



Physics Lab 211

Experiment No. 10

Torque and Angular Momentum

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Date: July 19, 2018

Data Sheet:

Part I:

$$r = 0.03 \text{ m}$$

$$m = 0.02 \text{ kg}$$

θ (rad)	$\pi/3$	$\pi/2$	$2\pi/3$	π	$4\pi/3$	$3\pi/2$	2π
t (s)	1.808	2.396	3.062	3.627	3.936	4.169	5.199
Δt (s)	0.285	0.23	0.201	0.168	0.136	0.126	0.113
$\omega = \frac{\Delta\theta}{\Delta t}$ (rad/s)	0.919	1.138	1.302	1.558	1.925	2.078	2.317

Part II:

$$r = 0.03 \text{ m}$$

$$\theta = \pi$$

$mass$ (g)	10	15	20	25	30
t (s)	5.197	4.517	3.531	3.179	3.003
Δt (s)	0.259	0.193	0.164	0.145	0.130
ω (rad/s)	1.011	1.356	1.596	1.806	2.014
α (rad/s ²)	0.233	0.308	0.504	0.622	0.697

Part III:

$$\theta = \pi$$

$$m = 0.015 \text{ Kg}$$

<i>Radius (m)</i>	0.015	0.03	0.045
<i>t (s)</i>	9.800	4.517	3.456
<i>Δt (s)</i>	0.255	0.205	0.158
<i>ω (rad/s)</i>	1.027	1.277	1.657
<i>α (rad/s²)</i>	0.065	0.308	0.526

Calculations:

From part I:

a- Graph I ($\log(\theta)$ vs. $\log(t)$):

$$\theta = \frac{1}{2} \frac{mgr}{I} t^2 = \frac{1}{2} \alpha t^2 \rightarrow \log(\theta) = \log\left(\frac{1}{2} \alpha t^2\right)$$

$$\log(\theta) = \log\left(\frac{1}{2}\right) + \log(\alpha) + \textcircled{2} \log(t)$$



$$\text{slope} = 1.78 \cong 2$$

$$\text{y_intercept} = -0.470 = -0.301 + \log(\alpha) \rightarrow \log(\alpha) = -0.169$$

$$\alpha = 0.678 = \frac{mgr}{I_1} \rightarrow I_1 = \frac{mgr}{0.678} = \frac{0.02 \times 9.8 \times 0.003}{0.678} = 8.673 \times 10^{-3} \text{ kg.m}^2$$

$$\frac{\Delta I_1}{I_1} = \ln 10 \times \Delta \text{y_int} \rightarrow \Delta_1 = (\ln 10 \times \Delta \text{y_int}) \times I_1$$

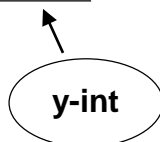
$$= (\ln 10 \times 0.063) \times 8.673 \times 10^{-3} = 1.2 \times 10^{-3} \text{ kg.m}^2$$

$$I_1 = (8.673 \pm 1.2) \times 10^{-3} \text{ kg.m}^2$$

b- Graph I ($\log(\omega)$ vs. $\log(t)$):

$$\omega = \frac{mgr}{I} t = \alpha t \rightarrow \log(\omega) = \log(\alpha t)$$

$$\log(\theta) = \log(\alpha) + \log(t)$$



$$\text{slope} = 0.93 \cong 1$$

$$\text{y_intercept} = -0.294 = \log(\alpha) \rightarrow \log(\alpha) = 0.508$$

$$\alpha = 0.508 = \frac{mgr}{I_2} \rightarrow I_2 = \frac{mgr}{0.508} = \frac{0.02 \times 9.8 \times 0.003}{0.508} = 11.575 \times 10^{-3} \text{ kg.m}^2$$

$$\frac{\Delta I_2}{I_2} = \ln 10 \times \Delta y_{int} \rightarrow \Delta I_2 = (\ln 10 \times \Delta y_{int}) \times I_2$$

$$= (\ln 10 \times 0.045) \times 11.575 \times 10^{-3} = 1.2 \times 10^{-3} \text{ kg.m}^2$$

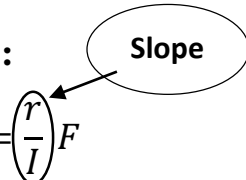
$$I_2 = (11.575 \pm 1.2) \times 10^{-3} \text{ kg.m}^2$$

$$\Delta I_{avg(1)} = \frac{\sigma_s}{\sqrt{2}} = \frac{2.052}{\sqrt{2}} = 1.451$$

$$\rightarrow I_{avg(1)} = (10.1 \pm 1.4) \times 10^{-3} \text{ kg.m}^2$$

From part II:

Graph I (α vs. F):



$$Slope = 2.535 = \frac{r}{I_3} \rightarrow I_3 = \frac{r}{2.535} = \frac{0.03}{2.535} = 11.834 \times 10^{-3} \text{ kg.m}^2$$

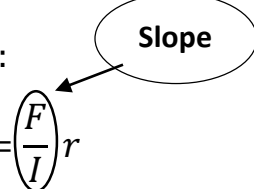
$$\frac{\Delta I_3}{I_3} = \frac{\Delta slope}{slope} = \frac{0.233}{2.535} = 0.092$$

$$\rightarrow \Delta I_3 = 0.092 \times I_3 = 0.092 \times 11.834 \times 10^{-3} = 1.089 \times 10^{-3} \text{ kg.m}^2$$

$$I_3 = (11.834 \pm 1.089) \times 10^{-3} \text{ kg.m}^2$$

From part III:

Graph I (α vs. r):



$$Slope = 15.354 = \frac{F}{I_4} \rightarrow I_4 = \frac{F}{15.354} = \frac{0.015 \times 9.8}{15.354} = 9.574 \times 10^{-3} \text{ kg.m}^2$$

$$\frac{\Delta I_4}{I_4} = \frac{\Delta slope}{slope} = \frac{0.470}{15.354} = 0.031$$

$$\rightarrow \Delta I_4 = 0.031 \times I_4 = 0.031 \times 9.574 = 0.297 \times 10^{-3} \text{ kg.m}^2$$

$$I_4 = (9.574 \pm 0.297) \times 10^{-3} \text{ kg.m}^2$$

$$I_{avg(2)} = 10.7 \times 10^{-3} \text{ kg.m}^2$$

$$\Delta I_{avg(2)} = \frac{\sigma_s}{\sqrt{2}} = \frac{1.598}{\sqrt{2}} = 1.13$$

$$\rightarrow I_{avg(2)} = (10.7 \pm 1.1) \times 10^{-3} \text{ kg.m}^2$$

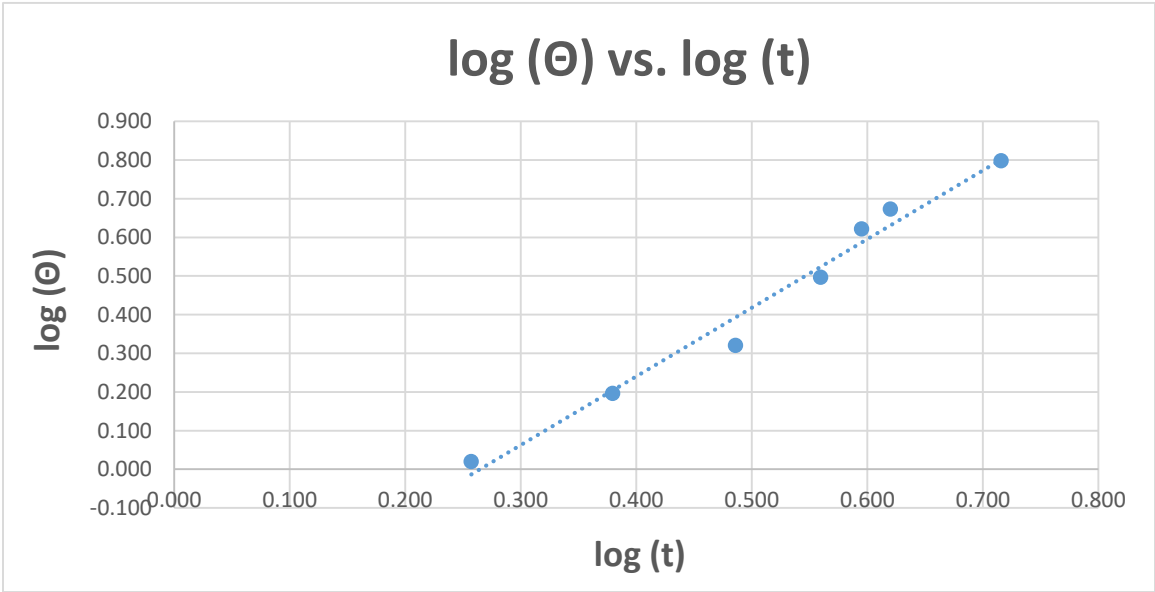
$$I_{avg} = 10.4 \text{ kg.m}^2$$

$$\Delta I_{avg} = \frac{\sigma_s}{\sqrt{2}} = \frac{1.538}{\sqrt{2}} = 0.8 \times 10^{-3} \text{ kg.m}^2$$

$$I_{avg} = (10.4 \pm 0.8) \times 10^{-3} \text{ kg.m}^2$$

GRAPH I

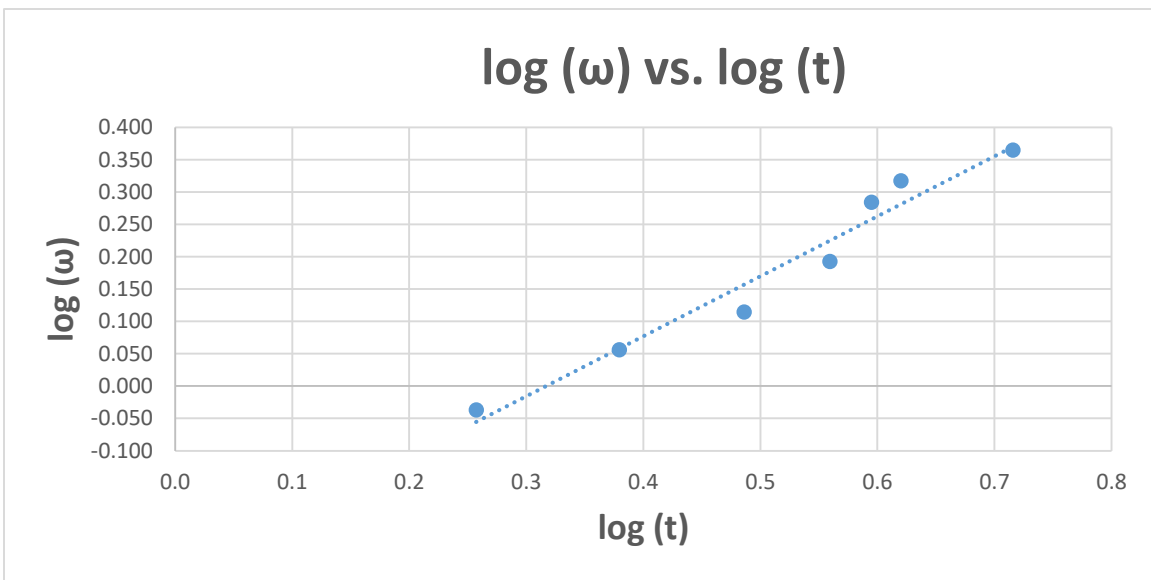
<i>log (t)</i>	<i>log (θ)</i>
0.257	0.020
0.379	0.196
0.486	0.321
0.560	0.497
0.595	0.622
0.620	0.673
0.716	0.798



	Slope	y-intercept
	1.7758428	-0.469813
error	0.11782	0.063143

GRAPH II

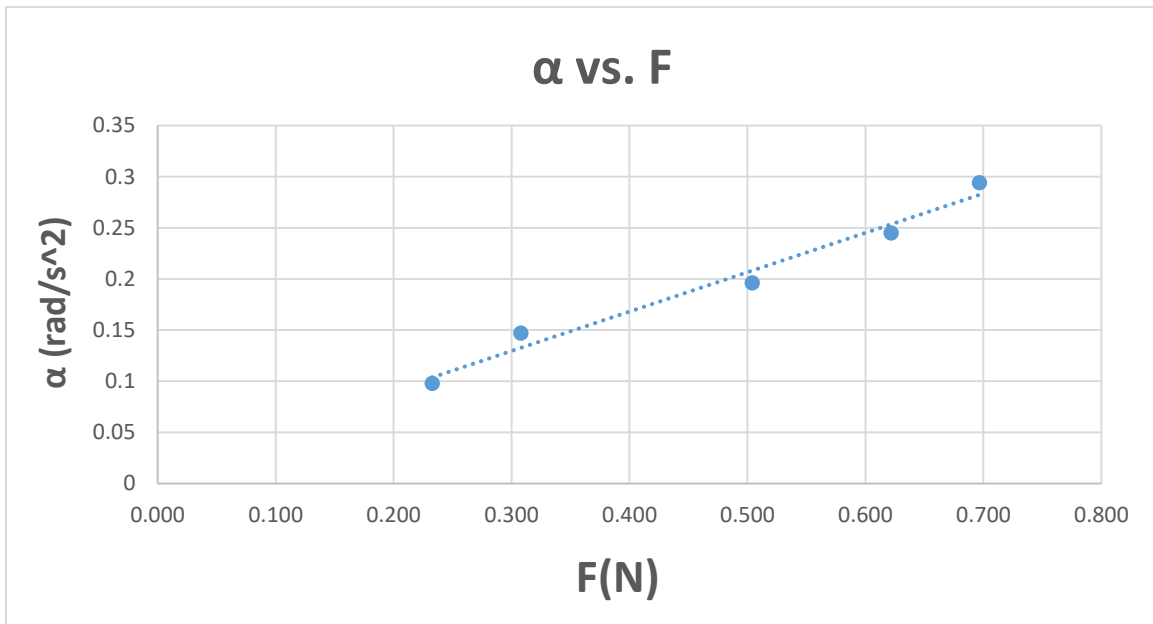
$\log(t)$	$\log(\omega)$
0.257	-0.037
0.379	0.056
0.486	0.115
0.560	0.193
0.595	0.284
0.620	0.318
0.716	0.365



	Slope	y-intercept
	0.9285509	-0.294481
error	0.0847144	0.045401

GRAPH III

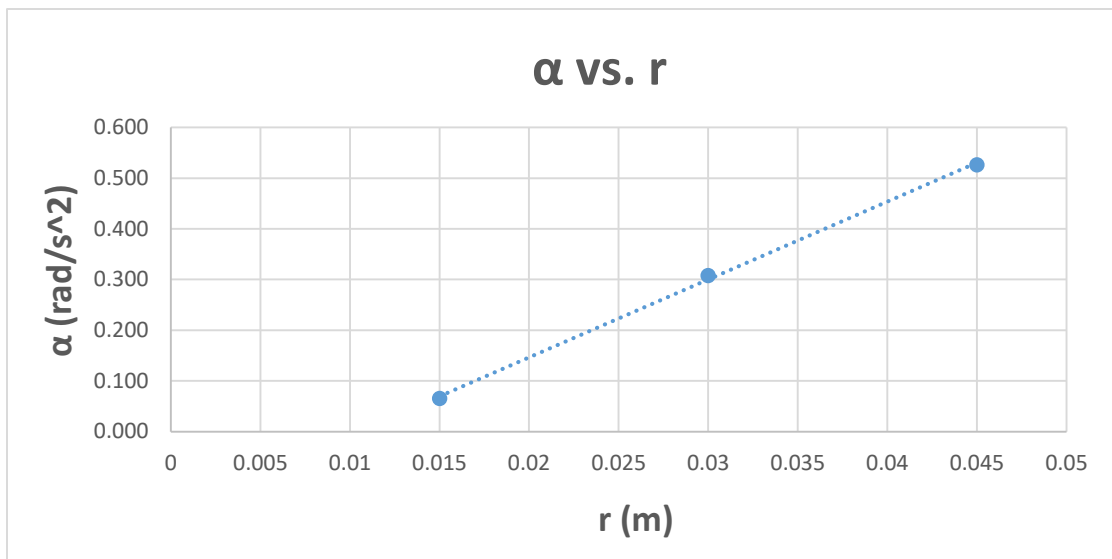
α (rad/s ²)	F(N)
0.233	0.098
0.308	0.147
0.504	0.196
0.622	0.245
0.697	0.294



	Slope	y-intercept
	2.534657	-0.024194
error	0.232687	0.048373

GRAPH IV

r (m)	α (rad/s ²)
0.015	0.065
0.03	0.308
0.045	0.526



	Slope	y-intercept
	15.35446	-0.160824
error	0.469966	0.0152286