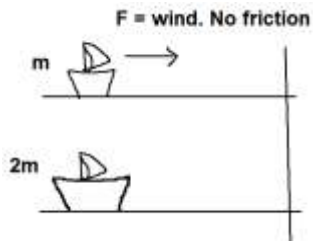
Conservation



#1 Two iceboats hold a race on a frictionless horizontal lake. The two iceboats have masses *m* and 2*m*. Each iceboat has an identical sail, so the wind exerts the same constant force **F** on each iceboat. The two iceboats start from rest and cross the finish line a distance *s* away. Describe your reasoning in the following questions. The answers could be: 1m iceboat, 2m iceboat, or both are the same.

a) Which iceboat crosses the finish line with greater kinetic energy?

b) Which iceboat wins the race?

c) Which iceboat spends more time along the surface?

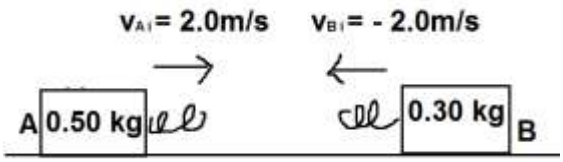
d) Which iceboat has the greater change in momentum?

e) If the iceboat of mass *m* has momentum of 350 kg.m/s at the finish line, how much momentum does the 2*m* iceboat have?

f) If the iceboats go off a ledge at the finish line and the 2*m* iceboat reaches the ground 10 m from the ledge, at what distance does the 1*m* iceboat reach the ground?

g) Which iceboat spends more time in the air, from cliff to ground?

*h) BONUS: By how many seconds does the winning iceboat win? Write the answer in terms of the mass *m*, distance *s*, and force *F*.



#7 Two gliders move toward each other on a frictionless linear air track. They have ideal spring bumpers so the collision is elastic. What are the velocities of A and B after the collision? Hint: Set up 2 equations: $p_i=p_f$ and $K_i=K_f$. Actually, instead of using the fact that kinetic energy stays the same, it is faster to use the consequential result that relative velocities after the collision have the same magnitude but opposite sign. That is, $v_{Af} - v_{Bf} = -(v_{Ai} - v_{Bi})$. ← Try to prove that too.

7 ** BONUS: For an elastic collision, prove that $v_{Af} - v_{Bf} = -(v_{Ai} - v_{Bi})$.

Hint: Use the 2 equations from conservation of momentum and conservation of kinetic energy.

#8 A ballistic pendulum is a system for measuring the speed of a bullet. The bullet, with mass m_B, is fired into a block of wood with mass m_W, suspended like a pendulum, and makes a completely inelastic collision with it. After the impact of the bullet, the block swings up to a maximum height y. Given the values of y, m_B, and m_W, show that the initial speed v_i of the bullet is

$$v_1 = \frac{m_B + m_w}{m_B}\sqrt{2gy}$$

Hint:

- During the inelastic collision, momentum is conserved. The only forces involved in the collision are horizontal.
- After the collision, mechanical energy is conserved and kinetic energy is transformed into gravitational potential energy.