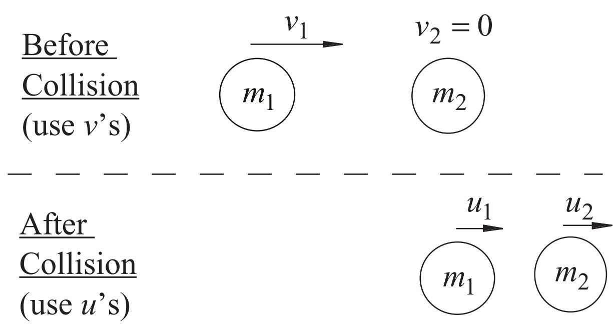
<u>Hooke's law</u>: $F=kx$; <u>Weight</u>: $W = F_G = mg, g = 9.81\,\mathrm{N/kg}$ (on Earth), <u>Torque($\mathbf{F}\perp\mathbf{r}$)</u>: $\tau = Fr$;
<u>Work</u>: $w = \langle \mathbf{F} \rangle \cdot \mathbf{s}$; <u>Potential Energy</u>: $PE_S = \frac{1}{2}kx^2$ (spring), $PE_G = mgh$ (gravity on Earth);
<u>Kinetic Energy</u>: $KE = \frac{1}{2}mv^2$; <u>Energy Conservation</u>: $KE + PE = KE_0 + PE_0 + w_{NC}$;
<u>Momentum</u>: $\mathbf{p} = m\mathbf{v}$; <u>No $F_{external}$</u>: Sum($\mathbf{p}$) = Sum($\mathbf{p}_0$); <u>2^{nd} law ($\mathbf{F}$ const.)</u>: $\mathbf{p} = \mathbf{p}_0 + \mathbf{F}\Delta t$



Two hockey pucks (masses m_1 and m_2), #1 moving with a speed v_1 and #2 at rest, collide head-on with energy conserved (an elastic collision, $w_{NC} = 0$).

1. What are the expressions for the kinetic energy and momentum of each puck before and after the collision?

   Before collision: $KE_1 =$______ , $\mathbf{p}_1 =$________, $KE_2 =$________, $\mathbf{p}_2 =$_______

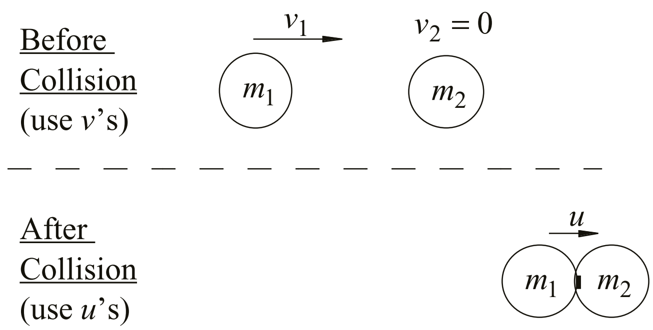
   After collision: $KE_1 =$______ , $\mathbf{p}_1 =$________, $KE_2 =$________, $\mathbf{p}_2 =$_______

2. What are the expressions for the total momentum, $\mathbf{p}_{tot} = \mathbf{p}_1 + \mathbf{p}_2$, and the total energy, $E_{tot} = KE_1 + KE_2$, of the two pucks before and after the collision?

   Before collision: $\mathbf{p}_{tot} =$_____________; After collision: $\mathbf{p}_{tot} =$________________

   Before collision: $E_{tot} =$_____________; After collision: $E_{tot} =$________________

3. Momentum conservation and energy conservation can now be used to solve for the two speeds, u_1 and u_2, in terms of the masses and the initial speeds. To simply the problem consider the two masses to be equal ($m_1 = m_2 = m$) and find the solution for the two speeds, u_1 and u_2, (hint: square the momentum conservation equation.) Does the solution make sense to you?



The same two hockey pucks collide again but this time they stick tightly together when they make contact.

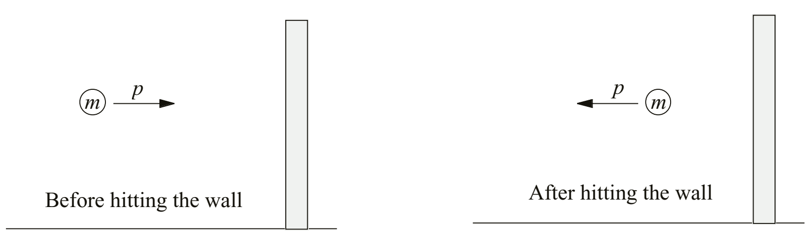
4. Expressions for the total momentum in the system before and after the collision are:
   Before collision: $\mathbf{p}_{tot}$ =____________; After collision: $\mathbf{p}_{tot}$ =______________

5. Using momentum conservation, the speed u , of the masses in terms of m's and v's is:

u =_____________

6. Use the speed from problem 5, to evaluate the total mechanical energy (*KE* and *PE*, not heat) of the masses (use m's and v's) and compare them.
   Before collision: E_{tot} =____________; After collision: E_{tot} =______________

7. The total mechanical energy in the system (*did* or *didn't*) change.
   Explanation:



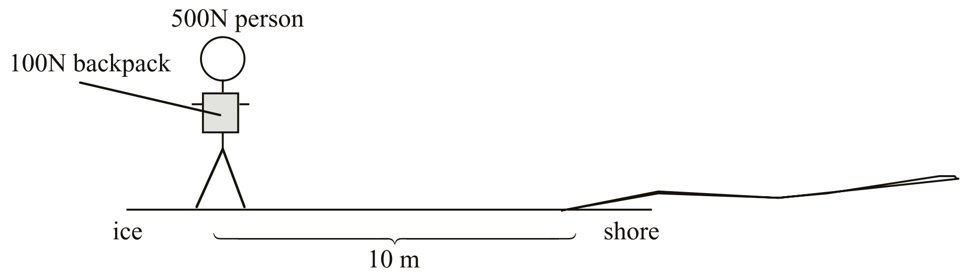
A mass with momentum, **p** , hits a wall and bounces off with momentum, – **p** .

8. Is the momentum of the small mass alone conserved ? ______________

9. In addition to the small mass, what other object(s) are involved in the collision _______

10. To conserve momentum, what is momentum *vector* of the object(s)? $\mathbf{p}_e$ =_________

11. Is the collision "*elastic*" or "*inelastic*" ? (see definition of "elastic" in prob. 1) ______



A person (weight 500N) wearing a backpack filled with CDs (weight 100N) is standing on a frozen lake that is too slippery to walk on but the shore is just 10m away.

12. Which direction should the backpack be thrown to get the person to the shore? (Throwing the CDs on the ice to make a path to shore is not the answer.)___________

13. How long does it take for the person to reach the shore if the backpack is thrown with a speed of 5m/s ? _____________

14. In which case is momentum **not** conserved?
   (a) when two objects collide and stick together.
   (b) when an internal force is applied to 2 unequal masses.
   (c) when both ends of a force are applied in opposite directions on two objects.
   (d) when the effects of a net force acting on a single mass are observed.
   (e) when masses are affected by an explosion.