# kinetic karnival
## rotation PART 2: ROTATION

***In which our hero proves his virility and masculinity by starting and stopping a merry-go-round with his bare hands, demonstrating martial artistry, taking an egg for a spin, and performing the patented "Doc Walker Swan Dive."***

The mechanics of rotation are more mysterious than those of linear motion, largely because of our lack of experience with rotation and the seemingly counterintuitive behavior of objects undergoing rotation.

I introduce the relationship between lever arm, torque and the force causing the torque. For these demonstrations I am stationed at a playground's merry-go-round. My torque on the merry-go-round causes an angular acceleration, but the size of that acceleration depends on the distribution of mass on the merry-go-round.The mass and its distribution is called the moment of inertia.

Still at the playground I discuss how the angular momentum of a rotating system must remain unchanged when there is no external torque on the system.The angular momentum is constant even if the system has an internal redistribution of mass and a consequent change in its moment of inertia. When the angular momentum is constant and the moment of inertia is altered, the angular speed of the object changes.The change is surprising, even in common examples such as a spinning ice skater.

Such subtle changes in the angular speed of a rotating object are responsible for much of the grace of ballet and somersaulting dives. For example, a ballet performer can alter her spin on her toes by drawing in or extending outward her arms.A diver from a high platform can increase or decrease his spin rate by extending his arms and legs or by curling up into a ball.

Angular motion can also help in the kitchen. In the show I demonstrate how you can distinguish a fresh egg from a hard-boiled one. First, spin the egg. One kind of egg spins smoothly while the other spins erratically.

As a second test, touch briefly each spinning egg, just enough to stop the rotation. One type of egg will lose its angular momentum completely due to the torque applied during the touch.The other type will spin again after the touch.

If you are still uncertain of the egg, give it a large spin. One kind of egg will stand up on one end, the other is too erratic in its spin to follow. Special types of tops will also stand up or invert themselves. With them or the hard-boiled egg the inversion is due to friction from the table.The friction creates a torque that rolls the egg or top over to its strange orientation.

*Jearl Walker*

**Professor of Physics**
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**JEARL-GO-ROUND...**

1. To begin a rotation, you must apply a _____torque_____.

2. The lever arm is the distance from the _____rim_____ to the _____center_____ of the merry-go-round.
[OK if these two are switched]

3. When the students are gathered at the center of the merry-go-round, the moment of inertia was relatively _____small_____; when they move to the outside of the merry-go-round, the moment of inertia becomes relatively _____large_____.

**...AND 'ROUND AND 'ROUND**

4. Angular momentum is the multiplication of an object's _____moment_____ _____of_____ _____inertia_____ and _____speed_____ of rotation.

5. When Jearl is spinning and he pulls in the bricks he's holding,

| | | | |
|---|---|---|---|
| his rotational inertia (I) | A. increases | **B. decreases** | C. remains constant |
| his angular speed (ω) | **A. increases** | B. decreases | C. remains constant |
| his angular momentum (L) | A. increases | B. decreases | **C. remains constant** |

6. When Jearl inverts the bicycle wheel so that its rotation goes from *counterclockwise* to *clockwise*, he starts
to rotate counterclockwise

**>>>MUSIC TRIVIA: Name the artist and title of that silky 1980 #1 instrumental hit.<<<**
[This item is not graded]

**JUDO JEARL**

7. Jearl wears
A. Italian penny loafers B. alligator slip-ons C. Birkenstocks D. snappy wingtips
**E. funky blue and white 1970's off-brand running shoes**

**JEARL IS THE EGGMAN (AGAIN)**

8. A fresh egg (select all that apply)
A. spins nicely
**B. continues to spin after a brief touch**
C. stands on end when spun rapidly

**JEARL IN A BATHING SUIT!**

9. When CSU diver Rich Karban leaves the diving platform, he
**A. has some angular momentum**
B. has no angular momentum

10. When the diver is bent over, he rotates _____quickly (or fast)_____;
When the diver is outstretched, he rotates _____slowly_____.

**JEARL-GO-ROUND...**

1. Torque is the multiplication of the force and the lever arm.

2. When the students move to the *outside* of the merry-go-round, Jearl finds it ( EASIER / **HARDER** ) to accelerate them and ( EASIER / **HARDER** ) to stop them.

**...AND 'ROUND AND 'ROUND**

3. While Jearl is spinning on his "piano stool" his angular momentum must remain constant as long as there's no torque acting on him.

4. When Jearl is spinning and he pulls in the bricks he's holding,

| | | | |
|---|---|---|---|
| his rotational inertia (I) | A. increases | **B. decreases** | C. remains constant |
| his angular speed ($\omega$) | **A. increases** | B. decreases | C. remains constant |
| his angular momentum (L) | A. increases | B. decreases | **C. remains constant** |

5. Not only does the amount of angular momentum have to stay constant, but the direction of angular momentum must stay the same, too.

**>>>MUSIC TRIVIA: Name the artist and title of that silky 1980 #1 instrumental hit.<<<**

[This item is not graded]

**JUDO JEARL**

6. In Judo, you try to move your opponent's

**A. center of mass**
B. support area
C. internal organs
D. cerebral hemispheres

7. Jearl wears

A. Italian penny loafers B. alligator slip-ons C. Birkenstocks D. snappy wingtips
**E. funky blue and white 1970's off-brand running shoes**

**JEARL IS THE EGGMAN (AGAIN)**

8. A hard-boiled egg (select all that apply)

**A. spins nicely**
B. continues to spin after a brief touch
**C. stands on end when spun rapidly**

**JEARL IN A BATHING SUIT!**

9. When CSU diver Rich Karban leaves the diving platform, he

A. has no angular momentum
**B. has some angular momentum**

10. When the diver is bent over, he rotates quickly (or fast); When the diver is outstretched, he rotates slowly.