Name: _____
Group members: _____ _____ _____

TAM 251 Worksheet 3

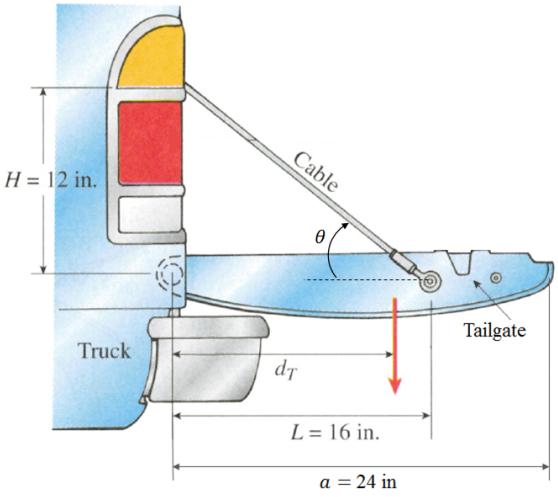
Objectives
The process of designing a tailgate requires the analysis of numerous components. This worksheet will focus on the design and analysis of the tailgate cable. You will

- determine suitable design loads,
- convert tailgate loads to support cable stresses, and
- examine trade-offs (cost, safety, performance) involved in the selection of a cable material.

The Problem
You are a design engineer at an automotive startup, working on a new, electric pickup truck. You have been asked to design the tailgate.

1) The founders and chief engineer have been busy raising capital and have not clearly identified target markets or consumer profiles for the truck. **Quickly** identify three potential consumer profiles. A short list of possible profiles is provided in the appendix. You are encouraged to create your own.

Due to packaging restrictions originating from design challenges in other engineering groups (frame, body, powertrain, etc.), the dimensions of the tailgate have been determined and are shown below. The tailgate weighs $W_T = 60$ lbs. Its center of mass is located at $d_T = 14$ in. We will assume that the tailgate is rigid.



2) For each consumer profile that you identified, **quickly** develop a typical loading scenario for the tailgate. Each loading scenario should include a minimum of four (4) items. Weights and dimensions of assorted materials are provided in the appendix. Sketch a free body diagram for each loading scenario. Be sure to include the reaction force, with components R_x and R_y, at the hinge. Assume that your design loads are supported equally by each cable-hinge pair.

3) Compute the load (normal force) in the cable for each loading scenario.

Based on the dimensions that you provided to your tailgate cable supplier, they have provided the following list of possible cables. Yield stresses are listed in the bottom row.

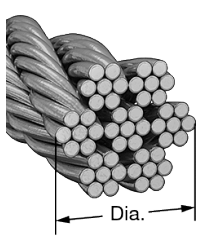
	Price per Cable, USD				
Dia. [in]	Steel	Steel, Coated	SS	SS, Coated	PE
0.063	0.27	0.37	0.41	0.53	–
0.094	0.27	0.41	0.55	0.59	–
0.125	0.51	0.68	1.05	0.91	0.48
0.188	0.72	1.08	1.43	1.38	0.94
0.250	1.17	1.76	2.3	2.81	1.49
0.313	1.45	2.23	3.77	3.47	2.37
0.375	1.81	2.73	4.63	4.75	3.13
Yield [ksi]	137	137	115	115	168

Steel
Steel cables have a galvanic (zinc) coating to provide corrosion resistance.

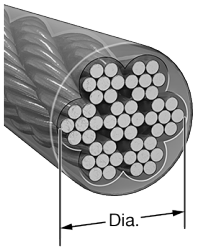
Stainless Steel (SS)
AISI 314 stainless steel relies on the formation of a chromium oxide layer to impede corrosion. Consequently, 314 stainless performs best in oxygen-rich environments.

Vinyl Coating
Coated cables have a black, UV- and weather-resistant vinyl coating.

Polyethylene (PE)
Polyethylene cables (often Spectra- or Dyneema-branded) have the look and feel of soft synthetic ropes. Their strength comes from the alignment of polyethylene molecules during manufacturing. These cables have an incredible strength-to-weight ratio and are used extensively for marine applications. However, they loose strength and melt at moderate temperatures ($> 140^\circ$ F). (Note that polyethylene is the most common industrial plastic. However, most polyethylene does not exhibit these incredible mechanical properties.)



Uncoated Metal



With Coating


Polyethylene

4) Apply a safety factor of 2 to the forces that you determined. For each loading scenario, determine the minimum cable diameter for each of the three cable materials.

5) There is a lot of hype surrounding the new truck. The founders are floating sales figures of 200,000 units in the first year of sales. Based on the cost of the cables, estimated sales volume, and your targeted markets, make a case for which cable to use. Does it make business sense to design for your worst-case design load? What are the implications of not designing for the worst-case load?

6) Reimagine and/or redesign the tailgate to reduce or eliminate the risk of cable failure.

Appendix

Partial List of Consumer Profiles

- Farmer
- Contractor
- Suburban do-it-yourselfer
- Off-road enthusiast
- Executive
- Brewer
- Football super-fan
- Hauler
- Consultant
- # VanLife

Sample Items, Dimensions, & Loads