ch 11 homework

Chapter 11: Rotational Dynamics

Conceptual problems

11.C.1 (7.00) You get a flat tire. You are trying to remove one of the lug nuts from the hubcap with a wrench. No matter how hard you pull, the nut will not budge. You examine the contents of your car to see if you have anything that will be useful. Which of the following objects can best help you remove the nut: a long, strong piece of rope; a long, hollow pipe; road flares; a first aid kit; 2 wool blankets; an ice scraper; your pet toy poodle. Explain.

11.C.2 (5.00) (a) Can an object have an angular velocity if there is no net torque acting on it? (b) Can an object have a net torque acting on it if it has zero angular velocity?

(a) ○ Yes ○ No
(b) ○ Yes ○ No

11.C.3 (5.00) On which of the following does the moment of inertia depend?

- ☐ Angular velocity
- ☐ Angular momentum
- ☐ Shape of the object
- ☐ Location of axis of rotation
- ☐ Mass
- ☐ Linear velocity

11.C.4 (5.00) An object of fixed mass and rigid shape has one unique value for its moment of inertia. True or false? Explain your answer.

○ True ○ False

11.C.5 **(5.00)** Compared to a solid sphere, will a hollow spherical shell (like a basketball) of the same mass and radius have a greater or a lesser moment of inertia for rotations about an axis passing through the center? Explain your answer.

○ Greater ○ Lesser

11.C.6 **(7.00)** Scoring in the sport of gymnastics has much to do with the difficulty of the skills performed, with higher scores awarded to more difficult tricks. The position of a gymnast's body in a trick determines the difficulty. There are three positions to hold the body in a flip: the tuck, in which the legs are bent and tucked into the body; the pike, in which the body is bent at the hips but the legs remain straight; and the layout, in which the whole body is straight. A layout receives a higher score than a pike which receives a higher score than a tuck. Use the principles of rotational dynamics to describe why the position of the body affects the difficulty of a flip.

11.C.7 **(7.00)** In extreme motocross events, daring though perhaps slightly lunatic motorcycle riders launch themselves from dirt ramps, then perform various acrobatic stunts before landing the vehicle on a second ramp. After the initial launch, the bike is aimed skyward, but for safety reasons, the wheels should both touch down at the same time upon the other downward-sloping ramp, which means that the body of the motorcycle must rotate while the bike is in flight. The rider can rotate the bike about a horizontal axis while it is flying through the air by using the accelerator or the brake, that is, by either speeding up or slowing down the rotation of the rear wheel.

(a) What principle(s) allow the rider to rotate the body of the motorbike while flying through the air? Check all that apply. (b) In order to tip the nose of the motorcycle downward, should the rider use the accelerator or the brake? (c) Explain your answer to part b.

(a)
- ☐ Conservation of angular momentum
- ☐ Conservation of linear momentum
- ☐ Parallel axis theorem

(b) ○ Accelerator ○ Brake

(c)

11.C.8 **(7.00)** A thin, small hoop is rolling slowly along the ground. An ant is walking on the inside of the hoop and a beetle is walking on top of the rolling hoop, in the directions shown. They walk at such a speed that they maintain their positions at the bottom and top of the hoop, respectively. (a) Which insect has to walk at a higher speed? (b) According to a nearby spider sitting on the ground watching the spectacle, which insect is moving faster with respect to the Earth?

(a)

(b)

Section 1: Torque

11.1.1 **(5.00)** The wheel on a car is held in place by four nuts. Each nut should be tightened to 94.0 N·m of torque to be secure. If you have a wrench with a handle that is 0.250 m long, what minimum force do you need to exert perpendicular to the end of the wrench to tighten a nut correctly?

N

11.1.3 **(5.00)** Bob and Ray push on a door from opposite sides. They both push perpendicular to the door. Bob pushes 0.63 m from the door hinge with a force of 89 N. Ray pushes 0.57 m from the door hinge with a force of 98 N, in a manner that tends to turn the door in a clockwise direction. What is the net torque on the door?

N·m

Section 2: Torque, angle and lever arm

11.2.1 **(5.00)** A 3.30 kg birdfeeder hangs from the tip of a *r* m pole that sticks up from the ground at a 65.0° angle. What is the magnitude of the torque exerted on the pole by the birdfeeder? Treat the bottom end of the pole as the pivot point.

N·m

11.2.2 **(5.00)** You want to exert a torque of at least 35.0 N·m on a wrench whose handle is 0.150 m long. If you can provide a force of 355 N to the end of the wrench, what is the minimum angle at which you can apply the force in order to achieve the desired torque?

°

11.2.4 **(7.00)** A straight 2.60 m rod pivots around a vertical axis so that it can swing freely in a horizontal plane. Jane pushes perpendicular to the rod at its midpoint with 98.0 N of force, directed horizontally, to create a torque. Matt has attached a rope to the end of the rod, and is pulling on it horizontally to create an opposing torque. The rope creates a 67.0° angle with the rod. With what force should Matt pull so that the net torque on the rod is zero?

N

Section 3: Cross product of vectors

11.3.1 **(5.00)** Two vectors **A** and **B** form a 57° angle when placed tail-to-tail. **A** has a magnitude of 3.0 and **B** has a magnitude of 5.6. What is the magnitude of their cross product?

Section 4: Torque, moment of inertia and angular acceleration

11.4.1 **(7.00)** The pulley shown in the illustration has a radius of 2.70 m and a moment of inertia of 39.0 kg·m^2. The hanging mass is 4.20 kg and it exerts a force tangent to the edge of the pulley. What is the angular acceleration of the pulley?

rad/s^2

Section 5: Calculating the moment of inertia

11.5.1 **(5.00)** Four small balls are arranged at the corners of a rigid metal square with sides of length 3.0 m. An axis of rotation in the plane of the square passes through the center of the square, and is parallel to two sides of the square. On one side of the axis, the two balls have masses 1.8 kg and 2.3 kg; on the other side, 1.5 kg and 2.7 kg. The mass of the square is negligible compared to the mass of the balls. What is the moment of inertia of the system for this axis?

kg·m^2

Section 6: A table of moments of inertia

11.6.1 **(5.00)** A tire of mass 1.3 kg and radius 0.34 m experiences a constant net torque of 2.1 N·m. Treat the tire as though all of its mass is concentrated at its rim. How long does it take for the tire to reach an angular speed of 18 rad/s from a standing stop?

s

11.6.3 **(5.00)** Three glass panels, each 2.7 m tall and 1.6 m wide and with mass 23 kg, are joined together to make a rotating door. The axis of rotation is the line where the panels join together. A person pushes perpendicular to a panel at its outer edge with a force of 73 N. What is the angular acceleration of the door?

rad/s^2

Section 9: Sample problem: an Atwood machine

11.9.1 **(7.00)** The pulley in the illustration is a uniform disk of mass 2.8 kg and radius 0.24 m, which is free to rotate without friction. The mass of the block is 1.2 kg. Downward and clockwise are negative directions. (a) What is the angular acceleration of the pulley? (b) What is the acceleration of the falling block?

(a) rad/s^2

(b) m/s^2

Section 11: Parallel axis theorem

11.11.2 **(5.00)** A thin rectangular slab, with dimensions 0.580 m by 0.830 m and mass 0.150 kg, is rotated about an axis passing through the slab parallel to the short edge. If the axis is 0.230 m from the short edge, what is the moment of inertia of the slab?

kg·m^2

Section 12: Rotational work

11.12.4 **(7.00)** The pulley in the illustration is a uniform disk of mass 2.40 kg and radius 0.220 m. The block applies a contant torque to the pulley, which is free to rotate without friction, resulting in an angular acceleration of magnitude 0.180 rad/s^2 for the pulley. As the block falls 0.500 m, how much work does it do on the pulley?

J

Section 13: Rotational kinetic energy

11.13.1 **(5.00)** A hollow closed cylinder of radius R is rolling without slipping. (Think of an empty tin can.) Each of the two endcaps has a mass of M, and the rest (the hollow tube) has a mass of $3M$, for a total object mass of $5M$. What is the ratio of linear kinetic energy to rotational kinetic energy? Enter your answer as a decimal number.

11.13.2 **(7.00)** A certain pulley is a uniform disk of mass 2.7 kg and radius 0.25 m. A rope applies a constant torque to the pulley, which is free to rotate without friction, resulting in an angular acceleration of 0.12 rad/s^2. The pulley starts at rest at time t = 0 s. What is its rotational kinetic energy at t = t s?

J

Section 15: Rolling objects and kinetic energy

11.15.1 **(5.00)** A m kg solid ball with a radius of 0.185 m rolls without slipping at 3.55 m/s. What is its total kinetic energy?

J

Section 19: Physics at play: a yo-yo

11.19.1 **(7.00)** A strange yo-yo is made up of two identical solid spheres connected by a short spindle. The radius of the spheres is 0.0340 m and each of them has mass 0.00750 kg. The spindle has radius 0.00550 m and mass 0.00350 kg, and the string is wrapped around the spindle. What is the magnitude of the acceleration of the yo-yo as it unreels and rolls down the string?

m/s^2

Section 21: Angular momentum of a particle in circular motion

11.21.1 What is the magnitude of angular momentum of a m kg car going around a

(5.00) circular curve with a 15.0 m radius at 12.0 m/s? Assume the origin is at the center of the curve's arc.

[ ] $kg\cdot m^2/s$

11.21.2 **(7.00)** Calculate the magnitude of the angular momentum of the Earth around the Sun, using the Sun as the origin. The Earth's mass is 5.97×10^{24} kg and its roughly circular orbit has a radius of 1.50×10^{11} m. Use a 365-day year with exactly 24 hours in each day.

[ ] $kg\cdot m^2/s$

Section 22: Angular momentum of a rigid body

11.22.1 **(5.00)** A thin rod 2.60 m long with mass 3.80 kg is rotated counterclockwise about an axis through its midpoint. It completes 3.70 revolutions every second. What is the magnitude of its angular momentum?

[ ] $kg\cdot m^2/s$

Section 26: Torque and angular momentum

11.26.1 **(5.00)** An electric drill delivers a net torque of 15.0 N·m to a buffing wheel used to polish a car. The buffing wheel has a moment of inertia of 2.30×10^{-3} $kg\cdot m^2$. At 0.0220 s after the drill is turned on, what is the angular velocity of the buffing wheel?

[ ] rad/s

Section 27: Conservation of angular momentum

11.27.1 **(5.00)** A 1.6 kg disk with radius 0.63 m is rotating freely at 55 rad/s around an axis perpendicular to its center. A second disk that is not rotating is dropped onto the first disk so that their centers align, and they stick together. The mass of the second disk is 0.45 kg and its radius is 0.38 m. What is the angular velocity of the two disks combined?

[ ] rad/s

11.27.4 **(7.00)** A puck with mass 0.28 kg moves in a circle at the end of a string on a frictionless table, with radius 0.75 m. The string goes through a hole in the table, and you hold the other end of the string. The puck is rotating at an angular velocity of 18 rad/s when you pull the string to reduce the radius of the puck's travel to 0.55 m. Consider the puck to be a point mass. What is the new angular velocity of the puck?

rad/s

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