Introduction:

This experiment gives students an opportunity to experiment with a cylinder that has a diameter/thickness ratio of more than 10, making it thin-walled. The cylinder will undergo pressure loading that will introduce hoop and longitudinal stresses on the surface of the material. The fact that the cylinder is thin-walled allows for the assumption that the hoop and longitudinal stresses are constant throughout the wall thickness or area. Two different conditions of pressure loading will be tested: “open end” and “close end”. The open end condition can be seen as studying a portion of a long pipeline, while closed end conditions can be imagined as looking at an enclosed gas tank that holds a certain amount of pressure. Using this computerized thin cylinder experiment we will introduce varying amounts of pressure into the cylinder and utilizing strain gage readings on the surface of the cylinder to determine Young’s modulus (E), Poisson’s ratio, ν, and to study the strain Mohr’s circles of the two different end conditions.

Apparatuses:

1) TQ SM1007 Computerized Thin Cylinder. The cylinder is made of aluminum (E = 69 GPa) and has strain gages attached as shown below:

2) Dell Computer with the SM1007 program installed
3) Printer (as a backup device)
**Procedure:**

**DETERMINATION OF YOUNG’S MODULUS (E)**
1) Ensure that the cylinder is at zero pressure by checking that the pressure relief valve on the hand pump is open.
2) Adjust the screw on the right hand side of the cylinder so that it simulates an “open end” condition.
3) Close the pressure relief valve by screwing it fully in.
4) Press F4 to zero the pressure and strain signals.
5) Press F2 to take one reading at zero pressure.
6) Then increase the pressure in 0.5 MPa increments. At each step allow a couple of seconds for the pressure and strain readings to stabilize and then press F2 to copy the current readings to the data table. If a mistake is made, use F3 to go back.
7) Students should take these readings down as the experiment proceeds along because the data table keeps scrolling.
8) Repeat steps 6 and 7 until 7 readings at have been reached at the pressure of 3 MPa.

**OPEN END CONDITION**
1) Ensure that the cylinder is at zero pressure by checking that the pressure relief valve on the hand pump is open.
2) Adjust the screw on the right hand side of the cylinder so that it simulates an “open end” condition.
3) Close the pressure relief valve by screwing it fully in.
4) Press F4 to zero the pressure and strain signals.
5) Increase the pressure until it reaches 3 MPa and then allow a couple of seconds for the pressure and strain readings to stabilize. Then press F2 to copy the current readings to the data table. If a mistake is made, press F2 again. Copy down this data table for the lab report.

**CLOSED END CONDITION**
1) Ensure that the cylinder is at zero pressure by checking that the pressure relief valve on the hand pump is open.
2) Adjust the screw on the right hand side of the cylinder so that it simulates a “closed end” condition.
3) Close the pressure relief valve by screwing it fully in.
4) Press F4 to zero the pressure and strain signals.
5) Increase the pressure until it reaches 3 MPa and then allow a couple of seconds for the pressure and strain readings to stabilize. Then press F2 to copy the current readings to the data table. If a mistake is made, press F2 again. Copy down this data table for the lab report.

**CALCULATION OF POISSON’S RATIO**
1) Once the open end condition experiment is completed simply run the Poisson’s ratio experiment off the pull down menu.
2) Copy down the results from the screen.
PRINCIPLE STRAINS
1) Once all of the above experiments are completed, run the Principle Strains experiment from the pull-down menu.
2) Note down all the results on the screen.

Analysis:
1) What is the difference between the “Open End” and “Closed End” conditions? Which case experiences “uniaxial state of stress” and which case experiences “biaxial state of stress”? Explain each case in detail including equations if necessary.
2) Using the strains, Poisson’s ratio and Young’s modulus obtained from the experiment read the Dowling textbook and come up with the hoop stress, $\sigma_H$, and the longitudinal stress, $\sigma_L$, for both cases (open and closed ends). There should be four results reported. (Hint: Look around section 5.3.2 in the Dowling textbook or section 7.5 in the Gere & Timoshenko textbook, and since this is a plane stress condition, neglect $\sigma_z$. Assume $\varepsilon_x$ is in the longitudinal direction and $\varepsilon_y$ is in the hoop direction.)
3) With the data obtained in the Young's Modulus experiment, plot on ONE GRAPH the hoop stress (in MPa) versus hoop strain (in $\mu$e) for gauges 1 and 6. With these two straight line fits, find the Young's Modulus E for both gauges (which are the slopes for the curves). Use these E values to determine an average E.
4) For the Open End condition experiment, use the theoretical gauge readings given by the program to draw a strain Mohr's circle like the one below. Then apply the experimental data points within the circle of the theoretical data and compare the results (use dotted and solid lines to distinguish between the two). For both the theoretical and experimental data, find their respective $\gamma$ values at points N and M. Comment on any differences that may be present.
5) With the results obtained for the Closed End condition experiment, draw another Mohr's circle as described in step 2 above. Again, compare the experimental data against the theoretical data and comment on differences.

6) From the two Mohr’s circles identify the following values and report them:
   - Principal strains, ($\varepsilon_L$ and $\varepsilon_H$)
   - Maximum in-plane shear strains ($\gamma_{LH}$)

Do this for both cases, open and closed ends. (There should be 6 values reported.)

7) In the Poisson's Ratio Experiment, how does the experimental result compare with the real Poisson's ratio of 0.33 for aluminum? Comment.