Problem 1.9

A jaguar A leaps from O with a velocity $\vec{v}_0$ to try and intercept a panther B. The unit vectors $\hat{u}_p$ ar $\hat{u}_q$ are parallel and perpendicular to the incline, respectively. The unit vectors $\hat{\imath}$ and $\hat{\jmath}$ are horizont and vertical, respectively. While airborne, the jaguar is subject to a constant acceleration with magnitude g and direction opposite to $\hat{\jmath}$. Denoting the magnitude of $\vec{v}_0$ by v_0 and denoting the (vector) acceleration of the jaguar by $\vec{a}_A$, provide the expression of $\vec{v}_0$ in the $(\hat{\imath}, \hat{\jmath})$ component system and the expression of $\vec{a}_A$ in the $(\hat{u}_p, \hat{u}_q)$ component system. Treat the angles β and θ as known.

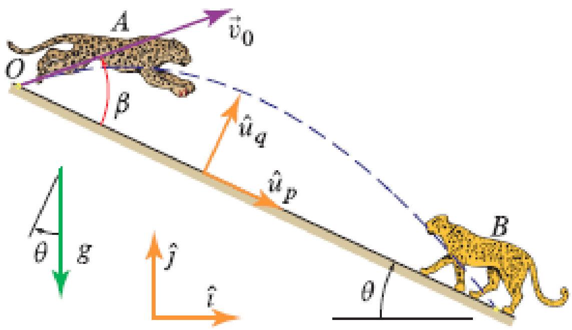

Figure P1.9

Problem 1.11

The motion of the telescopic arm is such that the velocity and acceleration vectors of the gear B are $\vec{v} = -v_0\,\hat{\jmath}$ and $\vec{a} = -a_0\,\hat{\jmath}$, respectively, with v_0 = 8 ft/s and a_0 = 0.5 ft/s^2. Determine the components of $\vec{v}$ and $\vec{a}$ in the direction of the unit vectors $\hat{u}_r$ and $\hat{u}_\theta$ for θ = 32°.

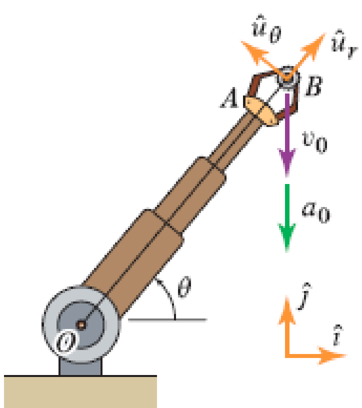

Figure P1.11

Point C is a point on the connecting rod of a mechanism called a *slider-crank*. The x and y coordinates of C can be expressed as follows: $x_C = R\cos\theta + \frac{1}{2}\sqrt{L^2 - R^2\sin^2\theta}$ and $y_C = (R/2)\sin\theta$, where θ describes the position of the crank. The crank rotates at a constant rate such that $\theta = \omega t$, where t is time.

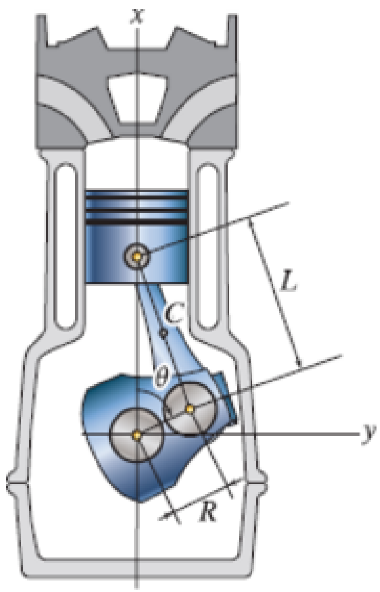

Figure P2.37–P2.38

Problem 2.37 Find expressions for the velocity, speed, and acceleration of C as functions of the angle θ and the parameters, R, L, and ω.

Problem 2.29

An airplane A takes off as shown with a constant speed equal to v_0 = 160 km/h. The path of the airplane is described by the equation $y = \kappa x^2$, where $\kappa = 6 \times 10^{-4}\ \text{m}^{-1}$. Using the component system shown, provide the expression for the velocity and acceleration of the airplane when x = 400 m. Express the velocity in m/s and the acceleration in m/s^2.

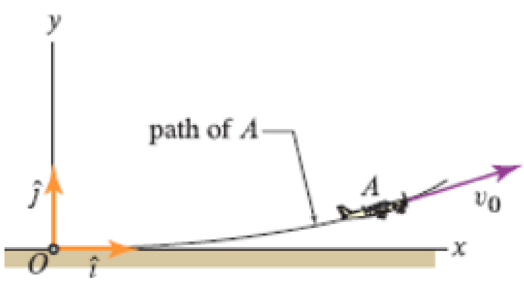

Figure P2.29

Problem 2.113

A trebuchet releases a rock with mass *m* = 50 kg at the point *O*. The initial velocity of the projectile is $\vec{v}_0 = (45\,\hat{\imath} + 30\,\hat{\jmath})\,\mathrm{m/s}$. If one were to model the effects of air resistance via a drag force directly proportional to the projectile's velocity, the resulting accelerations in the *x* and *y* directions would be $\ddot{x} = -(\eta/m)\dot{x}$ and $\ddot{y} = -g - (\eta/m)\dot{y}$, respectively, where *g* is the acceleration of gravity and η = 0.64 kg/s is a viscous drag coefficient. Find an expression for the trajectory of the projectile.

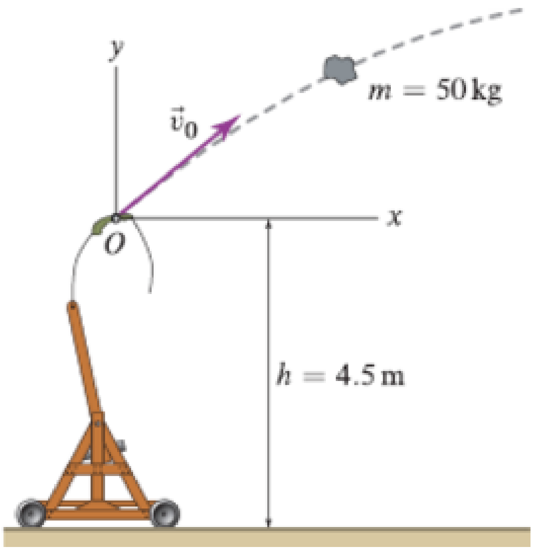

Figure P2.113–P2.116

Problem 2.135

A disk rotates about its center, which is the fixed point *O*. The disk has a straight channel whose centerline passes by *O* and within which a collar *A* is allowed to slide. If, when *A* passes by *O*, the speed of *A* relative to the channel is *v* = 14 m/s and is increasing in the direction shown with a rate of 5 m/s^2, determine the acceleration of *A* given that ω = 4 rad/s and is constant. Express the answer using the component system shown, which rotates with the disk. *Hint:* Apply the equation derived in Prob. 2.122 to the vector describing the position of *A* relative to *O* and then let *r* = 0.

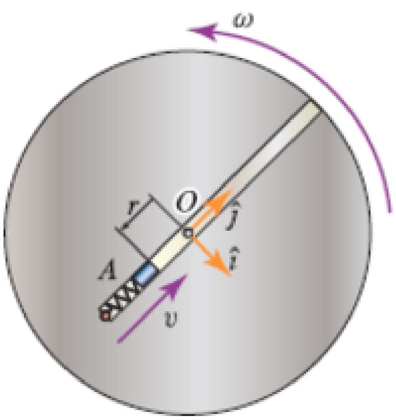

Figure P2.135

Problem 2.138

The mechanism shown is called a *swinging block* slider crank. First used in various steam locomotive engines in the 1800s, this mechanism is often found in door-closing systems. If the disk is rotating with a constant angular velocity $\dot{\theta} = 60\,\text{rpm}$, H = 4 ft, R = 1.5 ft, and r is the distance between B and O, compute $\dot{r}$ and $\dot{\phi}$ when θ = 90°. *Hint:* Apply Eq. (2.48) to the vector describing the position of B relative to O.

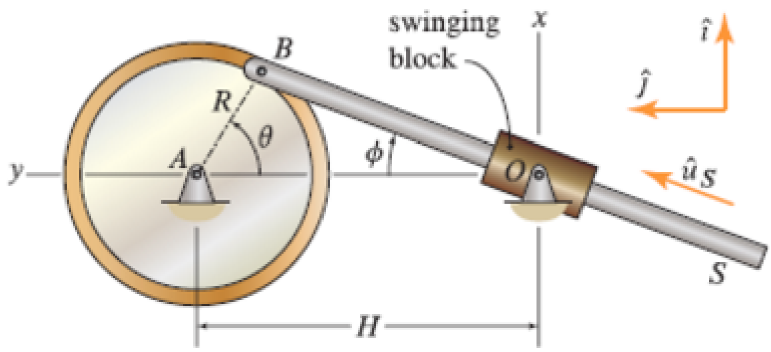

Figure P2.138

Problem 2.188

The polar coordinates of a particle are the following functions of time:

$$r = r_0 \sin(t^3/\tau^3) \quad \text{and} \quad \theta = \theta_0 \cos(t/\tau),$$

where r_0 and θ_0 are constants, τ = 1 s, and where t is time in seconds. Determine r_0 and θ_0 such that the velocity of the particle is completely in the radial direction for t = 15 s and the corresponding speed is equal to 6 m/s.

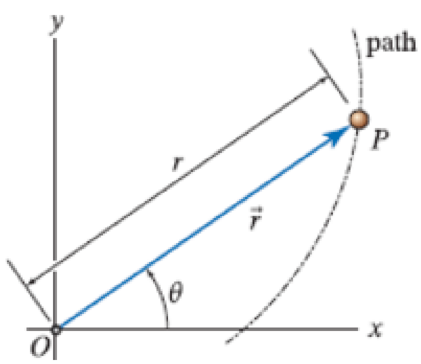

Figure P2.188

Problem 3.74

The cutaway of the gun barrel shows a projectile moving through the barrel. If the projectile's exit speed is v_s = 1675 m/s (relative to the barrel), the projectile's mass is 18.5 kg, the length of the barrel is L = 4.4 m, the acceleration of the projectile down the gun barrel is constant, and θ is increasing at a constant rate of 0.18 rad/s, determine

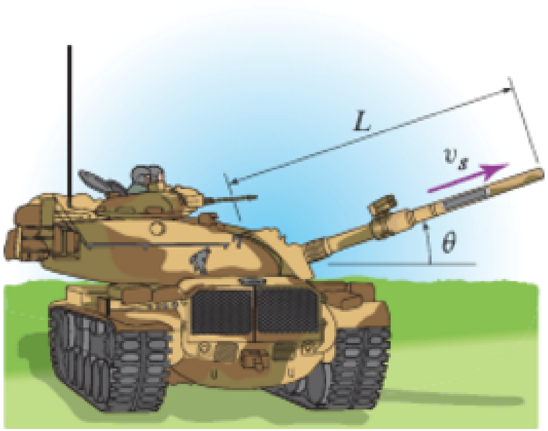

Figure P3.74

a. The acceleration of the projectile.

b. The pressure force acting on the back of the projectile.

c. The normal force on the gun barrel due to the projectile.

as the projectile leaves the gun, but while it is still in the barrel. Assume that the projectile exits the barrel when θ = 20°, and ignore friction between the projectile and the barrel.

Problem 3.71

Revisit Example 3.9 on p. 200 by letting the sphere be released at θ = 0 with a speed v_0 = 0.5 m/s. Neglecting friction, compute the angle at which the sphere separates from the cylinder if R = 1.35 m.

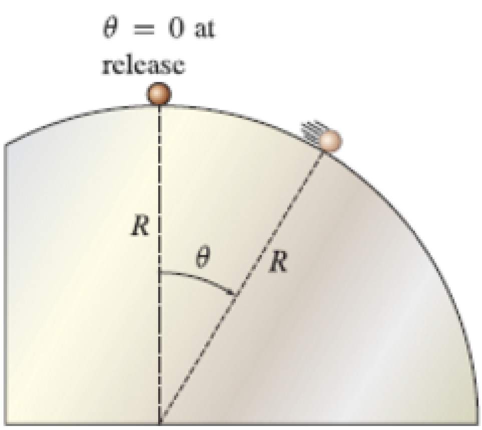

Figure P3.71

Problem 3.84

The package handling system is designed to launch the small package of mass m from A, using a compressed linear spring of constant k. After launch, the package slides along the track until it lands on the conveyor belt at B. The track has small, well-oiled rollers, making any friction between the packages and the track negligible. Modeling the package as a particle, determine the minimum initial compression of the spring so that the package gets to B without separating from the track, and determine the corresponding speed with which the package reaches the conveyor at B.

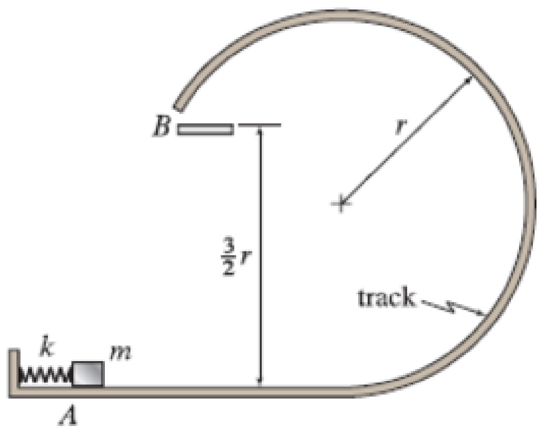

Figure P3.84

Problem 3.111

As seen in Fig. P 3.3.16(a), a window washing platform is controlled by the two pulley systems at AB and CD. The workers E and F can raise and lower the platform P by pulling on the cables H and I, respectively. The weight of each of the workers is 185 lb, and the platform P weighs 200 lb. A schematic representation of the pulley system is shown in Fig. P 3.3.16(b). If the workers start from rest and, in 1.5 s, uniformly start pulling the cable in at 2.5 ft/s, determine the force each worker must exert on the cables H and I during that 1.5 s. Neglect the mass of the pulleys, friction in the pulleys, and the mass of the cable. Assume each worker pulls with the same force, and ignore the departure from vertical of segments H and I.

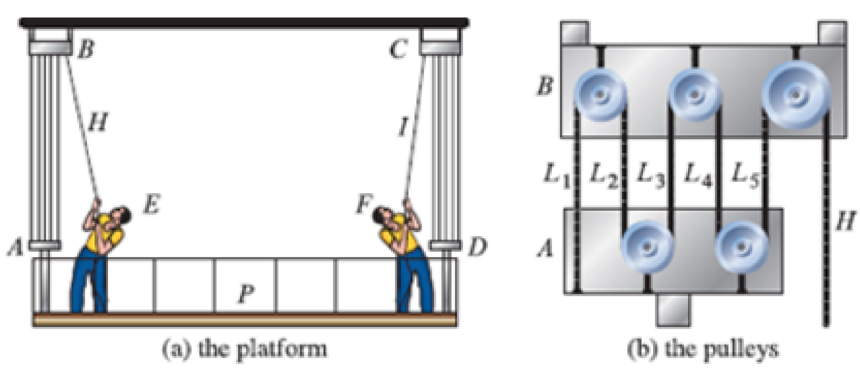

Figure P3.111

Problem 3.114

A force F_0 of 400 lb is applied to block *A*. Letting the weights of *A* and *B* be 55 and 73 lb, respectively, and letting the static *and* kinetic friction coefficients between blocks *A* and *B* be μ_1 = 0.25, and the static *and* kinetic friction coefficients between block *B* and the ground be μ_2 = 0.45, determine the accelerations of both blocks.

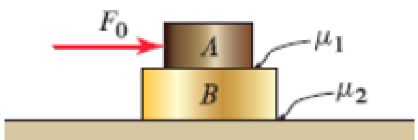

Figure P3.114

Problem 3.115

A force F_0 of 400 lb is applied to block *B*. Letting the weights of *A* and *B* be 55 and 73 lb, respectively, and letting the static *and* kinetic friction coefficients between blocks *A* and *B* be μ_1 = 0.25, and the static *and* kinetic friction coefficients between block *B* and the ground be μ_2 = 0.45, determine the accelerations of both blocks.

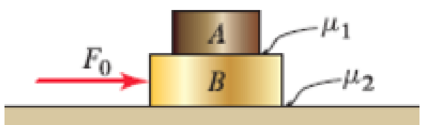

Figure P3.115

Problems 3.75 and 3.76

A simple sling can be built by placing a projectile in a tube and then spinning it. Consider a simple model in which the tube is pinned as shown and is rotated about the pin in the *horizontal* plane at constant angular velocity ω. Assume that there is no friction between the projectile and the inside of the tube and that the projectile is initially kept fixed at a distance *d* from the open end of the tube.

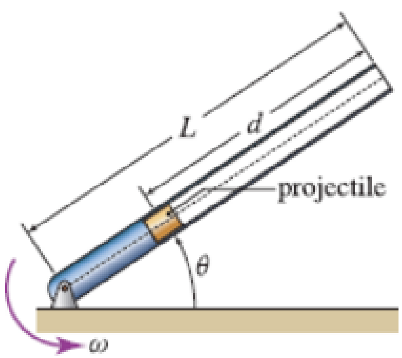

Figure P3.75 and P3.76

Problem 3.75 After the projectile is released, compute the normal force exerted by the inside of the tube on the projectile as a function of position of the projectile along the tube.

Problem 3.76 Letting d = 3 ft and L = 7 ft, determine the value of the tube's angular velocity ω if, after release, the projectile exits the tube with a speed of 90 ft/s.