Balancing a broom on your palm with the heavier, straw end upward isn't very hard. In contrast, trying to balance a broom with the straw end downward against your palm is very difficult (and this has nothing to do with the stiffness of the straw!). Discuss why this is so.

Key is distribution of mass about the axis

Considering the center of mass in the broom is on the straw end, **when the straw end is up the center of mass is farther away from the axis** and is allowed to be balanced better. Opposed to the straw end of the broom being in the palm of the hand, which is closer to the axis and less torque is involved so therefore it will be harder to balance.

That factor is expressed via the **moment of inertia**

When the straw end is further away then the moment of inertia is greater than when the straw end is on the hand. As the broom begins to fall, some torque will act on the broom causing some angular acceleration. **Larger moment of inertia means smaller angular acceleration which will give the person more time to adjust** and keep the broom up.

Important: you must explicitly identify the axis of rotation!

The reason that it is easier to balance a broom with the straw side up is that this is the orientation that has a greater moment of inertia. In the simplest (over-simplified) terms possible, **the moment of inertia is a measurement of how far away mass is distributed from the axis of rotation.** In this situation, **the axis of rotation runs through the point where the broom touches your palm.** Now, it is important to note that the part of the broom with straw is generally denser (or perhaps more massive even) than the shaft of the broom. Thus, when the straw is pointing up, it is far away from the axis of rotation (where your hand is), meaning that the moment of inertia is greater. The result of this is that the broom will resist changes to its angular motion (ideally 0 motion if you are trying to balance it) more than if it were straw side down. If the straw is down, it is closer to the axis of rotation, meaning that the most massive part of the broom is close to the axis of rotation, making a smaller moment of inertia. So, **when the straw side is down, any given torque will change the angular motion more than if the straw side were up.** As balancing involves trying to reduce motion and balance torques, it is easier to do with an object with a greater moment of inertia.

Curious feature: is the torque the same?

In a broom, the mass is not distributed in a uniform manner, but the majority of the mass is in the straw end. Therefore, the center of mass is closer to the straw end. When you balance the broom with the straw end on your palm, the center of mass is closer to your palm than if you balanced it with the straw end upward. **When the straw end is on your palm, the gravitational force has less of an impact than if it were flipped around, so torque in this scenario is less than it would be if the straw were facing upward. When the straw is up and torque is high, it is more likely to fall.**

Estimate your own moment of inertia. Explain your logic and don't forget the units!

Math included, but axis never explicitly defined!

My mass is about 75 kg

My height is about 1.83 m

My waist size is about 0.82 m

Inertia=(mr^2)/2 <- "Moment of" missing!

Using a cylinder, the circle of a cylinder is 2pi*r

Therefore r=0.82m/2pi which is about 1.3m **<- decimal point error!**

since r=1.3m then I=(75kg*1.3m^2)/2=>about 64kg*m^2

Axis of rotation identified

If **my feet are the axis of rotation**, my moment of inertial would most resemble that of a **cylinder with the axis at the end ML^2/3**. However, since more of my mass is distributed away from the axis of rotation, the coefficient would likely change (unfortunately, I do not know how it will change). Since I am 1.80 m tall and weigh 70 kg, my moment of inertia would be about (70 kg * (1.8 m)^2)/3 or (70 kg * 3.3 m^2)/ 3 or about **70 kg*m^2.**

Formally correct, but mixed units are an abomination

Considering that the vast majority of my weight is distributed in a cylindrical shape, I will use the inertia formula for a cylinder (**I=1/2MR^2**). I weigh roughly 85kg and have a waist size of 34 inches. 34/2pi yields a radius of around 6 inches. 80kg times 40 square inches is 3200 kg*inches^2. Divide that by 2 and it gives you a moment of inertia of **1600 kg*inches^2.**

Without looking back at the formulas (really!), which of the following would you expect to have the highest moment of inertia?

a. A solid, uniform ball of mass 1 kg and radius 10 cm
b. A hollow spherical shell of mass 1 kg and radius 10 cm
c. A circular hoop or ring of mass 1 kg and radius 10 cm
d. A uniform disk of mass 1 kg and radius 10 cm
e. They should all be the same