1. Cover Sheet:

MET 335

Module 2 - Pressure Gauge Calibration

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2. Purpose, Theory, and Procedure:
   A. Experiment Title:
      1. Pressure Gauge Calibration
   B. Purpose:
      1. The purpose of this lab is to learn about the operation of a Bourdon pressure gauge and how to properly calibrate said machine using a procedure that uses deadweights. This lab will also help to learn how to use a Bourdon pressure gauge to calculate the actual pressure due to the applied dead weights using a common equation. Using the calculated values, students will then graph the indicated gauge reading versus the actual pressure for both increasing and decreasing dead wights, and then students will cap off the lab report discussing the curves and their similarities or differences and make suggestions for improvement.
   C. Theoretical Considerations:
      1. Theoretical considerations that I need to consider during the lab are that the cylinder and connecting hose used water instead of the "normal" fluid which is oil, and that the Bourdon pressure gauge intentionally looks off in calibration (~1-2 $\frac{kN}{m^2}$ above 0).
   D. Description of Apparatus:
      1. Drawing or Sketch

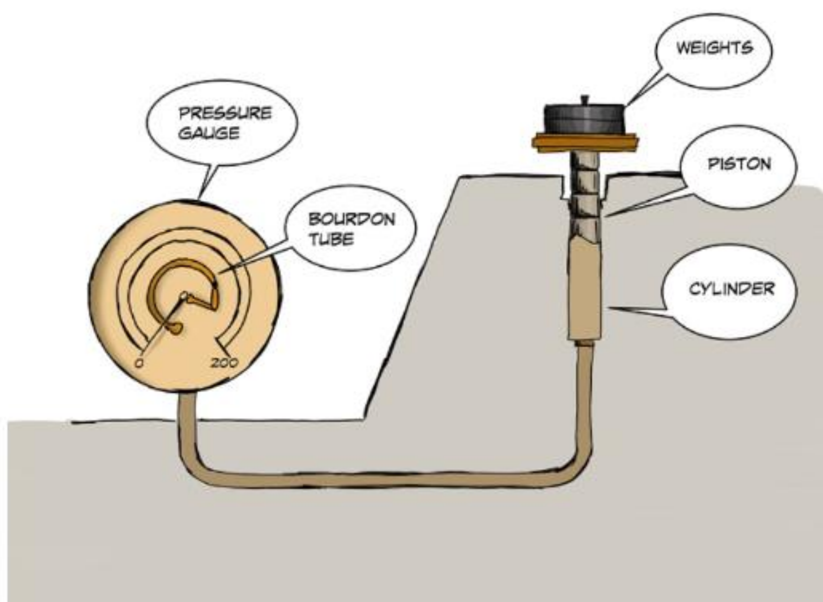


Figure 1 - Bourdon Pressure Gage Calibrator

         i.
         ii. Figured screenshotted from the Canvas 2.1.1. page (Description of Equipment)

2. Verbal Description:
    i. A Bourdon pressure gauge is an apparatus that uses a transparent dial that consists of a thin-walled oval cross-sectional tube that is bent to a circular arc that encompasses about two hundred and seventy degrees. This transparent dial allows the user to see the mechanism of the gauge. One end of the apparatus is fixed while the other end is free to move. The free end is also sealed. When pressure is admitted to the free end, the tube will then start to straighten, and this pressure operates the mechanical system that moves the pointer (pressure indicator) around the graduated scale. This means that the pressure is directly proportional to the movement of the pointer. The sensitivity of the Bourdon pressure gauge relies on a couple of things. These being the material and the dimensions of the tube that connects the pressure gauge to the piston cylinder. There is a vast range of pressure ranges commercially available.

E. Step-by-Step Procedure:
1. Identified all 5 components of the Pressure Gauge Calibration
    i. Weights
    ii. Piston and Plunger Platform
    iii. Cylinder
    iv. Connecting Hose
    v. Gauge
2. Found the cross-sectional area of the Piston
3. Found the mass of Plunger and Platform
4. Placed piston assembly in cylinder
5. Noted the reading at 0kg added weight (32 $\frac{kN}{m^2}$)
6. Added 0.5kg weight
7. Noted the reading at 0.5kg added weight (50 $\frac{kN}{m^2}$)
8. Removed 0.5kg weight
9. Added 1kg weight
10. Noted the reading at 1kg added weight (65 $\frac{kN}{m^2}$)
11. Added 0.5kg weight
12. Noted the reading at 1.5kg added weight (78 $\frac{kN}{m^2}$)
13. Added 0.5kg weight

14. Noted the reading at 2.0kg added weight (94 $\frac{kN}{m^2}$)
15. Removed 0.5kg weight
16. Added 1kg weight
17. Noted the reading at 2.5kg added weight (109 $\frac{kN}{m^2}$)
18. Added 0.5kg weight
19. Noted the reading at 3.0kg added weight (123 $\frac{kN}{m^2}$)
20. Removed 1kg and 0.5kg weight
21. Added 2kg weight
22. Noted the reading at 3.5kg added weight (139 $\frac{kN}{m^2}$)
23. Removed 0.5kg weight
24. Added 1kg weight
25. Noted the reading at 4.0kg added weight (152 $\frac{kN}{m^2}$)
26. Added 0.5kg weight
27. Noted the reading at 4.5kg added weight (167 $\frac{kN}{m^2}$)
28. Added 0.5kg weight
29. Noted the reading at 5.0kg added weight (181 $\frac{kN}{m^2}$)
30. Noted the reading at 5.0kg added weight (181 $\frac{kN}{m^2}$)
31. Removed 0.5kg weight
32. Noted the reading at 4.5kg added weight (167 $\frac{kN}{m^2}$)
33. Removed 0.5kg weight
34. Noted the reading at 4.0kg added weight (152 $\frac{kN}{m^2}$)
35. Removed 0.5kg weight
36. Noted the reading at 3.5kg added weight (139 $\frac{kN}{m^2}$)
37. Removed 0.5kg weight
38. Noted the reading at 3.0kg added weight (123 $\frac{kN}{m^2}$)
39. Removed 0.5kg weight
40. Noted the reading at 2.5kg added weight (109 $\frac{kN}{m^2}$)
41. Removed 0.5kg weight

42. Noted the reading at 2.0kg added weight (94 $\frac{kN}{m^2}$)
43. Removed 0.5kg weight
44. Noted the reading at 1.5kg added weight (78 $\frac{kN}{m^2}$)
45. Removed 0.5kg weight
46. Noted the reading at 1kg added weight (65 $\frac{kN}{m^2}$)
47. Removed 0.5kg weight
48. Noted the reading at 0.5kg added weight (50 $\frac{kN}{m^2}$)
49. Removed 0.5kg weight
50. Noted the reading at 0kg added weight (32 $\frac{kN}{m^2}$)
51. Completed lab

3. Recorded Data Table(s):
   A. Piston cross-sectional area (*mm^2*):
   B. Piston (plunger) and platform mass (*kg*):
   C.

Increasing Pressure	
Mass added to piston (kg)	Gauge reading ($\frac{kN}{m^2}$)
0	
0.5	
1	
1.5	
2	
2.5	
3	
3.5	
4	
4.5	
5	

   D.

Decreasing Pressure	
Mass added to piston (kg)	Gauge reading ($\frac{kN}{m^2}$)
5	
4.5	
4	
3.5	
3	
2.5	
2	
1.5	
1	
0.5	
0	

4. Sample Calculations:
   A. Equation 1:
      i. m = total mass of the dead weight, piston, and platform
      ii. g = gravity constant
      iii. A = cross-sectional area of the piston
      iv. P = Pressure
      v. $P = \frac{m \times g}{A}$
      vi. Sample calculation using data point 2.5 and equation 1:
         1. $P = \frac{(1kg + 2.5kg) \times 9.81\frac{m}{s^2}}{315mm^2}$
         2. $P = 0.109\,pascal$
         3. $1\frac{(\frac{(kg \times m)}{s^2})}{mm^2} = 1{,}000{,}000\,pascals$
         4. $0.109 \times 1{,}000{,}000 = 109{,}000\,pascals$
         5. $1\,pascal = 0.001\frac{kN}{m^2}$
         6. $109{,}000\,pascals \times 0.001 = \boxed{109\frac{kN}{m^2}}$
   B. Equation 2:
      i. $Gauge\,error = (Gauge\ pressure - Actual\ pressure)$
      ii. Gauge pressure = shown gauge pressure in lab
      iii. Actual pressure = calculated pressure
      iv. Sample calculation using data point 2.5 and equation 2:
         1. $Gauge\,error = (109\frac{kN}{m^2} - 109\frac{kN}{m^2}) = \boxed{0}$

5. Calculated Data Table(s):
   A. Piston cross-sectional area (mm^2): 315mm^2
   B. Piston (plunger) and platform mass (kg): 1kg
   C.

Gauge Pressure	
Increasing Pressure	
Mass added to piston (kg)	Gauge reading ($\frac{kN}{m^2}$)
0	32
0.5	50
1	65
1.5	78
2	94
2.5	109
3	123
3.5	139
4	152
4.5	167
5	181

   D.

Actual Pressure	
Increasing Pressure	
Mass added to piston (kg)	Gauge reading ($\frac{kN}{m^2}$)
0	31
0.5	47
1	62
1.5	78
2	93
2.5	109
3	125
3.5	140
4	156
4.5	171
5	187

Gauge Pressure	
Decreasing Pressure	
Mass added to piston (kg)	Gauge reading ($\frac{kN}{m^2}$)
5	181
4.5	167
4	152
3.5	139
3	123
2.5	109
2	94
1.5	78
1	65
0.5	50
0	32

E.

Actual Pressure	
Decreasing Pressure	
Mass added to piston (kg)	Gauge reading ($\frac{kN}{m^2}$)
5	187
4.5	171
4	156
3.5	140
3	125
2.5	109
2	93
1.5	78
1	62
0.5	47
0	31

F.

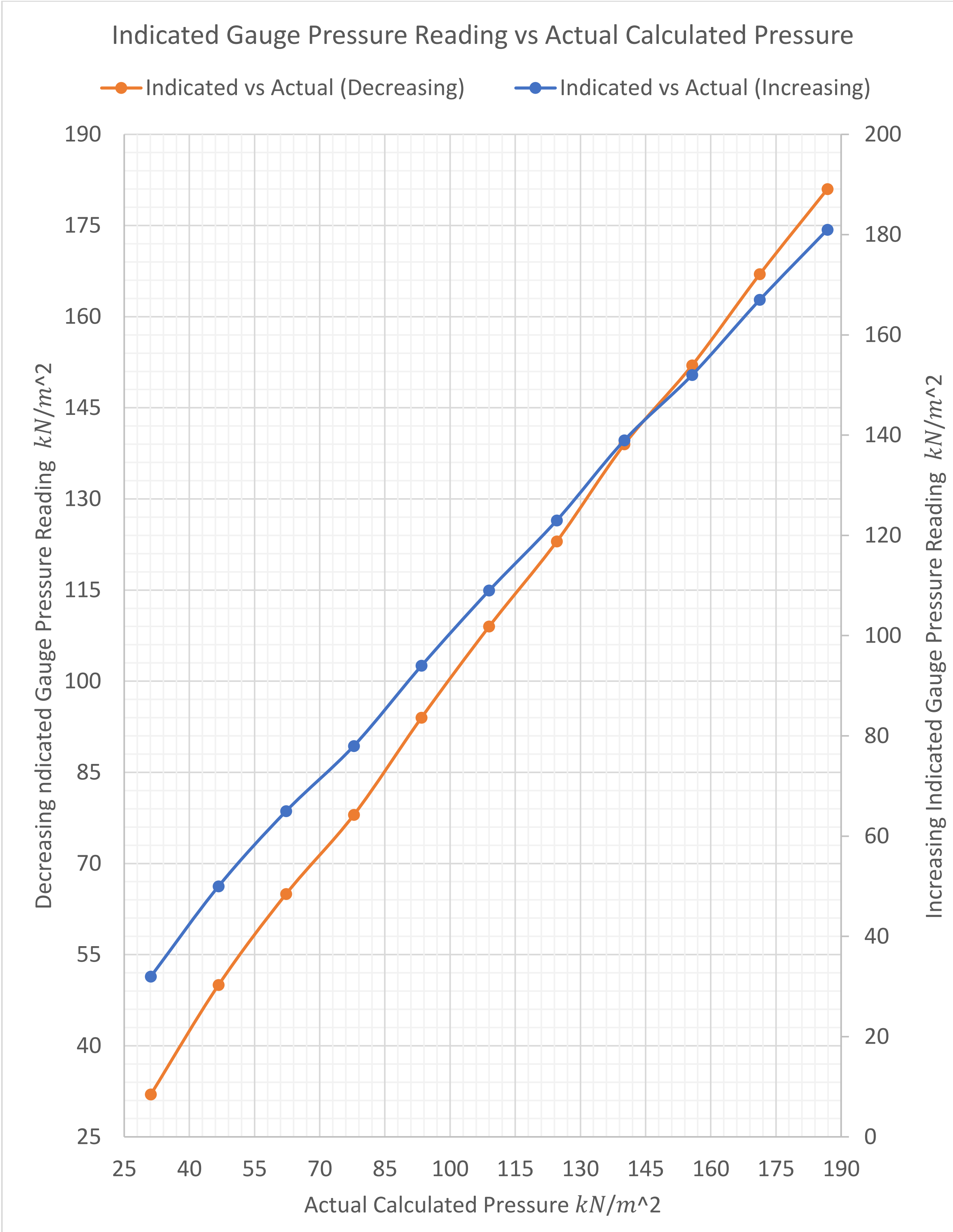
Delta
(=Gauge Pressure Increasing Pressure - Actual Increasing Pressure)
1
3
3
0
1
0
-2
-1
-4
-4
-6

G.

Delta
(=Gauge Pressure Decreasing Pressure - Actual Decreasing Pressure)
-6
-4
-4
-1
-2
0
1
0
3
3
1

H.

6. Graph(s): Increasing placed on secondary (right vertical axis) compared to Decreasing which is placed on the primary (left vertical axis)



A.

7. Discussion of Results and Conclusions:
   A. *The above graph shows the indicated pressure gauge reading (ordinate) versus the actual calculated pressure (abscissa) using two vertical axes. One being for the increasing (blue) values up to 5kg and the other being decreasing (orange) values for down to 0kg. The reason for a secondary axis was to allow readers the ability to see the other values (if both used primary axis, then the values would lay on top of each other). The curves for each the increasing and the decreasing values are very close to linear lines, however they have just enough variance to not be a straight linear curve.*
   B. *The difference in indicated pressure gauge readings and actual calculated pressure values aren't drastically different. The biggest gap between the readings is at the 5kg reading with a delta of 6* $\frac{kN}{m^2}$*. I did record two data points where the delta was 0 (1.5kg and 2.5kg).*
   C. *One key piece of information that was important in setting up the lab was noting that the pressure gauge was purposefully "off" of 0 for calibration reasons. If the gauge read true 0 versus the ~1-2* $\frac{kN}{m^2}$ *then the deltas for all readings would have been off even more than they already were.*
   D. *Overall, it looks as if the higher the pressure, the higher the delta and as pressure decreases, the lower the difference between indicated pressure gauge reading and the actual calculated pressure is. And as pressure difference decreases, there are a few overlaps (equivalences) between the two data entries as we saw during my report at 1.5kg and 2.5kg readings.*
   E. *A suggestion I would mention that could improve the apparatus is to change out the fluid in the connecting hose from water to the recommended oil. Another suggestion would be to calibrate the weights themselves. While you wouldn't think that the weight would be "off", just a 0.1kg difference makes a drastic change in the values of pressure since mass is a key proponent of the equation for pressure.*