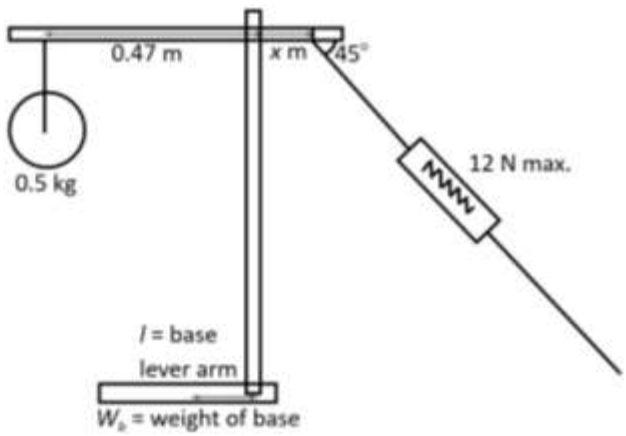
Collapsing Crane Final Lab and Report

Physics

From your work with the preliminary lab, you should now be able to determine the ideal location for a fixed-mass counterweight in order to create rotational equilibrium for a crane holding up a load. For the final lab, you will engineer a modified version of your crane tower that uses a guyline (a supporting string or rope) to stabilize your tower and create rotational equilibrium. Your lab writeup should consist of written answers to all the questions **in bold**. This is an individual assignment; while you will be working with lab partners to test your calculations (Part II), you should make all of the predictions in Part I individually and your analysis in Part III should represent your own thoughts, ideas, and writing.



Part I: ***Prediction***

Your crane tower will need to support a load of 4.9 N (0.5 kg; 500 g) at a distance of 0.47 m (47 cm) from the tower. The stabilizing guyline will be attached at about a 45° angle relative to the arm and will be limited to a force of approximately 12 N (beyond which we will assume the guyline will break and the crane will topple).

1. Using the clamp as your pivot point (in which case the back of the crane arm will be your lever arm), **identify the maximum perpendicular component of the force that can be generated by the guyline**.
2. Using the rotational equilibrium equation, **derive an equation for the length of the lever arm for the guyline attachment point** needed in order to allow the crane to hold its maximum load (at this point, the mass/weight and size of your base are unknown so your answer will be an equation with the weight of the base and the lever arm of its center of mass as variables).

Part II: ***Testing***

3. Select a ring stand base and find its weight. Rebuild the complex crane tower from the preliminary lab (so that it is mounted on a ring stand base and pole with the arm of the crane arranged so that the long end of the arm is over the long end of the base).
4. Using the equation you generated above, **calculate the actual length of the lever arm for the guyline attachment point**.
5. Create a guyline by attaching two strings to either end of a spring scale (test the spring scale with a variety of masses to ensure that it is calibrated correctly).

6. Set up the crane tower so that a) the front of the crane base is hanging off of the lab bench (!) and b) the guyline is the correct distance away from the tower (as you calculated above) and it is at the correct given angle relative to the crane arm (you can use a protractor for this or measure the perpendicular distances and use the inverse tangent). The crane should be supported by the portion of the base directly below the tower and your guyline should be tied to one of the sink spigots. Adjust the height of your guyline to achieve the correct angle.
7. Hang the load mass from the crane arm at the proper distance from the lever arm.
8. The spring scale, while it is actually measuring force, reads in grams or kilograms as it is designed to measure mass within the earth's gravitational field. From this number, **calculate and record the tension within the guyline string**.

Part III: Analysis and Discussion

9. **Was the tension in your guyline string within the 12 N limit**?
10. **Describe some of the specific measurements and calculations that might have been in error and how those errors might have come about**.
11. **Explain, based on the performance of your crane and the tension in your guyline, whether or not any errors were reasonable under the conditions of this lab or if there was likely to be a serious mistake in your calculations or measurements**.
12. The reason that it was important to position your crane base so that it was hanging over the edge of the lab bench is because there was a *fourth force* that was potentially creating torque (we did not discuss this force in the preliminary lab).
    a. **What is this force and where is it acting**?
    b. **How does the location of this force change depending on the position of your base and the load of the crane**?
    c. **How did you avoid needing to know this force when working on the preliminary lab**?
    d. **Why did hanging the base over the edge of the bench allow us to ignore this force in the final lab**?