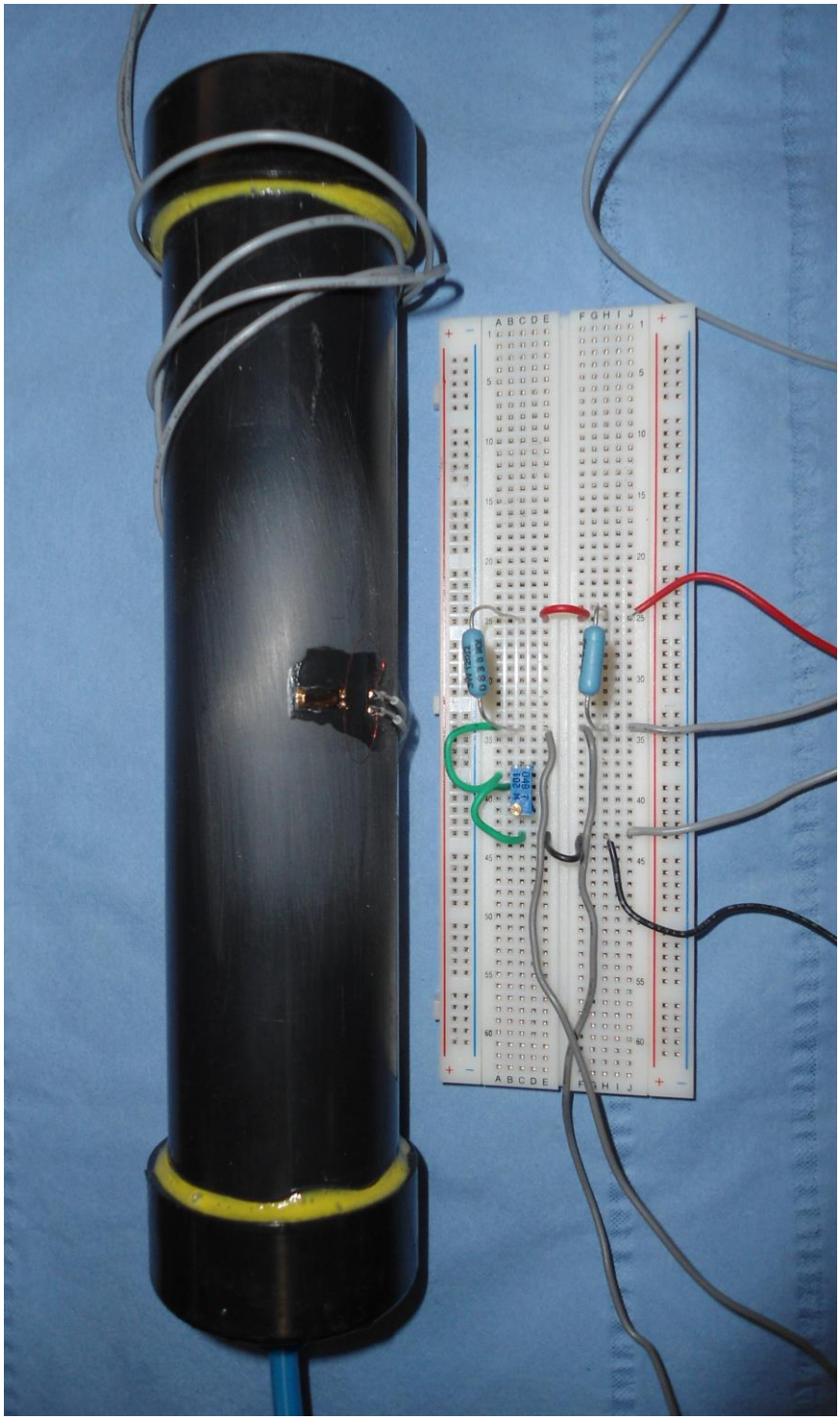
EXPERIMENTAL METHODS

STRAIN GAGE LAB

PURPOSE: The main purpose of this lab is to give you some experience with strain gage sensors. Another purpose is to calculate the error in sensor data.

SETUP: A pressure sensor has been constructed from abs plastic pipe and fittings. A strain gage has been attached in the hoop direction mid way along the pipe. A quarter bridge strain gage electric circuit has been constructed for the sensor.

OBSERVATIONS: Pressurize and depressurize the sensor to set levels and measure its voltage output. Plot the voltage output as a function of pressure. Is the relationship between voltage and pressure linear? Is the voltage sensitive to temperature? Is there any hysteresis? Do an error analysis on the device.



STRAIN GAGE LAB

DATA SHEET

PRESSURE (BAR)	SENSOR (MV)

BACKGROUND THEORY

The hoop stress σ for a pipe is:

$$\sigma = \Delta P \, D/[2t]$$

where ΔP is the pressure inside the pipe, D is the diameter of the pipe and t is the wall thickness.

Stress σ and strain ε are related by

$$\sigma = E \, \varepsilon$$

where E is the Modulus of Elasticity of the pipe wall material. The gage factor GF of a strain gage is:

$$GF = [\Delta R/R] \; / \; [\Delta L/L] = [\Delta R/R] \; / \; \varepsilon$$

where L is the length of the wire and R is its nominal resistance. For a quarter bridge circuit

$$\Delta V \; = \; V \, R/[2R] \; - \; V \, R/[2R+\Delta R]$$

where ΔV is the bridge voltage and V is the supply voltage. Simplification gives

$$\Delta V = V\,[R[2R+\Delta R]-R[2R]]\,/\,[[2R][2R+\Delta R]]$$

$$= V\,[R\Delta R]\,/\,[4R^2-2R\Delta R]$$

$$= V\,[\Delta R/R]\,/\,[4-2\Delta R/R]$$

Substitution into this gives

$$\Delta V = V\ GF\ \varepsilon\ /\ [4\ -\ 2\ GF\ \varepsilon]$$

Simplification gives

$$\Delta V = V/4\ GF\ \varepsilon$$

Substitution of ε into this gives

$$\Delta V = V/4\ [GF\ \sigma/E]$$

Substitution of σ into this gives

$$\Delta V = V/[4E]\ [GF\ [\Delta P\ D/[2t]]]$$

So the pressure versus voltage equation is

$$\Delta P\ =\ [4E]/GF\ \ [2t]/D\ \ \ \Delta V/V$$

PRESSURE SENSOR DATA

GAGE FACTOR GF = 2.09

ABS MODULUS E = 2.3 GPa

PIPE OD = 48.6 mm

PIPE ID = 40.0 mm

WALL t = 4.3 mm

RESISTORS R = 120 Ω

SUPPLY V = 10.0 VDC