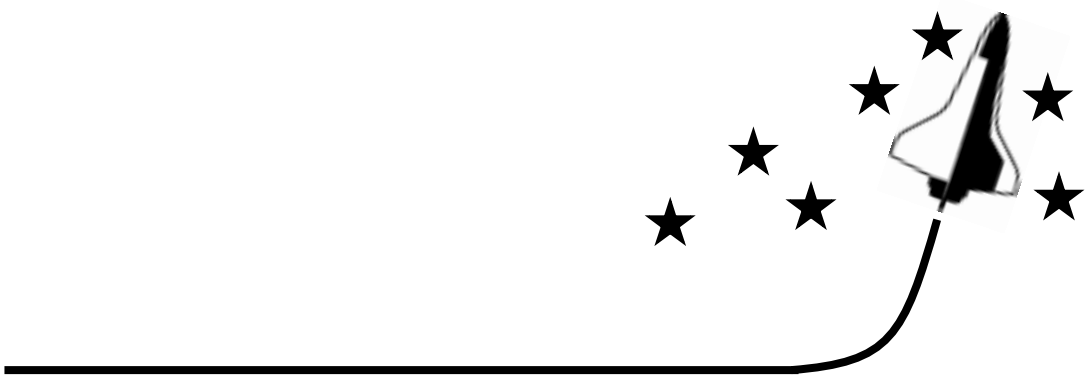
FACULTY NOTES

The LTAs and Spinoffs are designed so that each professor can implement them in a way that is consistent with his/her teaching style and course objectives. This may range from using the materials as out-of-class projects with minimal in-class guidance to doing most of the work in class. The LTAs and Spinoffs are amenable to small group cooperative work and typically benefit from the use of some learning technology. Since the objective of the LTAs and Spinoffs is to support the specific academic goals you have set for your students, the Faculty Notes are not intended to be prescriptive. The purpose of the Faculty Notes is to provide information that assists you to take full advantage of the LTAs and Spinoffs. This includes suggestions for instruction as well as answers for the exercises.



FACULTY NOTES

SPINOFF 13B

Wait a Moment for the Shear Fun of It All

Background Information

Math Subject Area: Torque, Moments, and Shear

Math Prerequisites: Solving basic equations (Calculus extension requires understanding of integrals)

Learning Technology Suggested: Scientific Calculator

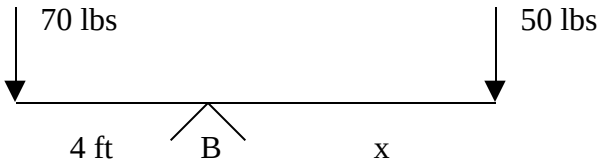
Approximate Class Time required for LTA: One class period plus homework

Solutions

1) Which way is the seesaw going to turn? Why?

   Since the resultant force is positive, the seesaw will turn clockwise.

2) Consider the seesaw below. At what distance x from Point B should the fifty pound force be applied so that the seesaw balances? (That is, what value of x will make the torque zero.)

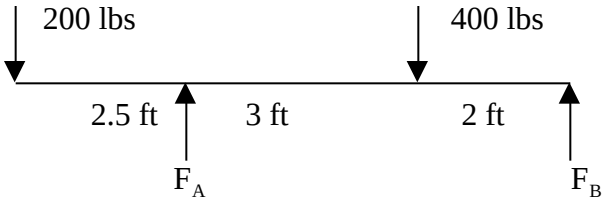


   $-(70)*4 + 50*x = 0$ so we get $x = 5.6$ ft

3) Use these two facts to determine the forces F_A and F_D.

   From the equation describing the sum of the torques, we get $F_D = 1400$ lbs
   And since $F_A + F_D = 2400$, $F_A = 1000$ lbs

4) Find the forces F_A and F_B being exerted by the two supports under the beam below:



$F_A + F_B = 600$ lbs
$-(200)*2.5 + 400*3 - F_B * 5 = 0$

So, $F_B = 140$ lbs and $F_A = 460$ lbs.

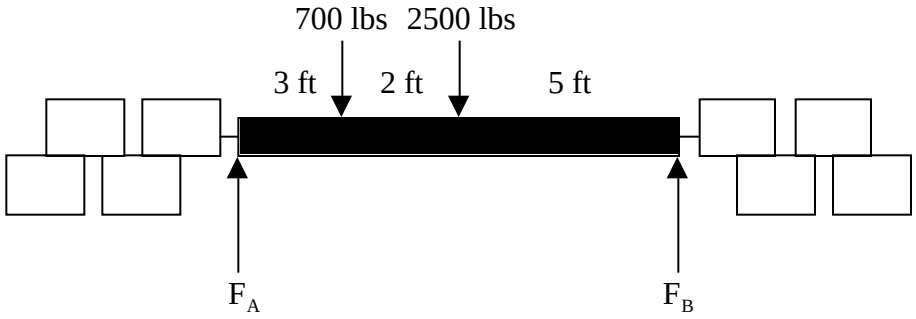
5) Use the diagram to determine forces F_A and F_B.

$F_A + F_B = 2500$

$F_A*5 - F_B*5 = 0$

So, $F_A = F_B = 1250$ lbs.

6) Suppose an engineer comes to you and asks if the structure could support an object weighing 700 lbs if its center was placed 3 feet from the left end of the beam. After looking through your resource manuals, you find that the steel rods on either end will be safe as long as neither F_A or F_B are more than 1600 lbs. Krista and her colleagues generally use a safety factor to make sure that they never get close to the actual limit of a material's abilities. With this in mind, figure in a 92% safety factor to be sure that neither F_A or F_B exceed 92% of their maximum abilities. Can the engineer safely place her load on our beam?



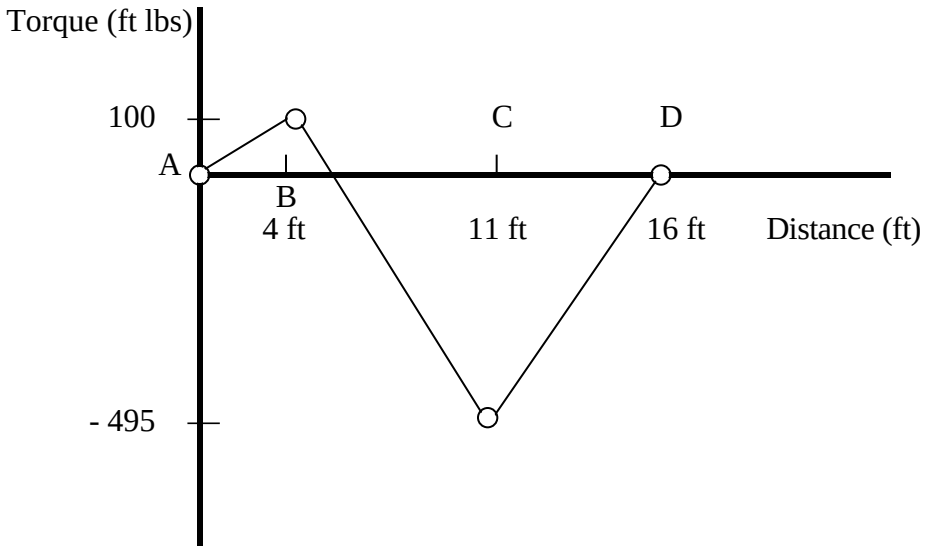
0.92*1600 = 1472 lbs, so F_A and F_B should not exceed 1472 lbs.
$F_A + F_B = 3200$
$700*3 + 2500*5 - F_B*10 = 0$

So, F_B = 1460 lbs. This is within the acceptable limit for the steel rod at the right end.
F_A = 1740 lbs. This is not within the acceptable limit for the steel rod at the left end.

Extensions for Calculus

7) Consider the torque of the beam about each of the points A, B, C and D taking into account only the part of the beam to the left of the point. For example, the torque about A would be zero because there is no beam to the left of A. The torque about B would be (25*4) = 100 ft-lbs. Because there is one force of 25 pounds to the left of B, and it is pushing clockwise, we count it as positive. Now, find the torque to the left of C and to the left of D. Next, plot these points on the graph below. It turns out that the torque graph in this case will be piecewise linear, so the points can be connected with lines to create a piecewise linear graph.

For C, we get 25*11 – 110*7 = – 495 ft-lbs.
For D, we get 25*16 – 110*12 + 184*5 = 0 ft-lbs.

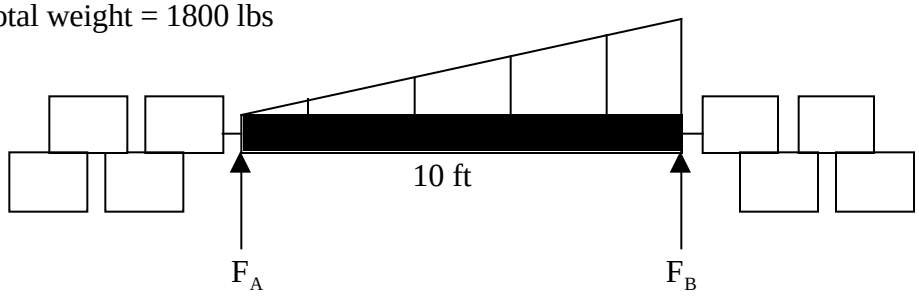


8) Look at the shear and the torque graphs very carefully. What is the relationship between shear and torque?

Torque is the integral of Shear.

9) What if the load on the beam is not uniform? Suppose the load looks like:

Total weight = 1800 lbs



There is a total weight on the beam of 1800 lbs. As you can see, more of the weight is concentrated at the right end than the left. Suppose that the density of the load is uniform and that the load rises to a height of 2 feet at the right end of the beam. Use calculus to find F_A and F_B. Are we within safety limits?

$F_A + F_B = 1800$

$$\int_0^{10} x \ \frac{1800}{1/2 \ \ 2 \ \ 10} \ \frac{1}{5} x \, dx \ - 10{*}F_B = 0$$

The first "x" is the distance from the left end. The fraction $\frac{1800}{1/2 \ \ 2 \ \ 10}$ is the density in lbs/ft^2. The factor (1/5)x*dx is a " small slice" of area.

So, F_B = 1200 lbs. Then F_A = 600 lbs. These values are within safety limits since they are less than 1472 lbs.