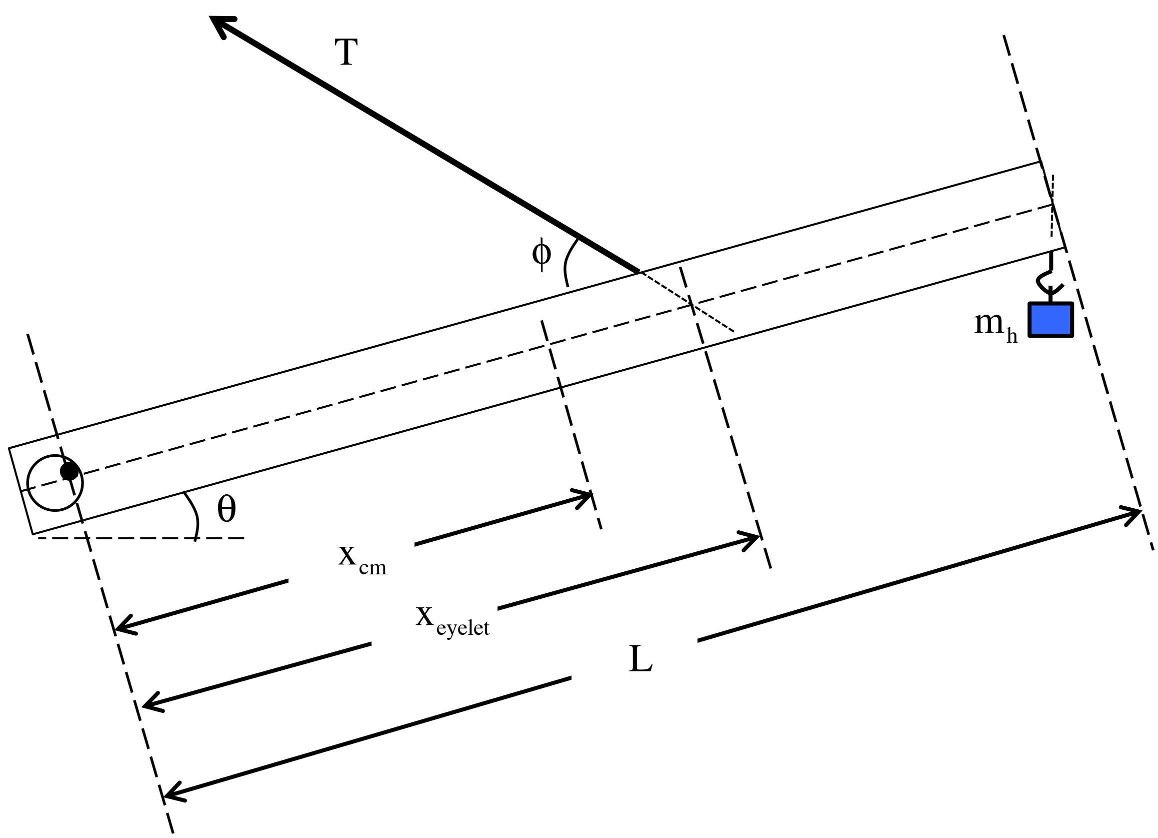
Name:____________________________Period____

Truncated Rigid Body Lab (L-56c)

The rotational counterpart to force is torque, and just as the translational version of Newton's Second Law states that a *net force* acting on a body will be proportional to the body's *acceleration*, the rotational version states that a *net torque* acting on a body will be proportional to the body's *angular acceleration.*

It stands to reason that the most bare-bones N.S.L. problem possible, then, would be one in which the sum of the force (in any direction) and the sum of the torque (about any point) would sum to zero (leaving the acceleration terms zero and the right-hand side of N.S.L. zero).

That is what rigid body problems are. Situations in which a body, due to the forces being applied, sits in equilibrium. The body you will be dealing with in this lab will be a pinned beam with a cable attached to provide tension support. A sketch of the set-up is shown below.



Data taking:

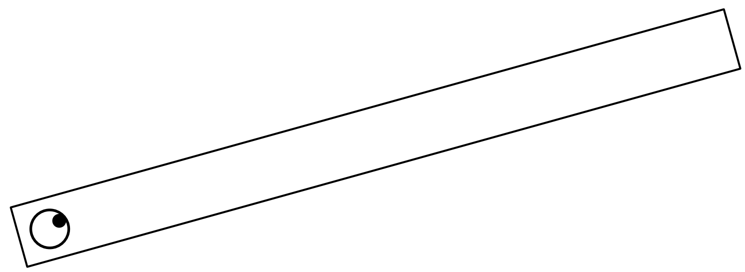
1.) You will be taking your data from a video located at https://youtu.be/J2fHPsjGugs. The only caveat is that in the videos, lengths along the beam are identified as "l" values, whereas in the sketch shown above, "x" variables are used. You can use either in your evaluation.

Name:_________________________Period____

Calculations

Part A: (pinned beam without additional hanging mass)

1.) Begin by listing all the data, appropriately labeled, presented in the video.



2.) Reproduce the beam shown to the right. Make it a third-of-a-page in size. On it, draw a free body diagram for the forces acting on the beam assuming the hanging mass *has not yet been attached* (we'll mess with that in the next section). You may assume that the force due to the beam's weight is simply a downward force equal to $m_b g$ acting at the beam's center-of-mass and that the force components at the pin are H (for horizontal component) and V (for vertical component).

3.) Using the parameters defined in the sketch, derive an algebraic expression for the torque about the pin due to the beam's mass (assumed acting at the beam's center-of-mass) using the $r_\perp$ (moment-arm) approach. Do not put in numbers.

4.) Using the parameters defined in the sketch, derive an algebraic expression for the torque about the pin due to the tension in the cable using the $F_\perp$ approach. Note that you should call this tension T_{theo}. Do not put in numbers.

5.) Summing the torques about the pin as you would in a classic Newton's Second Law problem (that is, with the sum equal to zero, as the angular acceleration is zero), derive a general algebraic expression for the theoretical tension T_{theo} in the cable. (Kindly notice that you already the torque expressions needed from your derivations above.)

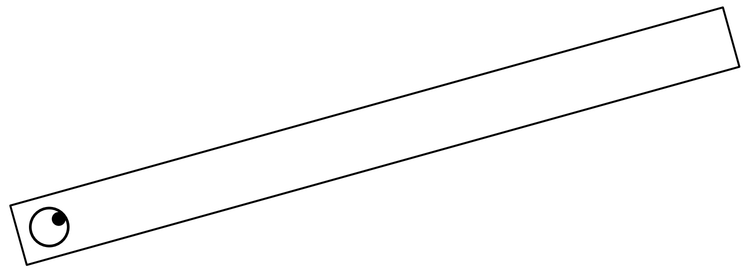
6.) Using the numbers provided in the video and your expression from Calculation 4, determine a numerical value for the theoretical tension T_{theo} in the cable for the situation in which there is no hanging mass attached to the beam.

7.) You recorded in Calculation #1 the experimentally determined tension in the cable for this situation from the video. Do a % deviation between the theoretical and experimental values. In this case, because you are comparing an experimental value to the theoretically maximum possible, that % deviation should look like:

$$\%\ \text{deviation} = \frac{|\text{theo} - \exp|}{\text{theo}} \text{x}100$$

Name:__________________________Period____

<u>Part B:</u> (pinned beam with additional hanging mass)



8.) Draw a second free body diagram for the forces acting on the beam, assuming the hanging mass *IS attached*. You may assume that force at the end of the beam is simply a downward force equal to $m_h g$.

9.) You've done this once, so we'll cut straight to the chase. Summing the torques about the pin, derive a general algebraic expression for the tension T_{theo} in the cable. You can use any torque-calculating approach you desire in doing this. Do not put in numbers.

10.) Using the numbers provided in the video and your expression from Calculation 9, determine a numerical value for the theoretical tension T_{theo} in the cable for the situation in which there is a hanging mass attached to the beam.

11.) Do a % deviation between the theoretical and experimental values of the tension in the cable for this situation.

<u>Question:</u>

A.) You now have two situations in which theory has predicted what *should have* happened and experimentation has presented what *actually* happened. In light of the % deviations you've done, does the model appear to be any good? (And if not, explain what may have gone wrong.)