



University of Illinois Urbana-Champaign
Theoretical and Applied Mechanics

Class: TAM 251

Assignment: D3

Originated by: TFG

Signed: R M

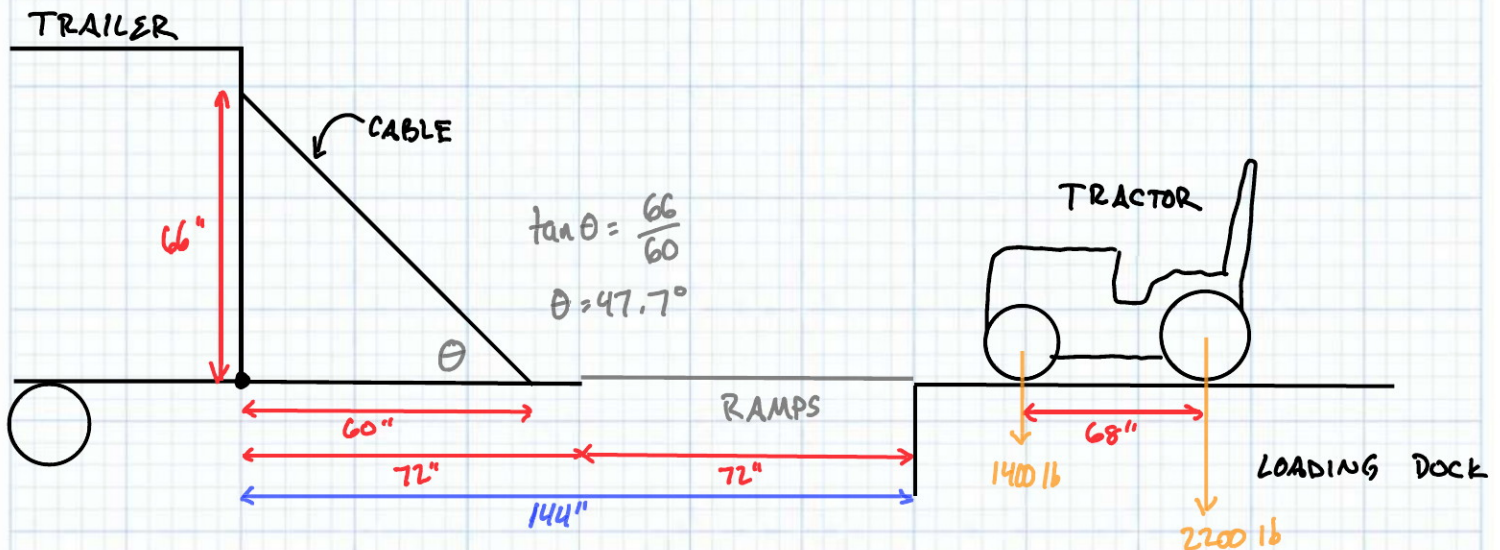
Date: 7/15/26

Checked by: TWK

Signed: KIM

Date: 9/18/26

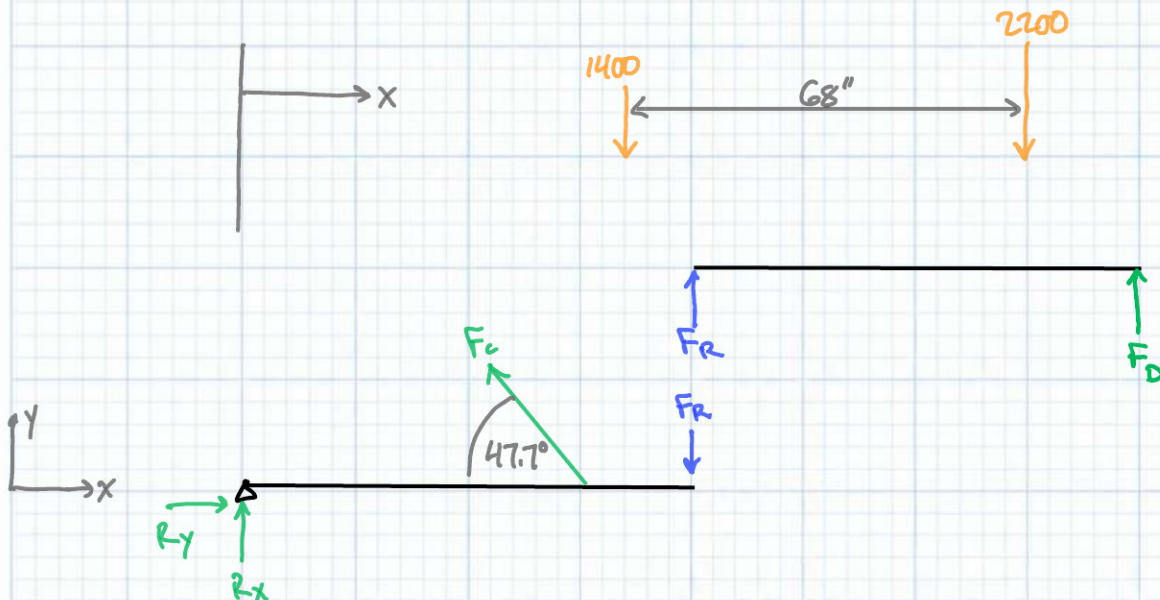
1) Schematic of the tractor loading:



2) The loading on the cables includes the weight of the door, the weight of the ramps and the weight of the tractor. Assume the weight of the door and ramps are negligible compared to the weight of the tractor. As the tractor crosses from the loading dock to the trailer, the cable stresses will vary. The location of the tractor that produces the highest stresses, the governing location, is not yet known. Assume the tractor moves slow enough such that all loads are static (no dynamic amplification). Assume the ramps are simply supported between the end of the trailer door and the loading dock, such that when the tractor axle loads are on the ramps, this load will be distributed to the trailer door and the loading dock.



3) Free body diagram(s)



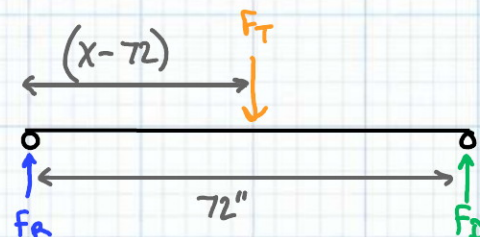
4) Solve for force in the cables. Set $x=0$ to be the location of the trailer door hinge (pinned boundary condition). Write a function to compute the force in the cables as a function of the trailer position.

X_1 = POSITION OF 1400 lb LOAD

X_2 = POSITION OF 2200 lb LOAD

$$X_2 = X_1 + 68''$$

IF $x > 72''$ FORCE IS ON RAMP, AND ONLY A PORTION GOES TO THE CABLES



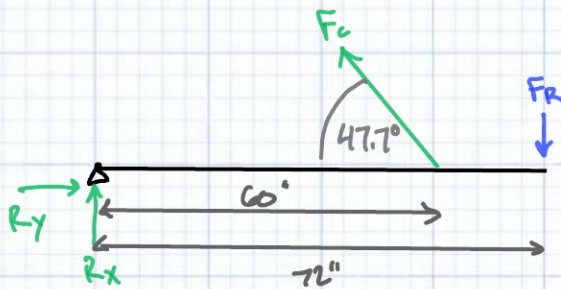
$$F_R(x) = F_T \left(\frac{72 - (x - 72)}{72} \right) = F_T \left(\frac{144 - x}{72} \right) \quad \text{for } 72 < x \leq 144$$

$$F_R(x) = F_T \quad \text{for } 0 \leq x \leq 72$$



Case 1: Both axles on ramp, set $x_1=72"$ and $x_2=140"$

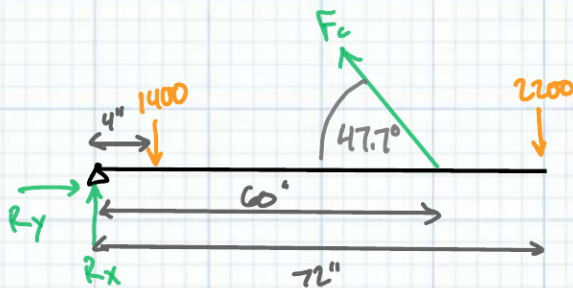
$$F_R = 1400 + 2200 \left(\frac{144-140}{72} \right) = 1522 \text{ lbf}$$



$$\sum M: F_c (\sin 47.7^\circ)(60) - (1522)(72) = 0$$

$$F_c = 2470 \text{ lbf}$$

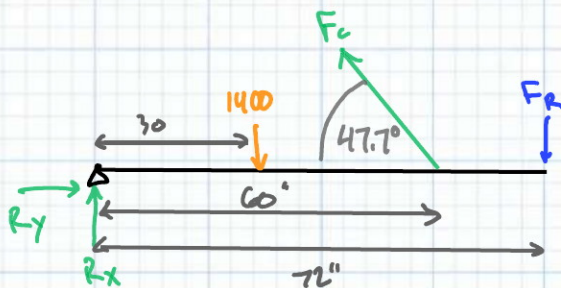
Case 2: Both axles on trailer door, set $x_1 = 4"$ and $x_2 = 72"$



$$\sum M: F_c (\sin 47.7^\circ)(60) - 2200(72) - 1400(4) = 0$$

$$F_c = 3695 \text{ lbf}$$

Case 3: One axle on ramp, one axle on door, set $x_1=30"$ and $x_2 = 98"$



$$F_R = 2200 \left(\frac{144-98}{72} \right) = 1406$$

$$\sum M: F_c \sin(47.7^\circ)(60) - 1406(72) - 1400(30) = 0$$

$$F_c = 3226 \text{ lbf}$$

Case 2 governs, moment would be less if the tractor were facing the other direction



5) Compute stress in the cables. Remember there are 2 cables
force in each is $3695 \text{ lbf}/2 = 1847.5 \text{ lbf}$.

$$\sigma_c = \frac{F}{A} = \quad \quad \quad A = \frac{\pi d^2}{4} = \frac{\pi (1/4)^2}{4} = 0.05 \text{ in}^2$$

$$\sigma_c = \frac{1847.5 \text{ lb}}{0.05 \text{ in}^2} = 36940 \text{ psi} = 36.94 \text{ ksi}$$

6) The safety factor for cable stress

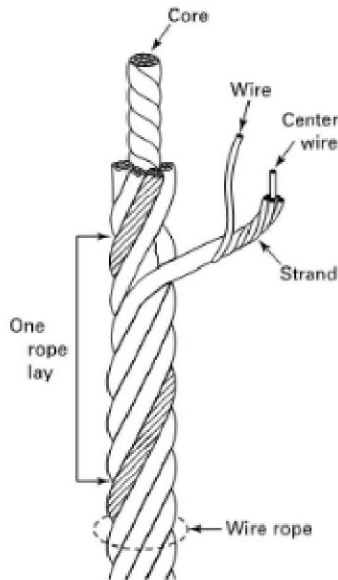
$$SF = \frac{\sigma_u}{\sigma_c} = \frac{70}{36.94} = 1.90$$

7) Is this sufficient? Most likely not. The design of wire rope for
lifting applications likely falls under ASME B30.9 which specifies a
design factor of 5 (see section 9-2.4)

https://asmestandardscollection-org.proxy2.library.illinois.edu/GetDoc.aspx?doc=ASME%20B30.9%202021#ASME_B30.9_2021_Page_29



Figure 9-2.0-2 Wire Rope



9-2.3.2 Configurations

(a) Single-leg slings and two-leg, three-leg, and four-leg bridle slings used in straight-line, choker, and basket hitches are covered by this Chapter.

NOTE: A straight-line hitch is commonly referred to as a vertical hitch.

(b) Slings made of rope with 6×19 and 6×36 classification and cable-laid slings shall have a minimum clear length of rope 10 times the rope diameter between splices, sleeves, or end fittings (see Figure 9-2.3.2-1), unless approved by the manufacturer or a qualified person.

(c) Braided slings shall have a minimum clear length of rope 40 times the component rope diameter between the loops or end fittings (see Figure 9-2.3.2-2), unless approved by the manufacturer or a qualified person.

(d) Grommets and endless slings shall have a minimum circumferential length of 96 times the body diameter of the grommet or endless sling unless approved by the manufacturer or a qualified person.

(e) Other configurations may be used. When used, the sling manufacturer or a qualified person shall provide specific data. These slings shall comply with all other requirements of this Chapter.

SECTION 9-2.4: DESIGN FACTOR

The design factor for wire rope slings shall be a minimum of 5.

SECTION 9-2.5: RATED LOAD

(a) The sling manufacturer shall establish the sling's rated load.

(b) At a minimum, the rated load shall be based on the following factors:

- (1) component strength
- (2) number of legs
- (3) design factor
- (4) type of hitch
- (5) angle of loading (see Figure 9-2.5-1)
- (6) fabrication efficiency
- (7) connection hardware shape and size

SECTION 9-2.6: PROOF TEST REQUIREMENTS

9-2.6.1 General

(a) Prior to initial use, all new swaged socket, poured socket, or turnback swaged eye type slings, and mechanical joint endless wire rope slings shall be proof tested by the sling manufacturer or a qualified person.

(b) Prior to initial use, all repaired slings shall be proof tested by the sling manufacturer or a qualified person.

(c) New wire rope slings incorporating previously used or welded fittings shall have the fittings proof tested before or after fabrication of the completed sling.

(d) All other new wire rope slings are not required to be proof tested unless specified by the purchaser.

9-2.6.2 Proof Load Requirements

(a) For single- or multiple-leg slings and endless slings, each leg shall be proof loaded to the following load requirements based on the fabrication method:

(1) *Mechanical Splice Slings.* The proof load shall be a minimum of 2 times and a maximum of 2.5 times the single-leg straight-line hitch rated load.

(2) *Swaged Socket and Poured Socket Slings.* The proof load shall be a minimum of 2 times and a maximum of 2.5 times the single-leg straight-line hitch rated load.

(3) *Hand-Tucked Slings.* If proof tested, the proof load shall be a minimum of 1 times and a maximum of 1.25 times the single-leg straight-line hitch rated load.

(b) The proof load for components (fittings) attached to single legs shall be the same as the requirement for single-leg slings in (a).

(c) Master links for two-leg bridle slings shall be proof loaded to a minimum of 4 times the single-leg straight-line hitch rated load.

(d) Master links for three-leg bridle slings shall be proof loaded to a minimum of 6 times the single-leg straight-line hitch rated load.

(e) Master links for four-leg bridle slings shall be proof loaded to a minimum of 8 times the single-leg straight-line hitch rated load.