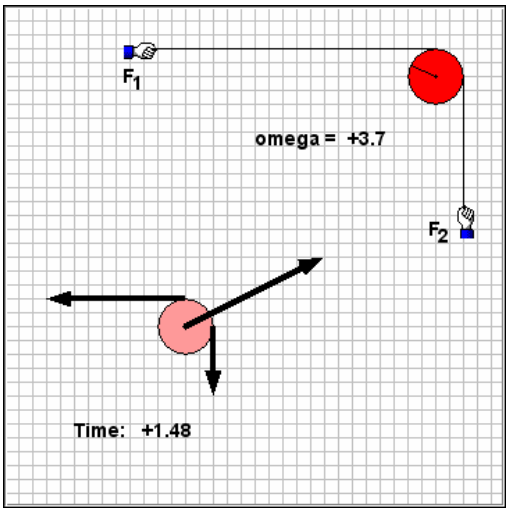
Worksheet for Exploration 10.4: Torque on Pulley Due to the Tension of Two Strings



A is a top view of a pulley on a table. The massive disk-shaped pulley can rotate about a fixed axle located at the origin. The pulley is subjected to two forces in the plane of the table, the tension in each rope (each between 0 N and 10 N), that can create a net torque and cause it to rotate as shown **(position is given in meters, time is given in seconds, and angular velocity is given in radians/second)**. Restart. Also shown is the "extended" free-body diagram for the pulley. In this diagram the forces in the plane of the table are drawn where they act, including the force of the axle.

Set the mass of the pulley to 1 kg, the radius of the pulley to 2 m, vary the forces and look at the "extended" free-body diagram.

a. How is the force of the axle related to the force applied by the two tensions?
   i. Sketch a head to tail vector addition figure for the two tensions and compare this to the axle force vector. Then discuss how these all relate.

b. How do you know that this must be the case? (explain the results from a)

For parts c-f set the mass of the pulley to 1 kg, the radius of the pulley to 2 m, and vary the forces.

c. What is the relationship between F_1 and F_2 that ensures that the pulley will not rotate?

d. For $F_1 > F_2$, does the pulley rotate? In what direction?

e. For $F_1 < F_2$, does the pulley rotate? In what direction?

f. What is the general form for the net torque on the pulley in terms of F_1, F_2, and r_{pulley}?
   i. Make sure that you include appropriate information about the signs. Note that F_1 and F_2 denote magnitudes of the forces only. The directions are as indicated in the animation.

For g set the mass of the pulley to 1 kg, F1 to 10 N, F2 to 5N, and vary the radius of the pulley.

g. How does the angular acceleration of the pulley depend on the radius of the pulley?
   i. Give a specific function of radius here. Check and verify your answer using the animation.

Set the radius of the pulley to 2 m, F1 to 10 N, F2 to 5N, and vary the mass of the pulley.

h. How does the angular acceleration of the pulley depend on the mass of the pulley?
   i. Give a specific function of radius here. Check and verify your answer using the simulation.

i. Given that the pulley is a disk, find the general expression for the angular acceleration in terms of F_1, F_2, m_{pulley}, and r_{pulley}.
   i. Make sure that the signs and limiting cases agree with your expression. Limiting cases to consider are letting the mass of the pulley get large or small, likewise with the forces. You should check that your results agree with the simulation.