## ­­CHAPTER 5: ROTATION

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| Notation | Linear  Translational | Angular  Rotational |
| Basic quantities | x (m)  v (m/s)  a (m/s2) | θ (rad)  ω (rad/s)  α (rad/s2) |
| Basic formula | a const  v = v0 ­+ at  x = x0 + v0t + at2  v2 – v02 = 2aΔx | α const  ω = ω0 + αt  θ = θ0 + ω0t + αt2  ω2 – ω02 = 2αΔθ |
| Inertia | mass: m (kg) | Moment of inertia  Rotational inertia   * I =∑mR2 (kg×m2) * I = … * I = ICM + MD2 |
| Speeding up  Slowing down | a⋅v | α⋅ω |
| Force  vs  Torque | Newton’s 2nd law:  = m (N) | (d: moment/lever arm)  Newton’s 2nd law:  (N⋅m) |
| Convention of + direction | y up  x to the right | Counterclockwise |
| Energy  E = K + U | K = ½mv2 (J)(eV)  Ug = mgh (y up, 0 at …)  Uel = ½kx2 (J)(eV) | K = ½Iω2 (J)(eV) |
| Work | (J)(eV) | (J)(eV) |
| Power | P=  (J/s)(W) | P=  (J/s)(W) |
| Momentum | (kg⋅m/s) | (kg⋅m2/s) |
| Impulse |  |  |
| Momentum conservation |  |  |

**Pure rotation relationship:**

s=Rθ

v=Rω

a­T=Rα

a=

**Rolling motion relationship:**

scm=Rθ

vcm=Rω

acm=Rα

vcm ? v

**Types of problems:**

1. Problems around basic quantities & formulas.
2. Calculate acceleration or things related to acceleration of:
   1. 1 sided pulley
   2. 2 sided pulley
   3. Semi pulley
3. Rolling motion:
   1. Yoyo
   2. Wheel
   3. Wood on a hill
4. Momentum conservation.

**Problems:**

**4-January-2016:** A torque of 1.6 Nm applied to a pulley increases its angular speed from 50 rev/min to 200 rev/min in 3.0s. Calculate:

1. The angular acceleration of the pulley.
2. Its rotational inertia.­­­­­­­­­­

**5-January-2016**:A uniform wheel of radius 0.5m rolls without slipping on a horizontal floor. Starting from rest, the wheel moes with a constant angular acceleration of 4.0 rad/s2. Find:

1. The acceleration of the center of mass of the wheel.
2. The distance traveled by the center of mass from t=0s to t=3s.
3. The kinetic energy of the wheel at t=3s.

Knowing the mass of the wheel is 2.0kg (rotational inertia for a uniform wheel is MR2).

**3-June-2016:** A wheel initially rotating at 100 rad/s, is slowed down with a constant angular acceleration of magnitude 5.0 rad/s2.

1. How much time does it take the wheel to stop?
2. Through what angle does the wheel rotate during that time?

**4-June-2016:** Determine the rotational inertia of a rigid body rotating about a fixed axis with an angular momentum L of 12.0 kg⋅ m2⋅s-1 and a rotational kinetic energy K of 1.0 J.

**5-June-2016:** A star of radius R is spinning with an angular velocity ω of 3.5×10-4 rad/s. If it shrinks until its radius becomes R/3, determine the final angular velocity of the star. (Assuming the star spins as a rigid body and its rotational kinetic inertia is

**4-August-2016:** A 2.20-kg ring 1.20m in diameter is rolling to the right without slipping on a horizontal floor at a steady angular speed of 3.00 rad/s. The moment of inertia of the ring with respect to its center is MR2.

1. What is the total kinetic energy of the ring?
2. Find the velocity vectors of the highest point and the lowest point on the ring as viewed by a person at rest on the ground.

**5-August-2016:** A thin, uniform metal bar, 2.00 m long and weigh 90.0 N, is hanging vertically from the ceiling by a frictionless pivot. Suddenly it is struck 1.50m below the ceiling by a small 3.00-kg ball, initially traveling horizontally at 10.0 m/s. The ball rebounds in the opposite direction with a speed of 6.00 m/s. The moment of inertia of the bar with respect to the pivot is

1. Find the angular speed of the bar just after the collision.
2. During the collision, why is the angular momentum conserved but not the linear momentum?

**4-June-2017:** A torque of 1.8N⋅m is applied to a disk increases the angular speed of the disk from 15.0 rev/min to 100.0 rev/min in 5.0s. Find the rotational inertia of the disk.

**5-June-2017:** A block of 3.0kg is attached to a rope of negligible mass wrapped around a pulley. The pulley has a radius of 4.0 cm. The block is released from rest and it falls 1.5 m in 0.8s. At this point, the rope comes off the pulley. The pulley comes to a stop in 0.4s. Determine:

1. The frictional torque acting on the pulley.
2. The rotational inertia of the pulley.

**4-January-2018:** A solid sphere of weight 36.0N rolls up an incline at an angle of 30o. At the bottom of the incline, the center of mass of the sphere has a translational speed of 4.90m/s. Knowing that the rotational inertia of a solid sphere with respect to its diameter is I = MR2, where M and R are the mass and radius of the solid sphere respectively.

1. What is the kinetic energy of the sphere at the bottom of the incline?
2. How far does the sphere travel up along the incline?

**5-January-2018:**

1. An ice skater is spinning on the tip of her skate with her arms extended. Explain why she has to pull her arms in toward her body if she wants to increase her angular speed.
2. During the spin, her angular speed increases from 1.50 rad/s to 15.0 rad/s. By what factor does her moment of inertia around her central axis change as she pulls in her arms and by what factor does her rotational kinetic energy change? Where does her extra rotational kinetic energy come from?