PHY 108 Collaborative Problem Solving Chapters 9 and 10
Answer Key and Hints

1. A shaft has two circular pulleys on it, one with a radius of 8.5 cm and one with a radius of 1.9 cm. A rope wrapped around the large pulley, and a 7.6 kg box is suspended from that rope. If a mass M is suspended from a rope wrapped around the smaller pulley, what value of M will cause the system to be in equilibrium?

a) 1.7 kg b) 3.8 kg c) 12 kg **d) 34 kg** e) 46 kg

Consider the sum of torques about the shaft holding the two pulleys. The forces are just the weights, and the distances are the radii of the pulleys.

2. Suppose five masses are placed along the x-axis, a 1 kg mass at 1 m, a 2 kg mass at 2 m, a 3 kg mass at 3 m, a 4 kg mass at 4 m, and a 5 kg mass at 5 m. What is the x-coordinate of the center of gravity for this system?

a) 2.0 m b) 2.7 m c) 3.0 m d) 3.3 m **e) 3.8 m**

The book gives the general formula as Equation 9.3 on p. 239. You can replace all the weights with masses, since g will appear as a common factor in both numerator and denominator. The answer is actually 3.7 m, so there's a rounding error in the answer given.

3. A 50 N•m torque acts on a wheel of moment of inertia 150 kg•m^2. If the wheel starts from rest, how long will it take the wheel to make one revolution?

a) 0.33 s b) 0.66 s c) 2.4 s **d) 6.1 s** e) 10 s

All you need is Newton's 2nd Law for rotational motion and $\theta = (1/2)\alpha t^2$, which is valid for motion that starts from rest.

4. A certain merry-go-round is accelerated uniformly from rest and attains an angular speed of 0.4 rad/s after 10 seconds. If the net applied torque is 2000 N•m, what is the moment of inertia of the merry-go-round?

a) 400 kg•m^2 b) 800 kg•m^2 c) 5000 kg•m^2 **d) 50,000 kg•m^2**
e) This cannot be determined since the radius is not specified.

Here you need the definition of α and Newton's 2nd Law for rotation.

5. Two uniform spheres A and B have the same mass. The radius of sphere B is twice that of sphere A. The axis of rotation for each sphere passes through the sphere's center. Which one of the following statements is true concerning the moments of inertia of the two spheres?

a) The moment of inertia of A is one-fourth that of B.
b) The moment of inertia of A is one-half that of B.
c) The moment of inertia of A is 5/4 that of B.
d) The moment of inertia of A is 5/8 that of B.
e) The two spheres have equal moment of inertia.

Since both spheres have the same mass, the difference in their moments of inertia must come from the difference in their radii. The one with the bigger radius will have the larger moment of inertia.

6. A 45-N brick is suspended by a light string from a 2.0 kg pulley, which may be considered a solid disk with a radius of 1.5 m. The brick is released from rest and falls to the floor below as the pulley rotates through 5.0 radians. What is the angular speed of the pulley when the brick hits the floor?

a) 7.3 rad/s b) 8.1 rad/s c) 9.4 rad/s d) 15 rad/s e) 17 rad/s

Use $s = R\theta$ to determine how far the brick falls when the wheel turns through 5 radians. Then use conservation of energy: the gravitational potential energy of the brick at the start of the motion must equal the kinetic energy (translational for the brick + rotational for the pulley), and the two velocities are related by $v = R\omega$.

7. A 1.0 kg wheel in the form of a solid disk rolls along a horizontal surface with a speed of 6.0 m/s. What is the total kinetic energy of the wheel?

a) 9.0 J b) 18 J **c) 27 J** d) 36 J e) 54 J

For rolling motion, the velocity of the center of the disk is related to the angular velocity by $v = R\omega$. You won't need the radius of the wheel, since it will cancel in the calculation of the wheel's rotational kinetic energy.

8. When a force of 20.0 N is applied to a spring, it elongates 0.20 m. Determine the period of oscillation for a 4.0 kg object suspended from this spring.

a) 0.6 s **b) 1.3 s** c) 3.1 s d) 4.1 s e) 6.3 s

You can get k from the data in the first sentence. Then, since ω is related to k and m and ω is also $2\pi/T$, you can find T.

9. The acceleration of a certain simple harmonic oscillator is given by $a = -(15.8\ \text{m/s}^2)\cos(2.51\ t)$. What is the amplitude of the simple harmonic motion?

a) 2.51 m b) 4.41 m c) 6.30 m d) 11.1 m e) 15.8 m

The value of ω is given in the argument of the cosine function, and the number in front of the cosine (in absolute value) is the maximum acceleration, which is $\omega^2 A$.

10. A 10 kg box is at rest, attached to one end of an unstretched horizontal spring, the other end of which is attached to a wall. The spring has a constant of 4000 N/m, and the surface under the box is frictionless. The mass is struck by a hammer, giving it a horizontal velocity of 6.0 m/s. What is the amplitude of the resulting simple harmonic motion?

a) 0.3 m b) 0.4 m c) 0.5 m d) 0.6 m e) 2 m

The hammer gives the mass its maximum velocity (the spring will immediately start to slow it down), which is related to ω and A.

11. The spring constant for the spring in a special cannon is 1800 N/m. In cocking the cannon, the spring is compressed 0.55 m. What is the initial speed of a 7.0 kg cannonball just as it leaves the end of the spring after being fired from the cannon?

a) 77 m/s b) 140 m/s c) 12 m/s **d) 8.8 m/s** e) 16 m/s

The problem doesn't say, but you can assume the cannon is horizontal or you can otherwise ignore gravity during the time the ball is in contact with the spring. Just use conservation of energy.

12. A pendulum is transported from sea level, where the acceleration due to gravity is $9.80\ \text{m/s}^2$, to the bottom of Death Valley. At this location, the period of the pendulum is decreased by 3.00%. What is the acceleration due to gravity in Death Valley?

a) $9.22\ \text{m/s}^2$ b) $9.51\ \text{m/s}^2$ c) $9.80\ \text{m/s}^2$ d) $10.1\ \text{m/s}^2$ **e) $10.4\ \text{m/s}^2$**

This one is pure algebra, so I'll just let you chew on it. However, it's instructive to note that you can eliminate three of the answers just by noticing what happens to the period of a pendulum if the value of g changes.