L16_Parallel Axis Theorem and Torque

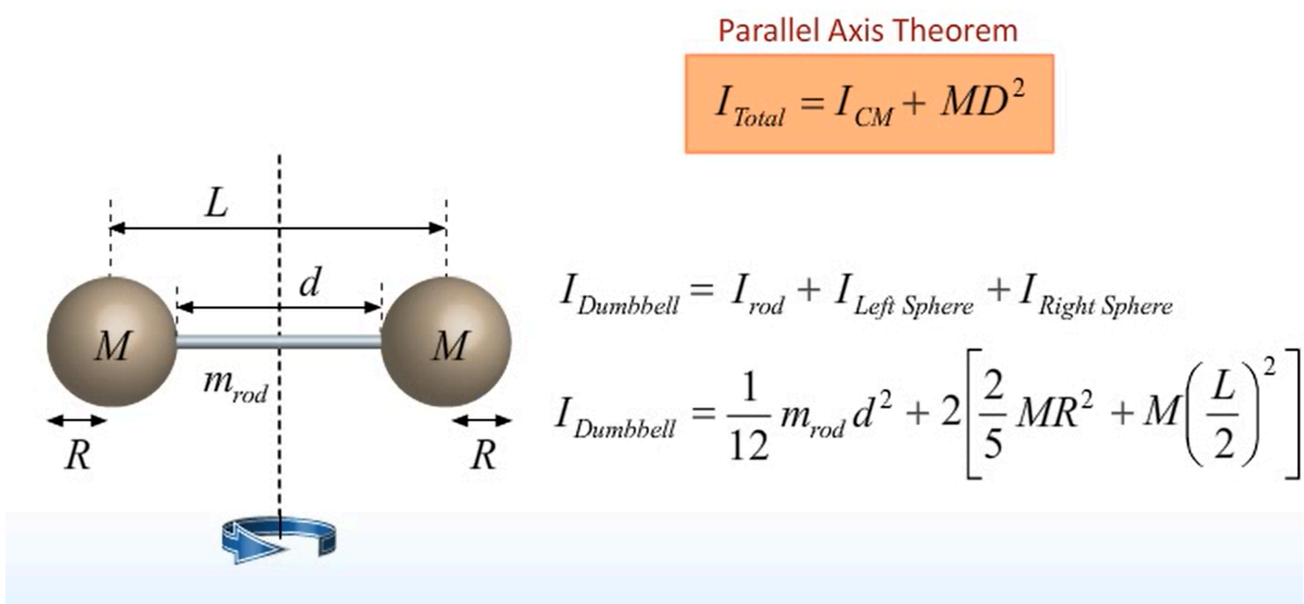
Parallel Axis Theorem

Formula for Parallel Axis Theorem

$$I_{new} = I_{cm} + Md^2$$

here I_{cm} is the moment of inertia when the axis is at the center of the masses, d is the displacement of the axis

- Note that the I that we give out is based on the object rotating around an axis through its cm



Torque

Formula

- $$\tau = Fr = r \times f$$
  - where r is the `moment arm` or `level arm`
  - Note that r is not the distance between the axis and where the force is exerted. It is the perpendicular distance from the axis of rotation to the line of action (parallel to the force)
  - $\tau = Fl$ is true only when force is perpendicular to l

Sign

- The force makes the object rotates in a clockwise direction, so the torque is negative
- The force makes the object rotates in a counterclockwise direction, so the torque is positive

Direction (Right hand rule)

1. To tell the direction of the torque τ , point the fingers from the axis to the action point, curl the fingers in the direction of the force, the direction of the thumb is the answer

Accelaration

1. Tangential component: 切向分量 α is the rotational acceleration

$$a_t = r\alpha$$

2. Radial component: 径向分量

$$a_r = r\omega^2$$

Right Hand Rule

1. To tell the direction of ω, curl the fingers as the direction of rotation, the direction of the thumb is the answer
2. To tell the direction of the angular accleration α, if the ω is increasing, then α is to the same direction of ω
3. To tell the direction of the angular momentum L, same as the ω ,so curl the fingers as the direction of rotation, the direction of the thumb is the answer
4. To tell the direction of the torque τ , point the fingers from the axis to the action point, curl the fingers in the direction of the force, the direction of the thumb is the answer
5. To tell the direction of the `precession` , tell by how the angular momentum changes, as shown in the image.

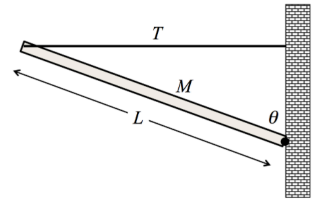
Relation with acceleration

- $$\tau = I\alpha$$

Good Questions

1. Note the direction of the torque is outward or inward, so there is no component on x or y

A beam of mass M = 2.7 kg and length L = 3.5 m is attached to a vertical wall by a hinge at its lower end and a horizontal massless wire at its top end, as shown in the diagram. The angle between the wall and the beam is θ = 63.



4) What is the x-component of the net torque about the z axis on the disk?

0 N-m

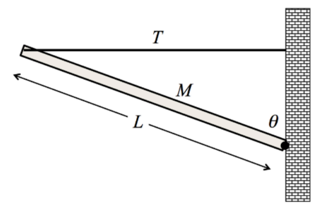
Submit

5) What is the y-component of the net torque about the z axis on the disk?

0 N-m

2. The torque of the system is exerted by gravity and the wire, the gravity is unchanged so is the torque. By moving up, the level arm increases, so the tension decreases

A beam of mass M = 2.7 kg and length L = 3.5 m is attached to a vertical wall by a hinge at its lower end and a horizontal massless wire at its top end, as shown in the diagram. The angle between the wall and the beam is θ = 63.



2) If the attachment point of the wire on the wall were moved upward by half a meter, but M, L and θ were the same as in the above question, how would the tension in the wire change? (Note that a longer wire is required to move the attachment point this way.)

- (selected) It would decrease.
- It would increase.
- It would stay the same.