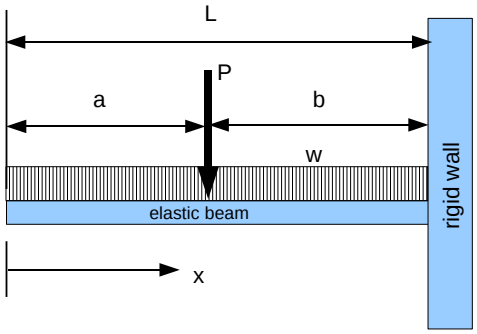
COEN 45, MATLAB Programming
Winter Quarter, 2011

Lab assignment #5

Cantilever beam
Feb 8, 9, 10

For this lab, you will write a function that computes the response of a cantilever beam to various loads. The right end is constrained against both displacement and rotation while the left end is free. Assume the `x` axis points to the right and the origin is at the left end of the beam.



The function will accept these inputs

- Information about the beam's geometry and material properties
- Intensity of uniform distributed load (force per unit length)
- Location and intensity of concentrated load(s)

and produce these outputs

- list of uniformly distributed `x` values from 0 to the end of the beam
- list of moment values `M(x)`
- list of shear values `V(x)`
- list of deflection values `y(x)`

These will be suitable for plotting moment and shear diagrams, which you will do in your calling script. As always, your function must do its work *quietly*! No soliciting input, output to the command window, or plotting.

The beam parameters are

E	modulus of elasticity, psi
I	moment of inertia for beam cross-section, in^4
ℓ	beam length, in.
w	distributed load, lb/in.
P	concentrated load, lb.

The formulas are:

1. For a uniform load w

$$\begin{aligned} M(x) &= \frac{1}{2}wx^2 \\ V(x) &= wx \\ y(x) &= \frac{x^4 - 4\ell^3 x + 3\ell^4}{24EI} \end{aligned}$$

2. For a concentrated P load at $x = a$,

$$M(x) = \begin{cases} 0 & \text{for } x \le a \\ P(x-a) & \text{for } x > a \end{cases}$$

$$V(x) = \begin{cases} 0 & \text{for } x \le a \\ P & \text{for } x > a \end{cases}$$

$$y(x) = \begin{cases} \frac{Pb^2}{6EI}(3\ell - 3x - b) & \text{for } x \le a \\ \frac{P(\ell-x)^2}{6EI}(3b - \ell + x) & \text{for } x > a \end{cases}$$

where $b = \ell - a$.

Hint: `find` could be used to get points $x \le a$ and $x > a$:

```
left = find(x<=a);
right = find(x>a);
V(left) = 0;
V(right) = P;
```

Call your function `cbeam`. It should start like this

```
function [M,V,y,x] = cbeam(len,E,I,w,P,xP)
%CBEAM moment and shear diagrams for cantilever beam
%
%  function [M,V,y,x] = cbeam(len,E,I,w,P,a)
%
%  Inputs:
%       len         length
```

```
%       E           modulus of elasticity
%       I           moment of inertia
%       w           uniform load (could be zero)
%       P           optional concentrated load
%       a           optional location of concentrated load
%  Outputs:
%       M           bending moment along beam
%       V           shear along beam
%       y           deflection along beam
%       x           list of x values along beam
%
error(nargchk(4,6,nargin));
dx = len/200;
x = 0:dx:len;
```

If there are no concentrated loads, the caller may omit the last two inputs. `w` must always be present but could be zero or null.

The outline for the rest of your function will be

1. Calculate M, V, y for the given w.
2. If there are any concentrated loads,
   (a) Calculate M, V, y
   (b) Add the results to the previous M, V, y.

Suggestion: check out your function from the command window. Then download `lab5.m` (incomplete) which exercises the cbeam function for these three loading conditions:

1. Uniform load only, 100 lb/ft
2. Concentrated load only, 500 lb at the beam midpoint
3. Both

For each case, you will get a figure with three subplots showing moment, shear, and deflection profiles. Check that the plots for the third case appear to show the sum of the results for the first two.

Let's use the following properties: beam length 8 ft, material mild steel, I=83.3 in^4.

Deliverables

1. Printouts of `lab5.m` and `cbeam.m`.
2. One of your plots, properly labeled.

As always, demo your work to the lab assistant when you are finished.