ME 2210 Dynamics Handout #7: Homework: 17.5, 17.11, 17.17, 17.23, 17.33, 17.37, 17.45, 17.55, 17.59, 17.63, 17.71, 17.75

17.1 It is known that 1500 revolutions are required for the 6000-lb flywheel to coast to rest from an angular velocity of 300 rpm. Knowing that the radius of gyration of the flywheel is 36 in., determine the average magnitude of the couple due to kinetic friction in the bearings.

17.3 Two disks of the same material are attached to a shaft as shown. Disk A is of radius r and has a thickness b, while disk B is of radius nr and thickness $3b$. A couple **M** of constant magnitude is applied when the system is at rest and is removed after the system has executed 2 revolutions. Determine the value of n which results in the largest final speed for a point on the rim of disk B.

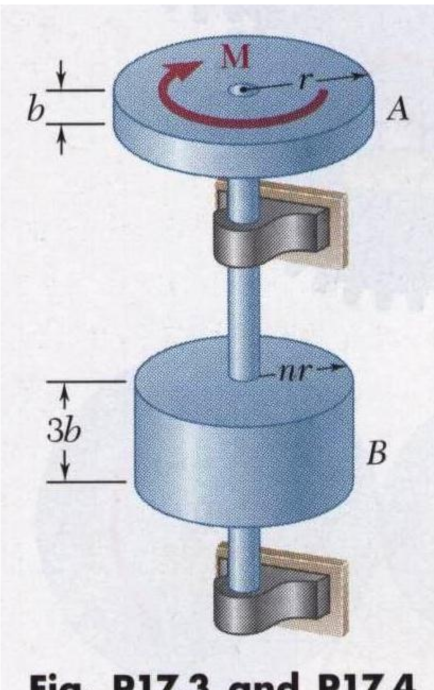

Fig. P17.3 and P17.4

17.4 Two disks of the same material are attached to a shaft as shown. Disk A has a mass of 15 kg and a radius r = 125 mm. Disk B is three times as thick as disk A. Knowing that a couple **M** of magnitude 20 N · m is to be applied to disk A when the system is at rest, determine the radius nr of disk B if the angular velocity of the system is to be 600 rpm after 4 revolutions.

17.5 The flywheel of a punching machine has a mass of 300 kg and a radius of gyration of 600 mm. Each punching operation requires 2500 J of work. (*a*) Knowing that the speed of the flywheel is 300 rpm just before a punching, determine the speed immediately after the punching. (*b*) If a constant 25-N · m couple is applied to the shaft of the flywheel, determine the number of revolutions executed before the speed is again 300 rpm.

17.6 The flywheel of a small punching machine rotates at 360 rpm. Each punching operation requires 1500 ft · lb of work and it is desired that the speed of the flywheel after each punching be not less than 95 percent of the original speed. (*a*) Determine the required moment of inertia of the flywheel. (*b*) If a constant 18 lb · ft couple is applied to the shaft of the flywheel, determine the number of revolutions that must occur between two successive punchings, knowing that the initial velocity is to be 360 rpm at the start of each punching.

17.7 Disk A is of constant thickness and is at rest when it is placed in contact with belt BC, which moves with a constant velocity $\mathbf{v}$. Denoting by μ_k the coefficient of kinetic friction between the disk and the belt, derive an expression for the number of revolutions executed by the disk before it attains a constant angular velocity.

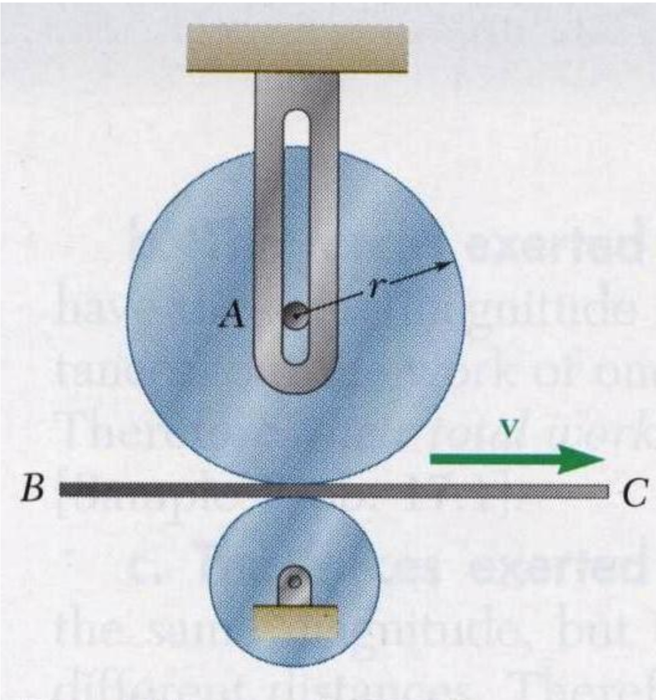

Fig. *P17.7* and P17.8

17.8 Disk A, of weight 10 lb and radius r = 6 in., is at rest when it is placed in contact with belt BC, which moves to the right with a constant speed v = 40 ft/s. Knowing that μ_k = 0.20 between the disk and the belt, determine the number of revolutions executed by the disk before it attains a constant angular velocity.

17.11 The double pulley shown weighs 30 lb and has a centroidal radius of gyration of 6.5 in. Cylinder A and block B are attached to cords that are wrapped on the pulleys as shown. The coefficient of kinetic friction between block B and the surface is 0.25. Knowing that the system is released from rest in the position shown, determine (*a*) the velocity of cylinder A as it strikes the ground, (*b*) the total distance that block B moves before coming to rest.

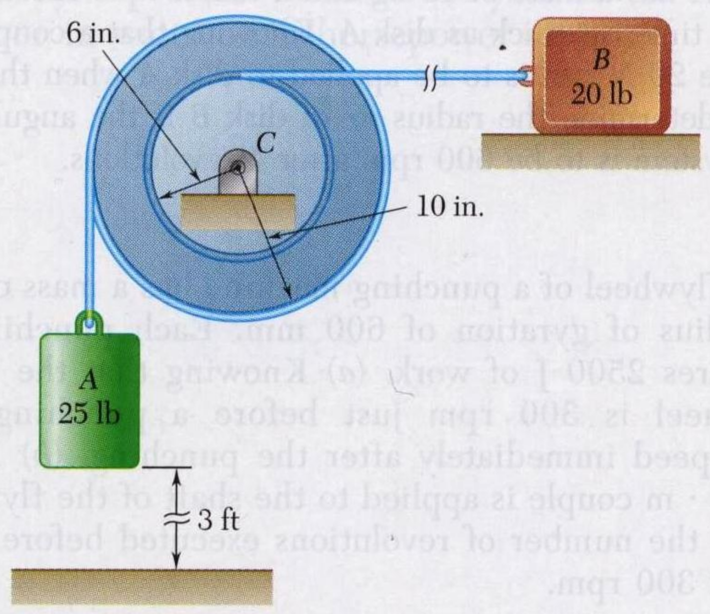

Fig. P17.11

17.12 The 8-in.-radius brake drum is attached to a larger flywheel that is not shown. The total mass moment of inertia of the flywheel and drum is 14 lb · ft · s^2 and the coefficient of kinetic friction between the drum and the brake shoe is 0.35. Knowing that the initial angular velocity of the flywheel is 360 rpm counterclockwise, determine the vertical force **P** that must be applied to the pedal *C* if the system is to stop in 100 revolutions.

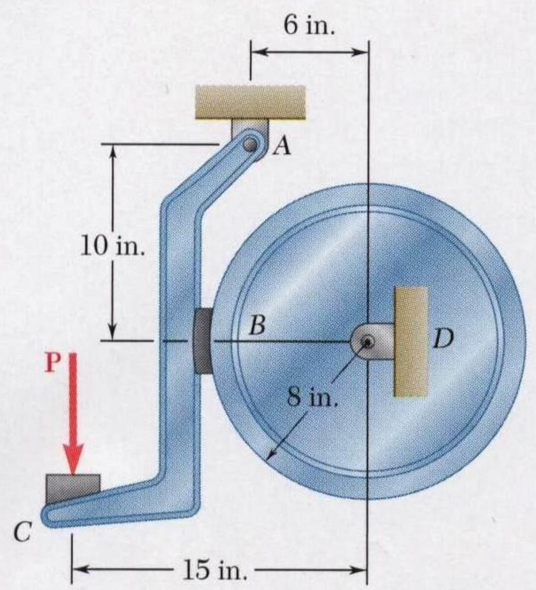

Fig. P17.12

17.13 Solve Prob. 17.12, assuming that the initial angular velocity of the flywheel is 360 rpm clockwise.

17.16 and 17.17 A slender 4-kg rod can rotate in a vertical plane about a pivot at B. A spring of constant $k = 400$ N/m and of unstretched length 150 mm is attached to the rod as shown. Knowing that the rod is released from rest in the position shown, determine its angular velocity after it has rotated through 90°.

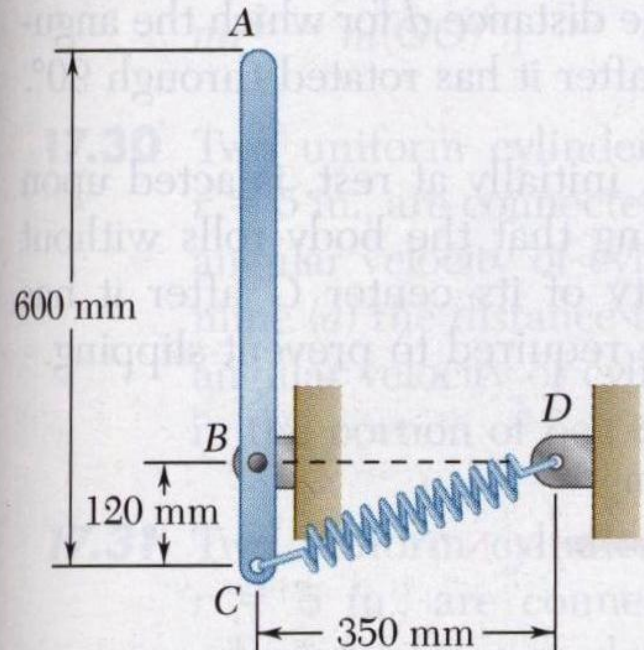

Fig. P17.16

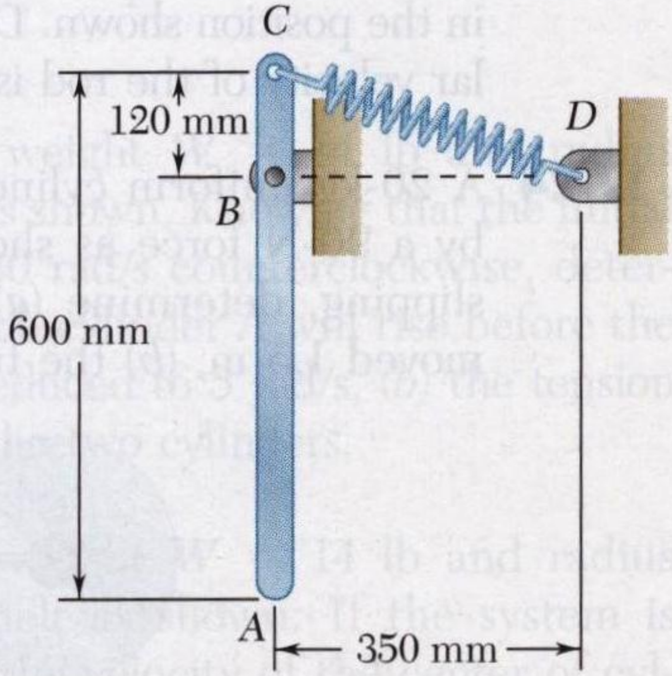

Fig. P17.17

17.18 A slender rod of length l and weight W is pivoted at one end as shown. It is released from rest in a horizontal position and swings freely. (*a*) Determine the angular velocity of the rod as it passes through a vertical position and determine the corresponding reaction at the pivot. (*b*) Solve part *a* for $W = 1.8$ lb and $l = 3$ ft.

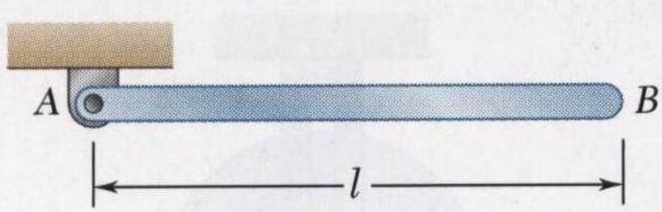

Fig. P17.18

17.19 A slender rod of length l is pivoted about a point C located at a distance b from its center G. It is released from rest in a horizontal position and swings freely. Determine (*a*) the distance b for which the angular velocity of the rod as it passes through a vertical position is maximum, (*b*) the corresponding values of its angular velocity and of the reaction at C.

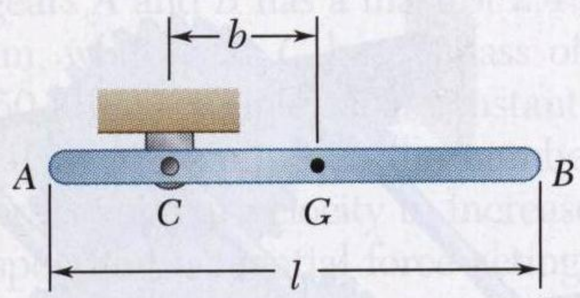

Fig. P17.19

17.22 A collar with a mass of 1 kg is rigidly attached at a distance d = 300 mm from the end of a uniform slender rod AB. The rod has a mass of 3 kg and is of length L = 600 mm. Knowing that the rod is released from rest in the position shown, determine the angular velocity of the rod after it has rotated through 90°.

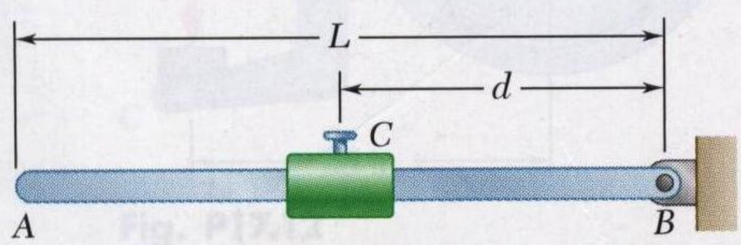

Fig. P17.22 and P17.23

17.23 A collar with a mass of 1 kg is rigidly attached to a slender rod AB of mass 3 kg and length L = 600 mm. The rod is released from rest in the position shown. Determine the distance d for which the angular velocity of the rod is maximum after it has rotated through 90°.

17.25 A rope is wrapped around a cylinder of radius r and mass m as shown. Knowing that the cylinder is released from rest, determine the velocity of the center of the cylinder after it has moved downward a distance s.

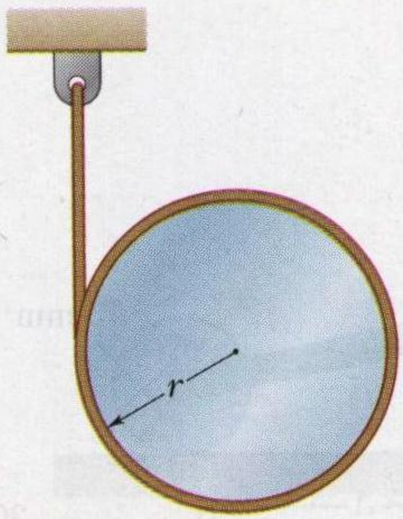

Fig. P17.25

17.30 Two uniform cylinders, each of weight $W = 14$ lb and radius $r = 5$ in., are connected by a belt as shown. Knowing that the initial angular velocity of cylinder B is 30 rad/s counterclockwise, determine (*a*) the distance through which cylinder A will rise before the angular velocity of cylinder B is reduced to 5 rad/s, (*b*) the tension in the portion of belt connecting the two cylinders.

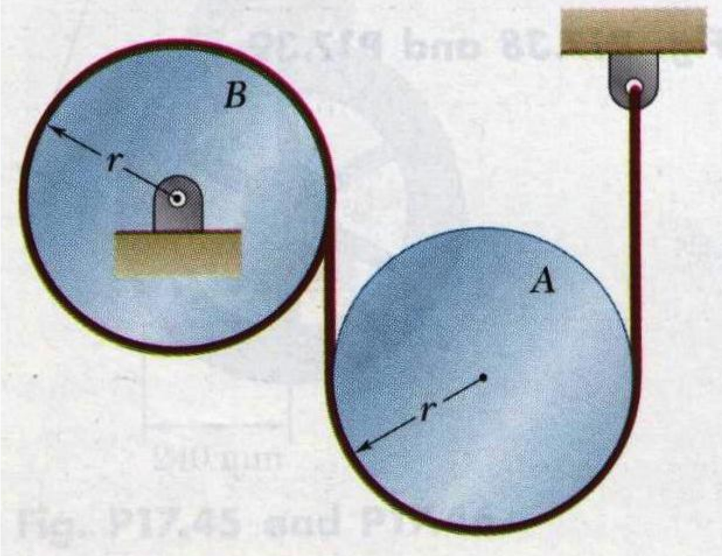

Fig. P17.30 and *P17.31*

17.31 Two uniform cylinders, each of weight $W = 14$ lb and radius $r = 5$ in., are connected by a belt as shown. If the system is released from rest, determine (*a*) the velocity of the center of cylinder A after it has moved through 3 ft, (*b*) the tension in the portion of belt connecting the two cylinders.

17.33 through 17.35 The 9-kg cradle is supported as shown by two uniform disks that roll without sliding at all surfaces of contact. The mass of each disk is $m = 6$ kg and the radius of each disk is $r = 80$ mm. Knowing that the system is initially at rest, determine the velocity of the cradle after it has moved 250 mm.

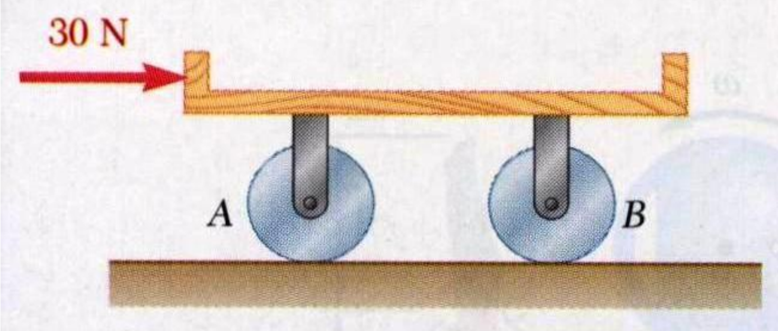

Fig. P17.33

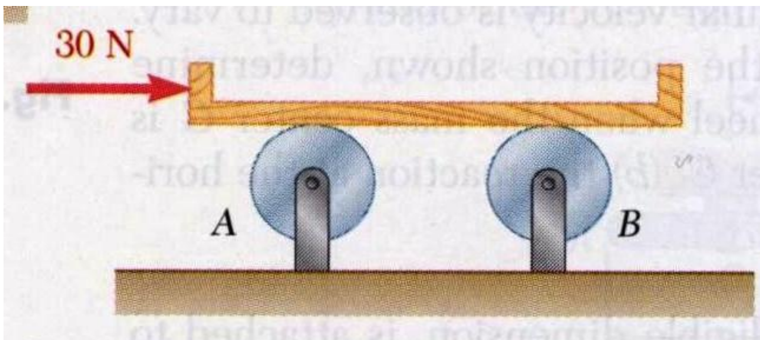

Fig. P17.34

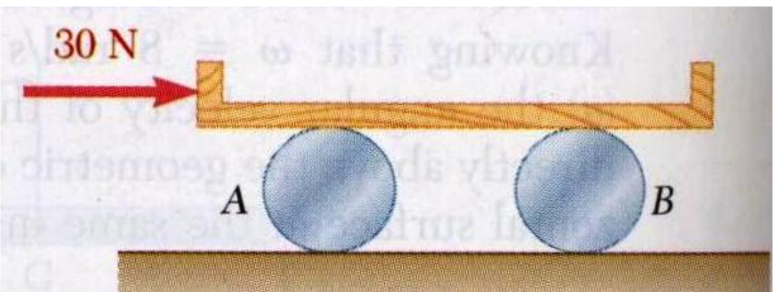

Fig. P17.35

17.36 The motion of the slender 10-kg rod AB is guided by collars of negligible mass that slide freely on the vertical and horizontal rods shown. Knowing that the bar is released from rest when $\theta = 30°$, determine the velocity of collars A and B when $\theta = 60°$.

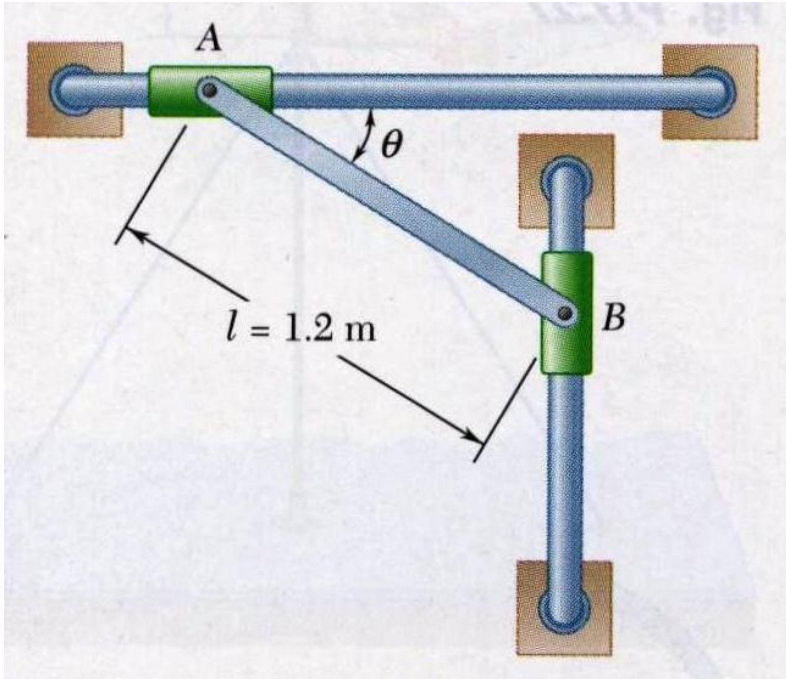

Fig. P17.36 and P17.37

17.37 The motion of the slender 10-kg rod AB is guided by collars of negligible mass that slide freely on the vertical and horizontal rods shown. Knowing that the bar is released from rest when $\theta = 20°$, determine the velocity of collars A and B when $\theta = 90°$.

17.38 The ends of a 9-lb rod AB are constrained to move along slots cut in a vertical plate as shown. A spring of constant $k = 3$ lb/in. is attached to end A in such a way that its tension is zero when $\theta = 0$. If the rod is released from rest when $\theta = 0$, determine the angular velocity of the rod and the velocity of end B when $\theta = 30°$.

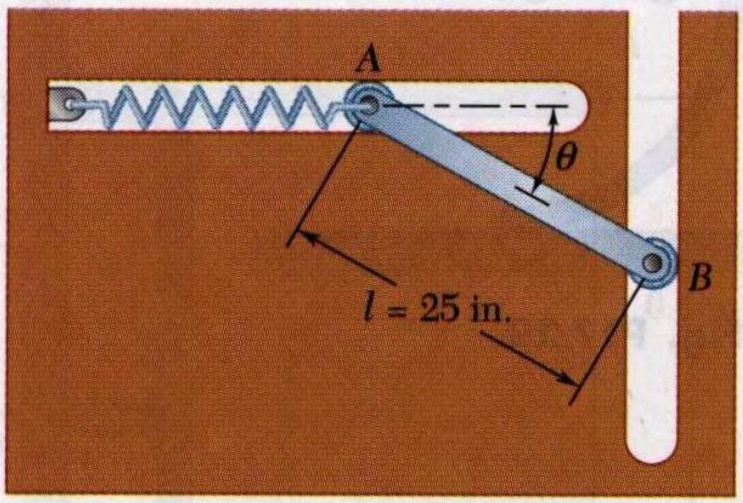

Fig. P17.38 and P17.39

17.42 Two uniform rods, each of mass m and length L, are connected to form the linkage shown. End D of rod BD can slide freely in the horizontal slot, while end A of rod AB is supported by a pin and bracket. If end D is moved slightly to the left and then released, determine its velocity (*a*) when it is directly below A, (*b*) when rod AB is vertical.

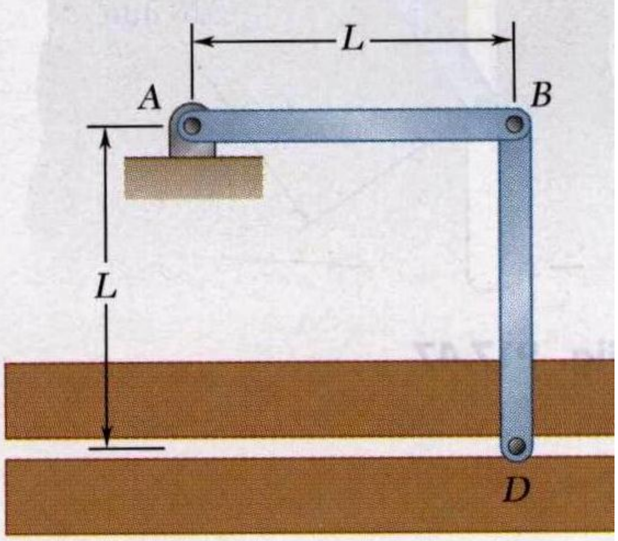

Fig. P17.42

17.43 The uniform rods AB and BC weigh 2.4 lb and 4 lb, respectively, and the small wheel at C is of negligible weight. If the wheel is moved slightly to the right and then released, determine the velocity of pin B after rod AB has rotated through 90°.

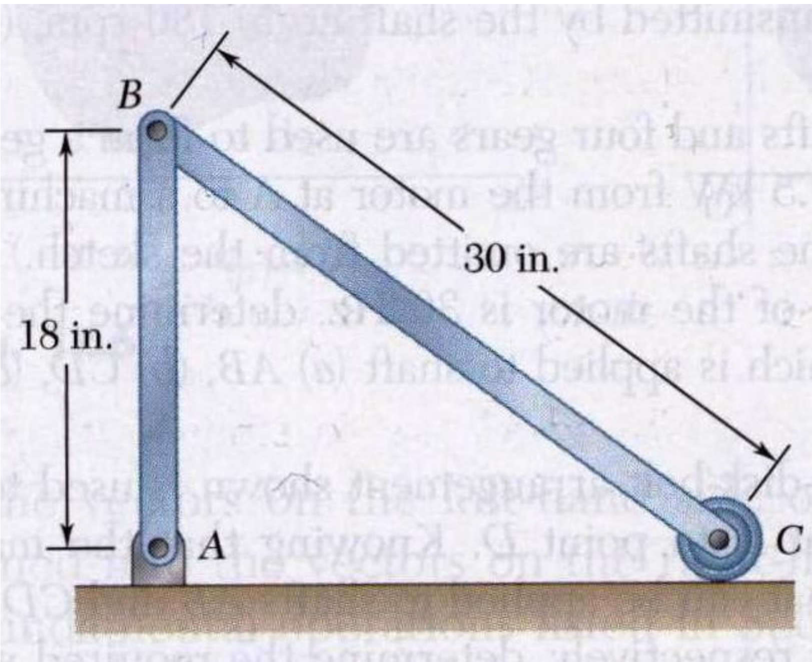

Fig. *P17.43* and P17.44

17.45 The 4-kg rod AB is attached to a collar of negligible mass at A and to a flywheel at B. The flywheel has a mass of 16 kg and a radius of gyration of 180 mm. Knowing that in the position shown the angular velocity of the flywheel is 60 rpm clockwise, determine the velocity of the flywheel when point B is directly below C.

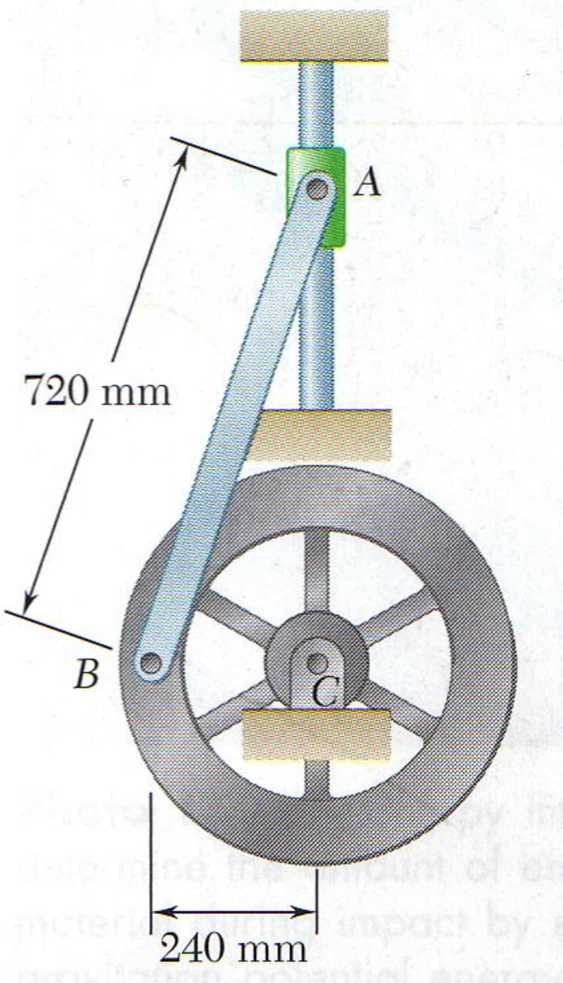

Fig. P17.45 and P17.46

17.52 The rotor of an electric motor has a mass of 25 kg, and it is observed that 4.2 min is required for the rotor to coast to rest from an angular velocity of 3600 rpm. Knowing that kinetic friction produces a couple of magnitude 1.2 N · m, determine the centroidal radius of gyration for the rotor.

17.53 A small grinding wheel is attached to the shaft of an electric motor which has a rated speed of 3600 rpm. When the power is turned off, the unit coasts to rest in 70 s. The grinding wheel and rotor have a combined weight of 6 lb and a combined radius of gyration of 2 in. Determine the average magnitude of the couple due to kinetic friction in the bearings of the motor.

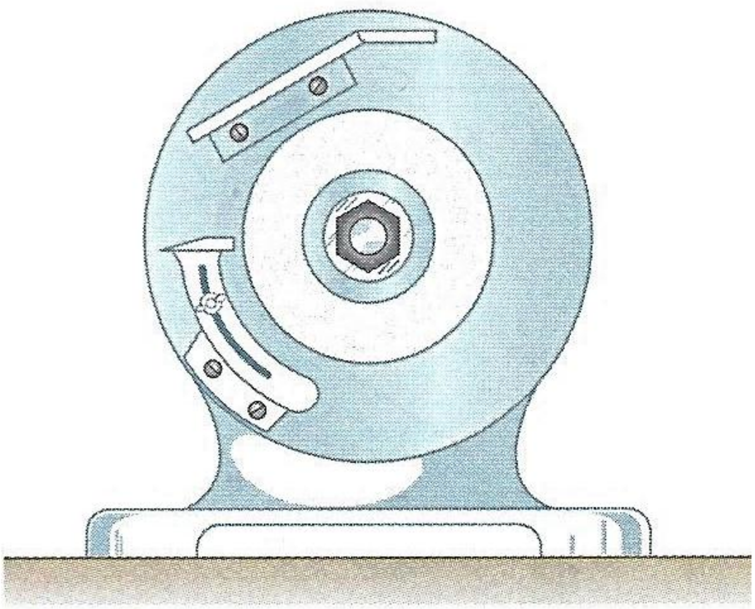

Fig. P17.53

17.54 A bolt located 50 mm from the center of an automobile wheel is tightened by applying the couple shown for 0.10 s. Assuming that the wheel is free to rotate and is initially at rest, determine the resulting angular velocity of the wheel. The wheel has a mass of 19 kg and has a radius of gyration of 250 mm.

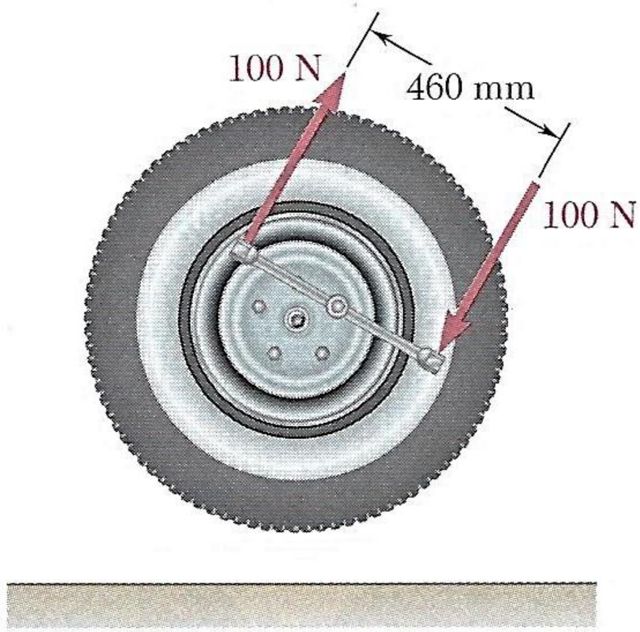

Fig. P17.54

17.55 Two disks of the same thickness and same material are attached to a shaft as shown. The 8-lb disk A has a radius $r_A = 3$ in., and disk B has a radius $r_B = 4.5$ in. Knowing that a couple **M** of magnitude 20 lb · in. is applied to disk A when the system is at rest, determine the time required for the angular velocity of the system to reach 960 rpm.

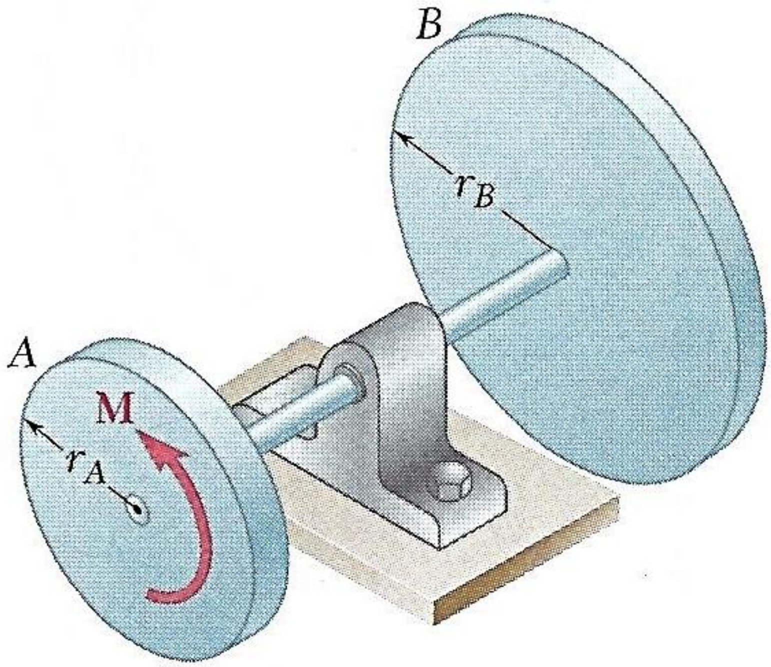

Fig. P17.55 and *P17.56*

17.56 Two disks of the same thickness and same material are attached to a shaft as shown. The 3-kg disk A has a radius $r_A = 100$ mm, and disk B has a radius $r_B = 125$ mm. Knowing that the angular velocity of the system is to be increased from 200 rpm to 800 rpm during a 3-s interval, determine the magnitude of the couple **M** that must be applied to disk A.

17.57 A disk of constant thickness, initially at rest, is placed in contact with a belt that moves with a constant velocity **v**. Denoting by μ_k the coefficient of kinetic friction between the disk and the belt, derive an expression for the time required for the disk to reach a constant angular velocity.

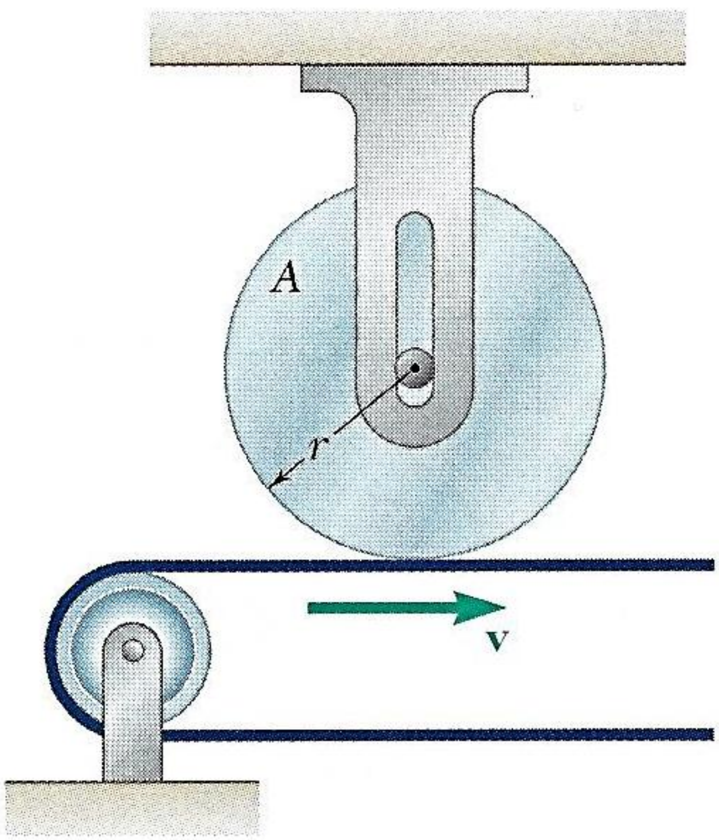

Fig. *P17.57* and P17.58

17.58 Disk A, of weight 5 lb and radius r = 3 in., is at rest when it is placed in contact with a belt which moves at a constant speed v = 50 ft/s. Knowing that μ_k = 0.20 between the disk and the belt, determine the time required for the disk to reach a constant angular velocity.

17.59 A cylinder of radius r and weight W with an initial counterclockwise angular velocity $\boldsymbol{\omega}_0$ is placed in the corner formed by the floor and a vertical wall. Denoting by μ_k the coefficient of kinetic friction between the cylinder and the wall and the floor, derive an expression for the time required for the cylinder to come to rest.

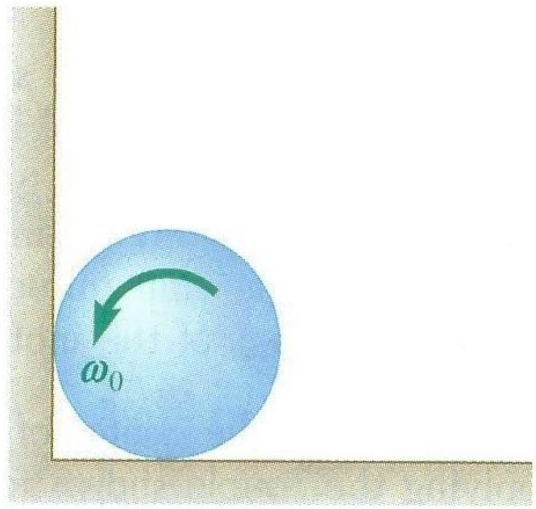

Fig. P17.59

17.60 and 17.61 Two uniform disks and two cylinders are assembled as indicated. Disk A has a mass of 10 kg and disk B has a mass of 6 kg. Knowing that the system is released from rest, determine the time required for cylinder C to have a speed of 0.5 m/s.

17.60 Disks A and B are bolted together and the cylinders are attached to separate cords wrapped on the disks.

17.61 The cylinders are attached to a single cord that passes over the disks. Assume that no slipping occurs between the cord and the disks.

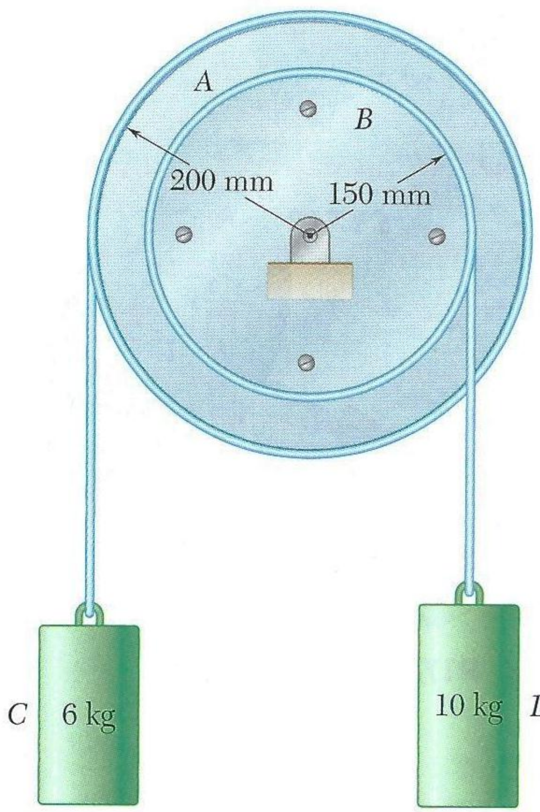

Fig. P17.60

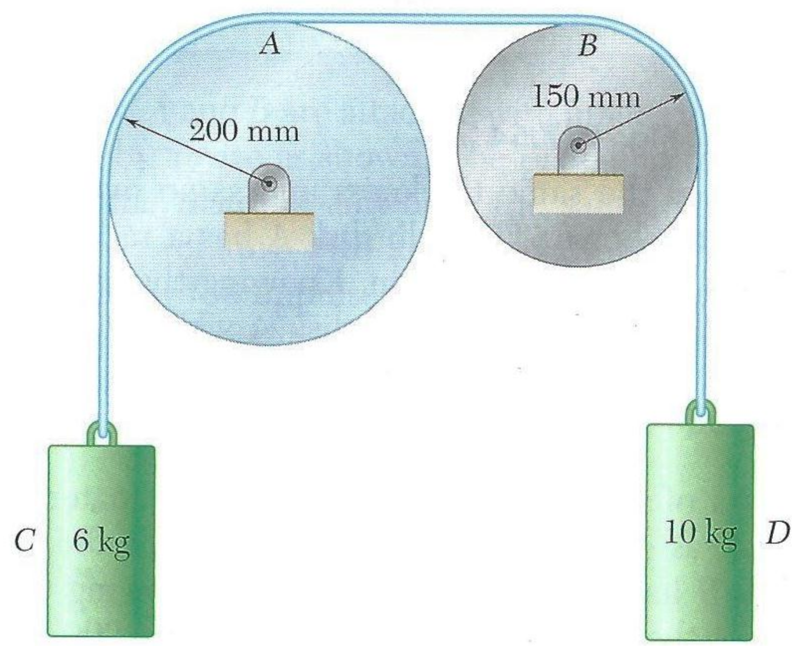

Fig. P17.61

17.62 Disk B has an initial angular velocity $\boldsymbol{\omega}_0$ when it is brought into contact with disk A which is at rest. Show that the final angular velocity of disk B depends only on ω_0 and the ratio of the masses m_A and m_B of the two disks.

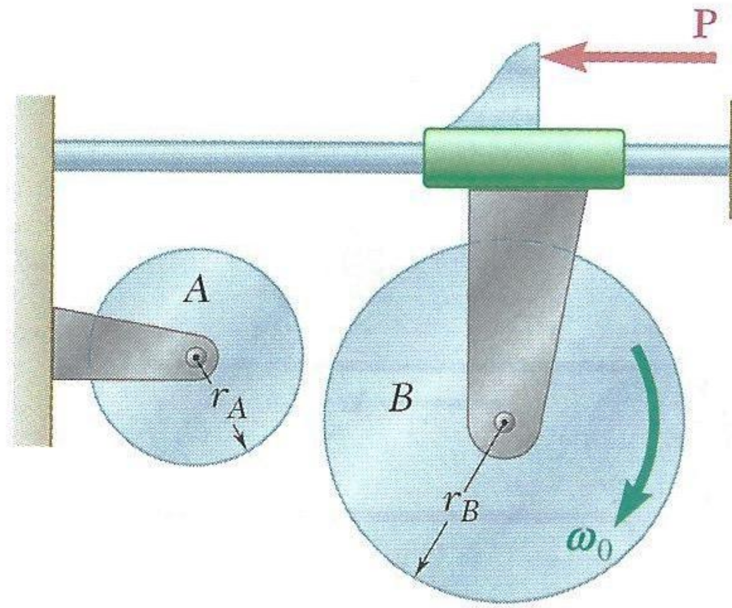

Fig. P17.62 and P17.63

17.63 The 7.5-lb disk A has a radius $r_A = 6$ in. and is initially at rest. The 10-lb disk B has a radius $r_B = 8$ in. and an angular velocity $\boldsymbol{\omega}_0$ of 900 rpm when it is brought into contact with disk A. Neglecting friction in the bearings, determine (*a*) the final angular velocity of each disk, (*b*) the total impulse of the friction force exerted on disk A.

17.64 A tape moves over the two drums shown. Drum A weighs 1.4 lb and has a radius of gyration of 0.75 in., while drum B weighs 3.5 lb and has a radius of gyration of 1.25 in. In the lower portion of the tape the tension is constant and equal to $T_A = 0.75$ lb. Knowing that the tape is initially at rest, determine (*a*) the required constant tension T_B if the velocity of the tape is to be $v = 10$ ft/s after 0.24 s, (*b*) the corresponding tension in the portion of the tape between the drums.

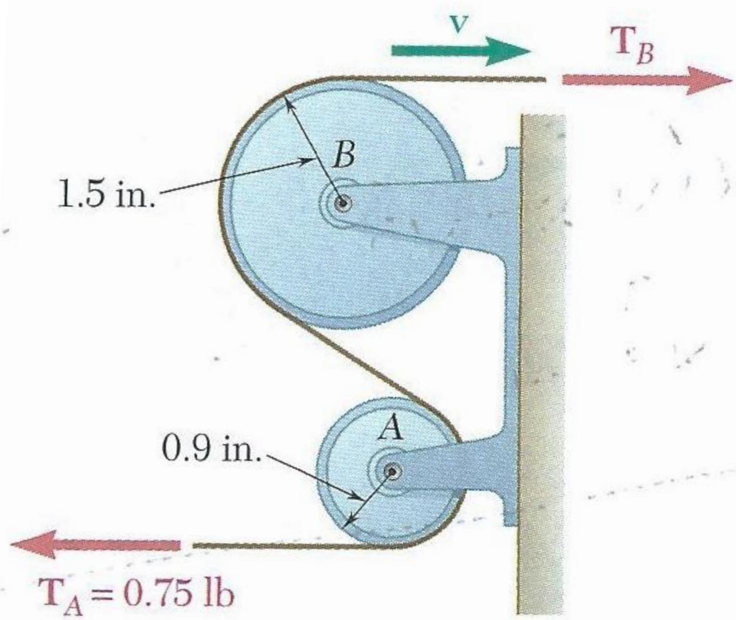

Fig. P17.64

17.69 A flywheel is rigidly attached to a 1.5-in.-radius shaft that rolls without sliding along parallel rails. Knowing that after being released from rest the system attains a speed of 6 in./s in 30 s, determine the centroidal radius of gyration of the system.

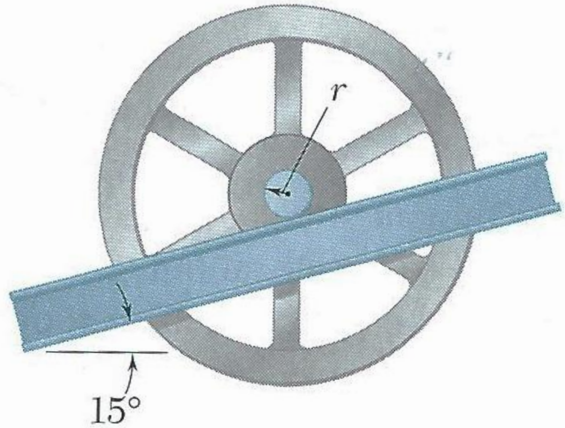

Fig. P17.69

17.70 A wheel of radius r and centroidal radius of gyration $\bar{k}$ is released from rest on the incline shown at time $t = 0$. Assuming that the wheel rolls without sliding, determine (*a*) the velocity of its center at time t, (*b*) the coefficient of static friction required to prevent slipping.

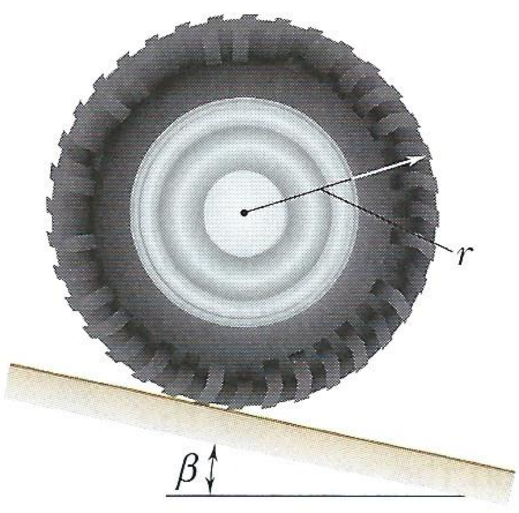

Fig. P17.70

17.71 The double pulley shown has a mass of 3 kg and a radius of gyration of 100 mm. Knowing that when the pulley is at rest, a force **P** of magnitude 24 N is applied to cord *B*, determine (*a*) the velocity of the center of the pulley after 1.5 s, (*b*) the tension in cord *C*.

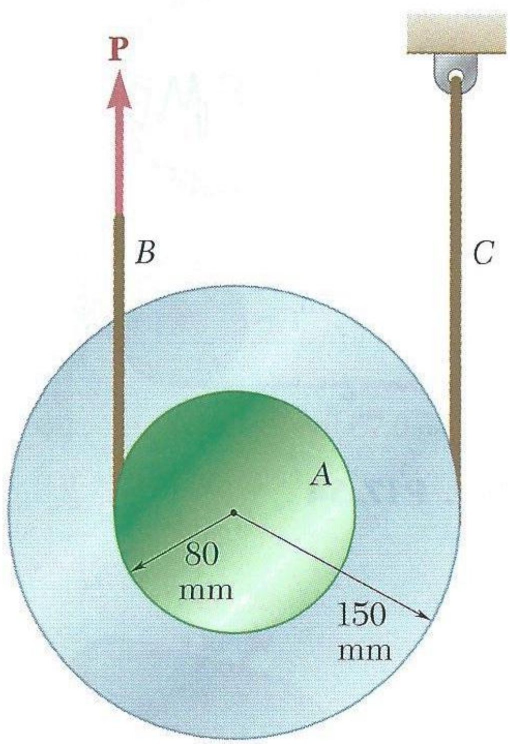

Fig. P17.71

17.72 and 17.73 A 9-in.-radius cylinder of weight 18 lb rests on a 6-lb carriage. The system is at rest when a force **P** of magnitude 2.5 lb is applied as shown for 1.2 s. Knowing that the cylinder rolls without sliding on the carriage and neglecting the mass of the wheels of the carriage, determine the resulting velocity of (*a*) the carriage, (*b*) the center of the cylinder.

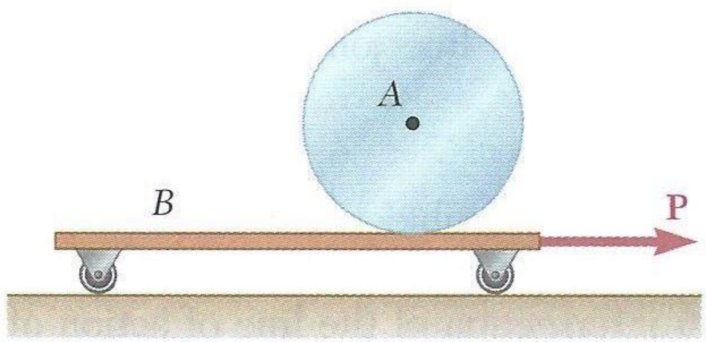

Fig. P17.72

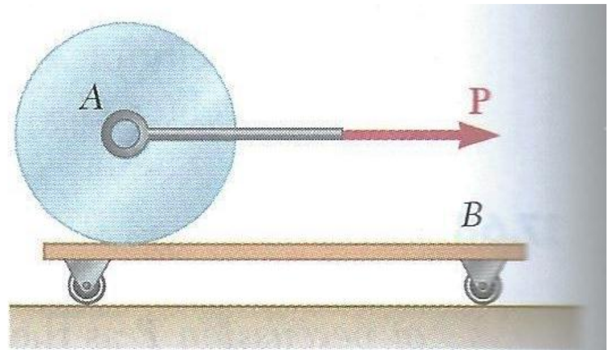

Fig. P17.73

17.74 Two uniform cylinders, each of mass $m = 6$ kg and radius $r =$ 125 mm, are connected by a belt as shown. If the system is released from rest when $t = 0$, determine (*a*) the velocity of the center of cylinder B at $t = 3$ s, (*b*) the tension in the portion of belt connecting the two cylinders.

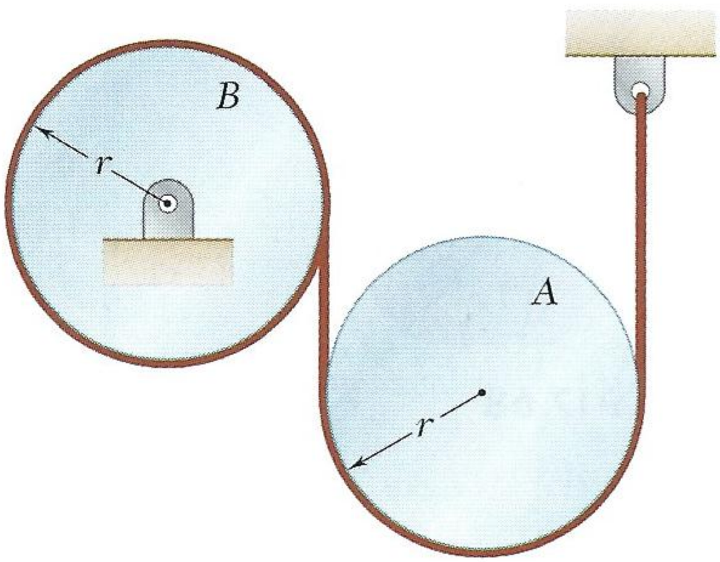

Fig. P17.74 and P17.75

17.75 Two uniform cylinders, each of mass $m = 6$ kg and radius $r =$ 125 mm, are connected by a belt as shown. Knowing that at the instant shown the angular velocity of cylinder A is 30 rad/s counterclockwise, determine (*a*) the time required for the angular velocity of cylinder A to be reduced to 5 rad/s, (*b*) the tension in the portion of belt connecting the two cylinders.