Pre-Lab Report

Lab section:

Name & Surname:

Table # :

***Before the Lab* complete this page YOURSELF! Hand it in *in the first 5 min*. of the session PERSONALLY!**

You MUST justify your answers and show all steps. NO COPYCAT answers, or NO credits!

Please read the relevant presentation on PHYS LAB Website.

Q1. In this experiment, a simple pendulum is going to be studied. **Justify your answers, show calculations if needed or no credits!**

a. What are the possible sources of systematic errors in this experiment? Answer this question with respect to the classification in your book.

b. At what point of its swing, does the ball have its maximum velocity? Maximum acceleration?

c. Assume that your pendulum passes through its equilibrium point every second. What is the period of this pendulum? What must be the length of this pendulum?

(2nd Question is on the next page!)

Q2. Imagine that you are performing the simple pendulum experiment on the Moon. The data you collected is presented below:

L_1= 170,0 cm t_1= 20,41sec
L_2= 175,4 cm t_2= 20,75 sec
L_3= 182,3 cm t_3= 21,03 sec

where t_i is the period for 10 oscillations. Calculate the gravitational acceleration for each measured data and take the average of these 3 values.

Write what you have found for the average gravitational acceleration on the Moon to the box below with correct significant figures and units.

Show your calculations below explicitly or no credits!

1

Lab Report

Lab section:

Name & Surname:

Table #:

***Complete this report YOURSELF except DATA taking parts! Use a pencil for plots only and a pen for the rest!* Show your work clearly, NO COPYCAT analysis allowed, or NO credits!**

OBJECTIVE : To study the motion of a simple pendulum and to determine the acceleration due to gravity using a simple pendulum.

THEORY : For small angular displacements less than about ten degrees, it can be shown that the motion of a point mass attached to the end of a string of length L is a periodic motion with the period:

$$T = 2\pi\sqrt{\frac{L}{g}}$$

We can calculate the gravitational acceleration, g, if we measure the length of the string and the period of oscillations:

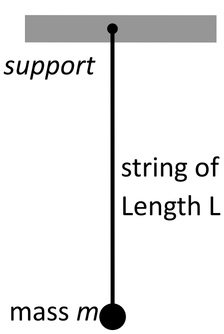
$$g = 4\pi^2 \frac{L}{T^2}$$

APPARATUS : A string of length L, a stopwatch, a metal ball and a meter stick.

PROCEDURE :

- Choose an initial length for the pendulum which should not be less than 120.0 cm.

- Set the pendulum into oscillation making sure that the maximum amplitude is less than ten degrees.



- Measure the time, t, for 10 complete oscillations using a chronometer and determine the period, T, corresponding to the chosen length. Use all the significant figures provided by your device.
- Repeat this for 4 more length values. Calculate g for each measurement.
- Take the average of 5 values you have calculated and compare it with the theoretical value.

2

DATA-TAKING

Description	Symbol		Value & Unit
Acceleration due to gravity	g_{TV}	=	9.808 m/s^2
Number of Oscillations	N	=	10

Length of Pendulum *L* ( )	*10 periods* *t* ( )	*One Period* *T* ( )

3

CALCULATIONS & RESULTS

Symbol		Calculations (show each step)	Result & Unit
g_1	=	. . . .	. . . .
g_2	=	. . . .	. . . .
g_3	=	. . . .	. . . .
g_4	=	. . . .	. . . .
g_5	=	. . . .	. . . .
$g_{average}$	=	. . . .	. . . .

% Deviation for *g*: . . . .

. . . .

Consult to the resources for this experiment from PHYS LAB Website:

PHYL101 Intro

Presentation #1

PHYL101 Lab Book

Pre-Lab Report

Lab section:

Name & Surname:

Table # :

***Before the Lab* complete this page YOURSELF! Hand it in *in the first 5 min*. of the session PERSONALLY!**

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Please read the relevant presentation on PHYS LAB Website.

In this experiment the idea of average velocity is important. Be careful while fitting the time data! The average velocity data should be fitted at the middle of time values.

Q1. Should the masses of the washers, which are placed on the hanger to overcome the friction, be added to the total mass? Why? **Justify your answer or no credits!**

(2nd Question is on the next page!)

Q2. If the velocity versus time graph does not pass through the origin, what is the meaning of this nonzero y-intercept value physically? **Justify your answer or no credits!**

1

Lab Report

Lab section:

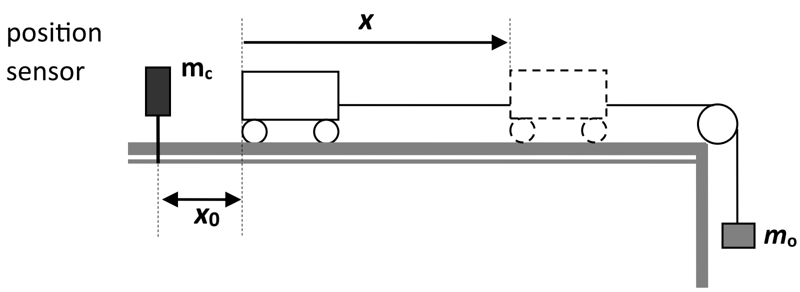
Name & Surname:

Table #:

***Complete this report YOURSELF except DATA taking parts! Use a pencil for plots only and a pen for the rest!* Show your work clearly, NO COPYCAT analysis allowed, or NO credits!**

OBJECTIVE : To measure the effect of force acting on a mass.

***THEORY* :** In this experiment, the motion of the car on a special track is studied. Masses are placed on the mass holder that is attached to the car. When the masses are released, they fall to the floor while applying a force on the cars due to the gravitation.



Acceleration of the car can be calculated from the Newton's Law:

$$M_{total} a = m_o g$$

$$a = \frac{m_o}{M_{total}} g$$

$$M_{total} = m_c + m_0$$

To measure the acceleration we have to record the motion of the mass+car system as a function of time. As you know, the velocity is the derivative of the position and the acceleration is the derivative of the velocity with respect to the time. So, if we know the position as a function of time, we can determine the velocity and the acceleration. However, it is difficult to record the position on a continuous base experimentally. We can only determine the position at specific times. Even though the velocity and the acceleration may not be constant, we can still determine the average velocity for a specific interval.

$$v_{average} = \Delta x / \Delta t$$

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Physics Department

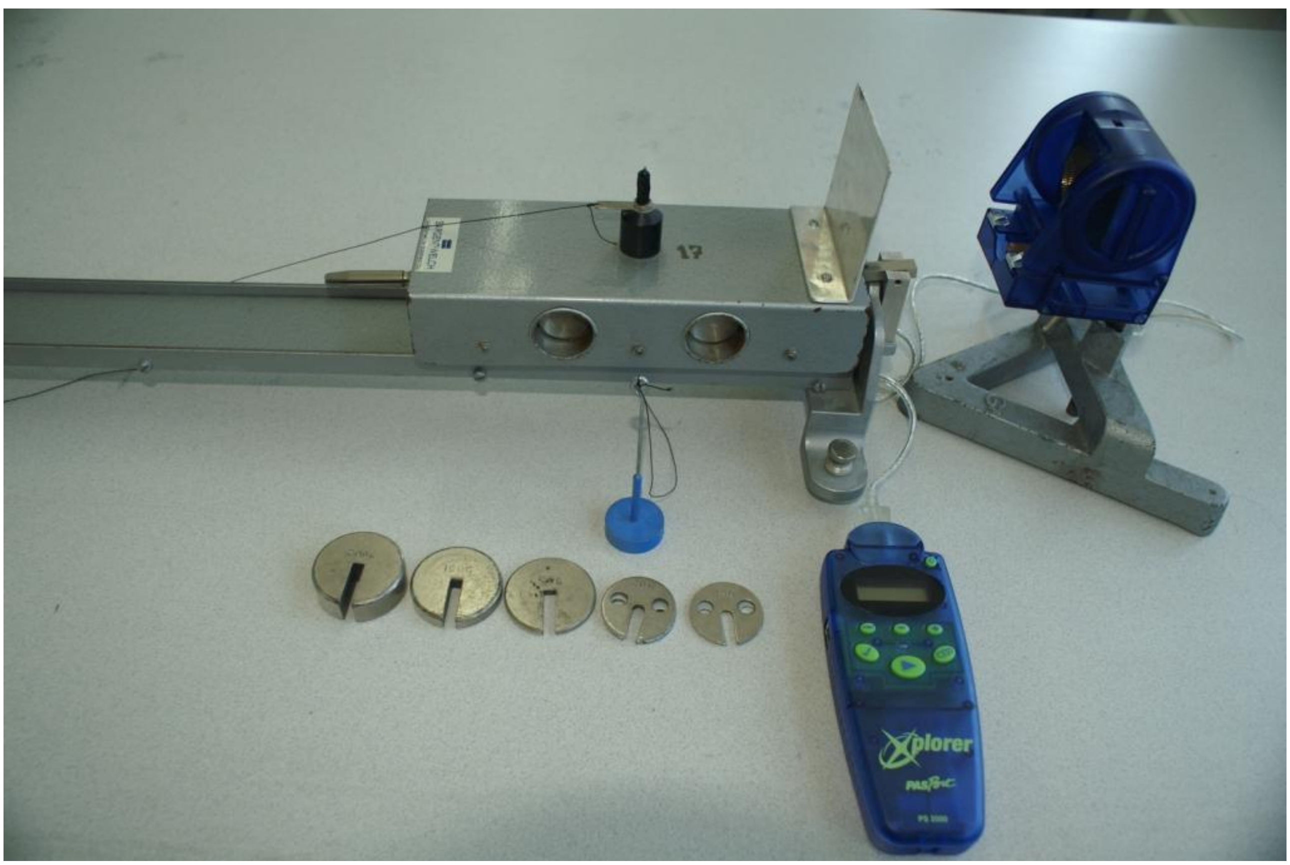
2

From the plot of the average velocity versus the time we can determine the acceleration by taking the derivative of the function defined by this graph.

APPARATUS : Car and track, masses with hanger, position sensor, data logger, balance.

PROCEDURE :

- You will be determining the positions with the help of a position sensor. The sensor works by sending ultrasound pulses forward and listening for the echoes. From the known speed of sound in the air and the time between the transmission and reception of the ultrasound signals, the data logger determines the distance to the sensor.
- Set the position sensor approximately 20 cm away from the car before releasing it.
- Adjust the data logger to an appropriate rate (suggested value is 10 per second) and compensate for the friction force.
- Place the given mass on the holder. Start the data logger and release the car. Stop the data logger when the mass holder hits the ground.



3

DATA-TAKING

- Using the up and down buttons on the data logger, read the position information in its memory and record the values in Table 2.1. (Consult to the appendix on page 7!)
- Measure the length of each interval and calculate the average velocity for each interval. Note them in Table 2.1
- On the graph paper given on the next pages, plot the average velocity versus time and determine the acceleration.

Description / Symbol	Value & Unit
Mass on the holder + mass of the holder m_o=	....
Initial distance of the Car x_0 =	....
Number of Cylinders in the Car =	....
Data Taking Rate =	....

4

t ( )	x ( )	Δx ( )	$V_{ave} = \Delta x / \Delta t$ ( )

Table2.1

5

6

CALCULATIONS & RESULTS

A) **From the line above, choose two SLOPE POINTS other than data points:**

SP_1 : (;)

SP_2 : (;)

B) **By using SP_1 and SP_2, calculate the slope and other quantities below:**

Description / Symbol		Calculations (show each step)	Result
SLOPE	=	. . . .	. . . .
		. . . .	
Acceleration a	=	. . . .	. . . .
Total Mass M_{total}	=	. . . .	. . . .
		. . . .	
Mass of the Car m_c	=	. . . .	. . . .
		. . . .	

APPENDIX: DATA LOGGER!

DATA LOGGER BUTTONS:

Mode Button: Switched between displays.

Arrow Button: Starts-stops data taking.

Plus-Minus Button: Switches between the elements of sub-menus.

Check Button: Alters the input values in sub-menus.

HOW TO USE THE DATA LOGGER:

1. Make sure data taking rate is 10 s^-1.
2. Make sure the device is in Position (m) mode.
3. Make sure the memory is clear. (You need to pick Data Memory sub-menu, then hit the Check Button, choose All Data Sets using the Plus and Minus Buttons and delete all data sets using the Check Button.)
4. Pick Position (m) sub-menu, if you hit Arrow Button it will start taking data, if you hit one more time it will stop.
5. Pick Review Set # 1 Position, hit the Check Button, then you will be able to view the data values.

Consult to the resources for this experiment from PHYS LAB Website:

PHYL101 Intro **Presentation #2** **PHYL101 Lab Book**

Pre-Lab Report

Lab section:

Name & Surname:

Table # :

***Before the Lab* complete this page YOURSELF! Hand it in *in the first 5 min*. of the session PERSONALLY!**

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Please read the relevant presentation on PHYS LAB Website.

Q1. What would the expression for uncertainty in the velocity that is Δv? Write an expression in terms of height and range values and their uncertainties. Consult page 28-29 in your book.

Q2. What are the possible sources of error in this experiment? Answer this question in terms of the classification given in your book. **Justify your answer or no credits!**

(3rd and 4th Questions are on the next page!)

Q3. In this experiment we are ignoring the effect of air friction. Assuming that the experiment is done in a very viscous liquid, discuss the effect of the friction due to the liquid on the motion of the ball. **Justify your answer or no credits!**

Q4. Assume that the ballistic pendulum is moving upward with a speed of v_b in the first part. Derive the equations for the range and the final velocity with which the ball strikes the floor. **Show your calculations below <u>explicitly or no credits</u>!**

1

Lab Report

Lab section:

Name & Surname:

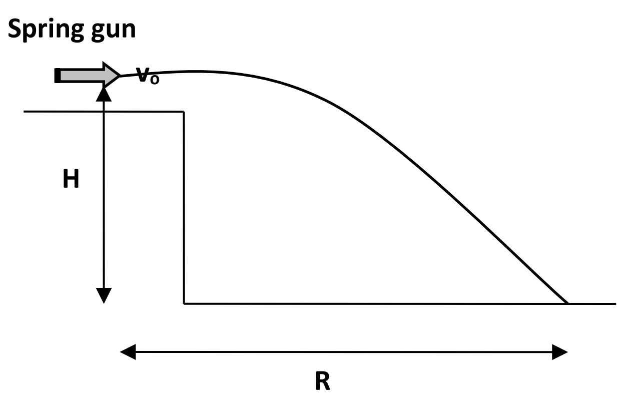
Table #:

***Complete this report YOURSELF except DATA taking parts! Use a pencil for plots only and a pen for the rest!* Show your work clearly, NO COPYCAT analysis allowed, or NO credits!**

OBJECTIVE : To study the fundamentals of projectile motion.

***THEORY* :** When the ball is shot with an initial speed v in the horizontal direction, its range will be

$$R = vt$$



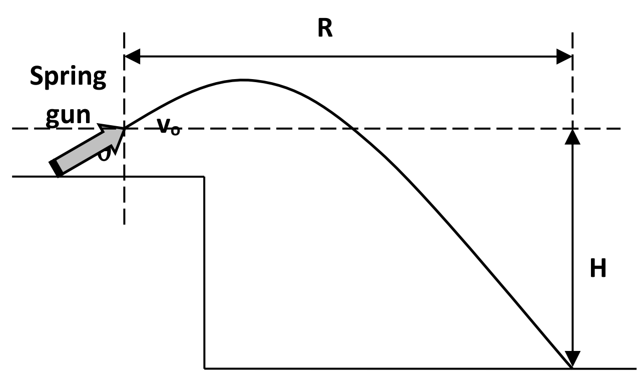
where t is the time of flight and it will be free falling. The height it falls down will determine the flight time:

$$H = \frac{1}{2}gt^2$$

By combining these two equations, we can determine the initial speed in terms of the range and the height:

$$v_o = R\sqrt{\frac{g}{2H}}$$

On the other hand, when the ball is shot at an angle θ, it will follow a parabolic trajectory:



It can be shown that the trajectory equation is

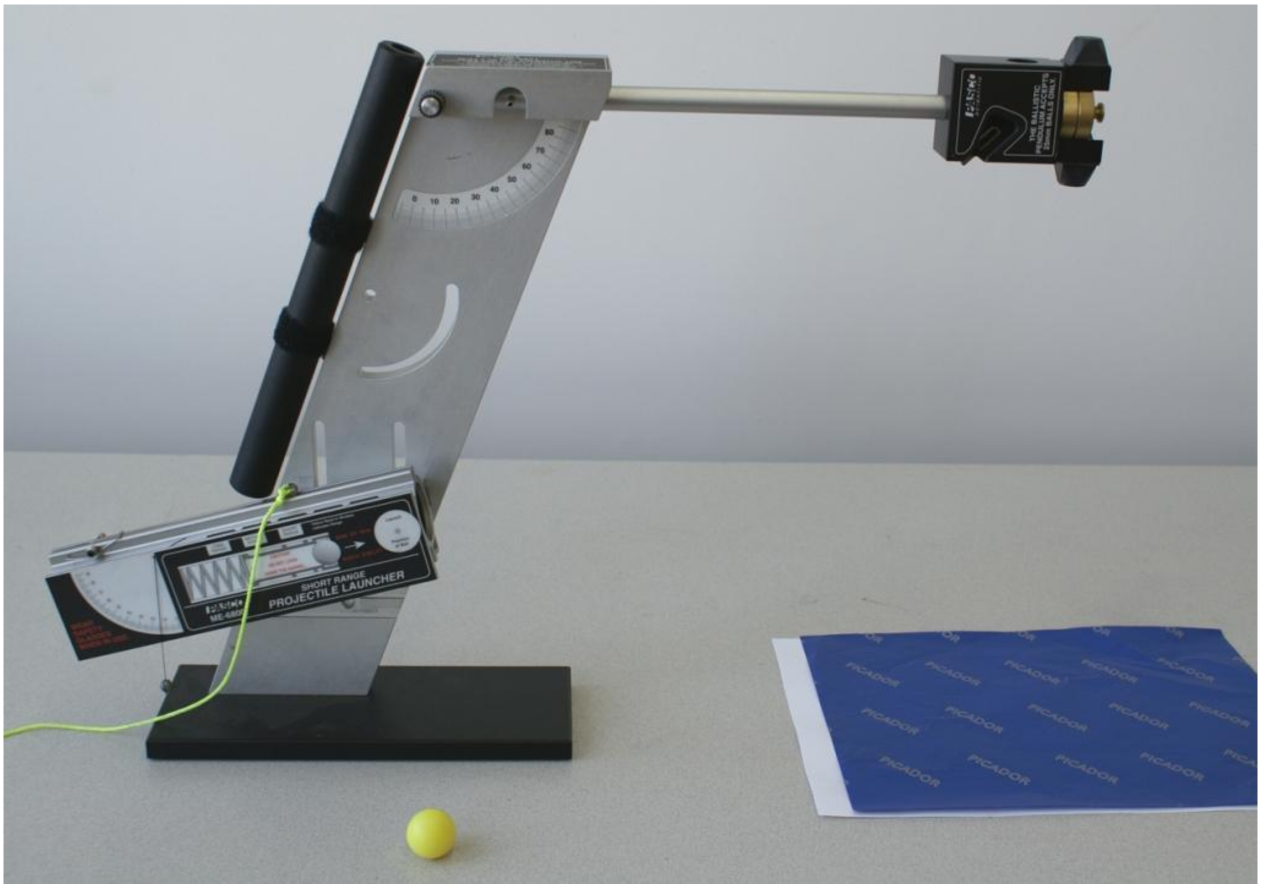
$$\frac{gR^2}{2v_o^2}\tan^2\theta - R\tan\theta + \left(\frac{gR^2}{2v_o^2} - H\right) = 0$$

2

APPARATUS : Ballistic pendulum with plastic ball, meter stick, balance, carbon paper.

PROCEDURE :

Part 1: The spring gun is leveled on the table and the plastic ball is projected horizontally. The initial velocity of the ball can be determined by measuring the range, R, and the initial height, H, of the ball.



Part 2: The spring gun is inclined at an angle θ with the horizontal and the ball is shot freely. Range, height and the initial velocity of the ball are used to calculate θ.

3

DATA & CALCULATIONS & RESULTS

PART 1 – HORIZONTAL MOTION

Description / Symbol			**Value & Unit**
Height	H	=	. . . .
Range (1st trial)	R_1	=	. . . .
Range (2nd trial)	R_2	=	. . . .
Average Range	R_{ave}	=	. . . .

Initial velocity

of the ball v_o = ...

4

PART 2 – PROJECTILE MOTION

Description and Symbol			Value & Unit
Height	H	=	. . . .
Range (1st trial)	R_1	=	. . . .
Range (2nd trial)	R_2	=	. . . .
Average Range	R_{ave}	=	. . . .
Measured Angle	θ_{MV}	=	. . . .

CALCULATIONS and RESULT:

Equation for θ :

$$\frac{gR^2}{2v_o^2}\tan^2\theta - R\tan\theta + \left(\frac{gR^2}{2v_o^2} - H\right) = 0$$

Solve for tanθ :

5

Description	Calculations (show each step)	Result & Unit
$Arctan\,\theta_{EV1}$ =	....	....
$Arctan\,\theta_{EV2}$ =	....	....

Chose the physically meaningful θ above as the experimental value and ignore the other one!

% Difference in θ experimental and measured values:

....

Consult to the resources for this experiment from PHYS LAB Website:

PHYL101 Intro

Presentation #3

PHYL101 Lab Book

Pre-Lab Report

Lab section:

Name & Surname:

Table # :

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You MUST justify your answers and show all steps. NO COPYCAT answers, or NO credits!

Please read the relevant presentation on PHYS LAB Website.

Q1. Give definitions of elastic and inelastic collisions. Compare them in terms of energy and momentum. **Justify your answer or no credits!**

Q2. At what height is half the kinetic energy converted into potential energy? Give your answer with respect to the maximum height H. **Show your calculations below explicitly or no credits!**

(3rd Question is on the next page!)

Q3. What are the possible sources of error in this experiment? Answer this question in terms of the classification in your book. **Justify your answer or no credits!**

1

Lab Report

Lab section:

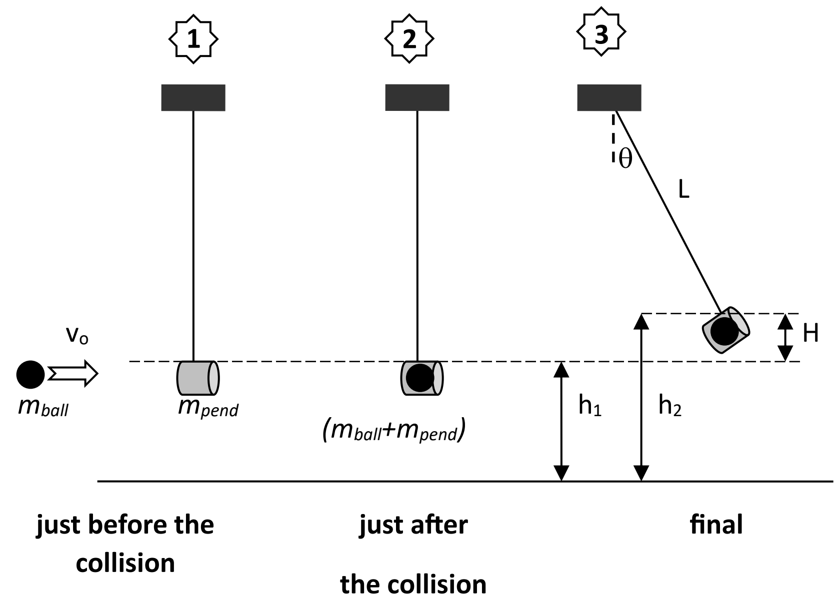
Name & Surname:

Table #:

***Complete this report YOURSELF except DATA taking parts! Use a pencil for plots only and a pen for the rest!* Show your work clearly, NO COPYCAT analysis allowed, or NO credits!**

OBJECTIVE : To study the principle of conservation of momentum, and by applying this principle to measure the initial velocity of a ball.

THEORY :



In this experiment we will study the conservation of momentum using the ballistic pendulum. When the steel ball is shot towards the pendulum attachment of the apparatus, it will hit and stay inside the pendulum attachment. This is an example of a completely inelastic collision. We can express the conservation of momentum during the collision as:

$$m_{ball} v_o = (m_{ball} + m_{pend}) v_{final} .$$

Since the pendulum attachment is free to swing up, it will do so until all its kinetic energy turns into the potential energy:

$$\frac{1}{2}(m_{ball} + m_{pend}) v^2{}_{final} = (m_{ball} + m_{pend}) gH$$

The pendulum attachment pushes a pointer as it swings up until it reaches the maximum. Using this maximum angle information and the length of the pendulum attachment, we can determine *H*:

$$H = L(1-\cos\theta)\,.$$

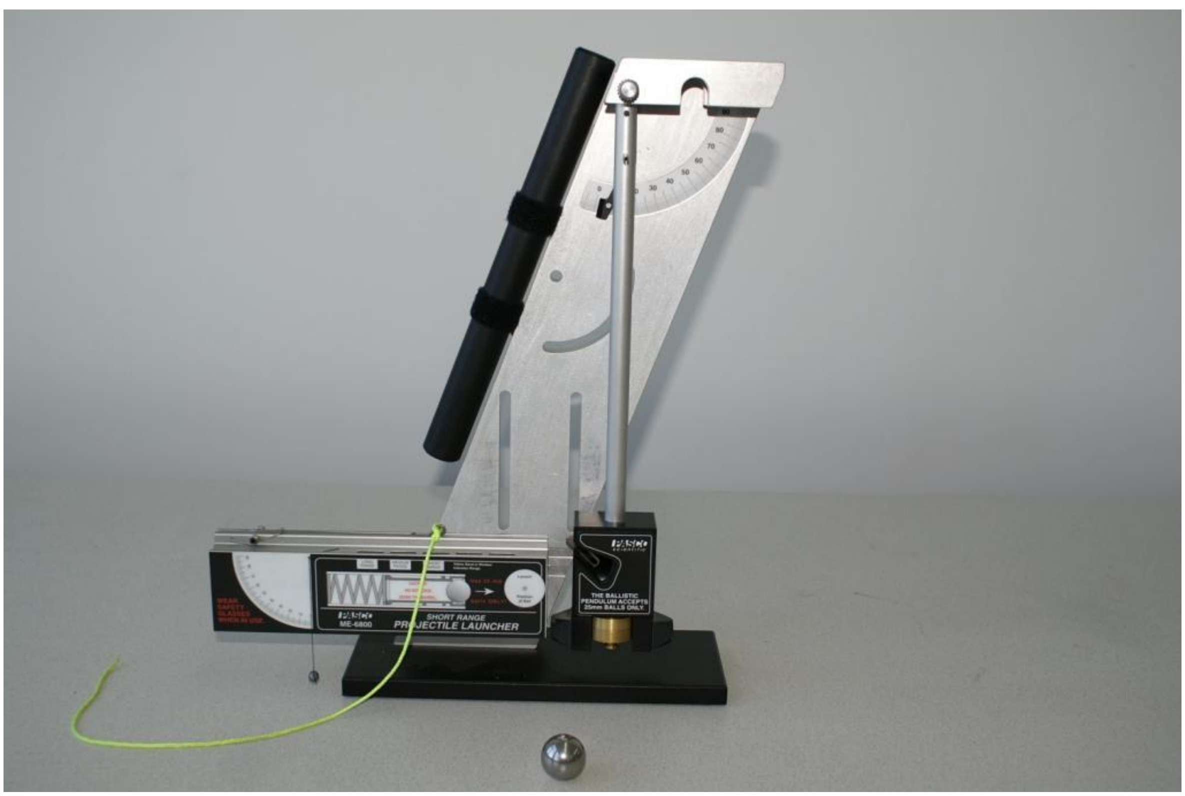
Then using this value and working backwards from the equations above, we can determine the initial velocity of the ball:

$$v_0 = \frac{m_{ball} + m_{pend}}{m_{ball}}\sqrt{2gH}$$

APPARATUS : Ballistic pendulum with the pendulum attachment, meter stick, balance, steel ball

PROCEDURE :

1. By equating the momentum before the collision to that after the collision, and equating the kinetic energy of the system just after the collision to the increase in potential energy at the height h_2, the initial velocity of the ball can be calculated.
2. Fire the ball into the pendulum two times for each compression level of the spring gun and determine the mean increase in height H. Do not forget to reset the angle pointer just before shooting the ball to the pendulum attachment. Calculate the initial velocity of the ball v_o for corresponding compression level.



3

DATA:

Description/Symbol			Value & Unit

Acceleration due to gravity g_{TV} = 9.81 m/s^2

Mass of the ball	m_{ball}	=	....
Mass of the pendulum	m_{pend}	=	....
Length of the pendulum	L	=	....

4

Short Range

Level of Compression	(i)	θ	$H = L(1-Cos\theta)$ ( )
Short Range Compression	1		
	2		
Average of H^{SR}		$\frac{1}{2}\sum_{i=1}^{2} H_i^{SR} =$	

Medium Range

Level of Compression	(i)	θ	$H = L(1-Cos\theta)$ ( )
Medium Range Compression	1		
	2		
Average of H^{MR}		$\frac{1}{2}\sum_{i=1}^{2} H_i^{MR} =$	

Long Range

Level of Compression	(i)	θ	$H = L(1-Cos\theta)$ ( )
Long Range Compression	1		
	2		
Average of H^{LR}		$\frac{1}{2}\sum_{i=1}^{2} H_i^{LR} =$	

5

CALCULATIONS & RESULTS

Description/Symbol		Calculations (show each step)	Result	Dimension
Velocity of the ball for SR				
$V_{SR\text{-}ave}$	=	....	....	....
		....		
Velocity of the ball for MR				
$V_{MR\text{-}ave}$	=	....	....	....
		....		
Velocity of the ball for LR				
$V_{LR\text{-}ave}$	=	....	....	....
		....		

Consult to the resources for this experiment from PHYS LAB Website:

PHYL101 Intro

Presentation #4

PHYL101 Lab Book

Pre-Lab Report

Lab section:

Name & Surname:

Table # :

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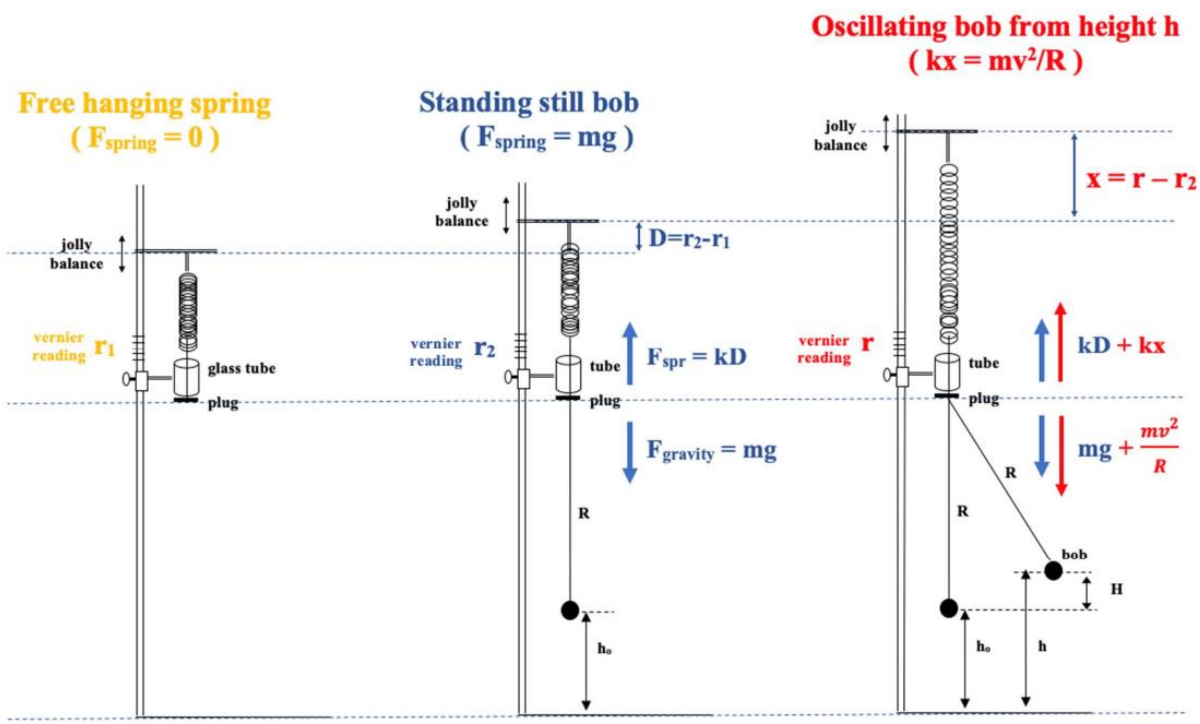
Please read the relevant presentation on PHYS LAB Website.

Q1. The below figure taken from the presentation describes the setup for Centripetal Acceleration.



Calculate R for the given values below and write the answer into the box below with correct significant figures and units. **Show your calculations below explicitly or no credits!**

r_1 =2.79 cm

r_2 =9.11 cm

r=11.01 cm

h_0 =50.9 cm

h=68.2 cm

Spring 2024

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Physics Department

PHYL 101

1

Lab Report

Lab section:

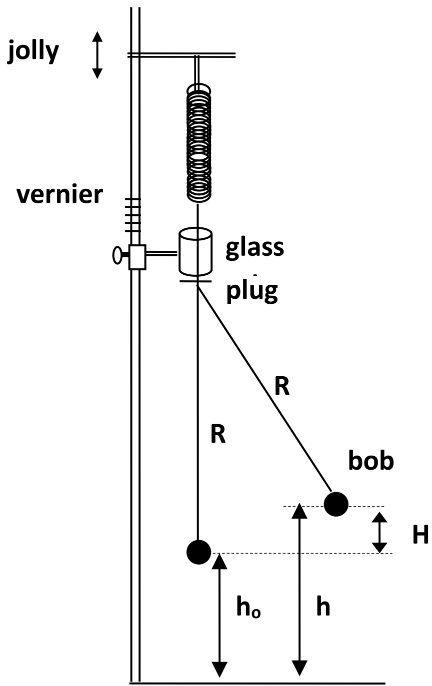
Name & Surname:

Table #:

***Complete this report YOURSELF except DATA taking parts! Use a pencil for plots only and a pen for the rest!* Show your work clearly, NO COPYCAT analysis allowed, or NO credits!**

OBJECTIVE : To study the motion of a body moving in a circle and verify the centripetal force equation.

THEORY :



A mass swinging at the end of a string does a circular motion. The mass undergoing a uniform circular motion has the acceleration given by

$$a_{cent} = \frac{v^2}{R} \quad (1)$$

where *R* is the length of the string. Since the velocity of the mass in a simple pendulum is not constant, the acceleration will be changing.

We will start the motion of the mass by releasing it from a height that we measure. When the ball passes through its lowest position, all the potential energy difference between the initial height and the lowest position will be converted into kinetic energy.

$$mgh = \frac{mv^2}{2} \quad (2)$$

Using the speed calculated from this expression, we can determine the acceleration at this position. The centripetal acceleration is usually caused by the tension in the string if the pendulum is just a string hanging from the ceiling.

$$F_{cent} = ma_{cent} \quad (3)$$

But we will hang the string from a spring to be able to measure the centripetal force. In this case the restoring force in the spring will be the centripetal force.

$$F_{rest} = kx = F_{cent} = \frac{mv^2}{R} \quad (4)$$

2

By combining Equations (2), (4), and the initial extension of the spring due to the mass of the bob:

$$mg = kD \tag{5}$$

we can get

$$\frac{mg}{D}x = \frac{2mgh}{R} \tag{6}$$

and

$$h = \frac{Rx}{2D}. \tag{7}$$

This is a straight line with a slope of $R/2D$. Hence, recording the height from which we release the bob and the corresponding extension of the spring, we can determine the slope by plotting the data. Then, we can calculate the length of the pendulum R and compare it with the measured value.

APPARATUS : Centripetal force apparatus, meter stick.

PROCEDURE :

1. Place the bob on the table.
2. To read r_1, adjust the jolly balance until the glass tube barely touches the shoulder of the plug.
3. Let the bob hang freely, pulling the spring down and adjust the jolly balance again until the glass tube barely touches the shoulder of the plug. Read r_2.
4. For the first measurement, extend the spring by a distance of 1.90 cm.
5. Find the height ***h***, so that it will pull the plug out of the tube by a distance of Δx cm when the bob swings through its equilibrium position. Since the elongation due to the centripetal force is $\Delta x \sim 0.10$ cm, total spring extension, ***x*** will be 2.00 cm.
6. Increase the spring extension at 2.00 cm increments, measure the corresponding ***h*** as a function of the spring extension.

7. Plot your data and determine the slope of the straight line that fits the data best.

DATA:

Description / Symbol			Value & Unit
Length of the pendulum	R_{TV}	=	. . . .
Height from the floor to the center of the bob	h_o	=	. . . .
Reading in vernier scale without the bob	r_1	=	. . . .
Reading in vernier scale with the bob	r_2	=	. . . .
Extension in the spring = $r_2 – r_1$ = due to bob	D	=	. . . .

Reading in vernier ***r* (　　　)**		**Total Extension in the spring** ***x* (　　　)**	**Height of the bob from floor** ***h* (　　　)**	***H = h – h*o** **(　　　)**

4

CALCULATIONS & RESULTS

5

A) From the graph, choose two SLOPE POINTS other than data points,

SP_1 : (;)

SP_2 : (;)

B) Calculate:

Symbol		Calculation (show each step)	Result	Dimension
Slope	=	. . . .	. . . .	. . . .
		. . . .		
R / 2*D*	=	. . . .	. . . .	. . . .
		. . . .		
R_{EV}	=	. . . .	. . . .	. . . .
		. . . .		

% Error for the Length of the Pendulum, *R*:. . . . .

Consult to the resources for this experiment from PHYS LAB Website:

PHYL101 Intro

Presentation #5

PHYL101 Lab Book

Pre-Lab Report

Lab section:

Name & Surname:

Table # :

***Before the Lab* complete this page YOURSELF! Hand it in *in the first 5 min*. of the session PERSONALLY!**

You MUST justify your answers and show all steps. NO COPYCAT answers, or NO credits!

Please read the relevant presentation on PHYS LAB Website.

Q1. Show the dimension analysis for inertia. **Show your derivation / formulae below explicitly or no credits!**

(2nd Question is on the next page!)

Q2. **In this experiment a mass connected to a rotating drum is free to descend down to the floor. With energy conservation the following expression is found for inertia:**

$$I = mr^2 \left[\frac{gt^2}{2h} - 1\right]$$

This expression so useful that inertia of any object depends only on r,h and t. (please learn what those values are from your book.) Actually independent from the shape of the object we can determine its inertia by putting it on top of a drum to which a mass m is connected and free to descend. Our system somehow is a scale for rotational motion, due to the analogy between the linear and rotational motion:

$$F = m.a \quad \leftrightarrow \quad \tau = I.\alpha$$

Why $2I_2 > I_1$ condition must be satisfied where $I_2 = I_{drum+disk}^{diameter}$ and $I_1 = I_{drum+disk}^{CM}$. **Justify your answers, show calculations if needed or no credits!**

1

Lab Report

Lab section:

Name & Surname:

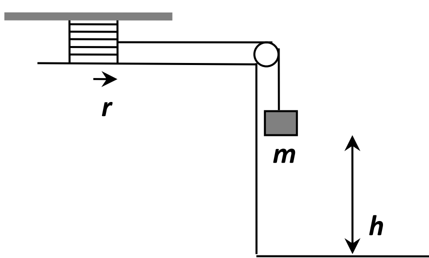
Table #:

***Complete this report YOURSELF except DATA taking parts! Use a pencil for plots only and a pen for the rest!* Show your work clearly, NO COPYCAT analysis allowed, or NO credits!**

***You must complete this report YOURSELF except DATA taking parts! Use a pencil for plots only and a pen for the rest!* You MUST show your work clearly, NO COPYCAT analysis allowed, or NO credits!**

OBJECTIVE : To determine experimentally the rotational inertia of a body.

THEORY :



A mass connected to a rotating drum is free to descend down to the floor. For this mass the loss in potential energy is equal to the gain in the translational and rotational kinetic energy:

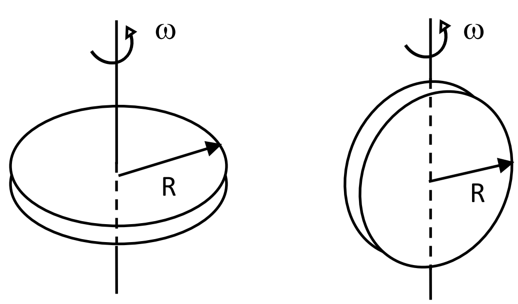
$$\frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 = mgh$$

The velocity of mass where it touches the floor and the corresponding angular velocity are:

$$v = \frac{2h}{t} \qquad \text{and} \qquad \omega = v/r$$

As a result, rotational inertia of the drum is given as:

$$I = mr^2\left[\frac{gt^2}{2h} - 1\right]$$



Disk about its CM   Disk about its diameter

2

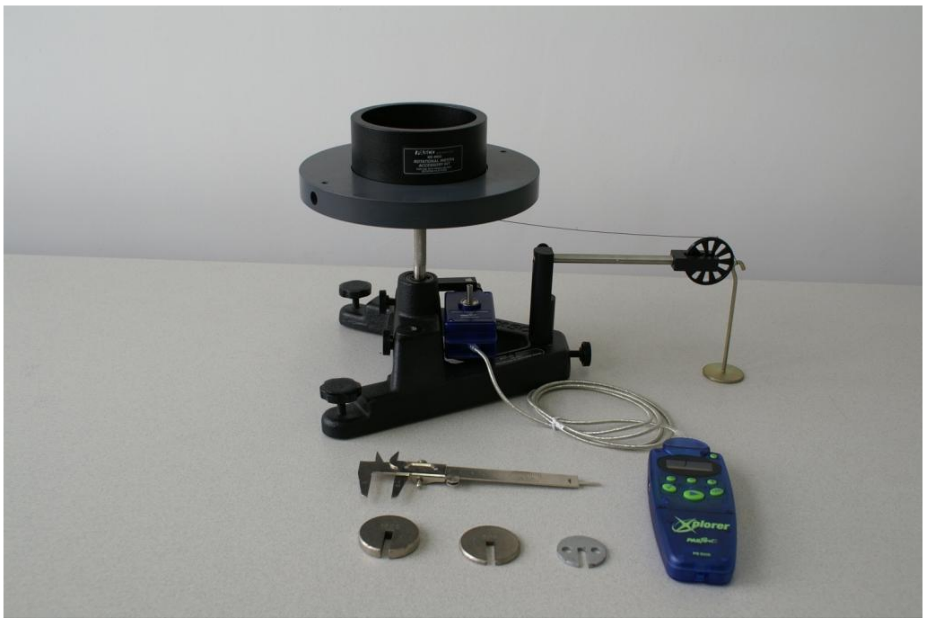
As a special case, the rotational inertia of a uniform disk about an axis passing through its center of mass (CM) and perpendicular to the disk is given by

$$I_z = \frac{1}{2} MR^2$$

or about its diameter:

$$I_r = \frac{1}{4} MR^2 .$$

APPARATUS : Rotational inertia apparatus, disk and ring masses, mass and hanger set, string.



PROCEDURE :

1. Wind the cord onto the drum and hang a mass m at the end of the cord. Place the disk mass on the drum. After determining the height of the mass above the floor, release the mass and determine the time for descent. Repeat twice and find the average t. Calculate the rotational inertia of the disk + drum assembly.
2. Repeat the same procedure with the disk mounted on its side. The difference of the moment of inertias should be equal to the moment of inertia of the disk mounted on its side or half the moment of inertia when it is mounted horizontally.
3. Calculate the moment of inertia of the disk and the drum part separately for both cases.
4. Calculate the moment of inertias theoretically from the geometry of the disk for both cases and compare your results to the values you determined in the previous step.

3

DATA & CALCULATIONS & RESULTS

Description / Symbol			Value & Unit
Diameter of the drum	d	=	....
Radius of the drum	r	=	....
Height of mass holder from the floor	h	=	....

Rotational Inertia of Disk

			ABOUT CM	ABOUT DIAMETER
Mass on the mass holder	m^*	=	....	....
Time for descent	t^*_1	=	....	....
Time for descent	t^*_2	=	....	....
Average time for descent	t^*_{ave}	=	....	....

4

Description / Symbol		Calculations (show each step)	Result
Rotational Inertia of the drum + Disk about its CM	$I^{CM}_{drum+disk}$ =	. . . .	. . . .
		. . . .	
Rotational Inertia of the drum + Disk about its DIAMETER	$I^{DIAMETER}_{drum+disk}$ =	. . . .	. . . .
		. . . .	

2 $I_2 > I_1$, If not, measure time for descent again

Rotational Inertia of the DISK about its CM	I^{CM}_{DISK} =	. . . .	. . . .
Rotational Inertia of the DISK about its DIAMETER	$I^{diameter}_{DISK}$ =	. . . .	. . . .
Rotational Inertia of the DRUM	I_{DRUM} =	. . . .	. . . .

5

Description / Symbol		Value & Unit
Mass of the Disk M_{disk}	=	. . . .
Diameter of the Disk D_{disk}	=	. . . .
Radius of the Disk R_{disk}	=	. . . .

Theoretical Values for *I*:

I_{DISK}^{CM} = ...

$I_{DISK}^{diameter}$ = ...

% Error for Rotational Inertia:

ΔI_{DISK}^{CM} :

$\Delta I_{DISK}^{diameter}$:

Consult to the resources for this experiment from PHYS LAB Website:

PHYL101 Intro

Presentation #6

PHYL101 Lab Book

Pre-Lab Report

Lab section:

Name & Surname:

Table # :

***Before the Lab* complete this page YOURSELF! Hand it in *in the first 5 min*. of the session PERSONALLY!**

You MUST justify your answers and show all steps. NO COPYCAT answers, or NO credits!

Please read the relevant presentation on PHYS LAB Website.

Q1. What does the Inertia of the system in this experiment depend on, in terms of the quantities you are going to measure? **Justify your answer or no credits!**

(2^{nd} Question is on the next page!)

Q2. Show the dimension **analysis** for torque **explicitly! Show your formulae and derivation step by step or no credits**!

1

Lab Report

Lab section:

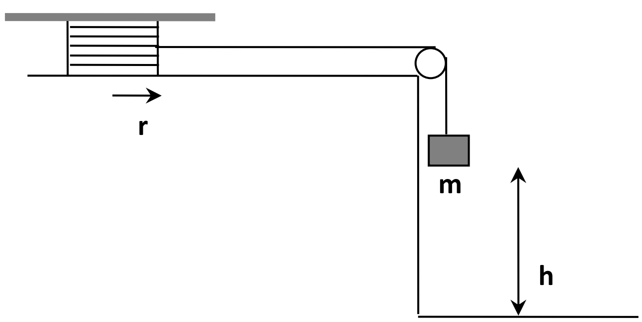
Name & Surname:

Table #:

***Complete this report YOURSELF except DATA taking parts! Use a pencil for plots only and a pen for the rest!* Show your work clearly, NO COPYCAT analysis allowed, or NO credits!**

OBJECTIVE : To measure the effect of torque acting on a rotating mass.

THEORY :



A rotating object also obeys the Newton's Laws of motion. When we apply a torque on an object, we can express the Newton's Law in terms of the torque and the angular acceleration:

$$\tau = I\alpha$$

where torque is applied through a string wrapped around the drum with a radius r attached to a free falling object of mass *m*.

$\mathcal{T}$ is tension in the string:

$$\tau = \vec{F}x\vec{r} = mgr = \mathcal{T}\text{r}$$

Then the torque and angular acceleration equation becomes

$$I\alpha = \mathcal{T}\text{r}$$

Using the force equation

$$\mathcal{T} - \text{mg} = -\text{ma} \quad (\text{a}=\alpha\text{r})$$

we can determine the moment of inertia by measuring the angular acceleration.

$$I = \frac{mgr}{\alpha} - mr^2$$

We can also determine the moment of inertia from the free fall time:

$$I = mr^2\left[\frac{gT^2}{2h} - 1\right]$$

APPARATUS : Rotational inertia apparatus with rotational sensor, data logger, mass and hanger set.

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2

PROCEDURE :

1. Using a small mass (50 g) on the mass holder, observe the rotational motion of the disk on the rotational inertia apparatus. You should set the data logger to **2 samples/s**. When the free fall is completed, retrieve the rotation angles as a function of time from the data logger.
2. Calculate the average angular velocity for successive time intervals and plot the result as a function time. ($\omega_{\text{average}} = \Delta\theta / \Delta t$)
3. From your graph, obtain the angular acceleration of the disk assembly by determining the slope of the straight line fit to your data.
4. Determine the moment of inertia of the disk assembly using the angular acceleration.
5. Determine the free fall time and the height of the mass holder from the floor and calculate the moment of inertia using the equation given above.
6. Compare both results for the moment of inertia and calculate the percentage difference between them:

$$\%\text{diff} = \frac{|I_1 - I_2|}{(I_1 + I_2)/2} \times 100$$

3

DATA:

Description / Symbol			Value & Unit
Diameter of the drum	d	=	. . . .
Radius of the drum	r	=	. . . .
Mass on the mass holder + mass of the holder	m	=	. . . .
Height of the mass holder from the floor	h	=	. . . .
Time for descent	T	=	. . . .

4

Δt ( )	t ( )	Θ ( )	$\Delta\Theta$ ( )	$\omega_{average} = \Delta\Theta / \Delta t$ ( )

5

From the line, choose two SLOPE POINTS other than data points,

SP_1 : (;)

SP_2 : (;)

6

CALCULATIONS & RESULTS

By using SP_1 and SP_2, calculate:

Description / Symbol		**Calculations(show each step)**	**Result**	**Dimension**
SLOPE	=	....	....	....
		....		
Angular Acceleration α	=	....	....	....
Moment of Inertia $I = \frac{mgr}{\alpha} - mr^2 =$		....	....	....
$I = mr^2\left[\frac{gT^2}{2h} - 1\right]$	=	....	....	....
		....		

%difference for *I*:

Consult to the resources for this experiment from PHYS LAB Website:

PHYL101 Intro

Presentation #7

PHYL101 Lab Book

Pre-Lab Report

Lab section:

Name & Surname:

Table # :

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You MUST justify your answers and show all steps. NO COPYCAT answers, or NO credits!

Please read the relevant presentation on PHYS LAB Website.

This experiment is combination of some of your previous experiments; Projectile motion, Rotational Inertia. Other than those Parallel Axis Theorem is going to be used.

Q1. Give a summary of what is going to be done in this experiment. Use the relevant formulae in your explanation. **Justify your answers, show calculations if needed or no credits!**

#8 Conservation of Angular Momentum

1 Lab Report

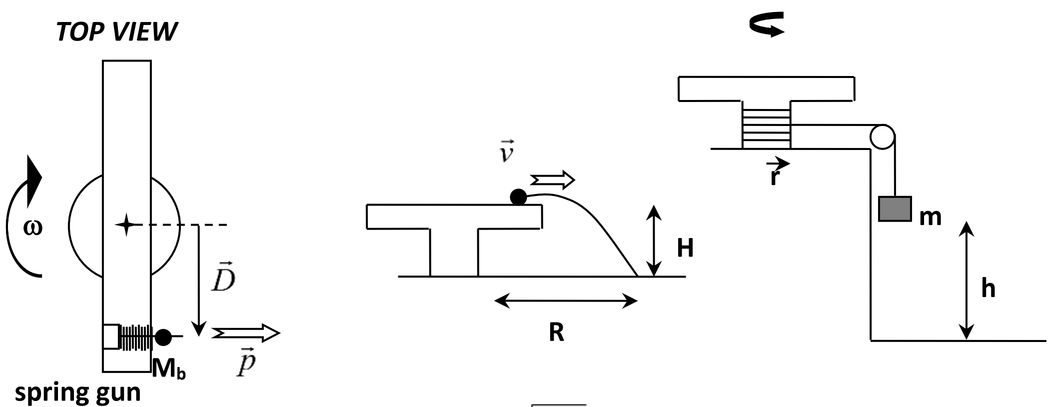
Lab section:

Name & Surname:

Table #:

***Complete this report YOURSELF except DATA taking parts! Use a pencil for plots only and a pen for the rest!* Show your work clearly, NO COPYCAT analysis allowed, or NO credits!**

OBJECTIVE : To study the conservation of angular momentum of a system about a fixed axis.



$$\vec{L}_{ball} = \vec{D} \times \vec{p}$$
$$\vec{L}_{TurnTable} = I \cdot \vec{\omega}$$

$$v = R\sqrt{\frac{g}{2H}}$$
$$\vec{p} = \boldsymbol{M_b}\vec{\boldsymbol{v}}$$

$$I = mr^2\left[\frac{gt^2}{2h} - 1\right]$$

THEORY :

In a system shown on the left of the figure above we can study the conservation of angular momentum. When the spring gun is released and shoots the ball, the ball has also an angular momentum defined by its linear momentum since the spring gun is fixed on the turntable. The turntable is free to rotate around its axis. Since this is like an inverse collision, the momentum and the angular momentum are conserved:

$$L_{ball} = L_{turn-table}$$

or

$$M_b vD = I\omega$$

Determining the moment of inertia of the spring gun assembly will be done similar to the previous experiment, **Rotational Inertia**. The important points are summarized on the right side of the figure above.

APPARATUS : Rotational inertia apparatus with rotational sensor, data logger, mass and hanger set.

PROCEDURE :

1. Fire the ball at 2 different positions (@10.0 cm and @20.0 cm) on the aluminum rotating platform by releasing the compressed spring. The initial velocity of the ball can be determined by measuring the range and the initial height of the ball.
2. Read the angular velocity of the turntable from the data logger.
3. For the rotational inertia of the turntable when the spring gun is placed at the center, wind the cord onto the drum and hang a mass m at the end of the cord. After determining the height of the mass above the floor, release the mass and determine the time for descent. Calculate the rotational inertia of the assembly when the spring gun is at the center ($I_{SPRINGGUN}^{CM}$).
4. Calculate *I* at 2 different positions (*D)* on the aluminum rotating platform by using parallel axes theorem ($I_D = I_{SPRINGGUN}^{CM} + M_{gun} D^2$)
5. Calculate M_b for different *D* values.

3

DATA:

Description / Symbol			Value & Unit
Mass of the ball	M_b	=	....
Mass of the spring gun	M_{gun}	=	....
Initial height of the ball	H	=	....
Mass on the mass holder + mass of the holder	m	=	....
Height of the mass holder from the floor	h	=	....
Time for descent	t	=	....
Diameter of the drum	d	=	....
Radius of the drum	r	=	....

4

CALCULATIONS & RESULTS:

D ( )	*R* ( )	*Velocity of the ball* *v* ( )

$I_{SPRINGGUN}^{CM}$ = ...

D ( )	ω ( )	I_D ( )	M_b ( )

Average mass of the ball M_b = ...

% Error for M_b **=** ....

Consult to the resources for this experiment from PHYS LAB Website:

PHYL101 Intro

Presentation #8

PHYL101 Lab Book

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