**Birzeit University**

**Physics department**

**Physics 211**

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**Experiment number: (10)**

**Experiment name: torque and angular momentum**

**Theory:**

**A rigid body rotating about a fixed axis is subject to rotational version of Newton’s 2nd law:**

**L=Iw**

**Where I is the moment of inertia and L is total angular momentum of the system ,and w is the angular velocity of the body .**

**A net torque causes the body to accelerate angularly**

**t= dL/dt=Idw/dt=Ia**

**where a is the angular acceleration of the rigid body and t is the torque acting on it t=rxf in our experiment t =rmg =Ia**

**for studying the time dependence of the angular displacement and angular velocity**

**w(t)=mgrt/I=at**

**Ѳ(t)=1/2(mgrt2/I)=1/2 at2**

**The inertia is fixed but the torque acting on the disk can be varied either by changing the weight or the radius around which the string holding the weight passes.**

**Procedure:**

**Preparation of apparatus:**

**1. setting an apparatus same as in the picture .**

**2. adjust rotary disk to be in horizontal position.**

**3. Connect and prepare the air blower to eliminate friction.**

**4. Set the light barrier and the timer to measure t and ∆t.**

**5. Switch on the air blower.**

**Part 1:Measurment of Ѳ and w as a function of time :**

**1. change position of the light barrier to choose from 7 angles from 0 to 360.**

**2. For each angle measure t and ∆t .**

**3. Determine w from you data .**

**Part 2 :dependence of the angular acceleration on the applied torque .**

**A: varying the hanging weight mg.**

**1. Fix the angle at Ѳ=2π**

**2. Change weight several times and measure t and ∆t .**

**3. Find w for each weight and the angular acceleration .**

**B: Varying the lever arm**

**1. Fix both the force and angle m=15 gm and Ѳ=π.**

**2. Repeat 1 for several radiuses .**

**Data:**

|  |  |  |  |
| --- | --- | --- | --- |
| **part 1** | **r=0.03 m** | **m=0.02 kg** | **∆θ=0.1309 rad** |
| **θ (rad)** | **t (s)** | **∆t (s)** | **w=∆θ/∆t(rad/s)** |
| **1.047198** | **1.422** | **0.069** | 1.897101 |
| **1.570796** | **2.261** | **0.055** | 2.38 |
| **2.094395** | **2.721** | **0.050** | 2.618 |
| **3.141593** | **2.862** | **0.042** | 3.116667 |
| **4.18879** | **3.961** | **0.037** | 3.537838 |
| **4.712389** | **4.302** | **0.040** | 3.2725 |
| **6.283185** | **4.595** | **0.027** | 4.848148 |
|  | | | | |
| **part2a** | **r=0.03 m** | **θ=π** |  |  |
| **m (kg)** | **t (s)** | **∆t** | **w=∆θ/∆t (rad/s)** | **α=2θ/t^2** |
| **0.01** | **4.922** | **0.222** | 0.58964 | 0.259225 |
| **0.015** | **3.562** | **0.204** | 0.641667 | 0.494962 |
| **0.02** | **3.096** | **0.170** | 0.77 | 0.655176 |
| **0.025** | **2.646** | **0.163** | 0.803067 | 0.896974 |
|  | | | | |
| **part 2b** | **m=15g** | **θ=π** |
| **r (m)** | **t (s)** | **∆t (s)** |
| **0.015** | **5.097** | **0.345** |
| **0.03** | **3.562** | **0.204** |
| **0.045** | **3.464** | **0.130** |

**Data analysis:**

**Part 1:Measurment of Ѳ and w as a function of time :**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **part 1** | **r=0.03 m** | | | **m=0.02 kg** | | **∆θ=0.1309 rad** | |  | | |
| **θ (rad)** | | **t (s)** | **∆t (s)** | | **w=∆θ/∆t(rad/s)** | | **log θ** | | **log w** | **log t** | |
| **1.047198** | | **1.422** | **0.069** | | 1.897101 | | **0.020029** | | 0.278091 | 0.1529 | |
| **1.570796** | | **2.261** | **0.055** | | 2.38 | | **0.19612** | | 0.376577 | 0.354301 | |
| **2.094395** | | **2.721** | **0.050** | | 2.618 | | **0.321059** | | 0.41797 | 0.434729 | |
| **3.141593** | | **2.862** | **0.042** | | 3.116667 | | **0.49715** | | 0.49369 | 0.45667 | |
| **4.18879** | | **3.961** | **0.037** | | 3.537838 | | **0.622089** | | 0.548738 | 0.597805 | |
| **4.712389** | | **4.302** | **0.040** | | 3.2725 | | **0.673241** | | 0.51488 | 0.63367 | |
| **6.283185** | | **4.595** | **0.027** | | 4.848148 | | **0.79818** | | 0.685576 | 0.662286 | |

**The slope = 1.5157**

**Ѳ(t)=1/2 mgr t2/I=1/2αt2**

**logѲ=log(α/2)+2log t**

**from log Ѳ vs log t, slope should be 2**

**experimental slope = 1.5**

**W(t)=1/2 mgr \* t/I = αt**

**Log w= log α+ log t**

**From logw vs log t ,slope should be 1**

**Experimental slope =0.68**

**I=10^(-0.1559)\*1/2(mgr)**

**I=0.002053 ± 0.0011 (Kg.m2)**

**Part 2a:dependence of the angular acceleration on the applied torque .**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **part2a** | **r=0.03 m** | **θ=π** |  | |  |  |
| **m (kg)** | **t (s)** | **∆t** | **w=∆θ/∆t (rad/s)** | | **α=2θ/t^2** | **F (N)** |
| **0.01** | **4.922** | **0.222** | 0.58964 | | 0.259225 | **0.098** |
| **0.015** | **3.562** | **0.204** | 0.641667 | | 0.494962 | **0.147** |
| **0.02** | **3.096** | **0.170** | 0.77 | | 0.655176 | **0.196** |
| **0.025** | **2.646** | **0.163** | 0.803067 | | 0.896974 | **0.294** |
| **part 2b** | **m=15g** | **θ=π** |
| **r (m)** | **t (s)** | **∆t (s)** | **α=2θ/t^2** |
| **0.015** | **5.097** | **0.345** | 0.24173 |
| **0.03** | **3.562** | **0.204** | 0.494962 |
| **0.045** | **3.464** | **0.130** | 0.523364 |

**Α=2Ѳ/t2 α=mgr/I**

**α vs F (mg ) ,slope = r/I**

**0.308=0.03/I 🡪 I= 0.097**

**∆I/I=∆slope/slope+∆r/r 🡪∆I=0.0002**

**α=2Ѳ/t2 α=mgr/I**

**α vs r, slope = mg/I**

**9.387=0.015\*9.8/I 🡪 I= 0.01566 (Kg.m2)**

**∆I/I=∆slope/slope+∆m/m 🡪∆I=0.0009**

**Results :**

|  |  |
| --- | --- |
| **I (Kg.m2)** | **∆I (Kg.m2)** |
| **0.00205** | **0.0011** |
| **0.0970** | **0.0002** |
| **0.0157** | **0.0009** |

**I(avg) =0.03824 ± 0.0016 (Kg.m2)**

**Log Ѳ vs log t , slope =2 , experimentally =1.55**

**Log w vs logt ,slope =1 experemintally =0.68**

**Discussion of results:**

**The slopes of the curves of the studied relationships between the variables under studying were positive indicating that the studied variables are directly proportional to what its being compared with .**

**The sources of error can be due to un exact fixation of the angles or the scattering of the light of the sensory by the air .**

**Conclusion :**

1. **The variation of the angel of rotation with time.**

**As the angel of rotation increased so did the time so they are directly proportional to each other .**

1. **The variation angular velocity with time :as the time increased the angular velocity increased .**
2. **The dependence of the angular acceleration on the applied torque**

**As the mass increased increasing the torque the angular acceleration also increased ,also by manipulating the size of the radius as the radius increased increasing the torque the angular acceleration increases .**