ______ m/s and the halfback’s velocity is ______ m/s. Which player has the greatest momentum and how much momentum does he have? __________________________ Explain.

2. A football fullback is running down the field at constant speed until he encounters a defensive back. The dot diagram depicts the motion of the fullback.

   . . . . . . . . . . . . . . . . . . . .

Indicate on the dot diagram (by means of an arrow) the approximate location at which the fullback-defensive back collision occurs.

Which direction (right or left) does the force upon the fullback act? ______ Explain how you know.

What happens to the momentum of the fullback upon colliding with the defensive back?

Using the $F \cdot t = m \cdot \Delta v$ Equation to Analyze Impulses and Momentum Changes:
3. Two cars of equal mass are traveling down Lake Avenue with equal velocities. They both come to a stop over different lengths of time. The dot diagrams for each car are shown below.

   - Car A . . . . . . . . . . . . . . . . . . . .
   - Car B . . . . . . . . . . . . . . . . . . . .

Which car (A or B) experiences the greatest acceleration? _____ Explain.

Which car (A or B) experiences the greatest change in momentum? _____ Explain.

Which car (A or B) experiences the greatest impulse? _____ Explain.

Which car (A or B) experiences the greatest force? _____ Explain.
4. When a boxer recognizes that he/she will be hit by an opposing fist, he/she rides the punch. Use physics to explain why.

5. Mountain climbers use nylon safety ropes due to their tendency to stretch considerably under stress. Use physics to explain why.

Consider the diagram at the right for the next three questions. The diagram depicts Before and After velocities of an 800-kg car in two different collisions with a wall. In case A, the car rebounds upon collision. In case B, the car hits the wall, crumples up and stops. Assume that the collision time for each collision is the same.

6. In which case does the car experience the greatest momentum change?
   a. Case A  b. Case B  c. Both the same  d. Insufficient information

7. In which case does the car experience the greatest impulse?
   a. Case A  b. Case B  c. Both the same  d. Insufficient information

8. The impulse encountered by the 800-kg car in case A has a magnitude of ___ N•s.
   a. 0  b. 800  c. 3200  d. 4000  e. 7200  f. Not enough information to determine.

9. Evaluate the potential hazard to a passenger involved in a head-on collision in which the two cars stick together compared to when they rebound upon impact. Explain.

10. The diagram below depicts the changes in velocity of a ball that undergoes a collision with a wall. Indicate which case (A or B) has the greatest change in velocity, greatest acceleration, greatest momentum change, and greatest impulse. Support each answer.

<table>
<thead>
<tr>
<th>Case A</th>
<th>Case B</th>
</tr>
</thead>
<tbody>
<tr>
<td>(v_i = 10 \text{ m/s})</td>
<td>(v_i = 30 \text{ m/s})</td>
</tr>
<tr>
<td>(v_f = 5 \text{ m/s})</td>
<td>(v_f = 28 \text{ m/s})</td>
</tr>
</tbody>
</table>

Greatest \(\Delta v\)? _____ Explanation: ________________
Greatest \(\Delta p\)? _____ Explanation: ________________
Greatest \(a\)? _____ Explanation: ________________
Greatest \(F\Delta t\)? _____ Explanation: ________________