Ph.D. Qualifying Examination

Mechanics of Materials

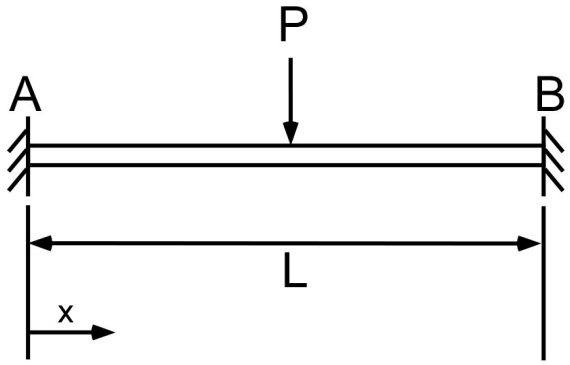
Spring 2011

Logistics Notes:

- Time allowed: 2 hours.
- Problems count 25 points each (total=100 points).
- Exam is closed-book and closed-notes (except for one sheet of "notes": 8.5×11 in.)
- State your assumptions, methods, and procedures. Show your work on these exam sheets. (Add additional sheets, if needed.)
- Calculators are allowed.
- Laptops and cell phones are not allowed.

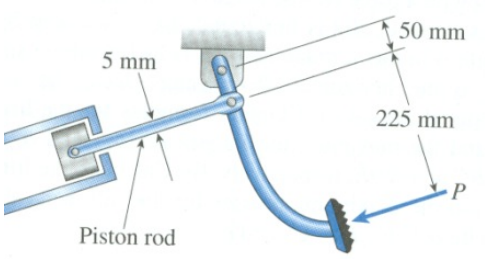
Problem 1

A fix-fix (clamp-clamp) beam *AB*, of length *L*, moment of inertia *I*, and elastic modulus *E*, has a point load (*P*) and applied to it at its center ($x = L/2$). Assuming small deflections and rotations, what is the shape, *y(x)*, of the beam and what is its maximum deflection in terms of the variables given?



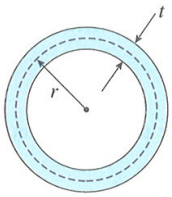
Problem 2

Calculate the compressive stress σ_c in the piston rod (see figure) when a force $P = 40$ N is applied to the brake pedal. (Note that the line of action of the force P is parallel to the piston rod. Also, the diameter of the piston rod is 5 mm, and the other dimensions shown in the figure are measured perpendicular to the line of action of the force P.)



Problem 3

Compare the maximum shear stress in a circular tube as shown, as calculated by the approximate theory for thin-walled tubes, with the stress calculated by the exact torsion theory. The tube has constant thickness t and radius r to the median line of the cross-section. Express your results in terms of the ratio $\alpha = r/t$ and discuss the validity of the thin wall approximation.



Problem 4

A thin walled cylindrical pressure vessel with a circular cross section is subjected to internal gas pressure *p* and simultaneously compressed by an axial load $P = 12\ k$ as shown. The cylinder has inner radius $r = 2.1\ in$. and wall thickness $t = 0.15\ in$.
Determine the maximum allowable internal pressure based upon an allowable shear stress of *6,500 psi* in the wall of the vessel.