LAB 7: STATICS AND TWO-DIMENSIONAL FORCES(TPL1)

Goals:
- Resolving forces in a "traffic light" problem

Introduction The study of Statics and Dynamics depends on the knowledge of the sum of the forces acting on an object. In this lab we will look at a "classic" static situation where multiple forces act on an object in a condition of equilibrium - all force vectors sum to zero.

Part 1 - "Traffic Light" Problem - One angle/different weights

Traffic lights often hang from wires strung across roads. There will be a "dip" in the wire due to the weight of the traffic light. The traffic light (in the absence of wind, etc.) is in a state of equilibrium - the force of gravity pulling down, and the tension in the cable pulling upward and sideways on the traffic light. A schematic is pictured to the right:

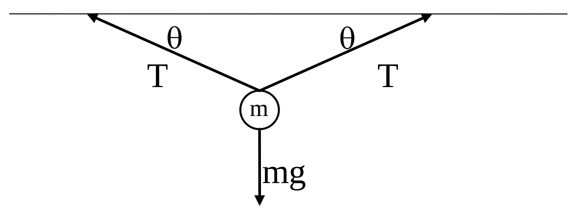


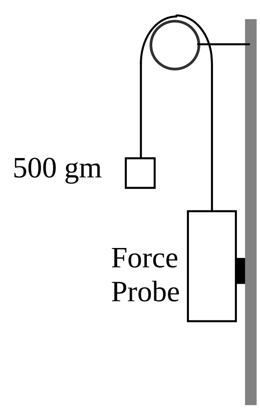
Figure 1 - Traffic light schematic

1. Analytical solution. What is the relationship between the Tension and the angle θ and the mass of the traffic light? [Use the components of the forces above in the X direction and in the Y direction to obtain a solution containing T, θ, and m.] Answer on the Data/Question sheet. [**Solve this like the "physics problem" that it represents. This is identical to the problem presented in lecture.**]

Preliminary activities

2. Prepare equipment. Connect the force probe through a USBLink, and then to the laptop (please follow the instruction in Blackboard). It would be very helpful to look at the online help page for this lab. Start the DataStudio software.

3. Load the experiment file. Download the DataStudio file **`Lab07_TrafficLight.ds`** from the lab schedule webpage, and open it in DataStudio.



4. Preparing the force probe. Press the ZERO button on the side of the probe (this is a "mechanical" tare for the probe). We can't "zero" the probe in DataStudio, so occasionally we might need to keep track of a zero "offset" and account for it

Traffic light problem

5. Mass of pulley. Determine the mass of the pulley to find out how much mass must be added to the amount that we put on the mass hanger (this should be about 17 grams). Record your value below:

Mass of pulley = ________ grams

6. Setting up a "traffic light" simulation. Use the string, poles, and clamps to set up the equipment as shown in the diagram below. The distance between the probe and the pulley will be used to change the angle the string makes with the horizontal (thus raising or lowering the "traffic light"). The masses in the center will be hung from a pulley so that the "traffic light" will try to hang from the lowest possible position (and make the angles equal). Remember to account for the mass of the pulley (and hanger if it is used) later! See the diagram below:

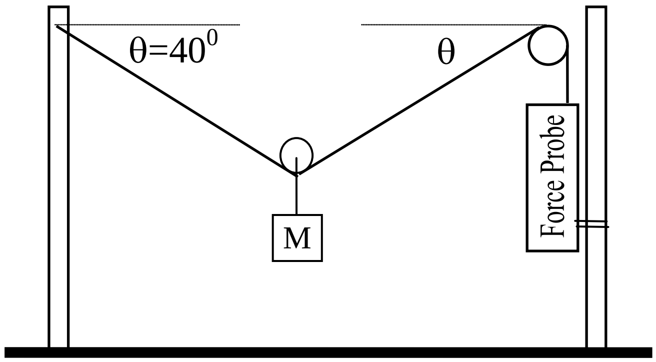
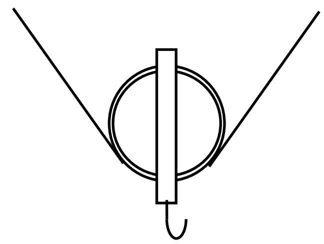


Figure 2 - Traffic light experiment.



Arrangement of pulley.

7. Original fixed angle. Set the original angle to be about 40 degrees [it does not have to be exactly 40, but record the value below].

Fixed angle = ________ degrees

8. Different masses. We will use two different hanging mass values (200 grams and 400 grams). When you record the mass in the table on the Data/question sheet, make sure you add in the mass of the pulley!

9. Measuring the tension. You will make 2 different "data runs" to get the values to fill in the table. It would be useful to set the hanging mass onto the rolling pulley, but before you click START, you should release the tension in the string near the force probe – then click START and grab a few seconds of data (of "zero" force), then allow the force probe to feel the tension, and then wait for the stable plateau. This will allow us to make sure the force probe is zeroed, and thus we should have an accurate reading. Record your measurements in the table {under the T [meas] row} on the Data/Question sheet. The calculated tension (T [calc]) can be found from the relationship you determined above {in Part 3.1}. The total mass column is the hanging mass plus the mass of the pulley.

Questions Answer on the Data/Question sheet.
a) How do the calculated and measured tension values compare to each other--does this support your relationship for the tension as developed in Part 1.1?

Part 2 - "Traffic Light" Problem - One weight/different angles

1. Fixed mass. Use 200 grams as the hanging mass for the traffic light.

Total hanging mass = _________ grams (include pulley and/or hanger)

2. Measuring angle. We will be changing the force probe position so as to change the angle the string makes with the horizontal. You should try moving the force probe to the two extremes possible (up and down) to see what range of angles you will be able to measure. The angle measurements will be a little “rough” but you should be able to estimate within 1-2 degrees. Use the protractor, or you could take a sheet of paper and draw out a known angle with two lines, and then put that "behind" the strings where they meet down at the middle pulley, and you can then adjust the force probe up or down until the actual strings "line up" with the lines drawn on the paper. Feel free to invent a method to measure the angles.

3. Different angle. Start with a large angle (hopefully 60 degrees or above) and measure the tension at that new angle (measure a few seconds of “zero” force – then the real tension). Calculate the tension expected at each angle. Record your measurements/calculations in the table on the Data/Question sheet.

Questions Record answers on the Data/Question sheet.

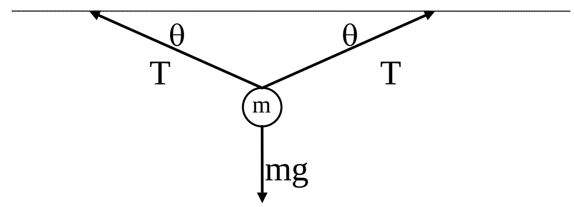
a) How do the calculated and measured tension values compare to each other--does this support your relationship for the tension as developed in Part 1.1?

b) What tension would be required to make the angle 0 (zero) degrees? Explain.

DATA/QUESTION SHEET - LAB 7: STATICS AND TWO-DIMENSIONAL FORCES

Part 1 - "Traffic Light" Problem - One angle/different weights

1. Analytical solution. What is the relationship between the Tension and the angle θ and the mass of the traffic light? [Use the components of the forces above in the X direction and in the Y direction to obtain a solution containing T, θ, and m.] Write out the full solution (from first steps). [Solve this like the "physics problem" that it represents.]



9. Measuring the tension. …. Record your measurements in the table {under the T [meas] row} on the Data/Question sheet. The calculated tension (T [calc]) can be found from the relationship you determined above {in Part 3.1}. The total mass column is the hanging mass plus the mass of the pulley.

Hanging mass >	200 gm	400 gm
Total mass		
Weight (mg)		
T [calc] (N)		
T [meas] (N)		
% difference		

Angle = 40 degrees

Figure 3 - Measured and calculated tension for Traffic Light (mass varied).

Questions a) How do the calculated and measured tension values compare to each other--does this support your relationship for the tension as developed in Part 1.1?

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Part 2 - "Traffic Light" Problem - One weight/different angles

3. Different angle. Calculate the tension expected at each angle. Use 200 grams - Use different a different angle (60 degrees or above) and copy the data for 40 degrees above.

Mass = 200 grams

Angle (deg)		
T[calc] (N)		
T[meas] (N)		
% difference		

If you are finding the force probe is not zeroed – you could use the "delta" feature of the SmartTool to easily measure the "corrected" force (actual - "zero" force) .

Figure 4 - Measured and calculated tension for Traffic Light (angle varied).

Questions a) How do the calculated and measured tension values compare to each other--does this support your relationship for the tension as developed in Part 1.1?

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b) What tension would be required to make the angle 0 (zero) degrees? Explain.

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Questions/Suggestions -> James Nolta - Nolta@LTU.EDU