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Torsion of shafts

Mechanics and dynamics (ACHA4026)

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1. Introduction

This report will cover the effects of weight on the rotational integrity of three different materials all the same dimensions. To do this an experimental procedure was conducted and will be explained in the report. To analyse the data Microsoft Excel will also be used to produce graphs and tables. This report will also research and compare the results of similar practices done by other parties, along with this it will evaluate how errors have been minimized and could be in the future with unlimited money and time.

2. Experimental Procedure

The experiment was conducted in a classroom setting with a group of five members. The first step of the experiment was to unbox the equipment that was to be used, after that the next step was to measure the diameter using a dial calliper gauge and length of a brass rod. That rod was then inserted into the rotating chuck; to secure the rod the grub screws were tightened with an Allen key. After this step the fixed chuck was fixed to the work panel, then the rotating chuck was attached parallel to the fixed chuck. A hook was attached to the rotating chuck and then the grub screws were tightened on the fixed chuck around the brass rod. The rotating chuck was then set and zeroed. After this step the experiment began, starting with 100g of washers being added onto the hook. After the weight was added the work panel was tapped to remove the effect of friction and then the twist angle was recorded from where it was being displayed on the rotating chuck. This process was repeated by adding washers in increments of 100g until the total load was 500g. The next step was to remove the weights and brass rod from the chucks. To remove the rod the rotating chuck was also removed from the work panel, then an aluminium rod was put in its place after being measured and the rotating chuck was secured back onto the work panel. The process of calibrating, adding load and measuring was then repeated until all relevant data was recorded except for 500g to avoid twisting the rod beyond its elastic limit. The same process of removal, measuring, reattaching, calibrating and data collection was repeated with a steel rod. Once all the material types were tested the work panel was disassembled and put back into the correct drawer.



Figure 1 shows the experimental procedure being conducted, with the work panel and a brass rod visible

3. Analysis

3.1 Raw Data

Table 1 displays the raw results recoded from the procedure.

Table 2 shows the recorded diameters of the rods.

Raw Results			
Load (g)	Twist Angle (degrees) Brass	Twist Angle (degrees) Aluminium	Twist Angle (degrees) Steel
100	6.5	8.5	3.5
200	13.5	16.5	6
300	19.5	24	8
400	25.5	32	10.5
500	31.5	N/A	13.5

Diameter (m) Brass	Diameter (m) Aluminium	Diameter (m) Steel
3.1	3.1	3.1

3.2 Calculated results

Table 3 displays the full data from the Brass rod test.

Load (m) (g)	Load (W) (N)	Torque (T) (Nm)	Twist Angle (degrees)	Twist Angle (θ) (radians)	TL	Jθ
100	0.981	0.0981	6.5	0.113461111	0.033354	1.02885E-12
200	1.962	0.1962	13.5	0.23565	0.066708	2.13683E-12
300	2.943	0.2943	19.5	0.340383333	0.100062	3.08654E-12
400	3.924	0.3924	25.5	0.445116667	0.133416	4.03624E-12
500	4.905	0.4905	31.5	0.54985	0.16677	4.98594E-12
Material: Brass		L = 0.34m		D = 3.1		J
					9.06782E-12	

Table 4 displays the full data from the Aluminium rod test.

Load (m) (g)	Load (W) (N)	Torque (T) (Nm)	Twist Angle (degrees)	Twist Angle (θ) (radians)	TL	Jθ
100	0.981	0.0981	8.5	0.148372222	0.033354	1.34541E-12
200	1.962	0.1962	16.5	0.288016667	0.066708	2.61168E-12
300	2.943	0.2943	24	0.418933333	0.100062	3.79881E-12
400	3.924	0.3924	32	0.558577778	0.133416	5.06508E-12
N/A	N/A	N/A	N/A	N/A	N/A	N/A
Material: Aluminium		L = 0.34m		D = 3.1	J	
					9.06782E-12	

Table 5 displays the full data from the Steel rod test.

Load (m) (g)	Load (W) (N)	Torque (T) (Nm)	Twist Angle (degrees)	Twist Angle (θ) (radians)	TL	Jθ
100	0.981	0.0981	3.5	0.061094444	0.033354	5.53994E-13
200	1.962	0.1962	6	0.104733333	0.066708	9.49703E-13
300	2.943	0.2943	8	0.139644444	0.100062	1.26627E-12
400	3.924	0.3924	10.5	0.183283333	0.133416	1.66198E-12
500	4.905	0.4905	13.5	0.23565	0.16677	2.13683E-12
Material: Steel		L = 0.34m		D = 3.1	J	
					9.06782E-12	

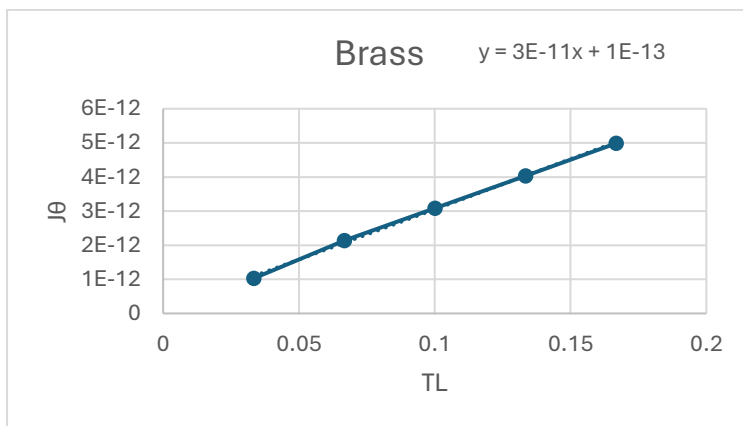


Figure 2 shows J Theta against TL for the Brass experiment with the gradient equalling 33 GPa.

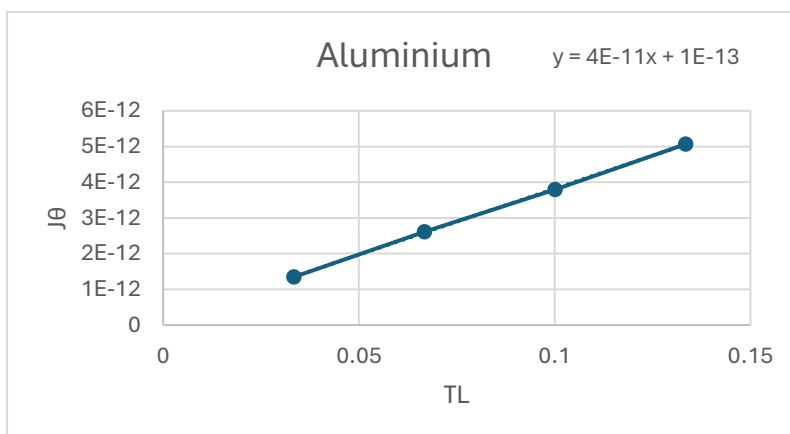


Figure 3 shows J Theta against TL for the Aluminium experiment with the gradient equalling 25 GPa.

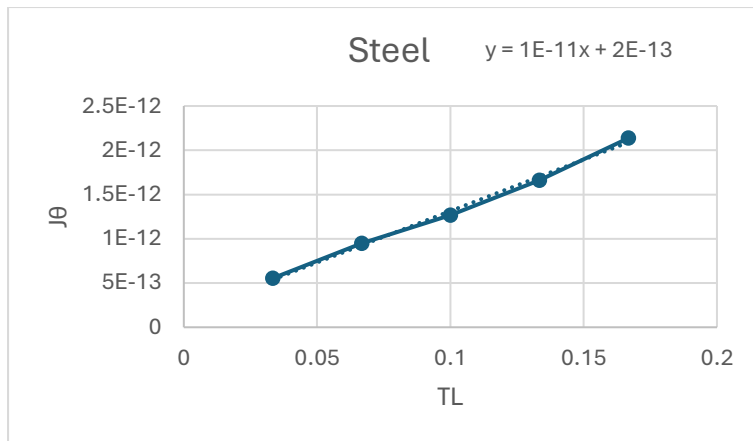


Figure 4 shows J Theta against TL for the Steel experiment with the gradient equalling 100 GPa.

In the figures 2-4 it can be seen on the graphs that the line travels in a largely linear fashion which displays the effect of Hooke's Law which states that within the elastic region, deformation is proportional to the applied load until the limit of proportionality.

4. Conclusion

The Shear Modulus values recorded in this experiment were 33 GPa, 25 GPa and 100GPa for the brass, aluminium and steel respectively. While not wholly inaccurate the Shear Modulus of brass according to ezlock.com (2019) is 37 GPa. The most accurate result was the Aluminium where according to Modulus Metal (2025) the GPa can rest between 25.3 and 26.6. The least accurate result produced by the practical was the steel with steeloncall.com (2024) stating that it should have a value of 80 GPa. While external factors such as alloy composition and temperature could alter the results it is likely that the errors with the steel and brass lie within human error. This error likely originates from two things, the level of impact from the washers being added to the hook and reading errors when reading the values displayed on the rotating chuck.

5. Evaluation

In this experiment there were multiple possible errors that could effect the results of the practical. The first major error that could have posed an issue originates from the setup of the work panel itself, to ensure that it was set up correctly the group was provided with an instructional diagram from which the precise position of the components could be replicated. Secondly to minimise error it was decided that the whole group would read the torque arm scale on the rotating chuck and decide together on the displayed value, so a single individual did not miss read the scale. Another potential error was the risk of deviation in the processes involved with the experiment between the different materials, to ensure this did not occur one member recorded each process in a notepad.

6. Further Work

While the practical conducted was of adequate accuracy and quality, there are many aspects that could be improved with the introduction of infinite money and time. The first of which would be the personnel, with infinite money top scientists could be sourced to ensure that correct procedures were being followed and data recorded correctly. The hardware used could also be revamped with things such as a dedicated machine for the purpose of conducting this experiment, this machine would have a fixed test position to ensure that every test was the same. It would also have a digital gauge to ensure accuracy to the decimal. Another addition would be a system that adds the weight without impact as to not greaten the effect on the twist angle. To have greater control over the variables the rods tested could also be manufactured in house to ensure the exact measurements needed. The last alteration would be the amount of times the experiment would be conducted as to get a wider base of results to work with.

7. References

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