BIRZEIT UNIVERSITY

Physics Lab 211

Experiment No. 10

Torque and Angular Momentum

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Data Sheet:

Part I:

$r = 0.03\ m$

$m = 0.02\ kg$

$\theta\ (rad)$	$\pi/3$	$\pi/2$	$2\pi/3$	π	$4\pi/3$	$3\pi/2$	2π
$t\ (s)$	1.808	2.396	3.062	3.627	3.936	4.169	5.199
$\Delta t\ (s)$	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:

$r = 0.03\ m$

$\theta = \pi$

$mass\ (g)$	10	15	20	25	30
$t\ (s)$	5.197	4.517	3.531	3.179	3.003
$\Delta t\ (s)$	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:

$\boldsymbol{\theta = \pi}$

$\boldsymbol{m = 0.015\ Kg}$

$\boldsymbol{Radius\ (m)}$	$\mathbf{0.015}$	$\mathbf{0.03}$	$\mathbf{0.045}$
$\boldsymbol{t\ (s)}$	9.800	4.517	3.456
$\boldsymbol{\Delta t\ (s)}$	0.255	0.205	0.158
$\boldsymbol{\omega\ (rad/s)}$	1.027	1.277	1.657
$\boldsymbol{\alpha\ \ (rad/s^2)}$	0.065	0.308	0.526

Calculations:

From part I:

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

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

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

y-int

slope

$slope = 1.78\ \cong 2$

$y\_intercept = -0.470 = -0.301 + \log(\alpha) \rightarrow \log(\alpha) = -0.169$

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

$$\frac{\Delta I_1}{I_1} = \ln 10\ \times \Delta y\_int\ \rightarrow \Delta_1 = (\ln 10\ \times \Delta y\_int) \times I_1$$

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

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

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

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

$$\boldsymbol{log(\theta) = \underline{log(\alpha)} + log(t)}$$

y-int

$slope = 0.93\ \cong 1$

$y\_intercept = -0.294 = \log(\alpha) \rightarrow \log(\alpha) = 0.508$

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

$$\frac{\Delta I_2}{I_2} = \ln 10 \times \Delta y\_int \rightarrow \Delta I_2 = (\ln 10 \times \Delta y\_int) \times I_2$$

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

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

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

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

From part II:

Graph I ($\boldsymbol{\alpha\ vs.\ F}$):

Slope

$$F \times r = I\alpha \rightarrow \alpha = \left(\frac{r}{I}\right) F$$

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

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

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

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

From part III:

Graph I ($\boldsymbol{\alpha\ vs.\ r}$):

Slope

$$F \times r = I\alpha \rightarrow \alpha = \left(\frac{F}{I}\right) r$$

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

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

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

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

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

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

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

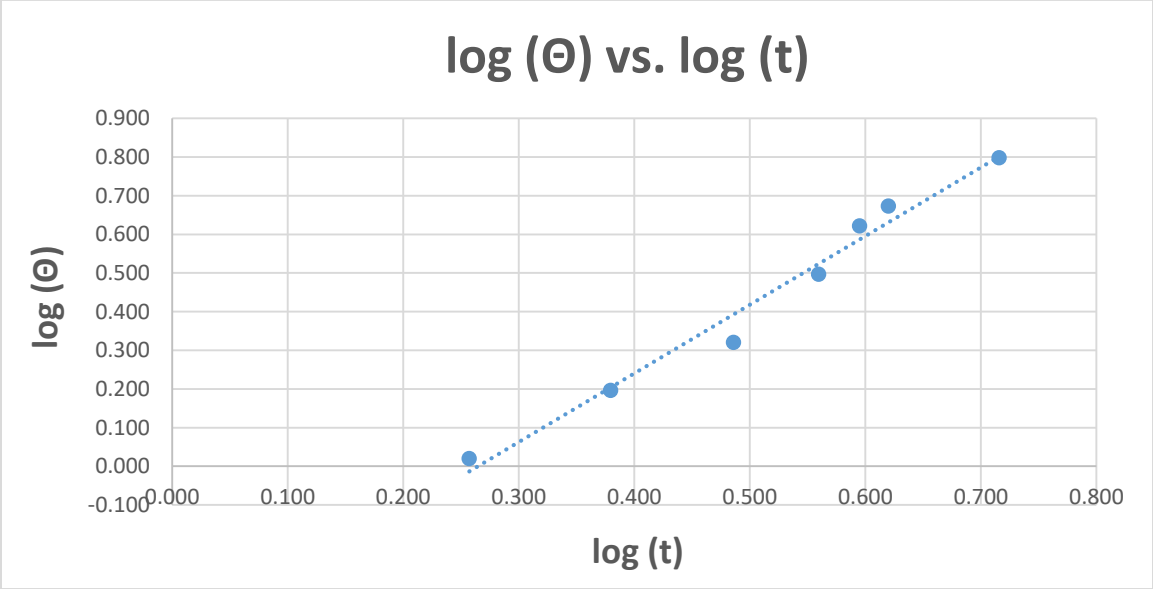
$I_{avg} = 10.4\ kg.m^2$

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

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

GRAPH I

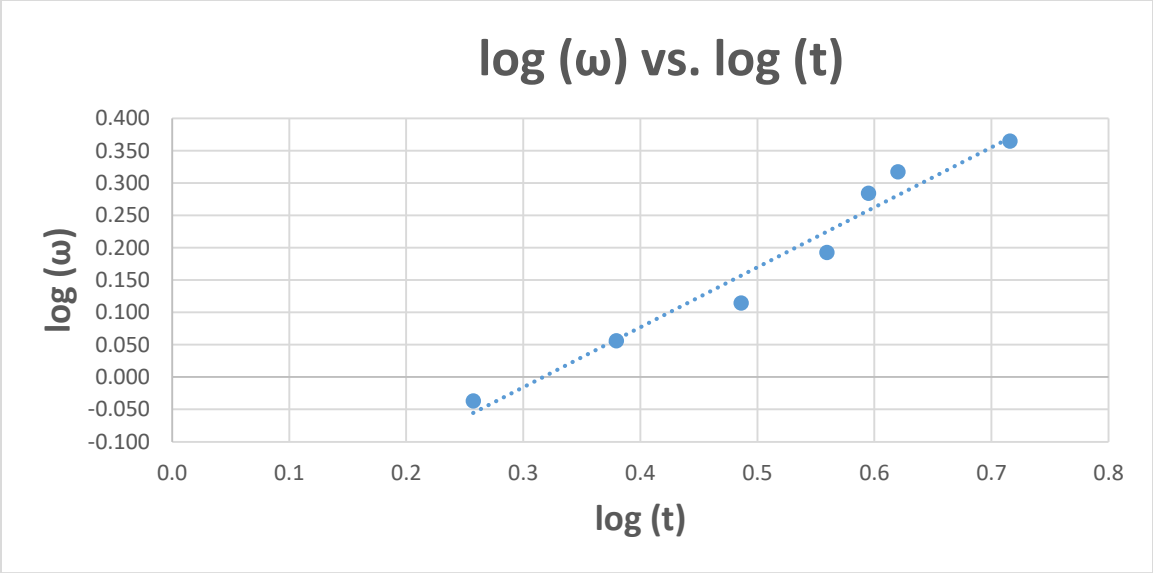
$log\ (t)$	$log\ (\Theta)$
0.257	0.020
0.379	0.196
0.486	0.321
0.560	0.497
0.595	0.622
0.620	0.673
0.716	0.798



	Slope	y-intercept
	1.7758428	-0.469813
error	0.11782	0.063143

GRAPH II

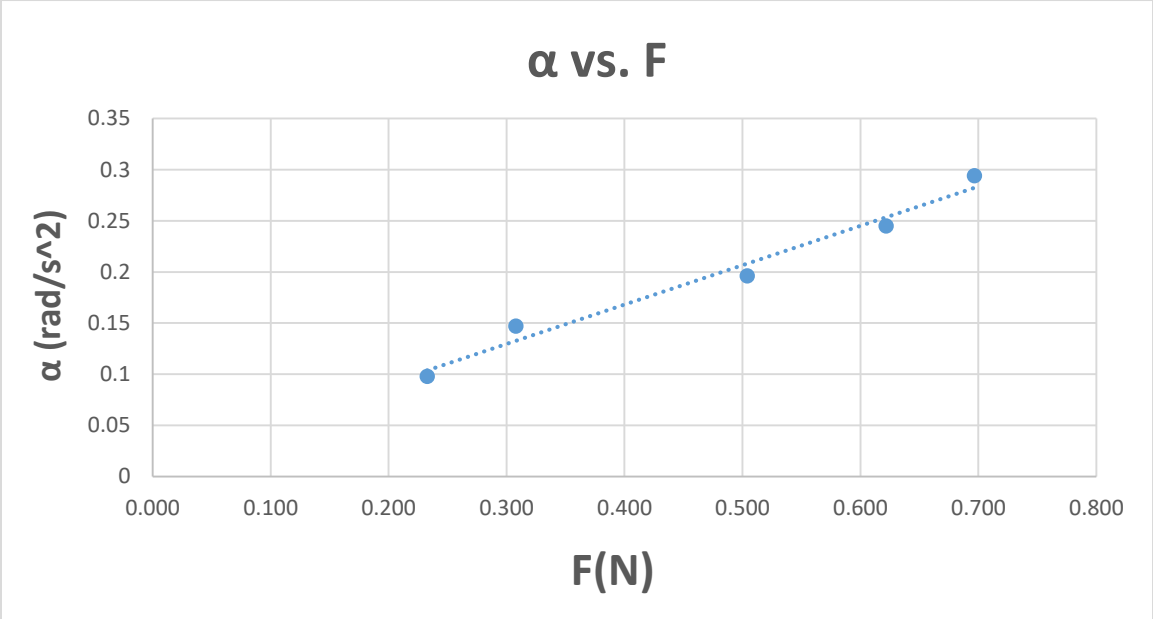
$log\ (t)$	$log\ (\omega)$
0.257	-0.037
0.379	0.056
0.486	0.115
0.560	0.193
0.595	0.284
0.620	0.318
0.716	0.365



	Slope	y-intercept
	0.9285509	-0.294481
error	0.0847144	0.045401

GRAPH III

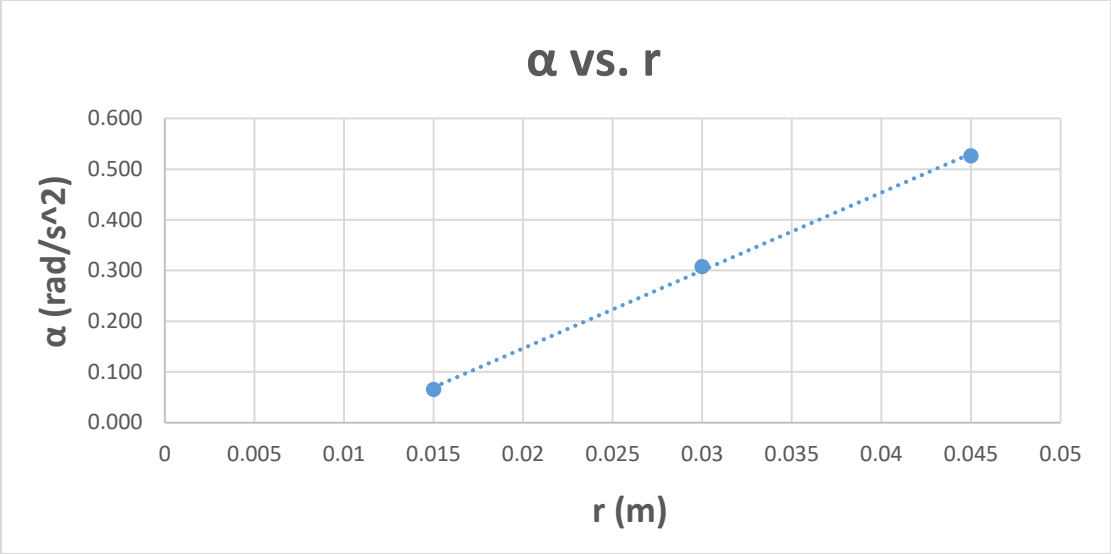
$\alpha\ (rad/s^2)$	F(N)
0.233	0.098
0.308	0.147
0.504	0.196
0.622	0.245
0.697	0.294



	Slope	y-intercept
	2.534657	-0.024194
error	0.232687	0.048373

GRAPH IV

$r\ (m)$	$\alpha\ (rad/s^2)$
0.015	0.065
0.03	0.308
0.045	0.526



	Slope	y-intercept
	15.35446	-0.160824
error	0.469966	0.0152286