# ECE 105 Quiz 8

## Thursday Tutorial

**Individual (10 marks):** A child (m = 30 kg) runs in a straight line toward a stationary merry-go-round (solid disk of M = 300 kg and R = 3 m) with initial linear velocity *vi*= 6 m/s and then jumps tangentially on the rim of the merry-go-round. There is no friction between the disc of the merry-go-round and the axis of rotation.

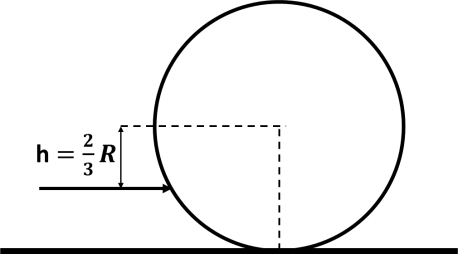
a) What is the angular speed, ω, of the merry-go-round immediately after the child lands onto it?

b) As soon as the child lands on the merry-go-round he begins to run along its circumference at 3 rad/s relative to it in direction opposite to the rotation of the merry-go-round. What is the angular speed of the merry-go-round relative to the ground?

**Group work:**

1. The magnitude of the angular momentum of the child with respect to the axis of rotation of the merry-go-round, before it lands on the rotating platform is:
   1. .
   2. , since the child runs along a straight line before it jumps on.
2. What is the angular momentum of the merry-go-round about its axis of rotation, before the child jumps on?
   1. 0
3. Neglecting air resistance, is the angular momentum of the system (child + disk) conserved as the child jumps on the merry-go-round?
   1. Yes, because the external forces acting on the system are parallel to the axis of rotation
   2. Yes, because there are no external forces acting on the system
   3. Yes, because the net external torque to the system is zero.
   4. No, because the external force of gravity is acting on the system.
4. Which of the statements below is true as the child walks along the circumference of the merry-go-round?
   1. The total angular momentum of the system increases.
   2. The child has zero angular momentum, as his linear velocity is always parallel to the tangential velocity of merry-go-round.
   3. The total angular momentum of the system does not change.
   4. None of the above are necessarily true.
5. As the child walks along the circumference and the merry-go-round spins in the opposite direction, does the system’s mechanical energy change?
   1. No, the total mechanical energy is conserved because there is no friction at the axis of rotation of the merry-go-round.
   2. No, because frictional forces between the feet of the child and the surface of the merry-go-round are internal to the system.
   3. Not possible to determine from the available information.
   4. Yes

## Friday Tutorial

**Individual (10 marks):** A billiard ball of mass 3 kg radius 20 cm initially at rest is given a sharp blow by a cue stick. The force is horizontal and is applied at a distance 2R/3 below the centerline, as shown in diagram. Assume friction can be neglected during the cue strike. After being struck by the cue stick, the speed of the center of mass of the ball is v0=19.6 m/s. If the coefficient of kinetic friction between ball and the surface is =0.15:

1. What is the initial angular speed of the ball immediately after the cue stick hits it?
2. What is the speed of the center of mass of the ball once it begins to roll without slipping?

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**Group work:**

**For the following, use a linear coordinate system with positive x-axis oriented left to right and a positive z-axis into the page (so clockwise rotation is positive)**

1. Immediately after being struck by the force F, which of the following is true?
2. What is the relationship between the applied force and the resulting linear velocity of the ball’s center of mass?
3. What is the relationship between the applied torque and the resulting angular velocity of the ball’s center of mass?
4. After the ball begins to move, which of the following is true about the force and torque due to kinetic friction?
5. Consider a ball rolling smoothly along a flat rough surface. At one point the ball encounters a patch of frictionless surface. How would the ball move along the frictionless surface?
   1. Slide only, as there is no force to sustain the rotational motion.
   2. The rolling motion will slow and the ball will eventually stop, as there is no friction from the surface to sustain the rotational motion.
   3. Spin in one place, as there is no frictional or any other force to propel the ball to translate along the surface.
   4. Continue rolling with no change to the rolling motion.

## Thursday Solutions

a) Relative to the centre of the merry-go-round, the child has an initial angular momentum:

and the merry-go-round has no angular momentum because it is not rotating. When the child jumps on the merry-go-round, the only external forces that are relevant are gravity and the normal force; these provide no torque about the axis of the merry-go-round’s rotation. Thus angular momentum about this axis is conserved, and we have

, where I is the moment of inertia of the whole system, . Thus .

b) Again, angular momentum is conserved. Relative to the ground, the child’s angular velocity is now , where is the unknown angular velocity of the disk. So

## Friday solution

The net linear impulse gives

The net angular impulse gives

Once it starts rolling, there is a net force due to kinetic friction, and this also provides a torque , so

When pure rolling starts, so

So