Part E: Angular Momentum

$$L = I\omega$$

Symbol	**Quantity**	**SI Unit**
L	Angular momentum	Kg m^2 /second
I	Rotational Inertia	Kg m^2
ω	Angular velocity	Radians / second [although, because radians are unitless, it is really 1/s]

Angular Momentum: Crucial Points

When angular momentum is constant, rotational inertia and angular velocity are *inversely proportional*.

Angular momentum is constant when there are *no external torques*.

Written Problem 11: The Skater Problem

A figure skater is spinning around very very quickly on the ice.
She moves her arms outward, and she begins spinning much slower.
She then moves them back in, and begins spinning much faster again.

Explain this phenomenon by using the concept of *angular momentum*.

Written Problem 12: The iPhone Problem

An iPod is hanging from a string.
Someone begins playing music on the iPhone and it starts *spinning*.
What's going on?

Deflection

An object moving with angular momentum is more difficult to deflect.

Written Problem 13: Problem: Spiral on a football

When a quarterback throws a football, they want it to travel straight.
In order for them to make it go straight and on target, they must make the ball spiral as it flies.
Explain this concept using angular momentum:
Compare a football that is spiraling to one that is not. Imagine a force (air turbulence) is attempting to knock the ball off of its path. How will it affect the two different footballs differently?

Written Problem 14: Knuckleballer
A knuckleball is a very unique baseball pitch. In order to throw a knuckleball, the pitcher must throw the ball with absolutely no spin. This is incredibly hard to do! If the ball has only a small spin, the knuckleball does not work, but if it has zero spin, then it moves around seemingly randomly as it flies. Explain this concept using the same principles as in problem 13.

What makes the world go round?
a. money
b. love
c. chocolate
d. angular momentum

[Seriously, the reason the earth spins is literally because it has angular momentum]

Written Question 11: Answers:
6 points:
1 point for mentioning that angular momentum is *constant* in this situation
1 point for mentioning that the reason angular momentum is *constant* is there are no external torques
1 point for referring to the L = I omega formula and pointing out that (if angular momentum is constant), I and omega are inversely proportional
2 points for mentioning that when the skater brings her arms in, rotational inertia goes *down* because mass is closer to her axis of rotation, and thus angular velocity goes *up* because the two are inverse proportional
2 points for mentioning that when the skater holds her arms out, rotational inertia goes *up* because mass is farther away from her axis of rotation, and thus angular velocity goes *down* because the two are inversely proportional

Written Question 12: Answers
3 points:
1 point for mentioning that angular momentum must be zero through this situation because nothing is spinning initially and there are no external toques
1 point for knowing that, inside the iPod, the hard drive begins spinning around when music is played.
1 point indicating that, for angular momentum to remain at *zero*, the iPod must begin spinning the opposite direction.

Bonus if you took the opportunity for a tirade against Apple slowing down old iPhones instead of simply allowing its customers to replace batteries.

Angular Momentum Name ______________________

A = constant * B
A and B are directly proportional.

constant = C * D
C and D are inversely proportional.

If C decreases, what happens to D?

$$\vec{L} = I\vec{\omega}$$

What does $\vec{L}$ stand for?

What does I stand for?

What does $\vec{\omega}$ stand for? [bonus: what letter is this?]

Which quantities are vectors, and which is a scalar?

What is the relationship between rotational inertia and angular velocity? What is the condition for this relationship?
[Whenever I say “what is the relationship” I am looking for something to do with proportionality.]

Explain something that has a very high rotational inertia and why.

Explain something that has a very high angular velocity and why.

Angular Momentum Name ______________________

Written Question: Please answer on another page
A student is holding out dumbbell weights and is sitting in a spinny chair.
Someone begins spinning them around, until he is moving somewhat fast.
Then, the student pulls his weights inward, and begins to spin much, much faster
Explain why.
[6 total points, so write quite a bit to get all the points]

Angular Momentum Name ______________________

Angular Momentum Problem Grading!
Person who wrote the answer:

Grader:

6 points total

	Did your friend get this point?
1 point for indicating the key concept in this problem is angular momentum.	
1 point for indicating that, after the student begins spinning, angular momentum is constant because there is no external torque.	
1 point for indicating that when angular momentum is constant, rotational inertia and angular velocity are inversely proportional.	
1 point for indicating that when the student brings the weights inward, rotational inertia is decreased.	
1 more point for referring specifically to the formula $I = mr^2$ and mentioning that mass closer to the axis of rotation counts for less than mass farther away from the axis of rotation.	
1 point for pointing out that as rotational inertia decreases, angular velocity increases (and thus, the kid spins faster).	
Negative 1 point for each incorrect statement written. [But the score cannot be below zero]	Number of points lost: