M7.1 (15 points) An aluminum rod has a solid circular cross-section with a 20-cm diameter and is 3 meters in length. The rod is clamped to a solid wall at one end, and is subjected to a distributed negative torque of linearly increasing intensity: from 0 at the wall to 100 N-m/m at the tip. There also is a concentrated positive torque of 200 N-m at the midpoint of the rod. The configuration is shown below. The modulus of aluminum is 67 GPa and the Poisson’s ratio is 0.3.

(a) Determine the torque distribution in the rod structural configuration and sketch this as a function of $x_1$.

(b) Determine the twist at the tip of the rod.

(c) Determine the maximum shear stress in the rod and its location.

(d) If the rod were a hollow tube with the same outer radius and a wall with a thickness of 20 mm, how would these answers change?