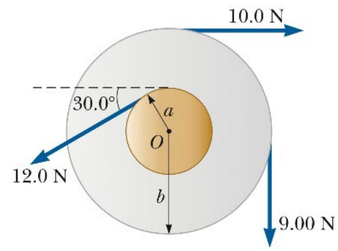
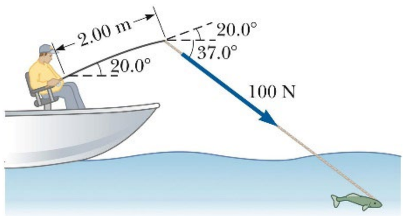
University Physics I

Homework Set 14

1. Find the net torque on a wheel (shown below) about the axle through O, taking $a = 10.0\ cm$ and $b = 25.0\ cm$.

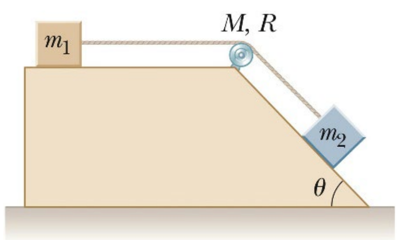


2. The fishing pole shown at right makes an angle of 20.0° with the horizontal. A force is applied at a point 2.00 *m* from the angler's hands. What is the torque exerted by the fish on the pole about the axis perpendicular to the page and passing through the angler's hand if the fish pulls on the fishing line with a force 100 N at an angle 37.0° below the horizontal?



3. A grinding wheel is in the form of a uniform solid disk of radius 7.00 *cm* and mass 2.00 *kg*. It starts from rest and accelerates uniformly under the action of the constant torque of 0.600 N that the motor exerts on the wheel.
   a. How long does the wheel take to reach its final operating speed of 1200 *rev*/*min*?
   b. Through how many revolutions does it turn while accelerating?

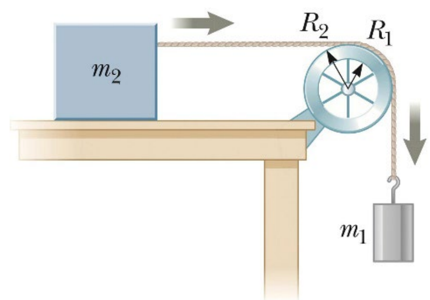
4. A block of mass $m_1 = 2.00\ kg$ and a block of mass $m_2 = 6.00\ kg$ are connected by a massless string over a pulley in the shape of a solid disk having radius $R = 0.250\ m$ and mass $M = 10.0\ kg$. The fixed, wedge-shaped ramp makes an angle of $\theta = 30.0°$ as shown in the figure at right. The coefficient of kinetic friction is 0.360 for both blocks.
   a. Draw a force diagram for both blocks and the pulley.
   b. Determine the acceleration of the two blocks.
   c. Determine the tensions in the string on both sides of the pulley.



5. A potter's wheel – a thick stone disk of radius 0.500 *m* and mass 100 *kg* – is freely rotating at 50.0 *rev*/*min*. The potter can stop the wheel in 6.00 *s* by pressing a wet rag against the rim and exerting a radially inward force of 70.0 N. Find the effective coefficient of kinetic friction between the wheel and the rag.

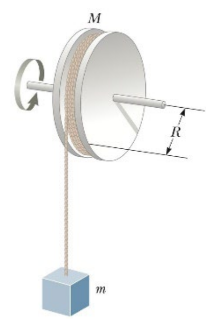
6. A flywheel of an engine has moment of inertia $1.60\ kg\ m^2$ about its rotational axis.
   a. What constant torque is required to bring it up to an angular speed of 400 *rev*/*min* in 8.00 *s*, starting from rest?
   b. How much work was done on the flywheel by the torque during this time?

7. In the figure at right, the hanging object has a mass of $m_1 = 0.420$ *kg*, the sliding block has a mass of $m_2 = 0.850$ *kg*, and the pulley is a hollow cylinder with a mass of 0.350 *kg*, an inner radius of R_1 = 0.020 *m* and an outer radius of $R_2 = 0.030$ *m*. Assume the mass of the spokes are negligible. The coefficient of kinetic friction between the block and the horizontal surface is μ_k = 0.250. The pulley turns without friction on its axle. The light cord does not stretch or slip on the pulley. The block has a velocity of $v_i = 0.820$ *m*/*s* toward the pulley when it passes a reference point on the table.



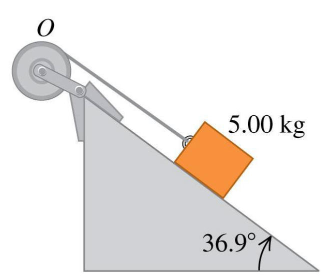
   a. Use energy methods to predict its speed after it has moved 0.700 *m*.
   b. Find the angular speed of the pulley at this same moment.

8. An object with a mass of $m = 5.10$ *kg* is attached to the free end of a light string wrapped around the reel of radius $R = 0.250$ *m* and mass $M = 3.00$ *kg*. The reel is a solid disk, free to rotate in a vertical plane about the horizontal axis passing through its center as shown in the figure at right. The suspended object is released from rest 6.00 *m* above the floor. Determine:



   a. The tension in the string
   b. The acceleration of the object
   c. The speed with which the object hits the floor

9. A block with mass $m = 5.00$ *kg* slides down a surface inclined at 36.9° to the horizontal as shown in the figure at right. The coefficient of kinetic friction is 0.250. A string attached to the block is wrapped around a flywheel on a fixed axis at O. The flywheel has mass 25.0 *kg* and moment of inertia 0.500 *kg* m^2 with respect to the axis of rotation. The string pulls without slipping at a perpendicular distance of 0.200 *m* from the axis.

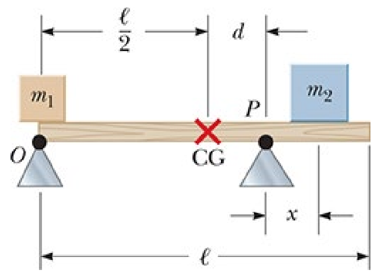


   a. What is the acceleration of the block down the plane?
   b. What is the tension in the string?

10. Given $\mathbf{A} = 2\,\hat{\boldsymbol{x}} - 3\,\hat{\boldsymbol{y}} + \hat{\boldsymbol{z}}$ and $\mathbf{B} = 4\,\hat{\boldsymbol{x}} + 5\,\hat{\boldsymbol{y}} - 2\,\hat{\boldsymbol{z}}$, calculate the vector product $\mathbf{A} \times \mathbf{B}$.

11. Given $\mathbf{A} = \hat{\boldsymbol{x}} + 2\,\hat{\boldsymbol{y}}$ and $\mathbf{B} = -2\,\hat{\boldsymbol{x}} + 3\,\hat{\boldsymbol{y}}$, calculate
   a. the vector product $\mathbf{A} \times \mathbf{B}$.
   b. the angle between **A** and **B.**

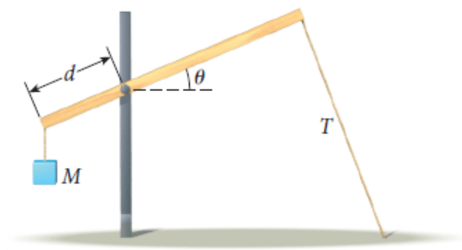
12. A uniform beam of mass m_b = 3.00 *kg* and length l = 1.00 *m* supports two blocks with masses m_1 = 5.00 *kg* and m_2 = 15 *kg* at positions shown in the figure at right. The beam rests on two triangular supports, with point P a distance d = 0.300 *m* to the right of the center of gravity of the beam. The position of the object of mass m_2 is adjusted along the beam until the normal force on the beam at position O is zero.



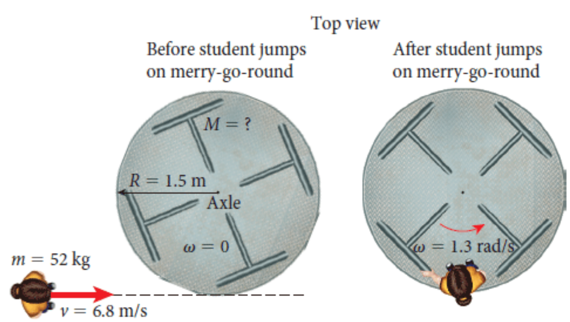
   a. Find the location x where m_2 must be placed for this setup.
   b. What is wrong with the answer in part (*a*)?
   c. What is the minimum mass necessary for m_2 to make this setup work?

Hint: Set the axis of rotation at point P since we need information at O.

13. A uniform beam with a length of 8.00 *m* and a mass of 100 *kg* is attached by a large bolt to a support at a distance d = 3.00 *m* from one end as shown in the figure at right. The beam makes an angle of θ = 30° with the horizontal. A mass M = 500 *kg* is attached with a rope to the left end of the beam, and a second rope is attached at a 90° angle to the right end of the beam. Find the tension T in the rope attached to the right side of the beam.



14. A student of mass 52.0 *kg* wants to measure the mass of a playground merry-go-round, which consists of a solid metal disk of radius R = 1.50 *m* that is mounted in a horizontal position on a low-friction axle. She tries an experiment: She runs with speed v = 6.8 *m/s* toward the outer rim of the merry-go-round and jumps on to the outer rim as shown in the figure below. The merry-go-round is initially at rest before the student jumps on and rotates at 1.30 *rad/s* immediately after she jumps on. You may assume that the student's mass is concentrated at a point.

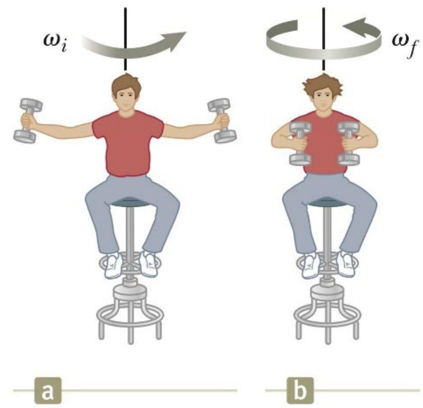


   a. What is the mass of the merry-go-round?
   b. If it takes 35.0 *s* for the merry-go-round to come to a stop after the student jumps on, what is the average torque due to friction in the axle?
   c. How many times does the merry-go-round rotate before it stops, assuming the torque due to friction is constant?

15. A uniform solid sphere of radius r = 0.500 *m* and mass m = 15.0 *kg* turns counterclockwise about a vertical axis through its center. Find its angular momentum vector **L** about this axis when its angular speed is 3.00 *rad/s*.

16. A playground merry-go-round of radius $R = 2.00\ m$ has a moment of inertia of $I = 250\ kg\ m^2$ and is rotating at 10.0 *rev*/*min* about a frictionless, vertical axis through its center. A 25.0 *kg* child hops on to the outer edge and hangs on. What is the new angular speed of the merry-go-round?

17. A student sits on a freely rotating stool holding two dumbbells, each of mass 3.00 *kg* as shown in the figure at right. When his arms are fully extended horizontally, the dumbbells are 1.00 *m* from the axis of rotation and the student rotates with an angular speed of 0.750 *rad*/*s*. The moment of inertia of the student plus the stool is $3.00\ kg\ m^2$ and is assumed to be constant. The student pulls the dumbbells inward horizontally to a position 0.300 *m* from the rotation axis.



    a. Find the new angular speed of the student.
    b. Find the rotational kinetic energy of the rotating system ***before*** and ***after*** he pulls the dumbbells inward.