PHYS 1511 Discussion Section: Week 9

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Review

Chapter 9: Rotational Dynamics

-Force and Torque

-Equilibrium of Torque (statics)

-Rotational motion about an axis

-Rotational Work and Energy

-Angular Momentum

-Conservation of Angular Momentum

Chapter 10: Simple Harmonic Motion (SHM) and Elasticity

-Ideal Spring and SHM

-Frequency, Period, acceleration in SHM

-Energy in SHM

-The Pendulum (concepts: Damped and driven motion)

-Elastic Deformation

-Stress, Strain and Hooke's Law

Review

$\vec{\alpha}$, $\vec{\omega}, \vec{L}$ are vectors so that means that they a positive and negative direction.

> (+) counterclockwise $\vec{\alpha}, \vec{\omega}, \vec{L}$
> (-) clockwise $\vec{\alpha}, \vec{\omega}, \vec{L}$

Relevant Equations

Chapter 9:

$$\vec{\tau} = |r||F|\sin(\theta) \qquad \text{(Torque)} \tag{1}$$

$$\Sigma\vec{\tau} = 0 \qquad \text{(Rotational Statics)} \tag{2}$$

$$\Sigma\vec{\tau} = \mathrm{I}\vec{\alpha}_{net} \qquad \text{(Rotational "Newton's 2nd law")} \tag{3}$$

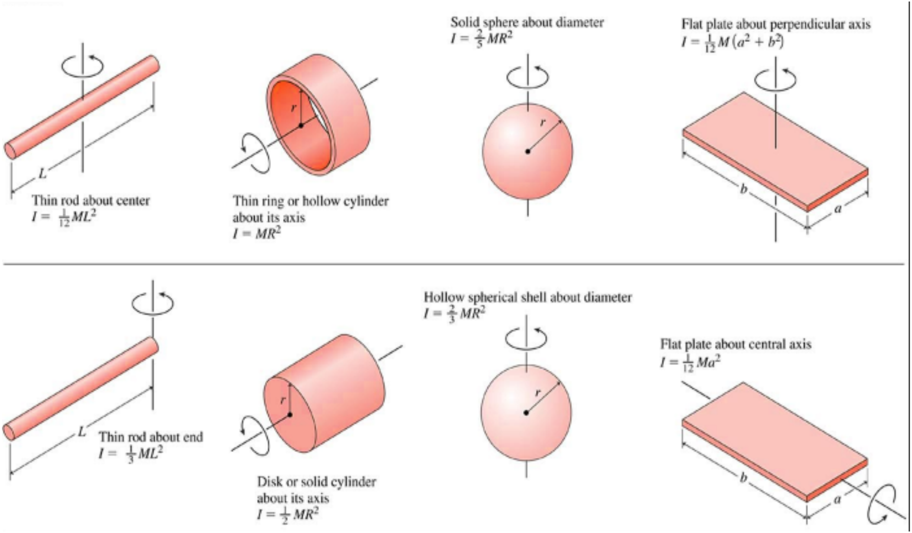
$$x_{cg} = \frac{W_1x_1 + W_2x_2 + \dots}{W_1 + W_2 + \dots} \qquad \text{(Center of Gravity)} \tag{4}$$

*** Won't cover today

$$\mathrm{KE_R} = \frac{1}{2}\mathrm{I}\omega^2 \qquad \text{(Rotational Kinetic Energy)} \tag{5}$$

$$\vec{L} = \mathrm{I}\vec{\omega} \qquad \text{(Angular Momentum)} \tag{6}$$

Relevant Equations



Point mass: $\mathrm{I} = MR^2$

Relevant Equations

Chapter 10:

$$\vec{F} = -kx \qquad \text{(Spring Resorting Force)} \tag{7}$$

$$\omega = \sqrt{\frac{k}{m}} \text{ or } k = \omega^2 m \qquad \text{(spring constant)} \tag{8}$$

$$W = \Delta\text{PE} = \frac{1}{2}kx^2 \qquad \text{(Work/Potential Energy done by spring)} \tag{9}$$

$$2\pi f = \sqrt{\frac{g}{L}} = \sqrt{\frac{mgL}{\mathrm{I}}} \qquad \text{(Pendulum frequency)} \tag{10}$$

$$F = Y\left(\frac{\Delta L}{L_o}\right)A \qquad \text{(Stretch)} \tag{11}$$

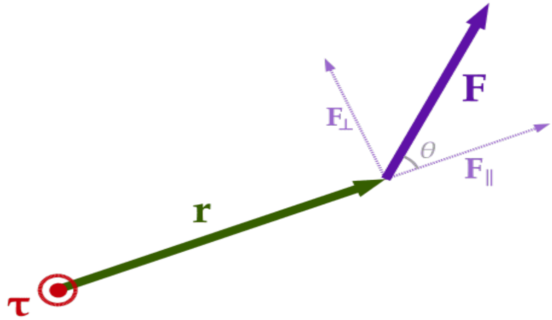
$$F = S\left(\frac{\Delta X}{L_o}\right)A \qquad \text{(Sheer Force)} \tag{12}$$

$$\vec{P} = \frac{\vec{F}}{A} \qquad \text{(Pressure Definition)} \tag{13}$$

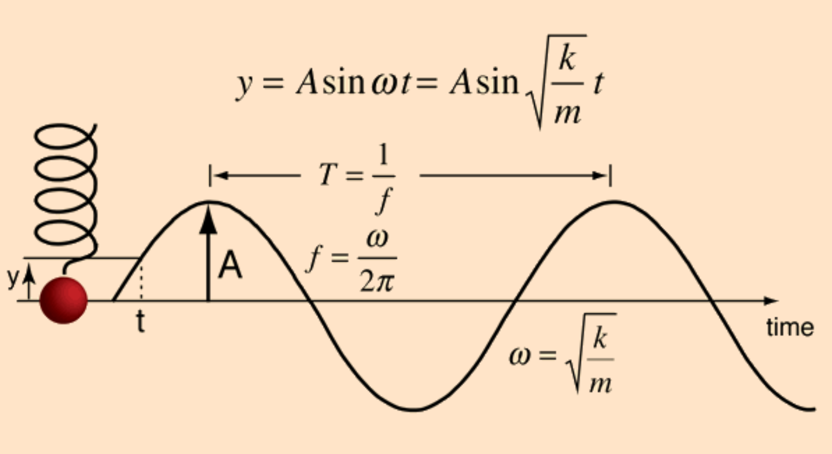
$$\Delta P = -B\left(\frac{\Delta V}{V_0}\right) \qquad \text{(Volume change by a pressure)} \tag{14}$$

*** Y,S & B are all constants that depend on the material

Review



Review



$y = A\sin\omega t = A\sin\sqrt{\frac{k}{m}}\,t$
$T = \frac{1}{f}$
A
$f = \frac{\omega}{2\pi}$
y
t
time
$\omega = \sqrt{\frac{k}{m}}$

Question #1

Torque Snapshot

Two children are playing on the seesaw at the park. The seesaw (L = 3m) acts as a board balancing around a fulcrum point that's at the center of the seesaw. Consider the moment the children are level with one another and let child 1 be on the left ($m_1 = 20kg$) and child 2 on right ($m_2 = 30kg$).

(a) What is the radius to the children from the fulcrum point?

(b) What are the magnitudes and direction of the torques acting on the seesaw? (careful of signs)

(c) Given your answer for for (b) which way will the seesaw move assuming no prior movement/forces? (clockwise/counterclockwise)

Challenge Q: At what point would I have to place the fulcrum so that the seesaw doesn't rotate when these children sit on it? (measured from the left side of seesaw)

Question #2

Physics Gambling

Your friends (who haven't taken physics) are betting money on which objects will roll from rest down an incline plane first. They roll a solid sphere and solid cylinder of equal mass and radius down the same incline plane. Set h=0 at the bottom of the incline and answer:

(a) How do the energies of the two objects compare at the top of the plane?

(b) What is the expression for the total energy of the solid sphere at the bottom of the incline?

(c) Repeat (b) for the solid cylinder

(d) Using the expression, $\omega = \frac{v}{R}$ in rotational kinetic energy, determine the ratio of the two linear velocities i.e. $\frac{v_{cyl}}{v_{sph}} =$? using your expressions in (b) and (c)

(e) Which object should you bet on to win?

(f) Is what you're doing to your friends ethical?

Question #3

Angular Momentum and memories

A merry-go-round is approximately a large disk spinning around its central axis. Consider a merry-go-round of $m = 120,000$g and radius 180cm where a child of mass 30kg suddenly jumps on. If the merry-go-round was initially spinning clockwise at 0.5 rad/s answer the following:

(a) What is the initial **angular momentum** of the merry-go-round system (be care of signs)

(b) If the child runs at the same angular velocity and jumps on the outer edge, what is the new angular **velocity** of the Merry-go-round? (treat the child as a point mass and the final moment of inertia as just a disk with a new mass)

(c) Repeat (b) if the child had run in the other way then jumped on

Question #4

Bored in Class

While bored in class, you compulsively start clicking your ballpoint pen, when suddenly you realize it functions upon a spring mechanism. Quickly taking out your phone (and force gauge) you measure that when you apply -1.2N of force the pen compresses 12mm.

(1) What is this spring's spring constant?

Suppose you took out the spring to play with it, and then attached another pen (m = 42g) and let it hang from the spring.

(2) How much would the spring stretch? (let downward acceleration be negative)

(3) How much work was done to stretch the spring this far?

Question #5

Tow Troubles

A tow truck is pulling a car out of a ditch by means of a steel cable that is 9.1m long and has a radius of 0.50cm. When the car just begins to move, the tension in the cable is 890N. How much has the cable stretched?
$\mathrm{Y}_{steel} = 2 \times 10^{11}$