Physics I: Torque and Angular Momentum

Spring 2023

Practice Version

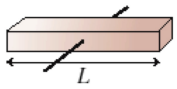
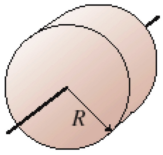
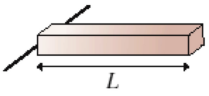
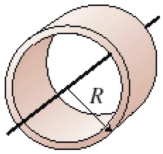
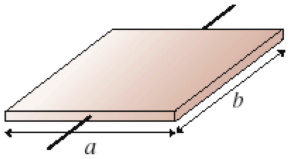
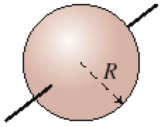
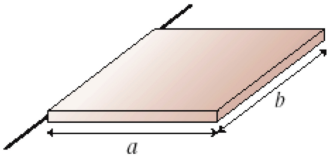
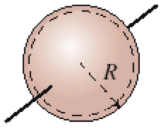
IMPORTANT: Except for multiple-choice questions, you will receive no credit if you show only an answer, even if the answer is correct. Always show in the space on your answer sheet some sketches, words, or equations which clearly justify your answer. Show the equations you use and the values substituted into them whenever equations are necessary. If you go from a formula directly to an answer without showing the values used, you will lose points. Points will also be deducted for missing or erroneous units.

Each individual answer is weighted roughly evenly throughout the exam.

You may use $g = 10\frac{\text{N}}{\text{kg}}$ throughout the exam in order to simplify calculations.

Name _____

TABLE 12.2 Moments of inertia of objects with uniform density

Object and axis	Picture	I	Object and axis	Picture	I
Thin rod, about center		$\frac{1}{12}ML^2$	Cylinder or disk, about center		$\frac{1}{2}MR^2$
Thin rod, about end		$\frac{1}{3}ML^2$	Cylindrical hoop, about center		MR^2
Plane or slab, about center		$\frac{1}{12}Ma^2$	Solid sphere, about diameter		$\frac{2}{5}MR^2$
Plane or slab, about edge		$\frac{1}{3}Ma^2$	Spherical shell, about diameter		$\frac{2}{3}MR^2$

$$\tau = rF\sin\phi \tag{1}$$

$$\sum_i \tau_i = I\alpha \tag{2}$$

$$L = I\omega \tag{3}$$

$$I_1\omega_1 = I_2\omega_2 \tag{4}$$

$$F = mg \tag{5}$$

1. An ice skater performs a pirouette (a fast spin) by pulling in his outstretched arms close to his body. What happens to his angular momentum about his axis of rotation?

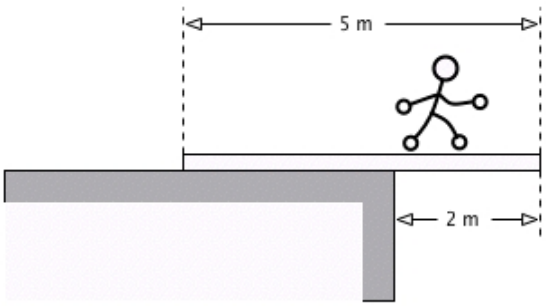
   (a) It increases.
   (b) It decreases.
   (c) It does not change.
   (d) It changes, but it is impossible to tell which way.

2. An ice skater performs a pirouette (a fast spin) by pulling in his outstretched arms close to his body. What happens to his angular velocity ω about his axis of rotation?

   (a) It increases.
   (b) It decreases.
   (c) It does not change.
   (d) It changes, but it is impossible to tell which way.

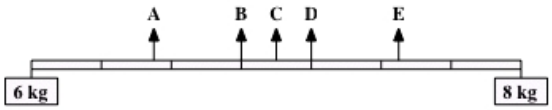
3. An ice skater performs a pirouette (a fast spin) by pulling in his outstretched arms close to his body. What happens to his rotational inertia I about his axis of rotation?

   (a) It increases.
   (b) It decreases.
   (c) It does not change.
   (d) It changes, but it is impossible to tell which way.



4. A 5-meter uniform plank of mass 100 kilograms rests on the top of a building with 2 meters extended over the edge as shown above. How far can a 50-kilogram person venture past the edge of the building on the plank before the plank just begins to tip?

   (a) $\frac{1}{2}$ m
   (b) 1 m
   (c) $\frac{3}{2}$ m
   (d) 2 m
   (e) It is impossible to make the plank tip, because the person would have to be more than 2 meters from the edge of the building.

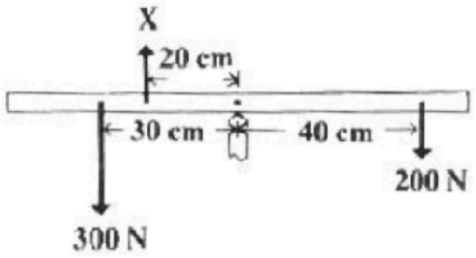


5. Two objects, of masses 6 and 8 kilograms, are hung from the ends of a stick that is 70 cm long and has marks every 10 centimeters, as shown above. If the mass of the stick is negligible, at which of the points indicated should a cord be attached if the stick is to remain horizontal when suspended from the cord?

   (a) A
   (b) B
   (c) C
   (d) D
   (e) E

6. A uniform meterstick of mass 0.20 kg is pivoted at the 40 cm mark. Where should one hang a mass of 0.50 kg to balance the stick?

   (a) 16 cm
   (b) 36 cm
   (c) 44 cm
   (d) 46 cm



7. A uniform meterstick is balanced at its midpoint with several forces applied as shown above. If the stick is in equilibrium, the magnitude of the force X in newtons (N) is

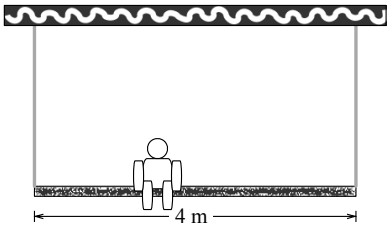
   (a) 50 N
   (b) 100 N
   (c) 200 N
   (d) 300 N

8. A uniform meter stick has a 45.0 g mass placed at the 20 cm mark as shown in the figure above. If a pivot is placed at the 42.5 cm mark and the meter stick remains horizontal in static equilibrium, what is the mass of the meter stick?

   (a) 45.0 g
   (b) 72.0 g
   (c) 120.0 g
   (d) 135.0 g

PROBLEMS

9. A thin, long, horizontal, uniform board of weight 125 N and length 4 m is supported by vertical chains at each end. A person weighing 500 N is sitting on the board 1.5 m from the left end.

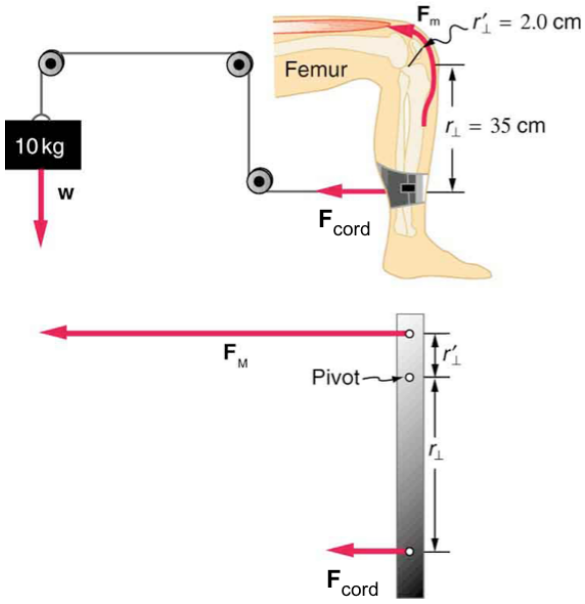


(a) What is the tension (aka "force") in the left chain?

_____

(b) What is the tension in the right chain?

_____



10. A device for exercising the upper leg muscle is shown above along with its free-body diagram. Calculate the force exerted by the upper leg muscle to lift the 10 kg mass at a constant speed.