Energy Conservation, Momentum Conservation (*Use g = 9.81 m/s^2 = 32.2 ft/s^2*)

When an object or system undergoes a change from state 1 to state 2, a rough statement is:

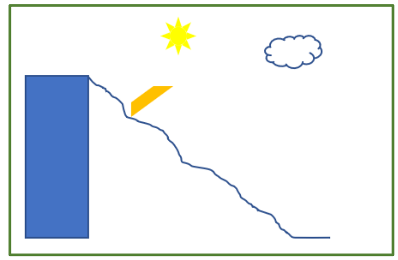
(Energy at 2) = (Energy at 1) + (Work increasing mechanical energy) – (Work decreasing mechanical energy).

To be more precise, the equation $KE_2 + PE_2 = KE_2 + PE_2 + W_{other}$ may be helpful.

1. Potential energy can be thought of as stored energy, as energy available because a "conservative force" can do work. Name at least two types of stored energy.

2. W_{other} is work done by non-conservative force(s). Give an example of a
   a) a non-conservative force performing positive W_{other}
   b) a non-conservative force performing negative W_{other}

Neither answer can involve "gravity" as gravity is a conservative force.

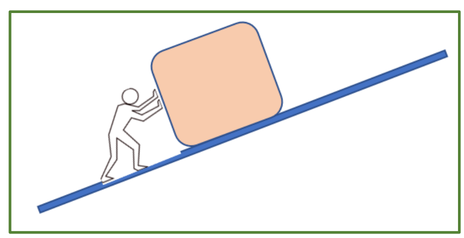


3. In each of the following problems, use $KE_2 + PE_2 = KE_2 + PE_2 + W_{other}$.

a) The orange figure represents a skier (total mass = 80 kg) going downhill. It started at height 100 meters with negligible speed. At the hill base, the skier has speed 30 meters/sec. Determine the work done by friction during this descent. Be sure your answer includes the correct algebraic sign.

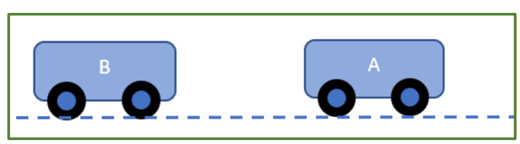
b) The 10 kg mass, which has compressed the spring 40 cm, is initially held at rest. The mass is not connected to the spring.

The mass is released and moves to the right; at the instant the mass loses contact with the spring, it moves with speed 6 meter/second. During this move to the right, the magnitude of the work done by friction is 40 joules. Determine i) the initial elastic potential energy ii) the value of the spring stiffness constant in N/m.



*c) The 5 slug crate is pushed up the incline at constant speed. The incline is at angle 30° above the horizontal. During the push, the crate rises vertical distance 10 feet. Determine the work done by the person pushing the crate. Be sure your answer includes the correct algebraic sign. (<u>Hint:</u> You should have 2 "W" terms in your $KE_2 + PE_2 = KE_2 + PE_2 + W_{other}$ equation, one positive and one negative).

Linear momentum can, "roughly" be thought of as quantifying how tough it is to stop an object. Some texts denote it with the equation $\vec{p} = m * \vec{v}$. In the following problems, consider "to the right" to be the positive direction.



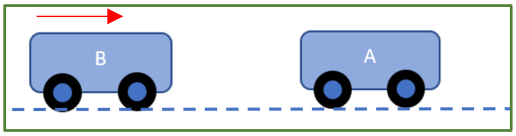
4. a) Find the momentum of cart A if it
   i. has mass 80 kg and moves left with speed 5 meter/sec.
   ii. has weight 644 pounds and moves right at speed 8 feet/sec.

b) Determine the momentum of the system consisting of carts A and B. B has mass 90 kg and moves to the right with speed 6 m/sec. A has mass 100 kg and moves to the left with speed 5 meters/sec.

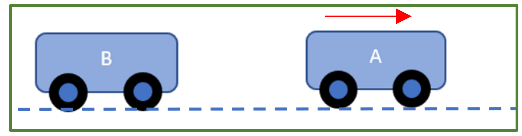
Be sure your answers have the correct algebraic sign.

5. ***Momentum Conservation:*** In a system of multiple objects, if the only unbalanced forces are "internal forces" (i.e. forces on a system object due to actions of other system objects), then ***system momentum is constant***. Consider the collision between two train cars depicted below where before the collision, B moves to the right and A is stationary. After the collision, A moves to the right and B is stationary. Assume negligible friction.

Before:



After:



a) Name the 3 forces acting on cart B during the collision. 1____________2________________ 3___________

2 of these forces cancel out. What is the one unbalanced force?

b) Name the 3 forces acting on A during the collision. 1____________ 2________________ 3___________

2 of these forces cancel out. What is the one unbalanced force?

c) Are the unbalanced forces internal or external to the system consisting of the 2 carts?

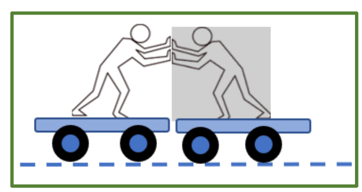
d) For the above collision is the following true or false? $\boldsymbol{m_A\vec{v}_A + m_B\vec{v}_B = m_A\vec{v}_A' + m_B\vec{v}_B'}$ (the "prime" symbols indicate velocities after the collision).

6. In the following "collision/explosion" problems i) use momentum conservation to find any unknown velocities (magnitude and direction) ii) find the system KE before the collision iii) find the system KE after the collision and iv) explain why the KEs differ (if they do). Assume negligible friction.

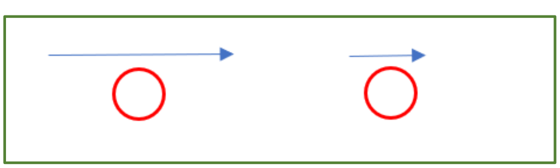
Before:

a)Train car B has mass 4000 kg and velocity 4 meters/sec; car A has mass 6000 kg and is stationary. The car's couple during the collision and afterwards move as a single unit.

b) Initially the two carts are moving together to the right with speed 5 feet/second. The total mass of the left "cart+ person" is 25 slugs while that of the right is 20 slugs. The people push hard against each other and separate; after, the right cart is moving with speed 10 feet/second to the right.



7. The two 400 gram "billiard balls" collide. Prior to the collision, the left ball is moving to the right with speed 4 meters/second while the right ball is also moving right but with speed 2 meters/second.
The collision is "perfectly elastic"; this means there is no lost kinetic energy.



Find the speeds of the balls after the collision. Assume negligible friction. Note that because there are two unknowns you will need two equations.

Also your "mathematics" will get you two possible sets of answers for the speeds. Only one of these sets of speeds is correct. The other can be eliminated by thinking about the physical situation.