Fall 2018 MET 211 Group 7: Torsion

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Purdue University | Polytechnic Institute

Lab 2: Directions

1. Verify the **torque/twist relation** given in the text.
2. Investigate the **deflection vs. torque characteristics** of a given rod (hollow or solid; wood, steel or <u>aluminum</u>).
3. Determine whether the **theoretical relation in the text is a reasonable model** of the actual behavior.

Lab 2: Parameters

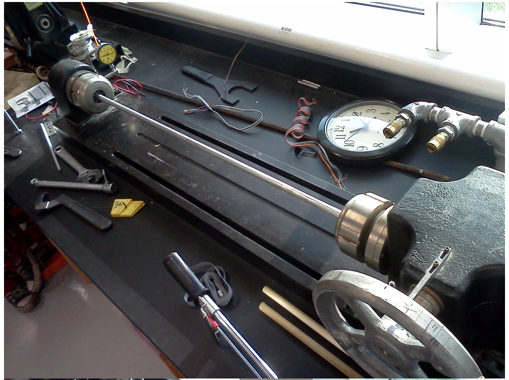
1. Verify the torque/twist relation given in the text

Given

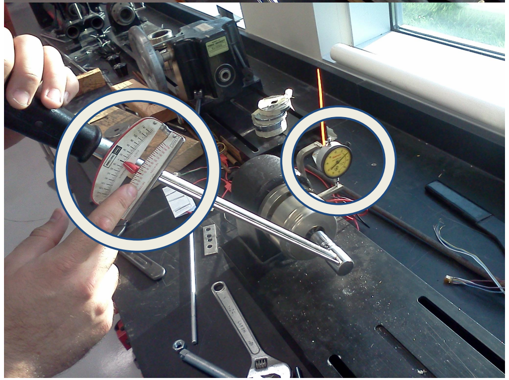
- 0.5 in (12.7 mm) Solid Aluminum Rod
- Torsion Tester - Room N1162
- 0.5 in Torque Wrench for test stand calibration

Find

- Theoretical Amount of deflection that occurs from torque
- Compare relationships from theoretical values with observed values



Aluminum Rod in Test Stand



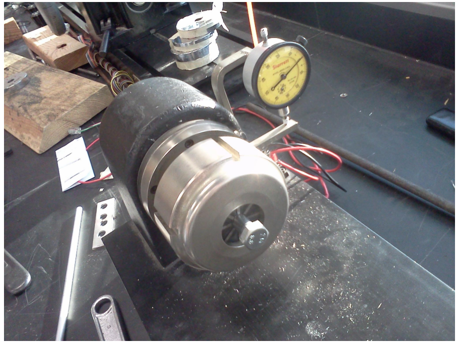
Calibration with Torque Wrench

Lab 2: Deflection vs. Torque?

2. Investigate the deflection vs. torque characteristics of a given rod solid aluminum.

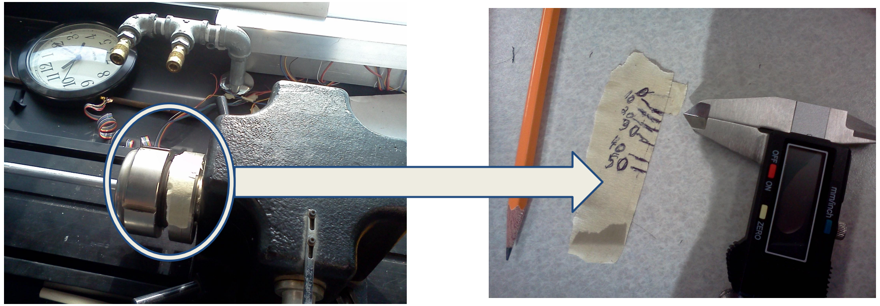
<u>Method</u>

- **Calibration:** Used torque wrench to find relationship between torque (in Nm) translation and deflection gauge reading (in mm) at different torque levels
- Marked zero point on tape placed on turning chuck, applied torque to rod in 0.1 mm increments at the dial
- **Removed tape (rotating) and measured length difference corresponding to rotational circumference transversal (in mm)**

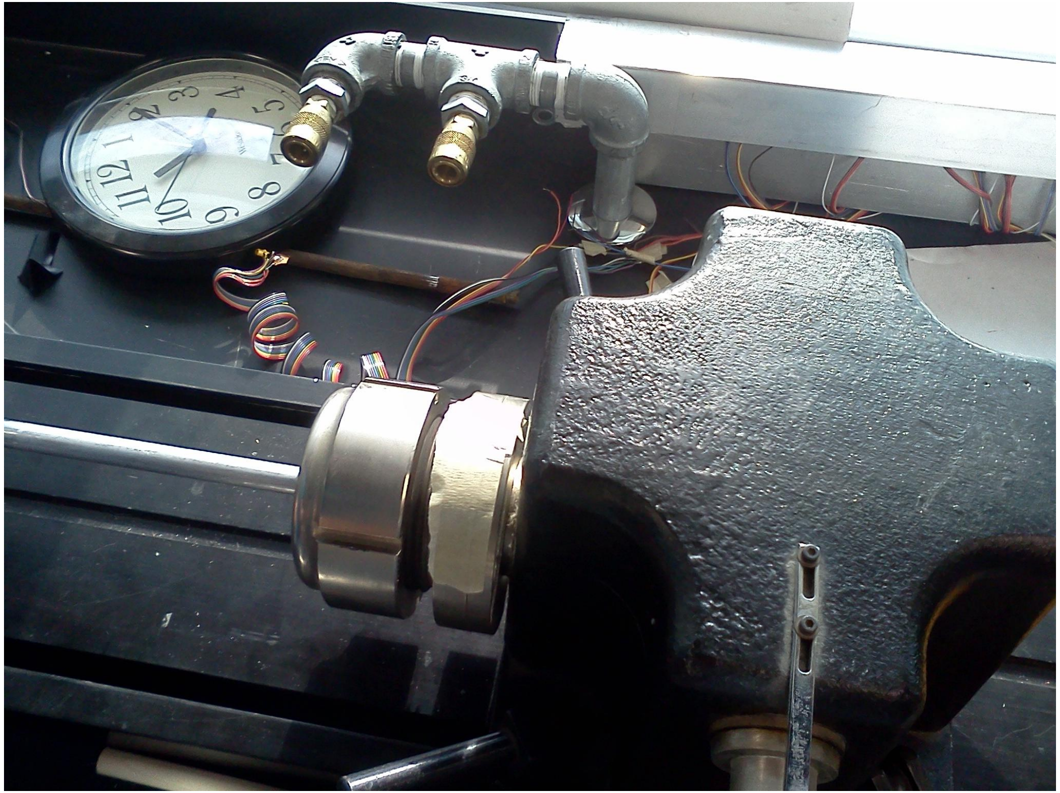


Torque Translation Reading

Direct Marking Readings



Lab 2: Testing Close Up



Lab 2: Equations 1 - Compute J

Compute J (Polar Moment of Inertia)

$$J = \frac{\pi * D^4}{32}$$

J = polar moment of inertia (in mm^4)

D = diameter of circular bar (in mm)

FIGURE 4–18 Torsional deformation in a circular bar.

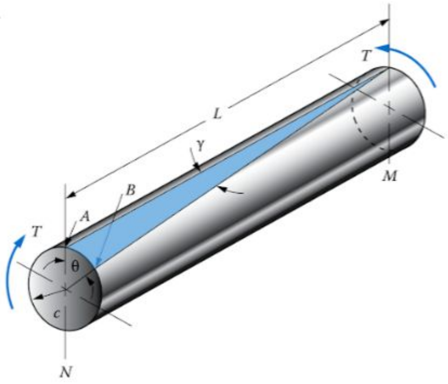


TABLE 4–4 Shear modulus of elasticity, G.

	Shear modulus, G	
Material	GPa	psi
Plain carbon and alloy steels	80	11.5×10^6
Stainless steel type 304	69	10.0×10^6
Aluminum 6061-T6	26	3.75×10^6
Beryllium copper	48	7.0×10^6
Magnesium	17	2.4×10^6
Titanium alloy	43	6.2×10^6

Lab 2: Equations 2 - Compute Angle (rad)

Compute Angle of Twist of a Circular Member

End of shaft M is fixed and torque T is applied to other end. Shaft will twist between two ends at angle θ (theta).

$$\theta = \frac{TL}{JG} \times \frac{(10^3 mm)^3}{1m^3} = rad$$

θ = resulting angle of twist (in radians)

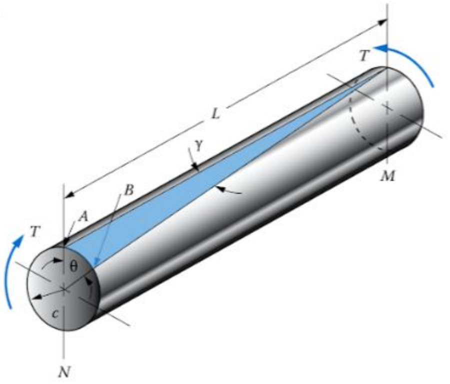
T = torque (in N * m)

L = initial length (in mm)

J = polar moment of inertia (in mm^4)

G = shear modulus of elasticity (in GPa)

FIGURE 4–18 Torsional deformation in a circular bar.



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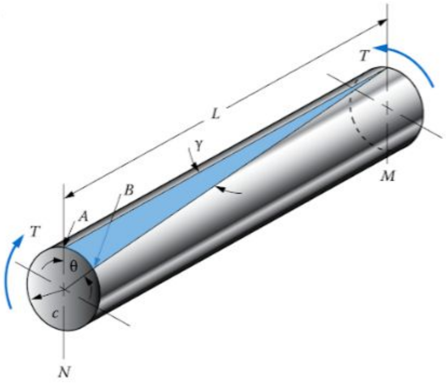
Lab 2: Equations 3 - Compute Angle (deg)

Compute Angle in Degrees

$$\theta = rad \times \frac{180(deg)}{\pi(rad)} = deg$$

θ = resulting angle of twist (in degrees)

FIGURE 4–18 Torsional deformation in a circular bar.



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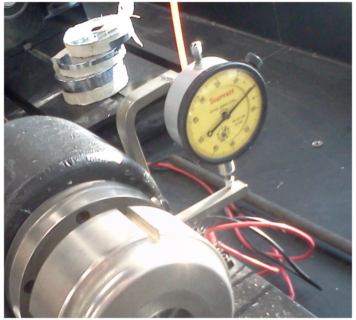
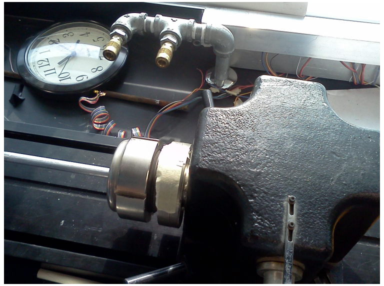
Lab 2: Deflection Results

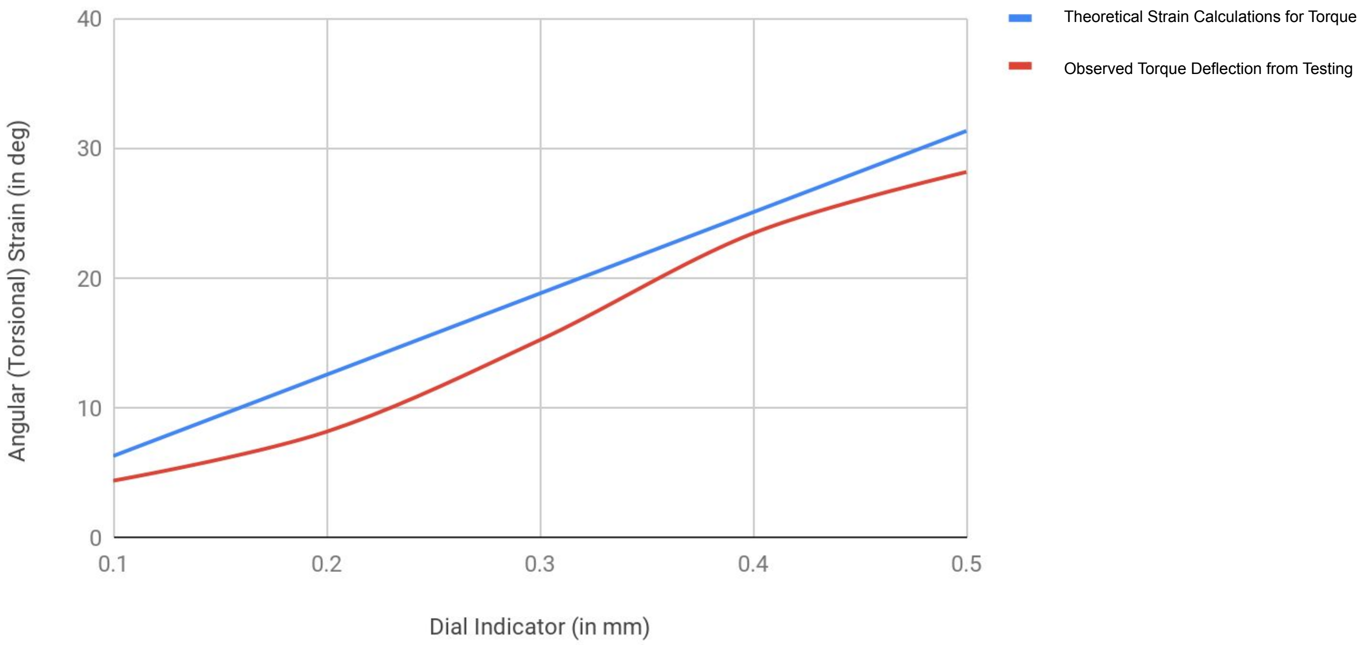
Calculations from Torque Translation vs Loading End Deflection

Dial Reading (mm)	**Calculated Torque** (N-m)	**Measured from Tape** (mm)	**From Torque** (Theoretical in Degrees) = (180*1000*T*L)/(PI*J*G)	**From Tape** (Visual Measure in Degrees) = 360*Measured/Circumference	**Percent Difference** = (Theoretical - Visual) / (Theoretical * 100)
0.1	7.951	3.87	6.263	4.360	30.385
0.2	15.902	7.22	12.525	8.135	35.050
0.3	23.854	13.49	18.787	15.200	19.093
0.4	31.805	20.79	25.050	23.425	6.487
0.5	39.756	24.98	31.312	28.146	10.111





Lab 2: Dial Indicator vs. Angular Strain



Lab 2: Theoretical Reasonable?

3. Determine whether the theoretical relation in the text is a reasonable model of the actual behavior.

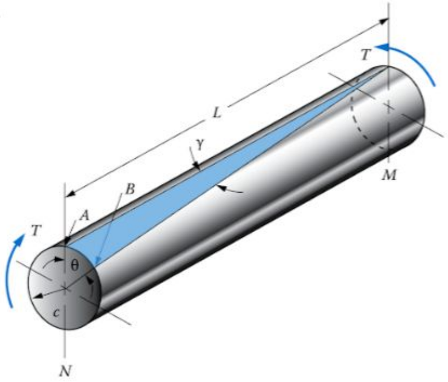
Confounding Variables & Sources of Error:

- Slippage in the torsion chucks
- Uncertainty of Material Specs
- Precision of Tape Markings and interpretation of measurements
- Torque Wrench readings

Reasonable?

- Somewhat with a 20.225% average higher difference from theoretical to observed, more measurements are needed to decrease uncertainty

FIGURE 4–18 Torsional deformation in a circular bar.



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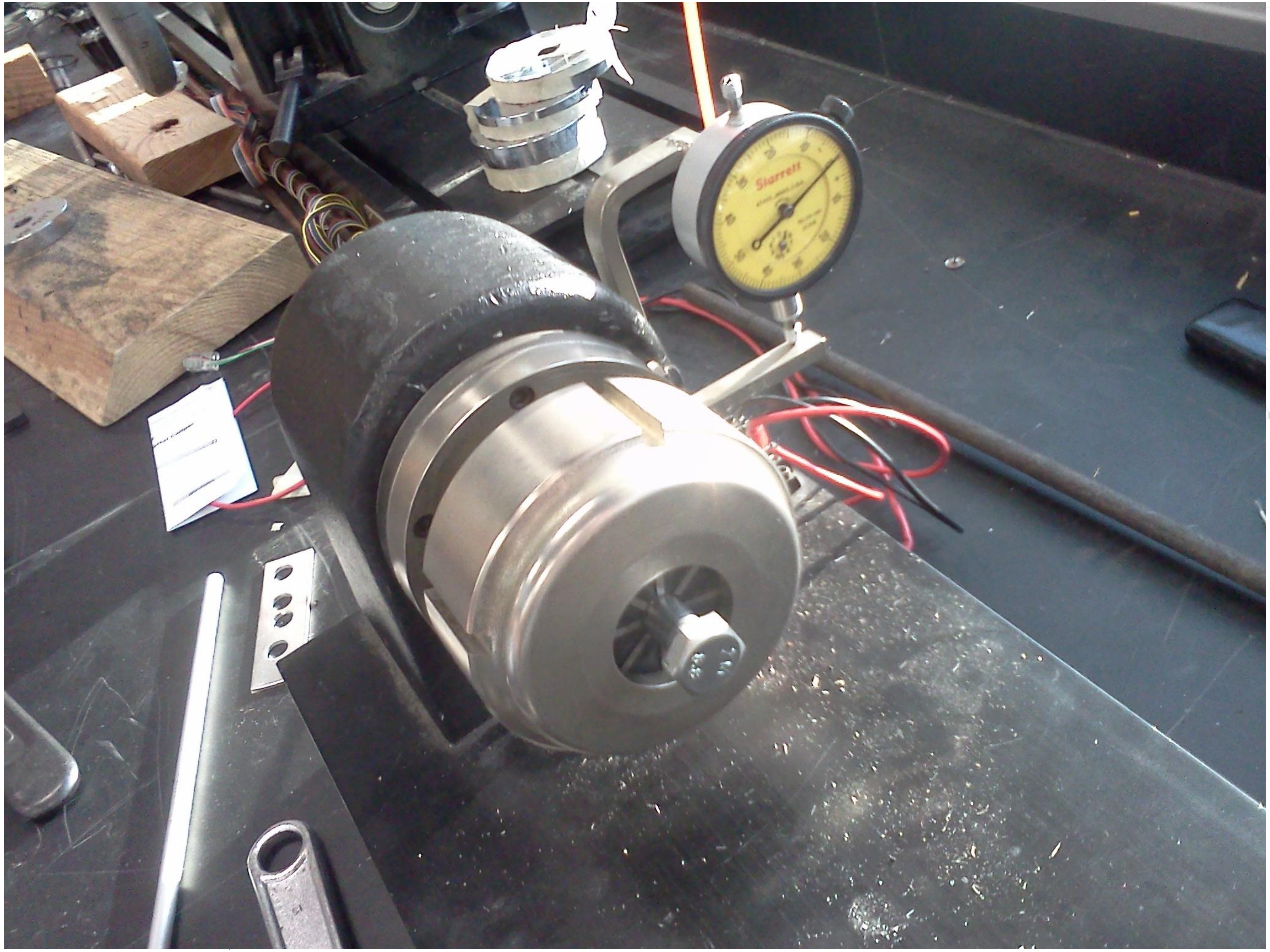
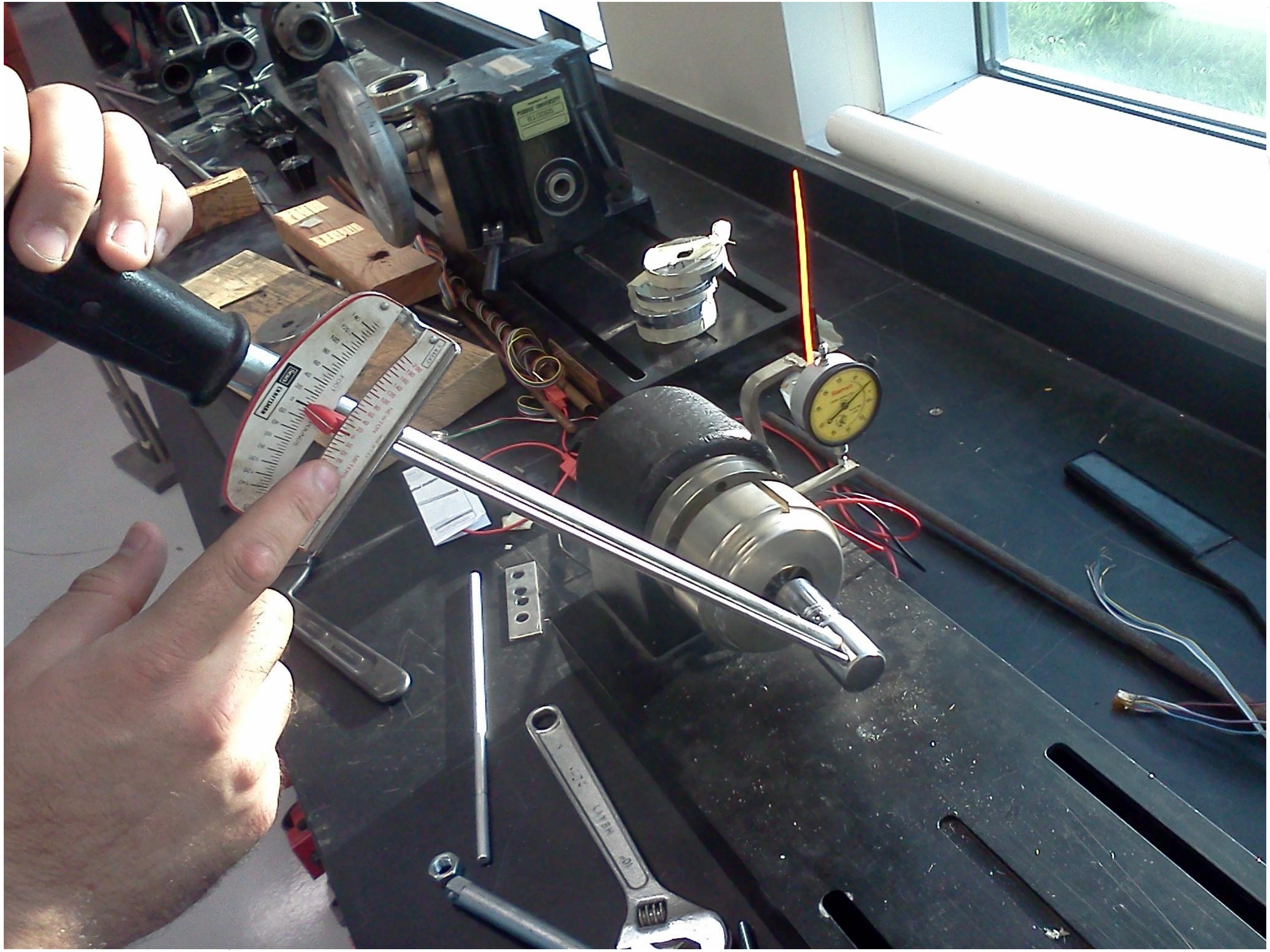
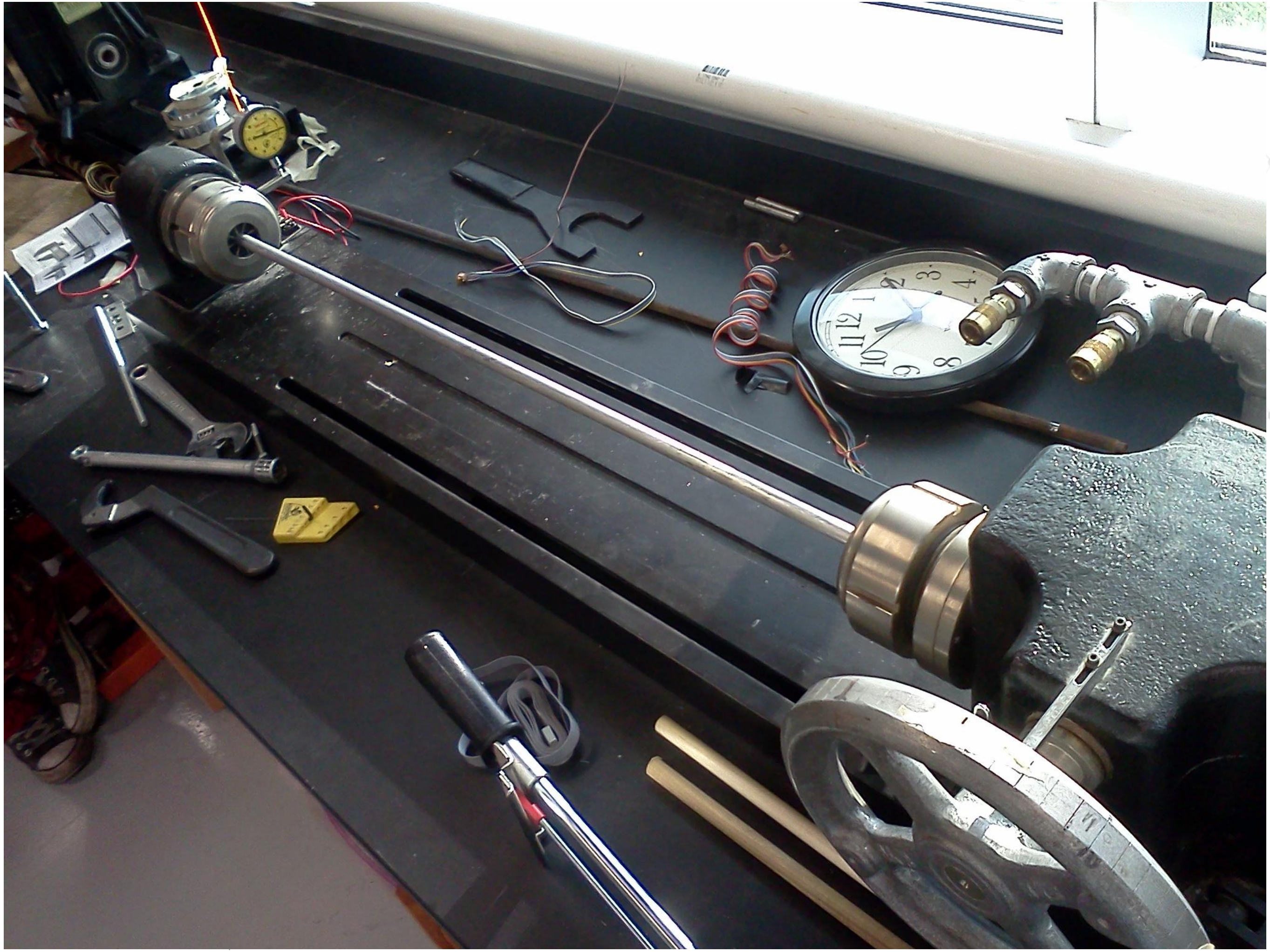
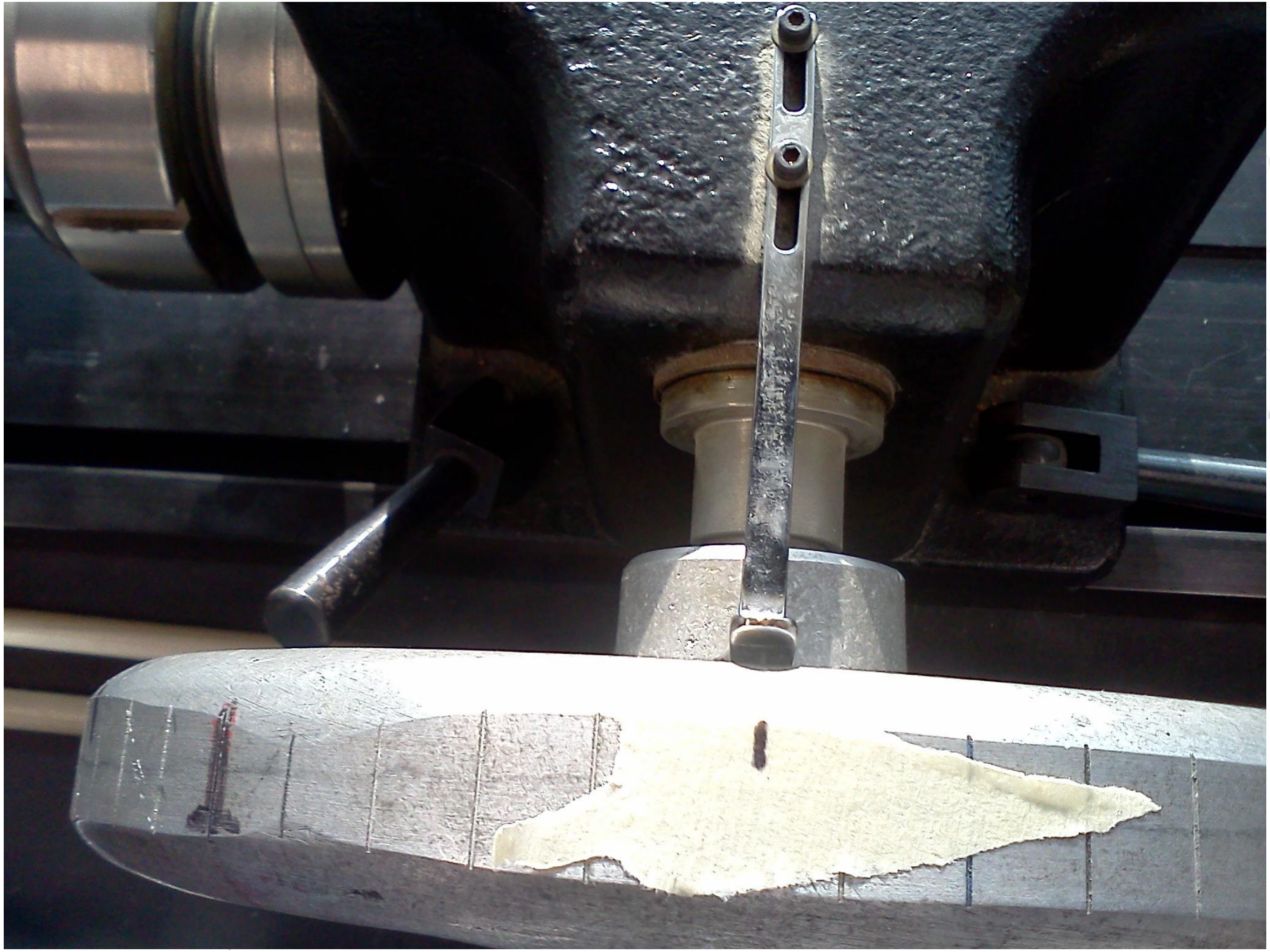
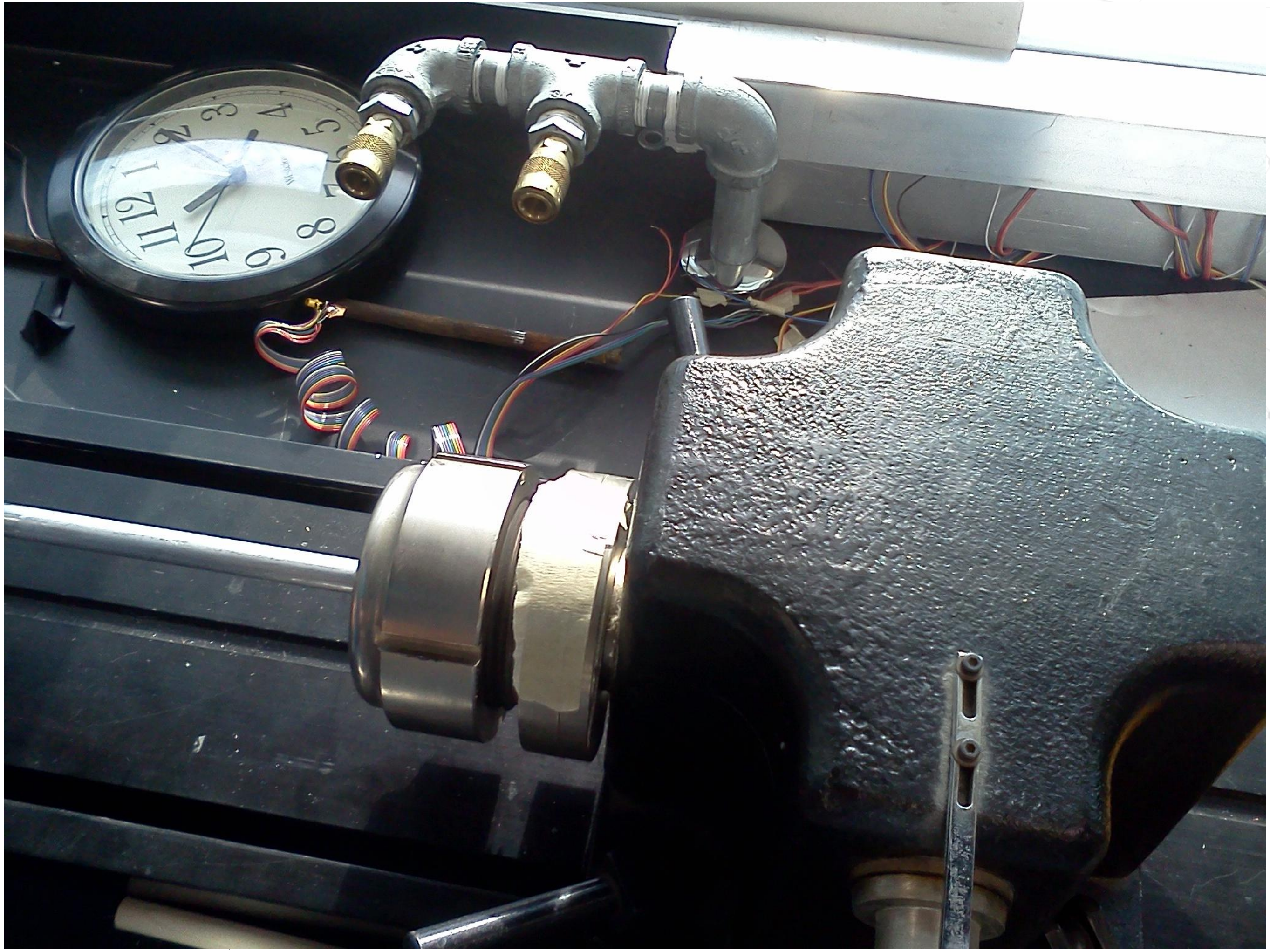

Starrett








GOODSENSE
50% Isopropyl Alcohol




10
20
30
40
50
OFF
ON
ZERO
mm/inch
70
80
90
100

per Sesh Al rand Solid

.503
.500
.497
.501
.499
} Dia

~~3? 15/16 in~~

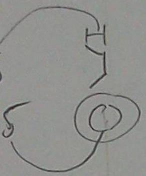
35- 15/16 in

4.000 in

$\boxed{\text{Dia } 4.000 \text{ in}}$

divide by circumference multiply by 360°

.045
.0445



circumference 319.186mm /

cm

dial .01mm		tape mm
45 = .45mm	30 Nm	13.49mm
28	20 Nm	7.22mm
56	40 Nm	20.79mm
9mm	10 Nm	3.87mm
		[illegible] mm

Lab2: References

[textbook] Mott, Robert L. *Applied strength of materials - 5th ed*. Upper Saddle River, N.J: Pearson/Prentice Hall, 2008. Print.

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