PhyzSpringboard: Intro to Angular Momentum

Before discussing angular momentum, it would be useful to recall some characteristics of linear momentum. Consider the following examples.

1. A baseball moving at 50 mph is ___easy ___hard for a ball player to stop. (Check the correct word, line out the incorrect one.) Draw a diagram to the right.

2. A loaded delivery truck moving at 50 mph is ___easy ___hard for a ball player (or anyone else) to stop. Draw a diagram to the right.

3. A bullet moving at 500 mph is ___easy ___hard to stop. Draw a diagram to the right.

4. A loaded delivery truck parked while making a delivery is ___easy ___hard to stop. Draw a diagram to the right.

5. Describe the characteristics of a hard-to-stop body.

Massive, Fast

6. **Momentum** is a measure of how difficult it is to stop a body. What determines momentum (write one algebraic expression in words and another in symbols)?

Momentum = mass · speed

$p = mv$

7. But that's not all.
a. Consider a railroad car moving along the track. It has a certain amount of _____mass_____ and a certain amount of _____speed_____ so it has a certain amount of momentum. Draw a diagram to the right.

b. If that car were to collide with and stick to an identical car initially at rest, the two would continue with a different speed. That speed would be such that the momentum of the coupled cars is equal to the original momentum of the moving car. Draw diagrams to the right to illustrate this, and determine the speed of the coupled cars (in terms of the original speed of the moving car).

c. The principal illustrated is the _____conservation_____ **of linear momentum.** Linear momentum is one of the three quantities in the universe whose total amount is the same now as it always has been and always will be.

And now on to angular momentum. Consider the following.

8. A merry-go-round rotating slowly with only one child on board (and standing halfway between the axis and the rim) is ___easy ___hard to stop. (Check the correct word, line out the incorrect one.) Draw a diagram to the right.

9. A merry-go-round rotating **quickly** with one child on board (and standing halfway between the axis and the rim) is ___easier ___harder to stop than the original situation described in exercise 8. Draw a diagram to the right.

10. A merry-go-round rotating slowly with **four** children on board (each standing halfway between the axis and the rim) is ___easier ___harder to stop than the original situation described in exercise 8. Draw a diagram to the right.

11. A merry-go-round rotating slowly with one child on board (standing **all the way out** at the rim) is ___easier ___harder ___equally difficult to stop compared to the situation described in exercise 10. Draw a diagram to the right.

12. Describe the characteristics of a hard-to-stop rotating body.

High rotational inertia, high angular speed

13. **Angular momentum** is a measure of how difficult it is to stop a rotating body. What determines angular momentum (write one algebraic expression in words and another in symbols)?

Angular momentum = rotational inertia · angular speed

$L = I\omega$

14. But that's not all.

a. Consider a person on a turntable holding weights out at arm's length and rotating with a certain angular speed. The person has a certain amount of angular momentum. Draw a diagram to the right.

b. If the person were to pull the weights in to her chest, reducing her rotational inertia to one half its original value, she would continue to rotate with a different angular speed. That angular speed would be such that her angular momentum with weights pulled in is equal to her original angular momentum with arms outstretched. Draw diagrams to the right to illustrate this, and determine her new angular speed.

c. The principle illustrated is the _____conservation_____ **of angular momentum.** Angular momentum is one of the three quantities in the universe whose total amount is the same now as it always has been and always will be.