Chapter 10

1

Rotation Of A Rigid Object About A Fixed Axis

1

Lecture 05

2

Newton's Second Law for Rotation

2

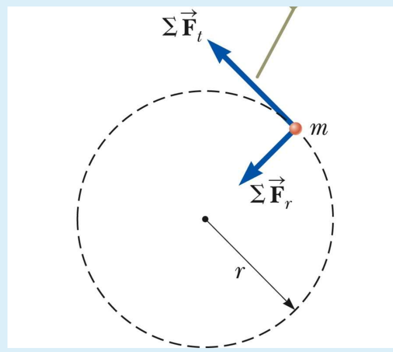
Torque and Angular Acceleration

3

- Consider a particle of mass m rotating in a circle of radius r under the influence of tangential force .
- The tangential force provides a tangential acceleration:

$$F_t = ma_t$$

- The radial force causes the particle to move in a circular path.



3

Torque and Angular Acceleration, Particle cont.

4

- The magnitude of the torque produced by $\sum \vec{F}_t$ on a particle about an axis through the center of the circle is

$$\sum \tau = \sum F_t r = (ma_t)r$$

- The tangential acceleration is related to the angular acceleration.

$$\sum \tau = (ma_t)r = (mr\alpha)r = mr^2\alpha$$

4

Torque and Angular Acceleration, Particle cont.

5

- Since mr^2 is the moment of inertia of the particle,

$$\sum \tau = I\alpha$$

- The torque is directly proportional to the angular acceleration and the constant of proportionality is the moment of inertia.

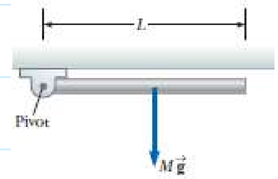
Rotating Rod

Saturday, 30 January, 2021 16:20

Lecturer: Mustafa Al-Zyout, Philadelphia University, Jordan.

- [x] R. A. Serway and J. W. Jewett, Jr., *Physics for Scientists and Engineers*, 9th Ed., CENGAGE Learning, 2014.
- [ ] J. Walker, D. Halliday and R. Resnick, *Fundamentals of Physics*, 10th ed., WILEY,2014.
- [ ] H. D. Young and R. A. Freedman, *University Physics with Modern Physics*, 14th ed., PEARSON, 2016.
- [ ] H. A. Radi and J. O. Rasmussen, *Principles of Physics For Scientists and Engineers*, 1st ed., SPRINGER, 2013.

A uniform rod of length L and mass M is attached at one end to a frictionless pivot and is free to rotate about the pivot in the vertical plane. The rod is released from rest in the horizontal position.



- What are the initial angular acceleration of the rod and
- the initial translational acceleration of its right end?

$$\sum \tau_{\text{ext}} = Mg\left(\frac{L}{2}\right)$$

$$(1) \quad \alpha = \frac{\sum \tau_{\text{ext}}}{I} = \frac{Mg(L/2)}{\frac{1}{3}ML^2} = \boxed{\frac{3g}{2L}}$$

$$a_t = L\alpha = \boxed{\tfrac{3}{2}g}$$

$$a_t = r\alpha = \frac{3g}{2L}r$$

$$a_t = g = \frac{3g}{2L}r$$

$$r = \tfrac{2}{3}L$$

Angular Acceleration of a Wheel

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A wheel of radius R, mass M, and moment of inertia I is mounted on a frictionless horizontal axle. A light cord wrapped around the wheel supports an object of mass m. When the wheel is released, the object accelerates downward, the cord unwraps off the wheel, and the wheel rotates with an angular acceleration. Calculate:

- the angular acceleration of the wheel,
- the translational acceleration of the object, and
- the tension in the cord.

$$\sum \tau_{\text{ext}} = I\alpha$$

$$(1) \quad \alpha = \frac{\sum \tau_{\text{ext}}}{I} = \frac{TR}{I}$$

$$\sum F_y = mg - T = ma$$

$$(2) \quad a = \frac{mg - T}{m}$$

$$(3) \quad a = R\alpha = \frac{TR^2}{I} = \frac{mg - T}{m}$$

$$(4) \quad T = \boxed{\frac{mg}{1 + (mR^2/I)}}$$

$$(5) \quad a = \boxed{\frac{g}{1 + (I/mR^2)}}$$

$$\alpha = \frac{a}{R} = \boxed{\frac{g}{R + (I/mR)}}$$