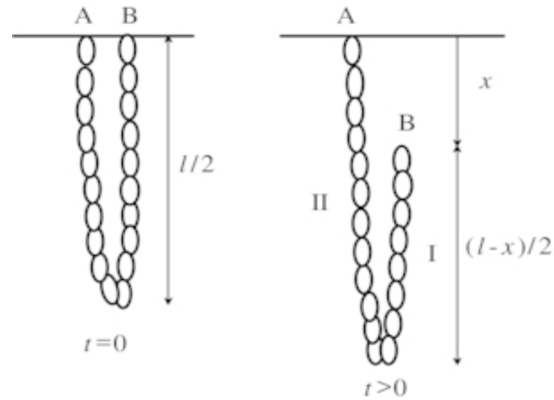
PS 12a Names:

Lab 8: The Falling Chain

In this lab you will do some experimental exploration of a falling chain system. You will compare motion data that you collect in lab to your model predictions. As you will often experience in doing science, the interesting physics shows up when your data departs from agreement with your model.

We are interested in the motion of the tail end of the falling chain (B). Specifically how fast is the end link traveling as it falls a distance x. Because the chain travels quickly we will use some high frame rate cameras to capture the data.



Warm Up: Initial Model

Q1. Consider a ball falling in freefall. Use conservation of energy to find its velocity as a function of displacement from the top. Make a sketch of v vs. x.

Q2. When you drop the chain how does each link affect other links? Should the falling section of the chain fall slower, faster, or the same as the gravitational acceleration would dictate?

Experiment:

- Set up the camera to film the entire falling chain at a high frame rate (≈400fps). You will want to add some light from below. Also, make sure that there is a meter stick that is visible in the shot.
- "insert" movie into MATLAB
- Track the motion of the last chain link. See the lab bench for additional instructions
- Set a distance scale using the visible ruler, and also set an axis where positive displacement is downwards

Import this information into MATLAB. Plot your data (*v* vs *x*) and overlay the prediction from the warm-up. Note: Change the smoothing of the velocity data vefore exporting to MATLAB. "File"-"Settings"-derivative to 3pt smoothing.

Q3. How well does your initial model and the data compare?

Q4. What does this mean about the energy conservation of the falling chain?

Refined Model:

The initial model does not allow for the conservation of energy in the entire chain. Design a model that accounts for the conversion of the potential energy of the entire chain into the kinetic energy of the part that is falling at a given time.

Hints:

- Think about removing a section of chain (*x*) from the top and adding that section to the bottom. We can summarize the location of each of these sections as the location of their COM.
- The mass of this section of chain *x* can be described as mass = $\sigma * x$ where σ represents the mass per unit length of the chain.
- Solve out for the velocity of the chain as a function of how far it is has fallen.
- Overlay this model onto the previous plot.

Q4. How well does your refined model and the data compare?

Challenge: The time for a link to fall in free fall (initial model) is given as

t=sqrt(2L/g)

What will be the time to fall with the refined model? Remember *v=dx/dt*

Interest: Google Zeno's Paradox