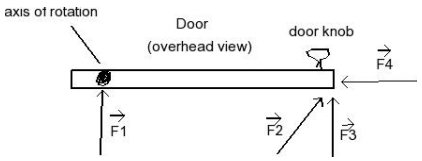
AP Physics 1
6.1 – The Action of Forces and Torques on Rigid Objects
Focusing on Concepts/Problems Assessment

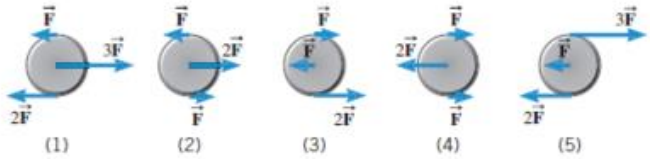
Name: _____ Period: _____

1) The wheels on a moving bicycle have both translational (or linear) and rotational motions. Given a spinning wheel on a bicycle in motion, what is meant by the phrase, "a rigid body, such as a bicycle wheel, is in equilibrium?"

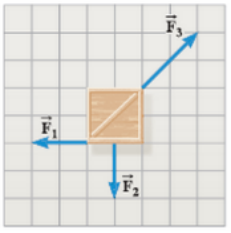
2) The drawing illustrates an overhead view of a door and its axis of rotation (the axis is perpendicular to the page). There are four forces acting on the door, and they all have the same magnitude. Rank the torque τ that each force produces, from largest to smallest.



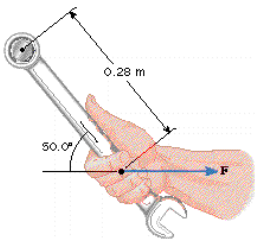
3) Five hockey pucks are sliding across frictionless ice, as shown in the drawing. Three forces, each having different magnitudes, are acting on each puck at different locations. Which puck is in equilibrium and why?



4) The drawing shows a top view of a square box lying on a frictionless floor. Three forces, drawn to scale, are acting on the box. Given an axis of rotation running perpendicular to the page, will the box have translation acceleration, angular acceleration, both, or neither? Why?

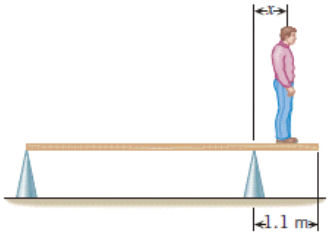


5) You are installing a new spark plug in your car, and the manual specifies that it be tightened to a torque that has a magnitude of 45 N-m. Using the data provided in the drawing, determine the magnitude F of the force that you must exert on the wrench.

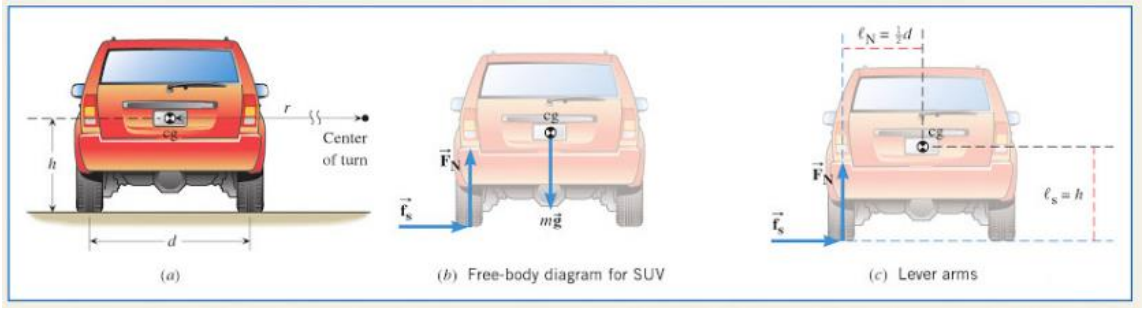


6) A person is standing on a level floor. His head, upper torso, arms, and hands together weigh 438 N and have a center of gravity that is 1.28 m above the floor. His upper legs weigh 144 N and have a center of gravity that is 0.760 m above the floor. Finally, his lower legs and feet together weigh 87 N and have a center of gravity that is 0.250 m above the floor. Relative to the floor, find the location of the center of gravity for his entire body.

7) A uniform plank of length 5.0 m and weight 225 N rests horizontally on two supports, with 1.1 m of the plank hanging over the right support. To what distance x can a person who weighs 450 N walk on the overhanging part of the plank before it just begins to tip?

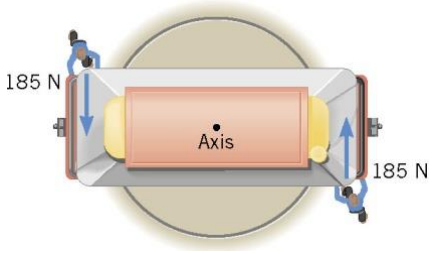


8) The figure shows a sport utility vehicle that is moving away from you and negotiating an unbanked, horizontal turn. The radius of the turn is 16 m. The center of gravity of the vehicle is 0.94 m above the ground and is located midway between the left and right wheels, which are 1.7 m apart. What is the greatest speed at which the SUV can negotiate the turn without rolling over? The free-body diagrams have been provided for you.

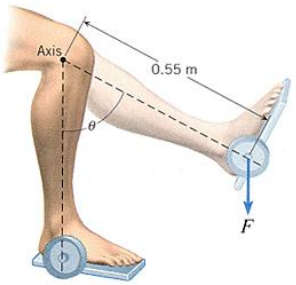


Problems

1) Railroad cars and trolley cars must be turned around in a space-efficient manner when they reach the end of their tracks. One way to do this is with a rotating platform. This is used in San Francisco, for example. The trolley car rolls onto a turntable, which can rotate about a vertical z-axis through its center. Two people then push perpendicularly on each end of the car, as shown, for one-half revolution. If the length of the car is 9.20 m and each person pushes with a force of 185.0 N, what is the magnitude of the net torque applied to the car?

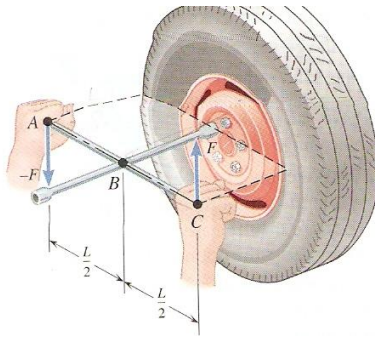


2) The engine of a certain car applies a torque of 295 N-m to a wheel (radius = 0.350 m). The wheel does not slip when making contact with the road surface. This means that the road is applying a force of static friction to the wheel that produces a countertorque. Since the car is moving with a constant velocity, the countertorque must balance the applied engine torque. What is the magnitude of the static frictional force?
3) Exercise is the name of the game! Consider someone exercising their lower-leg, as shown in the diagram below. A 49.0 N weight is being lifted at the knee, making a final angle θ.
    a. When $\theta = 90^{o}$, find the magnitude of the torque that the weight creates.
    b. At what angle θ does the magnitude of the torque equal 15 N-m?



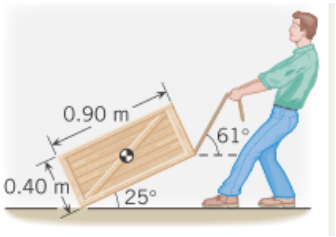
4) A type of pinwheel uses a square (0.40 m on each side) through which an axis is mounted through the center of the square (z-axis, or perpendicular to the plane of the square). A force of 15 N lies in this plane and is applied to the square. What is the magnitude of the maximum and minimum torques that such a force could produce?

5) According to Newton's Third Law, for every action there is an equal and opposite reaction. A pair of forces with equal magnitudes, opposite directions but different lines of action are called "coupled forces," or a "couple." When a couple acts on a rigid object, the couple produces a torque that does not depend on the location of the axis. Consider the drawing below, in which a couple is acting on a tire wrench, with each force perpendicular to the wrench. Determine an expression (in terms of the magnitude of F and the length L of the wrench) for the torque produced by the couple when the axis is perpendicular to the tire and passes through
   a. Point A.
   b. Point B.
   c. Point C.



6) Speaking of exercise, imagine a hiker (W = 985 N) is walking through a mountain trail and comes across a horizontal bridge. This bridge has a uniform density and a weight of 3610 N. It is supported by two concrete supports, located at each end. Our hiker stops one-fifth of the way across the bridge to enjoy the view. What is the magnitude of the force that a concrete support exerts on the bridge
   a. at the near end, and
   b. at the far end.

7) New equipment has finally arrived for the AP Physics classes! A fancy photon transmogrifier arrives in a wooden crate that has a total mass of 72 kg. A student pulls on the crate with a strap attached to the bottom of the crate, causing the crate to tilt 25° above the horizontal. The strap itself is tilted 61° above the horizontal (see drawing). The center of gravity of the crate lies at its geometric center. Find the magnitude of the tension in the strap.



8) An A-shaped stepladder is one that has sides of equal length. Consider the A-shaped stepladder shown below. This ladder is standing on a horizontal, frictionless surface, and only the crossbar, which has a negligible mass, of the "A" keeps the ladder from collapsing. The ladder is uniform an has a mass of 20 kg. Determine the tension in the crossbar of the ladder.