Exam 3 review

Physics 211
Syracuse University, Physics 211 Spring 2017
Walter Freeman

April 13, 2017

Announcements

- HW8 is due next Tuesday
- **Group exam 3: Friday during recitation. You may bring a reference sheet.**
- **Exam 3: Tuesday during the normal time**

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- HW8 is due next Tuesday
- **Group exam 3: Friday during recitation. You may bring a reference sheet.**
- **Exam 3: Tuesday during the normal time**
- **Alternate date/time for Exam 3: Wednesday, 7:30 PM**
- **Review sessions:**
  - **Monday, 2PM-5PM: Physics Clinic (Walter)**
  - **Saturday or Sunday: reviews run by coaches (will announce this by email)**

Homework questions?

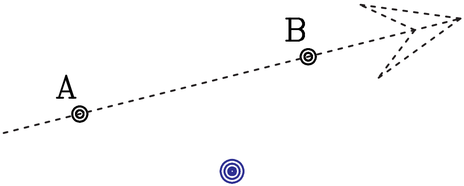
Angular momentum of a single object

A single object moving in a straight line also has angular momentum.

$$L = mv_\perp r = mvr_\perp$$

If we are to trust this relation, then the angular momentum of an object moving with constant $\vec{v}$ should be constant!

Is the angular momentum the same at points A and B?

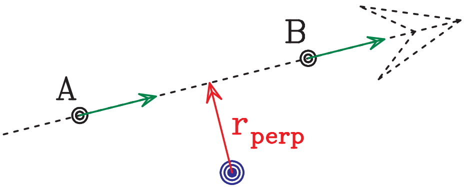


A single object moving in a straight line also has angular momentum.

$$L = mv_\perp r = mvr_\perp$$

Is the angular momentum the same at points A and B?

Yes: $r_\perp$ (and v) are the same at both points.



An example problem

A child of mass m runs at speed v straight east and jumps onto a merry-go-round of mass M and radius R, landing 2/3 of the way toward the outside. If she lands on the south edge, how fast will it be turning once she lands?

We'll do this together on the document camera.

An example problem

A child of mass m runs at speed v straight east and jumps onto a merry-go-round of mass M and radius R, landing 2/3 of the way toward the outside. If she lands on the south edge, how fast will it be turning once she lands?

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(The solution is on the next slide, for those studying these notes later)

The solution to our example

We use conservation of angular momentum:

$$\sum L_i = \sum L_f$$
$$L_{\text{child},i} = L_{\text{child+disk},f}$$

Model the child as a point object moving at a constant velocity:

$$L_{\text{child},i} = m v_\perp r = \frac{2}{3} m v R$$

This gives us $\frac{2}{3} m v R = I_{\text{total}} \omega_f$. We now need I_{total}.

After the child jumps on, $I_{\text{total}} = I_{\text{disk}} + I_{\text{child}} = \frac{1}{2} M R^2 + \frac{2}{3} m R^2$. Thus,

$$\frac{2}{3} m v R = \left(\frac{1}{2} M R^2 + \frac{2}{3} m R^2 \right) \omega_f$$

Solve for ω_f:

$$\omega_f = \frac{\frac{2}{3} m v R}{\left(\frac{1}{2} M R^2 + \frac{2}{3} m R^2 \right)}$$

Angular momentum demonstrations

What happens to the person on the platform if they catch the ball?

Angular momentum demonstrations

What happens to the person on the platform if they catch the ball?
What happens when they throw it?

Review: The work-energy theorem

- Translational work-energy theorem: $\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = \vec{F} \cdot \vec{d} = Fd\cos\theta$ (if this is constant)
- Rotational work-energy theorem: $\frac{1}{2}I\omega_f^2 - \frac{1}{2}I\omega_i^2 = \tau\Delta\theta$

Potential energy is an alternate way of keeping track of the work done by conservative forces:

- $PE_{\text{grav}} = mgh$
- $PE_{\text{spring}} = \frac{1}{2}kx^2$

Review: Conservation of energy

$$\mathrm{PE_i} \quad + \quad \tfrac{1}{2}mv_i^2 + \tfrac{1}{2}I\omega_i^2 \quad + \quad W_{\text{other}} \quad = \quad \mathrm{PE_f} \quad + \quad \tfrac{1}{2}mv_f^2 + \tfrac{1}{2}I\omega_f^2$$

Review: Conservation of energy

$$\mathrm{PE_i} + \tfrac{1}{2}mv_i^2 + \tfrac{1}{2}I\omega_i^2 + W_{\text{other}} = \mathrm{PE_f} + \tfrac{1}{2}mv_f^2 + \tfrac{1}{2}I\omega_f^2$$

(initial PE) + (initial KE) + (other work) = (final PE) + (final KE)

Review: Conservation of energy

$$\text{PE}_\text{i} \quad + \quad \tfrac{1}{2}mv_i^2 + \tfrac{1}{2}I\omega_i^2 \quad + \quad W_\text{other} \quad = \quad \text{PE}_\text{f} \quad + \quad \tfrac{1}{2}mv_f^2 + \tfrac{1}{2}I\omega_f^2$$

(initial PE) + (initial KE) + (other work) = (final PE) + (final KE)

(total initial mechanical energy) + (other work) = (total final mechanical energy)

Review: Conservation of energy

$$\mathrm{PE_i} \quad + \quad \frac{1}{2}mv_i^2 + \frac{1}{2}I\omega_i^2 \quad + \quad W_{\text{other}} \quad = \quad \mathrm{PE_f} \quad + \quad \frac{1}{2}mv_f^2 + \frac{1}{2}I\omega_f^2$$

$$\text{(initial PE)} \quad + \quad \text{(initial KE)} \quad + \quad \text{(other work)} \quad = \quad \text{(final PE)} \quad + \quad \text{(final KE)}$$

$$\text{(total initial mechanical energy)} \quad + \quad \text{(other work)} \quad = \quad \text{(total final mechanical energy)}$$

Since conservation of energy is the broadest principle in science, it's no surprise that we can do this!

Review: rotational motion

Translation	Rotation
Position $\vec{s}$ Velocity $\vec{v}$ Acceleration $\vec{a}$	Angle θ Angular velocity ω Angular acceleration α
Kinematics: $\vec{s}(t)\frac{1}{2}\vec{a}t^2 + \vec{v}_0 t + \vec{s}_0$	$\theta(t) = \frac{1}{2}\alpha t^2 + \omega_0 t + \theta_0$
Force $\vec{F}$ Mass m Newton's second law $\vec{F} = m\vec{a}$	Torque τ Rotational inertia I Newton's second law for rotation $\tau = I\alpha$
Kinetic energy $KE = \frac{1}{2}mv^2$ Work $W = \vec{F} \cdot \Delta\vec{s}$ Power $P = \vec{F} \cdot \vec{v}$	Kinetic energy $KE = \frac{1}{2}I\omega^2$ Work $W = \tau\Delta\theta$ Power $P = \tau\omega$
Momentum $\vec{p} = m\vec{v}$	Angular momentum $L = I\omega$

Review: computing torques and static equilbrium

"Signpost problem" from recitation

Review: combining translational and rotational motion

"Yo-yo problem" from recitation

What would you like to talk about?