1. In Fig., wheel A of radius \( r_A \) 10cm is coupled by belt B to wheel C of radius \( r_C \) 25 cm. The angular speed of wheel A is increased from rest at a constant rate of 1.6 rad/s\(^2\). Find the time needed for wheel C to reach an angular speed of 100 rev/min, assuming the belt does not slip. (Hint: If the belt does not slip, the linear speeds at the two rims must be equal.)

2. Figure shows an early method of measuring the speed of light that makes use of a rotating slotted wheel. A beam of light passes through one of the slots at the outside edge of the wheel, travels to a distant mirror, and returns to the wheel just in time to pass through the next slot in the wheel. One such slotted wheel has a radius of 5.0 cm and 500 slots around its edge. Measurements taken when the mirror is \( L \) 500 m from the wheel indicate a speed of light of \( 3.0 \times 10^5 \) km/s. (a) What is the (constant) angular speed of the wheel? (b) What is the linear speed of a point on the edge of the wheel?

3. In Fig., block 1 has mass \( m_1 \) 460 g, block 2 has mass \( m_2 \) 500 g, and the pulley, which is mounted on a horizontal axle with negligible friction, has radius \( R \) 5.00 cm. When released from rest, block 2 falls 75.0 cm in 5.00 s without the cord slipping on the pulley. (a) What is the magnitude of the acceleration of the blocks? What are (b) tension \( T_2 \) and (c) tension \( T_1 \)? (d) What is the magnitude of the pulley's angular acceleration? (e) What is its rotational inertia?
4. In Fig., a cylinder having a mass of 2.0 kg can rotate about its central axis through point \( O \). Forces are applied as shown: \( F_1 6.0 \text{N}, F_2 4.0 \text{N}, F_3 2.0 \text{N}, \) and \( F_4 5.0 \text{N} \). Also, \( r 5.0 \text{cm} \) and \( R 12 \text{ cm} \). Find the (a) magnitude and (b) direction of the angular acceleration of the cylinder. (During the rotation, the forces maintain their same angles relative to the cylinder.)

5. A uniform spherical shell of mass \( M 4.5 \text{ kg} \) and radius \( R 8.5 \text{ cm} \) can rotate about a vertical axis on frictionless bearings (Fig.). A massless cord passes around the equator of the shell, over a pulley of rotational inertia \( I 3.0 \times 10^{-3} \text{ kg m}^2 \) and radius \( r 5.0 \text{ cm} \), and is attached to a small object of mass \( m 0.60 \text{ kg} \). There is no friction on the pulley's axle; the cord does not slip on the pulley. What is the speed of the object when it has fallen 82 cm after being released from rest? Use energy considerations.

6. Two 2.00 kg balls are attached to the ends of a thin rod of length 50.0 cm and negligible mass. The rod is free to rotate in a vertical plane without friction about a horizontal axis through its center. With the rod initially horizontal (Fig.), a 50.0 g wad of wet putty drops onto one of the balls, hitting it with a speed of 3.00 m/s and then sticking to it. (a) What is the angular speed of the system just after the putty wad hits? (b) What is the ratio of the kinetic energy of the system after the collision to that of the putty wad just before? (c) Through what angle will the system rotate before it momentarily stops?

7. Wheels A and B in Fig. are connected by a belt that does not slip. The radius of B is 3.00 times the radius of A. What would be the ratio of the rotational inertias \( I_A/I_B \) if the two wheels had (a) the same angular momentum about their central axes and (b) the same rotational kinetic energy?
8. A uniform wheel of mass 10.0 kg and radius 0.400 m is mounted rigidly on a massless axle through its center (Fig.). The radius of the axle is 0.200 m, and the rotational inertia of the wheel – axle combination about its central axis is 0.600 kg m². The wheel is initially at rest at the top of a surface that is inclined at angle $\theta = 30.0^\circ$ with the horizontal; the axle rests on the surface while the wheel extends into a groove in the surface without touching the surface. Once released, the axle rolls down along the surface smoothly and without slipping. When the wheel – axle combination has moved down the surface by 2.00 m, what are (a) its rotational kinetic energy and (b) its translational kinetic energy?

9. In Fig., a block weighing 14.0 N, which can slide without friction on an incline at angle $\theta = 40.0^\circ$, is connected to the top of the incline by a massless spring of unstretched length 0.450 m and spring constant 120 N/m. (a) How far from the top of the incline is the block's equilibrium point? (b) If the block is pulled slightly down the incline and released, what is the period of the resulting oscillations?

10. In Fig., two blocks ($m = 1.8$ kg and $M = 10$ kg) and a spring ($k = 200$ N/m) are arranged on a horizontal, frictionless surface. The coefficient of static friction between the two blocks is 0.40. What amplitude of simple harmonic motion of the spring – blocks system puts the smaller block on the verge of slipping over the larger block?

11. In Fig., a solid cylinder attached to a horizontal spring ($k = 3.00$ N/m) rolls without slipping along a horizontal surface. If the system is released from rest when the spring is stretched by 0.250 m, find (a) the translational kinetic energy and (b) the rotational kinetic energy of the cylinder as it passes through the equilibrium position. (c) Show that under these conditions the cylinder's center of mass executes simple harmonic motion with period
\[ T = 2\pi \sqrt{\frac{3M}{2k}} , \]

where \( M \) is the cylinder mass. (Hint: Find the time derivative of the total mechanical energy.)

12. As a gas is held within a closed chamber, it passes through the cycle shown in Fig. 18-41. Determine the energy transferred by the system as heat during constant-pressure process \( CA \) if the energy added as heat \( Q_{AB} \) during constant-volume process \( AB \) is 20.0 J, no energy is transferred as heat during adiabatic process \( BC \), and the net work done during the cycle is 15.0 J.

13. In Fig., two identical rectangular rods of metal are welded end to end, with a temperature of \( T_1 \), 0 C on the left side and a temperature of \( T_2 \), 100 C on the right side. In 2.0 min, 10 J is conducted at a constant rate from the right side to the left side. How much time would be required to conduct 10 J if the rods were welded side to side as in Fig.? 

14. Figure shows a cylinder containing gas and closed by a movable piston. The cylinder is kept submerged in an ice–water mixture. The piston is quickly pushed down from position 1 to position 2 and then held at position 2 until the gas is again at the temperature of the ice–water mixture; it then is slowly raised back to position 1. Figure is a \( p\text{-}V \) diagram for the process. If 100 g of ice is melted during the cycle, how much work has been done on the gas?

15. The area \( A \) of a rectangular plate is \( ab \), 1.4 m\(^2\). Its coefficient of linear expansion is \( 32 \times 10^{-6} / \text{C} \). After a temperature rise \( \Delta T \), 89 C, side \( a \) is longer by \( \Delta a \) and side \( b \) is longer by \( \Delta b \) (Fig.). Neglecting the small quantity \( (\Delta a \Delta b)/ab \), find \( \Delta A \).

16. A generator at one end of a very long string creates a wave given by
and a generator at the other end creates the wave

Calculate the (a) frequency, (b) wavelength, and (c) speed of each wave. For \( x \geq 0 \), what is the location of the node having the (d) smallest, (e) second smallest, and (f) third smallest value of \( x \)? For \( x \geq 0 \), what is the location of the antinode having the (g) smallest, (h) second smallest, and (i) third smallest value of \( x \)?

17. In Fig. 16-42, a string, tied to a sinusoidal oscillator at \( P \) and running over a support at \( Q \), is stretched by a block of mass \( m \). Separation \( L \) 1.20 m, linear density \( \mu \) 1.6 g/m, and the oscillator frequency \( f \) 120 Hz. The amplitude of the motion at \( P \) is small enough for that point to be considered a node. A node also exists at \( Q \). (a) What mass \( m \) allows the oscillator to set up the fourth harmonic on the string? (b) What standing wave mode, if any, can be set up if \( m \) 1.00 kg?

18. Explain how Maxwell’s speed distribution law is used to find the fraction of molecules with speeds in a certain speed range.

19. One mole of gas \( A \), with molecular diameter \( 2d_0 \) and average molecular speed \( v_0 \), is placed inside a certain container. One mole of gas \( B \), with molecular diameter \( d_0 \) and average molecular speed \( 2v_0 \) (the molecules of \( B \) are smaller but faster), is placed in an identical container. Which gas has the greater average collision rate within its container?

20. Explain the conditions which lead two overlapping waves to produces standing waves, and find the displacement equation for the resultant wave and calculate the amplitude in terms of the individual wave.

21. Calculate the moment of inertia of a wheel constructed as shown in figure for rotations around an axis perpendicular to the drawing and going through the wheels center. Assume that both the spokes and the circumference are constructed out of the same kind and thickness of iron rod. (Hint: Break the wheel down into three parts that all rotate around the same axis: 2 rods and one hoop. What fraction of the mass of the whole is the mass of the hoop?)