Birzeit University

Physics Department

Phys211

Experiment #6

**Torsional Torque & Torsional Modulus**

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**Abstract**

**The Aims of the experiment**

* To study the elastic properties of Aluminum and steel rods.
* To find the moment of inertia of the system.
* To determine the torsional constant and to analyse its dependence on Rod Geometry.
* To find the Shear modulus of the Aluminum.

**The method used**

A massive dumbbell shaped object was fixed to a thin metallic rod (Al). Then, the system is twisted and start to oscillate ,by measuring the period of oscillations, the lengths of the rods and the diameters of he rods ,we find the moment of inertia of the system ,the torsional constant and the shear modulus of rods.

**The main results**

**I =** 0.033 kg.

**2**

**G = 16**

**Theory**

**The period for small oscillations is given by**

|  |
| --- |
|  |

**T :period**

**I :moment of inertia**

**K : torsional constant**

**We can assume that I is constant for the whole experiment since the mass of the rod is very small compared to the dumbbell’s mass.**

**The torque for the elastic twisting of the rod by an angle is given by , ( k : torsional constant) and k depends on the feometry of the rod by**

**G :shear modulus**

**d : rod’s diameter**

**L : rod’s length**

**Procedure**

**In part I , we only used on rod, we twisted the system by a force (F) at six different angles , we also measured the period of oscillation for the system, then we found and plotted vs . Finally , we found the moment of inertia of the system.**

**In part II , 3 Aluminum rods of the same length were taken and then the diameter of each &the period were measured. After that, the value of K was found. From the graph (log k vs log L) the values of n & G were obtained.**

**In part III, 3 Aluminum rods of the same diameter were taken and then the length of each &the period were measured. After that, the value of K was found. . From the graph (log k vs log d) the values of m & G were obtained.**

**Data**

**Part I**

|  |  |
| --- | --- |
| (deg) | F (N) |
| 10 | 0.09 |
| 20 | 0.18 |
| 30 | 0.27 |
| 40 | 0.36 |
| 50 | 0.45 |

r = 15cm

t = 2.318 s

**Part II**

|  |  |  |
| --- | --- | --- |
| **Rod #** | **L (cm)** | **T (sec)** |
| 1 | 47.8 | 2.318 |
| 2 | 37.9 | 2.062 |
| 3 | 27.0 | 1.778 |

**part III**

|  |  |  |
| --- | --- | --- |
| **Rod #** | **d(mm)** | **T(sec)** |
| 1 | 1.91 | 2.318 |
| 2 | 2.90 | 1.054 |
| 3 | 3.90 | 0.615 |

**Calculations**

**Part I**

t =2.318 s

r = 0.15 m

|  |  |  |  |
| --- | --- | --- | --- |
| **θ (deg)** | **θ (rad)** | **F (N)** | **τ(N.m) = rFsin90** |
| 10 | 0.174444444 | 0.09 | 0.0135 |
| 20 | 0.348888889 | 0.18 | 0.027 |
| 30 | 0.523333333 | 0.27 | 0.0405 |
| 40 | 0.697777778 | 0.36 | 0.054 |
| 50 | 0.872222222 | 0.45 | 0.0675 |

|  |  |  |
| --- | --- | --- |
|  | **Slope** | **Y-int** |
| **Value** | 0.077388535 | -1.38778E-17 |
| **Error** | 9.77713E-18 | 5.65672E-18 |

**Slope = = 0.077388535 = 0.077 N.m/rad**

**I = =** 0.033106544 = 0.033 kg.

**Part II**

**d** =1.91 mm

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Rod #** | **L (cm)** | **T (sec)** | **k** | **log (L)** | **log (K)** |
| 1 | 0.478 | 2.318 | 0.24222 | -0.3206 | -0.6158 |
| 2 | 0.379 | 2.062 | 0.30609 | -0.4214 | -0.5141 |
| 3 | 0.27 | 1.778 | 0.41169 | -0.5686 | -0.3854 |

|  |  |  |
| --- | --- | --- |
|  | **slope** | **y-int** |
| **Value** | -0.924636 | -0.90905567 |
| **Error** | 0.0370504 | 0.016619868 |

**,**

**log k = m log L + log**

**Slope = m = -0.924636 = -1**

**Part III**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Rod #** | **d(mm)** | **T(sec)** | **k** | **log(d)** | **log k** |
| 1 | 1.91 | 2.318 | 0.242217972 | -2.718966633 | -0.615793636 |
| 2 | 2.9 | 1.054 | 1.1715262 | -2.537602002 | 0.068752006 |
| 3 | 3.9 | 0.615 | 3.440986714 | -2.408935393 | 0.536682996 |

|  |  |  |
| --- | --- | --- |
|  | **slope** | **Y-int** |
| **Value** | 3.721042581 | 9.504436087 |
| **Error** | 0.038218728 | 0.097776158 |

**log k = n log d + log**

**n=slope =** 3.721042581 **= 3.72**

**2**

**-To find the shear modulus G :**

**In part II**

**log k = m log L + log**

**y-int = log**

**=**

**G =**

**In Part III**

**log k = n log d + log**

**Y-int = log**

**G =**

**G = 16**

**G =**

**G = 16**

**Conclusion**

**I =** 0.033 kg.

**2**

**G = 16**

**For m :**

**D = 1-0.92 = 0.08**

**2 = 0.08 = D ( Acceptable value)**

**For n :**

**D = 4- 3.72 = 0.28**

**2 <D ( the value is not acceptable according to discrepancy test).**

**For G**

**D = 24-16.455 = 7.545**

**2(the value is not acceptable)**

**There were many sources of error :**

* **The angle between the force and the dumbble was not 90 exactly.**
* **The time lag in measuring the periods .**
* **The friction in the system .**
* **The deviation of the values of n &m affects significantly the value of calculated G .**