Physics 213 **Problem 7** **Week 1**

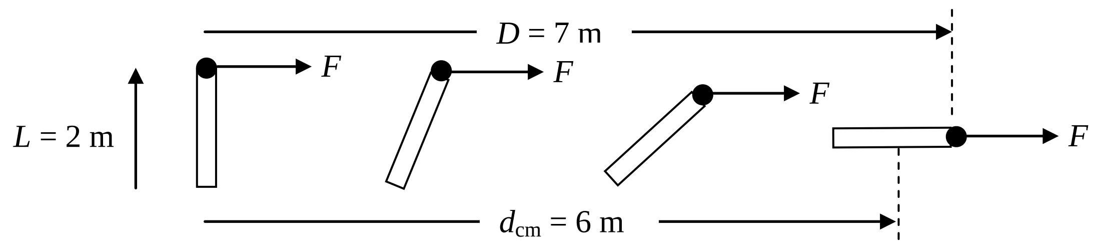
Work and Energy

As discussed in the notes above, the Work Energy theorem

$$W = \Delta(KE),$$

needs to be made more precise. The work done *on* a system or an object W_{on} (equal to the sum of the forces dotted into the displacements of their points of application) will change the KE of the center of mass, but can also cause a change in the system's *internal energy,* for example its rotational or vibrational energies. A more precise statement is $W_{on} = \Delta(KE_{cm}) + \Delta U_{int}$. Nevertheless the formula from Phys 211 is still valid: The work done on the *center of mass* displacement is equal to the change in the *center of mass* KE, even if the forces are not applied at the center of mass.

1) Consider the case of a board of length L = 2 m and mass m = 3 kg initially at rest on ice. A rope pulls with constant force F = 10 N at one end. Here are some snapshots of the motion:



Notice that the force acts through a distance of D = 7 meters but the center of mass of the board travels only d_{cm} = 6 meters. Mark true (T) or false (F) for the statements below and give short justifications of your answers.

a) $W_{on} = FD$

b) $W_{on} = Fd_{cm}$

c) $a_{cm} = F/m$

d) $a_{cm} < F/m$

e) $Fd_{cm} = \frac{1}{2} mv_{cm}^2$

f) $W_{on} = \Delta(KE_{cm}) + \Delta(KE_{rot})$

2) Determine the rotational energy KE_{rot} of the board at the time of the last snapshot above using conservation of energy. *(No moment of inertia or angular velocity required here.)*