ME 305 Fall 2015
Lab 3: Bending
Grading Rubric

Introduction (10 points)

- Objective of lab (stated in lab handout), what about this lab is important and why is this useful to an engineer?

Theory (15 points)

- Deflection curve formula (v(x) in the lab handout) for three-point bending loaded at the midpoint (1 point)
- Explain that the cantilever beam is loaded at tip or use diagram (1 point)
- $P = k_{bending}\delta$ (2 point)
- Boundary conditions (2 points)
- $k_{bending} = \frac{3EI}{L^3}$ (cantilever) and $k_{bending} = \frac{48EI}{L^3}$ (three-point) (3 points)
- $\tilde{k}_{bending} = \frac{EI}{L^3}$ and $\tilde{k}_{bending} = \frac{k_{bending}}{3}$ (cantilever) and $\tilde{k}_{bending} = \frac{k_{bending}}{48}$ (three-point) (3 points)
- $\theta_{max} = 3\frac{\delta_{max}}{L}$ and $\pm\Delta\delta = \pm\theta_{max} * g$ (2 points)
- $\frac{1}{L} * \sqrt[3]{\frac{1}{\tilde{k}_{bending}}}$ = constant for each material (1 point)

Measurements/Procedure (15 points)

- *Equipment* (1.5 points)
  - Megazord apparatus
  - Samples – 3 materials
  - Weights
- *Procedure - cantilever (5.5 points)*
  - Level apparatus (0.5 points)
  - Measure and record the length of the cantilever beam from the collar to the hole the paper clip hangs from (1 point)
  - Load the sample and clamp into place, calibrate vernier gauge (1 point)
  - Add weights to paper clip in 20 g increments, up to 80 g, measuring the deflection at the paper clip for each weight increment (3 points)
- *Procedure - three-point (5 points)*
  - Set U-bolt 12 in. from wall support, record this as the length of the beam (1point)
  - Load sample and calibrate vernier gauge (1 point)
  - Add weights to hanger located at the midpoint of the beam in 50 g increments, up to 200 g, measuring the deflection at the midpoint for each weight increment (3 points)
  - Repeat the three-point procedure for lengths of 15 in and 18 in (1 point)
- *Procedure - deflection curve (2 points)*
  - For a three-point deflection length of 18 in, first with a load of 100 g and then with a load of 200 g, measure the deflection as a function of length in one inch increments from the wall of the apparatus to the midpoint of the beam (2 points)

Results and Analysis (25 points)

- Reporting all measurements (2 points)
- Load vs. deflection for all loading situations for all three materials (6 points)
- Fit a line to all linear data sets and either display the equation for the line or the slope of the line and the y-intercept of the line (giving $k_{bending}$ and δ_{offset}) (2 points)
- All 12 $\tilde{k}_{bending}$ values (1 point)
- All 12 $\frac{1}{L}*\sqrt[3]{\frac{1}{\tilde{k}_{bending}}}$ values and their percent difference (2 points)
- $\delta_j = \delta_j(200g) - \delta_j(100g)$ values for each (1 point)
- δ_{max} values (1 point)
- $\Delta\delta$ values (2 points)
- Comparison of $\Delta\delta$ to the precision of the vernier gauge (2 points)
- Plots with experimental deflection curves (including error bars) and comparing calculated theoretical deflection curve (6 points)

Discussion and Conclusion (25 points)

- *Discussion (20 points)*
    - Sources of error (2 points)
    - How can the experiment be improved (2 points)
    - Was the goal of the lab achieved (2 points)
    - Qualitative comparison of results (in the context of a practical application for an example) (2 points)
    - Answer the discussion questions in the handout (12 points)
- *Conclusion (5 points)*