Rotational Motion II -- Conceptual Questions

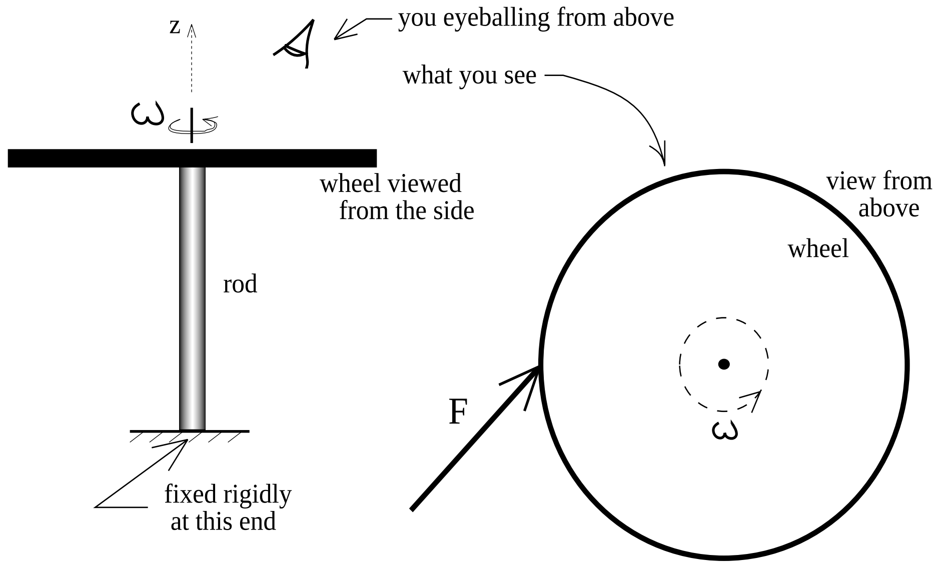
1.) A rotating wheel is supported by a fixed rod oriented as shown. A force *F* is applied to the wheel.

At the moment depicted in the sketch:

a.) In what direction is the torque due to ***F***, relative to the wheel's center?

b.) In what direction is the wheel's resulting angular acceleration?

c.) In what direction is the wheel's angular momentum?



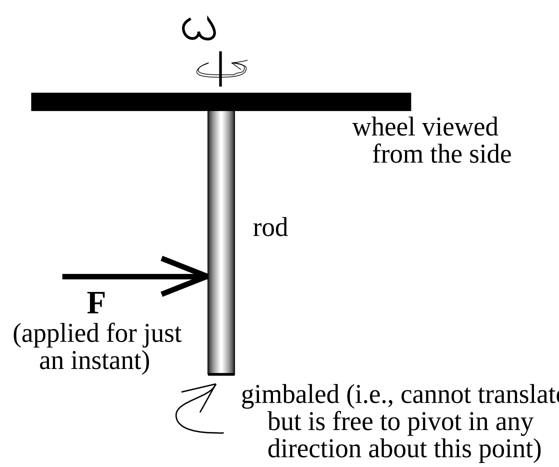
Note: Although this next question has a seemingly perverse result, its weirdness will be addressed at the end of the chapter. For now, view it as an exercise in the use of the *right hand rule* coupled with a bit of thinking about the rotational version of both *Newton's Laws* and *momentum*.

2.) The rotating wheel shown is supported by a gimbaled rod (that is, the rod cannot physically translate but it can rotate about its end in any direction). Ignore gravity (i.e., think of this as being an experiment done in the weightlessness of space). A force *F* is applied for just a moment to the wheel/rod system as shown in the sketch.

a.) In what direction is the resulting torque *about the gimbaled end*?

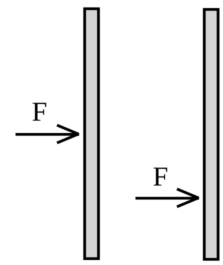
b.) In what direction is the system's resulting angular acceleration?

c.) Assuming the angular velocity starts out in the *+**k** direction* (i.e., the wheel is rotating counterclockwise as viewed from above), what is the system's angular momentum vector going to do due to the application of ***F***?



3.) Can an object that is not translating have kinetic energy?

4.) A meter stick sitting on a frictionless surface has a force F applied at its *center of mass*. The same force is then applied to an identical meter stick halfway between its *center of mass* and its end (see sketch).



a.) In the second situation, why might the phrase "the stick's acceleration due to F" be somewhat misleading?

b.) In the second situation, the phrase *the stick's acceleration due to F* is misleading but the phrase *the stick's angular acceleration due to F* is NOT misleading. How so?

c.) Will the acceleration of each stick's *center of mass* be different in the two situations? If so, how so?

d.) Will the stick's angular acceleration about its *center of mass* be different in the two situations?   If so, how so?

e.) Will the velocity of each stick's *center of mass* be different? If so, how so?

f.) Will the angular velocity about the stick's *center of mass* be different in the two situations? If so, how so?

g.) Assume the force in both cases acts over a small displacement d. How does the work done in each case compare?

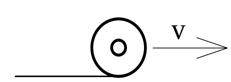
h.) Assume the force in both cases acts over a small *center of mass* displacement d (say, 2 centimeters). How does the work done in each case compare?

5.) Why does a homogeneous ball released from rest roll downhill? That is, what is going on that motivates it to roll? (Hint: No, it's not just that there is a force acting! There are all sorts of situations in which forces act and rolling does not occur).

6.) A spinning ice skater with his arms stretched outward has kinetic energy, angular velocity, and angular momentum. If the skater pulls his arms in, which of those quantities will be conserved? For the quantities that aren't conserved, how will they change (i.e., go up, go down, what?)? Explain. (Hint: I would suggest you begin by thinking about the *angular momentum*.)

7.) An object rotates with some angular velocity. The angular velocity is halved. By how much does the rotational kinetic energy change?

8.) If you give a roll of relatively firm toilet paper an initial push on a flat, horizontal, hardwood floor, it may not slow down and come to a rest as expected but, instead, pick up speed. How so?



9.) A meter stick of mass *m* sits on a frictionless surface. A hockey puck of mass *2m* strikes the meter stick perpendicularly at the stick's *center of mass* (call this *case A*). A second puck strikes an identical meter stick in the same way on an identical frictionless surface, but does so halfway between the stick's *center of mass* and its end (call this *case B*).

a.) Is the average force of contact going to be different in the two cases? If so, how so?

b.) Is the puck's after-collision velocity going to be different in the two cases? If so, how so?

c.) Is the puck's after-collision angular velocity (relative to the stick's *center of mass*) going to be different in the two cases? If so, how so?

10.) A meter stick on a frictionless surface is pinned at its *center of mass*. A puck whose mass is the same as that of the meter stick strikes and sticks to the meter stick at the .33 meter mark. A second meter stick experiences exactly the same situation except that its puck strikes and sticks at its end.

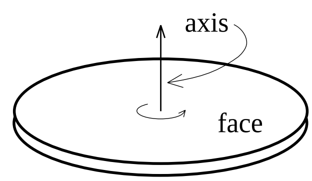
a.) Is energy conserved through each collision?

b.) In which case will the final angular speed be larger, and by how much?

11.) A rotating ice skater has 100 joules of rotational kinetic energy. The skater increases her *moment of inertia* by a factor of 2 (i.e., she extends her hugely muscular arms outward). How will her rotational speed change?

12.) It is easier to balance on a moving bicycle than on a stationary one. Why?

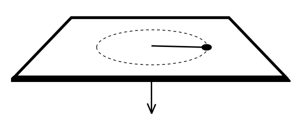
13.) A disk lying face-up spins without translation on a frictionless surface. At its *center of mass*, its angular velocity about an axis perpendicular to its face is measured and found to equal *N*. Its angular momentum at that point is measured to be *M*.



a.) Is there any other *point P* on the disk where the angular velocity about *P* is equal to *N*? Explain.

b.) Is there any other *point P* on the disk where the angular momentum about *P* is equal to *M*? Explain.

14.) A string threaded through a hole in a frictionless table is attached to a puck. The puck is set in motion so that it circles around the hole. The string is pulled, decreasing the puck's radius of motion. When this happens, the puck's angular velocity increases. Explain this using the idea of:

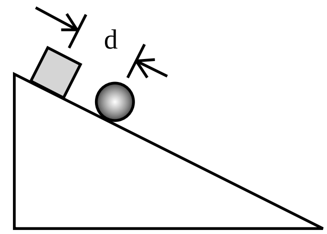


a.) Angular momentum.

b.) Energy.

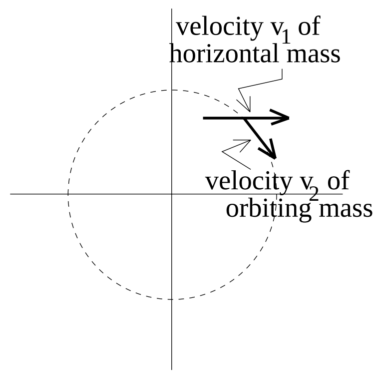
15.) When a star supernovas, it blows its outer cover outward and its core inward. For moderately large stars (several solar masses), the implosion can produce a structure that is so dense that one solar mass's worth of material would fit into a sphere of radius *less than 10 miles*. All stars rotate, so what would you expect the rotational speed of the core of a typical star to do when and if the star supernovaed? Explain using appropriate conservation principles.

16.) A cube and a ball of equal mass and approximately equal size are *d* units apart on a very slightly frictional incline plane (frictional enough for the ball to grab traction but not frictional enough to take discernible amounts of energy out of the system). By the time the ball gets to the bottom of the ramp, will the distance *d* be larger, smaller, or the same as it was at the beginning of the run? Use *conservation principles* to explain.



17.) Assume global warming is a reality. How will the period of the earth's rotation change as the Arctic ice caps melt?

18.) An object of mass m moves in circular motion with a radius of motion equal to r. At a particular instance, a second mass of the same size moving horizontally passes the first mass (see sketch). Is it possible for the two objects to have the same angular momentum?



19.) Two experiments are done involving a puck sliding over a frictionless surface and striking a meterstick at its end. In the first case, the puck stays motionless after the hit (that is, the puck hits and, as a consequence of the contact, loses all of its kinetic energy). In the second case, the puck sticks to the meterstick. If you wanted to derive an expression for, say, the angular velocity of the meterstick after the collision, there would be one major difference in the way you would set the two problems up. What might that difference be?