PHYS 1511 Discussion Section: Week 7

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Review

Chapter 7: Impulse and Momentum

-Momentum

-Conservation of momentum (both x and y direction)

-Collisions in 1D and 2D

-Elastic and Inelastic Collisions

-Center of Mass

Chapter 8: Rotational Kinematics

-Angular Displacement

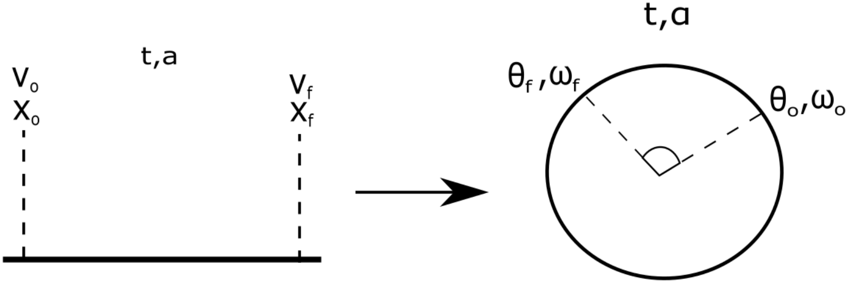
-Angular Velocity

-Angular Variables

-Rotational Kinematics

-Rolling without slipping (won't cover in these slides)

Review



Note:

- α and ω are vectors
- Sign convention:

  (+) counterclockwise $\vec{\alpha}, \vec{\omega}$

  (-) clockwise $\vec{\alpha}, \vec{\omega}$

Relevant Equations

Chapter 7:

$$\vec{p} = m\vec{v} \qquad \text{(Momentum)} \tag{1}$$

$$\overrightarrow{P_{total_o}} = \overrightarrow{P_{total_f}} \qquad \text{(Conservation of Momentum)} \tag{2}$$

$$x_{cm} = \frac{\sum m_i x_i}{\sum m_i} \implies = \frac{m_1 x_1 + m_2 x_2 + m_3 x_3}{m_1 + m_2 + m_3} \qquad \text{(Center of Mass 3 objects)} \tag{3}$$

Relevant Equations

Chapter 8:

*(Every angle is in **radians**)

$$S = r\theta \qquad \text{(Arc Length)} \tag{4}$$

$$\omega = \frac{\Delta\theta}{\Delta t} \qquad \text{(\textbf{Angular} Velocity)} \tag{5}$$

$$\alpha = \frac{\Delta\omega}{\Delta t} \qquad \text{(\textbf{Angular} Acceleration)} \tag{6}$$

$$s = r\theta \qquad \text{(linear length - angular length connection)} \tag{7}$$

$$v = r\omega \qquad \text{(linear velocity - angular velocity connection)} \tag{8}$$

$$a = r\alpha \qquad \text{(linear accel. - angular accel. connection)} \tag{9}$$

Rotational Kinematics

$$\begin{aligned} v_f &= v_o + at^2 & & \omega_f = \omega_o + \alpha t^2 \\ \Delta x &= v_o t + \frac{1}{2}at^2 & \leftrightarrow \quad & \Delta\theta = \omega_o t + \frac{1}{2}\alpha t^2 \\ v_f^2 &= v_o^2 + 2a\Delta x & & \omega_f^2 = \omega_o^2 + 2\alpha\Delta\theta \end{aligned} \tag{10}$$

Question #1

Ballistic Basics

A rifleman embeds a 4.2g bullet directly into a 10kg wooden block (at rest) to test the force of the rifle. If we assume the bullet doesn't lose velocity once it leaves the barrel, it will have a muzzle velocity of 762 m/s. Pretending the momentum transferred due to friction/heat is negligible (but not zero) answer the following:

(a) What type of collision is this?

(b) What is the expression (formula) for the total momentum in the system before the bullet strikes the block?

(c) Repeat (b) for after the bullet strikes

(d) What is the final speed of the bullet-block system? (give your answer to 4 decimal places)

Question #2

Converse your momentum

A person fires a T-shirt cannon on the back of small moving truck at a Football game. The cannon is fired at an angle of 45° towards the crowd and the T-shirts come out at a muzzle velocity of 15 m/s and the cannon faces directly backward from the movement of the truck. Before the cannon is fired the truck moves at 2 m/s and after the cannon fires it moves at 2.5 m/s. If the T-shirts have a mass of 1.2kg:

(a) What is the expression for the total momentum of the truck/shirt/person system before the cannon fires?

(b) Repeat (a) for after the cannon fires

(c) What is the mass of the truck/person system? (requires a bit of algebra)

Question #3

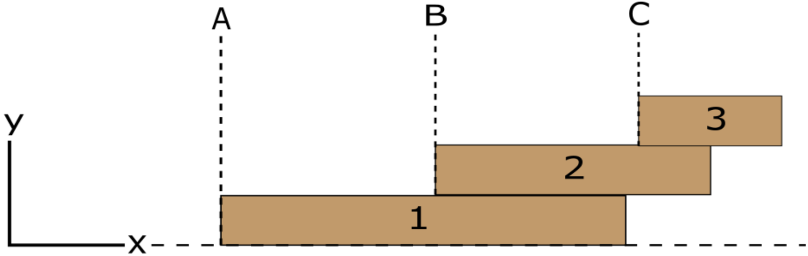
Finding your center

Three wooden planks **of the same mass** are set on top of one another as show below. Find the x-direction center of mass in the coordinate system given the following lengths:

A= 0.5m
B=0.90m
C= 1.25m

L_1=0.75m
L_2=0.5m
L_3= 0.2m

(*A,B,C are all measured from x=0)



Question #4

Spinning your wheels

Consider a car tire in a professional drag race where a vehicle accelerates quickly from rest. The tire has a radius of $r = 70\text{cm}$. Assuming a constant acceleration and no tire slipping, answer the following:

(a) If the tire makes 227.4 revolutions as it crosses the finish line, what is the angular distance covered? What about the linear distance?

(b) If the car in (a) had a final linear velocity of 150 m/s, what is the tire's final angular velocity?

(c) What is the tire's angular acceleration?

(d) How long did it take the car to traverse its linear distance?

Question #5

Life and Death Physics

Earth is a rocky oblate spheroid, but with the oceans its virtually a perfect sphere. The radius of earth is $R_E = 6.38 \times 10^6 m$ and it rotates along its central axis.

(a) What is the average angular velocity of earth at Ecuador (roughly on the equator) from a stationary outside observer's point of view?

(b) What is your tangential speed from the perspective of (a) in Ecuador?

(c) Why don't you/planes/cars appear to experience the answer you got for (b) in your everyday life?