UNIVERSITY OF CALIFORNIA BERKELEY
Department of Civil Engineering
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Structural Engineering,
Mechanics and Materials
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HW 4 Due Wednesday Feb. 19

[Problems numbers are from revision (d) of the book.]

1. (10 pts) Book Problem 2.6

2. (10 pts) Consider the (Wheatstone) bridge circuit shown below.

   (a) Determine the $\boldsymbol{A}$ matrix.

   (b) Determine the matrix $\boldsymbol{K} = \boldsymbol{A}^T \lceil 1/R \rfloor \boldsymbol{A}$.

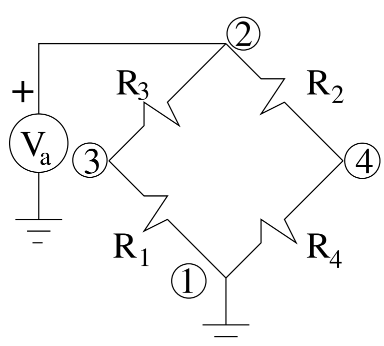
   (c) Identify the two unknown voltages and two unknown current "sources".

   (d) Solve the governing equations for the two unknown voltages.

   (e) Now assume that $R_1 = R_3 = R_4$ and that $R_2 = (1+\epsilon)R_4$, where $|\epsilon| \ll 1$; i.e. the resistance in branch is 2 is almost the same as the others. Show that under these conditions, that $V_o = V_4 - V_3 \approx -\frac{V_a}{4}\epsilon$.

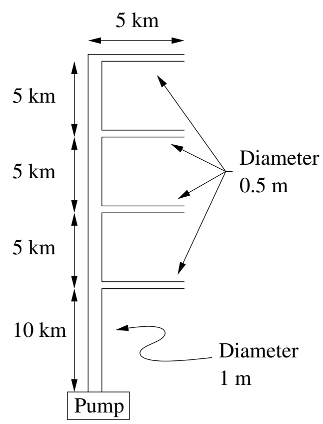
   Note: You must use the given numbering scheme. The node numbers are given in the figure and the branch numbers are given by the subscripts for the resistors.

   [Remark: This circuit is a common way of detecting small changes in a given resistor. It has wide applications, for example in the measurement of mechanical strain using resistive foil-gauges.]



3. (20 pts; MATLAB Problem) Book Problem 2.8

4. (20 pts; MATLAB Problem) Consider the piping system shown below. The system is to carry an oil with density $\rho = 950$ kg/m^3 and kinematic viscosity $\nu = 10^{-4}$ m^2/s. The pump provides oil at a constant pressure P_{pump}. The pressure at the end of each line is taken to be 0 (gauge pressure). What is the maximum allowed pump pressure to ensure that the flow remains laminar (non-turbulent)? In what section will the system first transition from laminar to turbulent flow. Assume turbulence sets in at a Reynold's number of 2100, where $\text{Re} = \frac{qd}{\mu} = \frac{(q/\rho)d}{\nu}$, where q is a pipe flux and d is a pipe diameter.



Warning: page 30 of the reader incorrectly states $R = 32\mu/d^2$, where μ is the viscosity. The correct relation is $R = 32\nu/d^2$, where $\nu = \mu/\rho$ is the kinematic viscosity.