Writing a physics report

Science, Physics

Physics 221L Lab 12 ROTATIONAL MOTION: Rolling Objects 4/15 Purpose of the experiment:

To use our cumulative knowledge of Physics to perform an experiment without the benefit of computers

Theory

An object exhibits both rotational motion and transitional motion as it rolls down a plank. If it rolls without slipping, its bottom is momentarily at rest and the distance, velocity, and acceleration of the centre of mass is directly related to the angle of rotation, angular velocity, and angular acceleration of the centre of mass. The total mechanical energy of the object is the sum of its kinetic energy of its centre of mass, rotational energy about its centre of mass and gravitational potential energy of its centre of mass. (Rotational Motion)

Let m – mass of the object

v – Velocity of the object

g – Gravitational pull

h – Height above the reference ground

I – moment of inertia of the object

w – Angular velocity of the object

Then:

Total mechanical energy = ½ Mv2 + ½ Iw2 + mgh

Where: ½ Mv2 – kinetic energy

½ Iw2 – rotational energy

mgh – potential energy

Apparatus

1. Plank 4. Stopwatch

2. Object that rolls well

3. Meter stick.

Procedure

The object was timed as it rolls a distance of 1 meter starting from rest near the top of the inclined plank and recorded. The height of the inclined plank was also recorded.

The plank was turned over and the first procedure repeated, making sure that the object rolls the same distance along the plank and that, the vertical distance is the same.

The average time for each side of the plank and the standard deviation of the mean for each side was determined using the formulas below

Average time = total time/number of trials

Standard mean deviation = √ (variance)

Results/Experimental data

Data table

Trail

Time in seconds (side A)

Time in seconds (side B)

1

2. 78

2, 24

2

2. 42

2, 63

3

2. 58

2. 70

4

2. 24

2. 24

5

2. 71

2. 75

6

2. 28

2. 34

7

2. 22

2. 64

Average

2. 46

2. 51

S. D. M = √Variance

0. 211

0. 207

Mass of the object = 2. 036Kg Radius of the object = 0. 027mHeight = 0. 08m

Data analysis and calculations

Final velocity “ v” (of the centre of mass) in terms of “ x” and “ t” for the object to roll a distance 1m along the plank in average time t for each side of the plank (experimental velocity).

H = 0. 08m 0. 08m

X = 1m 900 1m

For rotational velocity down the slope

Velocity of centre of mass = 0m/s

For translational motion down the slope

Velocity of centre of mass v = u + at

Where; v - final velocity

u – Initial velocity

t – Time taken

From the equation s = ut + ½ at2where; s = displacement

a = acceleration

Since u = 0 i. e. the object is at rest at the starting point then s = ½ at2

s = 1m 1m = ½ at2

For side A 1 = ½ a (2. 462) thus; a = (1 * 2)/2. 462

a = 0. 33049m/s2

Velocity VA = at = (0. 3349 * 2. 46) = 0. 813m/s

For side B 1 = ½ a (2. 512)thus; a = (1 * 2)/2. 512

a = 0. 3175m/s2

Velocity VB = at = (0. 3175 * 2. 51) = 0. 7968m/s

Uncertainty in the final velocity by using the S. D. M. for the time and an estimated uncertainty in distance.

Uncertainty in velocity for side A of the plank

Mean = (2. 78+2. 42+2. 58+2. 24+2. 71+2. 28+2. 22)/7

Mean = 2. 46s

S. D. M = [(2. 78-2. 462) +(2. 42-2. 462)+(2. 58-2. 462)+(2. 24-2. 462)+(2. 71-2. 462)+(2. 282-2. 462)+(2. 22-2. 46)2]/6 = 0. 211

Percentage uncertainty = (0. 211/2. 46) * 100 = 8. 5%

Uncertainty in time = x+/- least count

Least count 0. 01/2 = 0. 005

Percentage uncertainty = 0. 5%

Total uncertainty = (8. 5+0. 5) = 9%

Uncertainty in VA = 0. 813±9%

0. 73983≤ 0. 813 ≥0. 88617

Uncertainty in velocity for side B of the plank

Mean = (2. 24+2. 63+2. 70+2. 24+2. 75+2. 34+2. 64)/7

Mean = 2. 51s

S. D. M = [(2. 24-2. 512)+(2. 63-2. 512)+(2. 70-2. 512)+(2. 24-2. 512)+(2. 75-2. 512)+(2. 34-2. 512)+(2. 64-2. 512)]/6 = 0. 207

Percentage uncertainty in time = (0. 207/2. 51) * 100%

= 8. 23%

Percentage uncertainty in distance = (0. 005/1) * 100%

= 0. 5%

Total uncertainty = (8. 23+0. 005) = 8. 73%

Uncertainty in VB = (8. 73/100) 0. 7968 = ±0. 0696

Uncertainty in VB = 0. 7968 ± 0. 0696

Predicting the velocity using conservation of mechanical energy along with the measured vertical distance h.

0. 08m θ 1m

900

(Sin 900/1) = (sin θ/0. 08)

θ = 4. 60

From mgh = ½ Iw2 + ½ Mv2

Mass = 2. 036Kg

Radius = 0. 027m

w = v/r

Mgh = ½ I(v/r)2 + ½ mv2 = ½ Iv2/r2 + ½ mv2

Mgh = v2(½ I/r2 + ½ m)

v2 = mgh/(½ I/r2 + ½ m)

v = √ [mgh/(½ I/r2 + ½ m)]

But I = ½ mr2

v = √ [(1/4m + ½ m)]

v = √mgh/(3/4 m)

v = √[3gh/4]

v = √0. 5886

v = 0. 7672m/s

Questions

Description of the rolling object.

The disk exhibits both rotational motion and transitional motion as it rolls down the plank. Since it rolls without slipping, its bottom is momentarily at rest and the distance, velocity, and acceleration of the centre of mass is directly related to the angle of rotation, angular velocity, and angular acceleration of the centre of mass. The total mechanical energy of the disk is the sum of its kinetic energy of its centre of mass, rotational energy about its centre of mass and gravitational potential energy of its centre of mass.

1. Time for different sides of the plank.

The total time for the sides are different, time for when the plank is warped concave up is longer than when the concave is warped down since the disk faces higher friction when the concave is warped up hence taking more time and energy in overcoming friction to reach the end

Check the plank for warps. Make a sketch that shows the warp of the plank. Make sure to label the top and bottom sides.

Concave warped upconcave warped down

2. Relationship between final velocity and predicted if the plank is warped concave up, Concave down as from the data.

Predicted velocity is lower on both cases as evidenced by the data i. e. predicted velocity is 0. 7672m/s while velocity in the first and second case are 0. 7968m/s and 0. 813m/s respectively. This is so because predicted velocity does not take care of friction effects and errors in performing the experiment.

Reference

Rotational Motion Retrieved 15th April 2013. www. cliffsnotes. com/study_guide/Rotational-Motiom-of-a-Rigid-Body. topicArticleId-10453, articled-10419. html