COEN 45, MATLAB Programming
Spring Quarter, 2010

Lab assignment #5

Cantilever beam
May 3, 4

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
%
%  Inputs:
%       len         length
%       E           modulus of elasticity
%       I           moment of inertia
%       w           uniform load (could be zero)
%       P           optional concentrated load(s)
%       xP          optional location(s) of concentrated load(s)
%  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;
```

Notice there is provision for more than one concentrated load, meaning `P` and `xP` could be vectors. 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, write a `for` statement that handles each of them:
   (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 the driver script `hw5.m` 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
4. Uniform load + 2000 lb at beam midpoint + 2000 lb at beam left end

For each case, you will get a figure with three subplots showing moment, shear, and deflection profiles.

Let's use the following properties: beam length 8 ft, material steel (modulus 29.5×10^6 psi), I=200 in^4.

Deliverables

1. Printout of cbeam.m
2. One of your plots, properly labeled.

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