Lab 1.1 Makeup: Statics Self Study

Task 1: Cantilever Design Concepts

(20 pts) Draw a FBD of a 2 ft long cantilevered beam with a fixed support at one end and a point load at the other. Include the weight of the beam.

(20 pts) Ignoring the weight of the beam, determine the moment (torque) at the support due to a 2.5 lb load at a distance $L = 2$ ft. Moment due to 2.5 lb load (lb ft) = _________________

Under this loading condition (a cantilever beam with a point load at the end), the bending moment (torque) increases linearly from zero at the free end to its maximum value at the fixed end (shown at left). **Stress** is inversely proportional to the **moment of inertia** of the beam. A beam cross section with a higher moment of inertia has less stress. Sections with more material at a greater distance from the neutral axis (where the neutral axis is the horizontal axis at the center of mass) have a higher moment of inertia.

Figure 2

Application of cantilevers to biomedical engineering:

When holding a weight out with your arm, it is acting like a cantilever. A prosthetic forearm (shown at right) uses the concepts of cantilever design. Explain how the design of the prosthetic tentacle (far right) might follow the design principles discussed above. Which end is the fixed end? Which end typically has the load? How does the shape mimic the beam shape shown in Figure 3 and why?

(10 pts) Write your answers here:
Task 2: Cable Design Concepts

**Cables**

(20 pts) Draw a Free Body diagram of a cable supporting a cantilevered beam at the beam's midpoint (include the beam and the cable in the FBD).

(10 pts) Think about a tightrope at the circus. Relate the amount of tension in the cable to deflection due to a tightrope walker. As the tension increases the deflection of the cable increases / decreases.

**Application of cables to structural engineering:**

Many large span older bridges (built in the 19th and early 20th century) were suspension bridges. Suspension bridges require massive costly anchor points at each end of the bridge to keep the cables in tension and resist the bridge loading. On modern suspension bridges, the roadway is suspended by vertical suspender cables, called hangers.

More recently, modern large span bridges are often cable-stay bridges. Unlike suspension bridges, cable stay bridges do not need anchor blocks. The cables are fixed to either side of each tower - this means that the weight of each side of the bridge counter balances the opposite side.

The absence of anchor blocks substantially reduces the amount of materials needed and the cost of building the bridge. Also, the towers tend to be positioned down the center of the roadway, so half as many towers are needed compared to suspension bridges. Lastly, less cabling is required, since the hangers connect directly to the towers.

One well known cable stay bridge is the Millau Viaduct in Southern France. This cable stay bridge is the highest bridge in the world, with its deck almost at the same height as the Eiffel Tower. The Millau Viaduct’s largest cables are made up of 91 bundles of seven wire strands.

The ultimate tensile strength of a cable is $f_u = 1860 \text{ N/mm}^2$. The (effective) area of a cable is $A_{eff}=12,300 \text{ mm}^2$. The total strength of the cable is $F_u = A_{eff} f_u$.

(10 pts) What is the total strength of a cable in terms of force in kN? ____________________

The tension in a cable on the Millau Viaduct is approximately 9000 kN. The factor of safety of a cable is equal to the total strength divided by the tension.

(10 pts) What is the factor of safety? ____________________