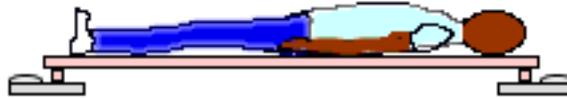


Torque and Angular Momentum

1. Finding the C.O.M.

You will be provided with a plank and two digital bathroom scales. Place each digital scale on the small "step" palettes (just to raise them a few inches off the floor) and place them on the floor such that the rubber feet on each end of the plank rests approximately in the middle of each scale. Place the plank on the two scales and record the values (you may need to experiment a bit on how to initiate the scale to read. They will flash just before fixing on a value. Using the fact that $\Sigma F = 0$ and $\Sigma \tau = 0$ for the plank, determine the mass/weight and the location of the center of mass (c.o.m.) of the plank. The feet are located 2.000m apart, and they will be the point of contact with the scales.

With a volunteer laying on the plank, again record the value on each of the two scales. Measure the distance from the volunteer's feet to the line marked on the board. Determine the location of the center of mass (c.o.m.) of the volunteer, again using $\Sigma F = 0$ and $\Sigma \tau = 0$. Don't forget to include the plank's mass and c.o.m. in the calculations. Then use the distance from the feet to the marked line to find the c.o.m. relative to their feet. Find the ratio of the height of the c.o.m. to the total height of the person.



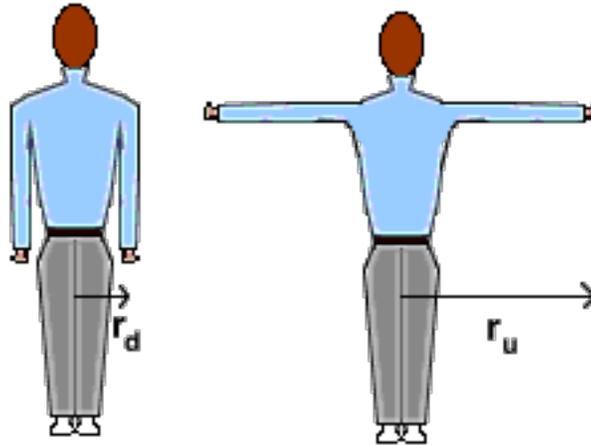
2. $\tau = \Delta L / \Delta t$

Each member of the group sits on the platform and is handed the bicycle wheel spinning in the vertical plane. Give the subject a small horizontal push to give them an angular velocity on the platform. Repeat several times reversing the direction of spin of the wheel and platform. Repeat with the wheel spinning in a horizontal plane. For each case, the subject should note the forces exerted by each hand and direction of the resultant torque necessary to maintain the wheel's orientation. Using top and side view diagrams, show the direction of \mathbf{L} , the change in \mathbf{L} ($\Delta \mathbf{L}$), and the applied torque τ in each case.

3. $L_i = L_f$

One person from your group is seated stationary on the rotation platform. This person is handed a bicycle wheel spinning in a horizontal plane. Note the direction of the angular momentum (\mathbf{L}) of the wheel. The person now rotates the wheel axis through 180 degrees. Using diagrams indicate what happens and explain the results using conservation of angular momentum.

4. $I_i\omega_i = I_f\omega_f$



A volunteer member of the group stands on the platform with arms hanging vertically at their side. Try a few gentle spins to be sure the person is center on the platform. Give the subject a small angular velocity (< 1 rps) and measure this value by finding the time required for 2 rotations. The subject then quickly raises the arms to a horizontal position and the new time for two rotations is measured. Do not touch the subject during the procedure. There is a double time feature on the stopwatches that will minimize the number of rotations required to do this. Or you may use two persons, each with their own stopwatch.

Repeat the procedure with 1 kg masses held in the hands, and a third time using 2 kg masses if the volunteer is strong enough. (It is possible that the rotation with the arms out will be slow enough that measuring the time of one rotation will be sufficient.)

Find the ratio of the rates of rotation for each experiment. Then compare the ratios to one another. Can you identify any trends in the ratio resulting from the addition of the masses?

(2 pt Bonus: Using two sets of your data, determine the moment of inertia of the student with hands down. Compare this to a theoretical value estimated by measuring the student's "diameter" and mass, and then assuming the person is a cylinder.)

5. L_{cat} ?

A cat with its back to the ground can rotate itself 180 degrees while falling in order to land on its feet. It does this with *no initial or net angular momentum!*

Can you explain this? First, use the platform and the bicycle wheel to convince yourself that rotations can be achieved without a net angular momentum.

Seat yourself on the platform and devise a method to achieve a net rotation using your arms and legs. Do not use the friction inherent in the platform by using quick, jerking motions! You may wish to put weights in your hands to increase the effectiveness of arm motions. (A cat has great flexibility that allows for very effective movements.) Describe your method.