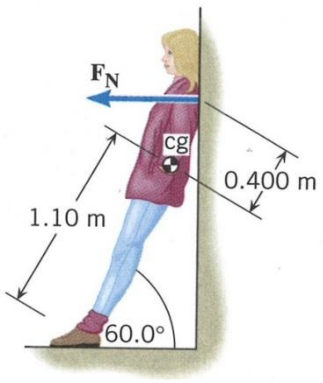
PHYS 1210 Discussion 9. Torque and angular momentum

1. A woman who weighs 500 N leans against a frictionless vertical wall, as the drawing shows. The distance from the bottom of her feet to her shoulders, which touch the wall, is 1.50 meters, and from the bottom of her feet to her center of gravity cg is 1.10 meters. The vector from where her feet touch the ground to where her shoulders rest against the wall is 60 degrees above horizontal. Find:



   A. the vertical component of the force exerted on her shoes by the ground.

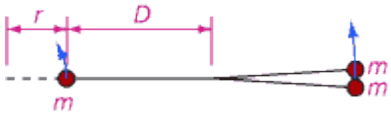
   B. the force F_N (directed perpendicular to the wall) exerted on her shoulders by the wall.

   C. the horizontal component of the force exerted on her shoes by the ground.

2. Argentine *gauchos* use a device known as *bolas* to hunt. The device consists of several weights at the ends of cords connected in the middle. The gaucho throws spinning bolas (the word appears to be self-plural, like "scissors" or "pants") at the animal, and the weights wrap around the animal's legs, immobilizing it.

   A conventional design (*boleadoras*) consists of three weights of mass *m* connected to a central knot by cords of length *D*. To throw the boleadoras, the gaucho holds one of the weights in his hand and swings it in a circle of radius *r* over his head. The other two weights move as far away from the handled weight as the cords allow, and travel in circular paths about the same center.

Archives of Pearson Scott Foresman, donated to the Wikimedia Foundation.



   A. When the boleadoras are in this configuration, how far from the center of the circle is their center of mass?

   B. When the boleadoras are in this configuration, what is their moment of inertia I_1 about their center of mass? Express in terms of *m* and *D*.

C. When the boleadoras are in this configuration, what is their moment of inertia I_2 about the center of the circle? Express in terms of r, m, and D.

D. When the gaucho swings the boleadoras in a circle of radius r with angular speed ω_1, what is the speed of the center of mass of the boleadoras? Express in terms of ω_1, r, m, and D.

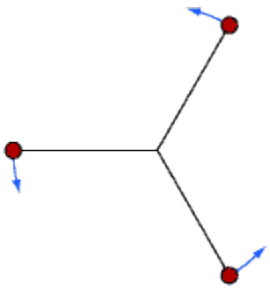
E. When the gaucho swings the boleadoras in a circle of radius r with angular speed ω_1, what is the kinetic energy of the boleadoras? Express in terms of ω_1, r, m, and D.

F. Immediately after the gaucho releases the boleadoras from his hand, what is the speed of the center of mass of the boleadoras? Express in terms of ω_1, r, and D.

G. Immediately after the gaucho releases the boleadoras from his hand, what is the kinetic energy of the boleadoras? Express in terms of ω_1, r, m, and D.

H. Immediately after the gaucho releases the boleadoras from his hand, what is the angular velocity ω_2 of the boleadoras?

After the gaucho releases the boleadoras, they fan out into a new configuration, with the three weights evenly distributed about the central knot.



I. What is the moment of inertia I_3 of the boleadoras about their center of mass in this new configuration?

J. To maintain the angular momentum of the boleadoras, what is their new angular velocity ω_3?

K. Is kinetic energy conserved when the boleadoras fan out?