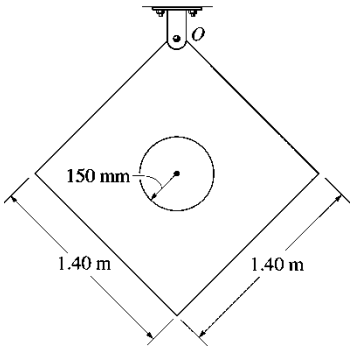
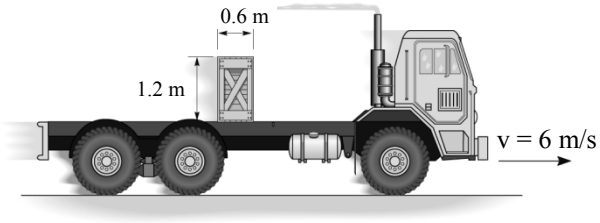
CE222 Spring 2014-2015
Home Exercise 5
Rigid Body Kinetics

Q1. Determine the moment of inertia of the thin plate about an axis perpendicular to the page and passing through the pin at *O*. The plate has a hole in its center. Its thickness is 50 mm and the material has a density of $\rho = 50$ kg/m^3.



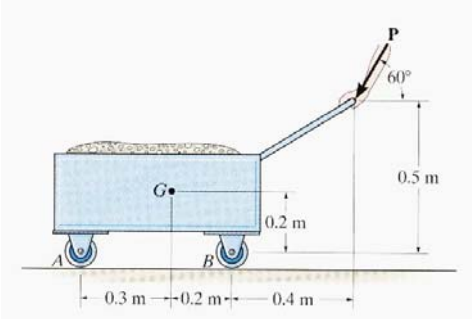
Q2. The crate is uniform and weighs 100 kg. If the coefficient of static friction between it and the truck is $\mu_s = 0.3$, determine the shortest distance *s* in which the truck can stop without causing the crate to tip or slide. The truck is traveling at $v = 6$ m/s.



Q3. The handcart has a mass of 200 kg and center of mass at *G*.

(a) Determine the normal reactions at each of the two wheels at *A* and the two wheels at *B* if a force of $P = 50$ N is applied to the handle.

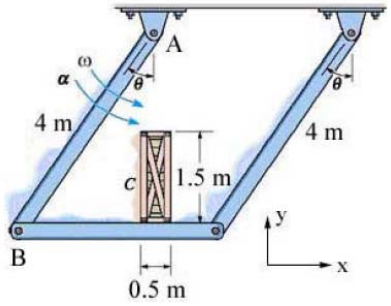
(b) Determine the magnitude of the largest force **P** that can be applied to the handle so that the wheels at *A* or *B* continue to maintain contact with the ground. *Neglect the mass of the wheels.*



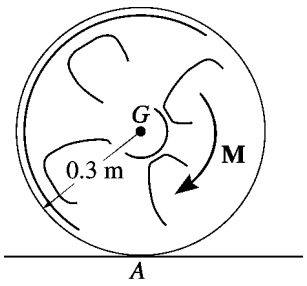
Q4. The 50 kg uniform crate rests on the platform for which the coefficient of static friction is $\mu_s = 0.5$.

(a) If the supporting links have an angular velocity $\omega = 1$ rad/s, determine the greatest angular acceleration α they can have so that the crate does not slip or tip at the instant $\theta = 30°$ as shown.

(b) If at the instant $\theta = 30°$ the supporting links have an angular velocity $\omega = 1$ rad/s and angular acceleration $\alpha = 0.5$ rad/s^2, determine the friction force on the crate.



Q5. The wheel has a mass of 80 kg and a radius of gyration $k_G = 0.25$ m. If it is subjected to a couple moment of $M = 50$ N.m, determine its angular acceleration. The coefficients static and kinetic friction between the ground and the wheel are $\mu_s = 0.2$ and $\mu_k = 0.15$, respectively.

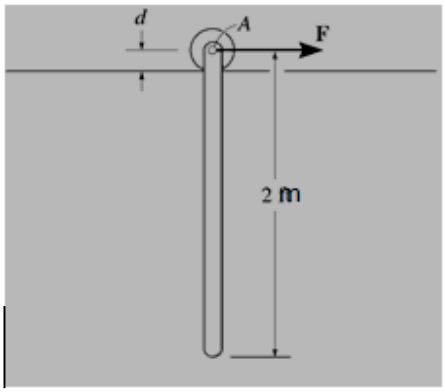


Q6. A uniform rod having a weight of 3 N is pin supported at *A* from a roller which rides on a horizontal track.

(a) If the rod is originally at rest, and a horizontal force of $F = 15$ N is applied to the roller, determine the acceleration of the roller.

(b) If the roller at *A* is replaced by a slider block having a negligible mass. The coefficient of kinetic friction between the block and the track is $\mu_k = 0.2$.

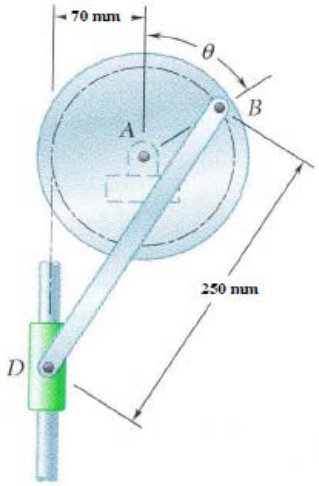
Neglect the mass of the roller and its size *d* in the computations.



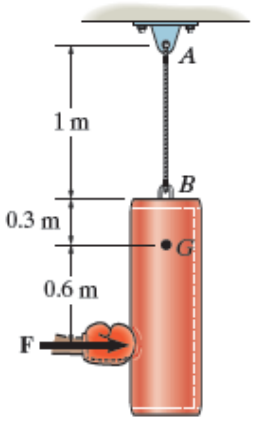
Q7. Collar D slides on a fixed vertical rod. Knowing that the disk has a constant angular velocity of 15 rad/s in the clockwise direction

(a) Determine the angular velocity and angular acceleration of bar BD, and the velocity and acceleration of collar D when $\theta = 0°$ and $\theta = 90°$.

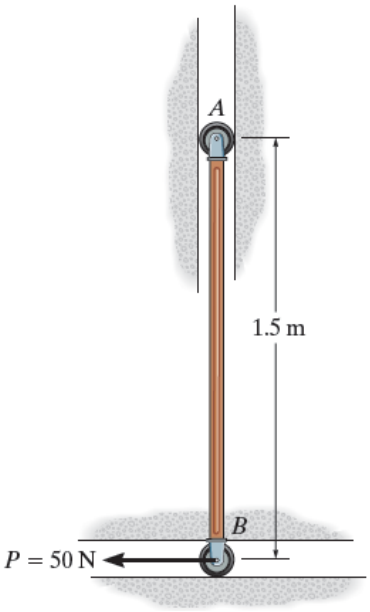
(b) For the given two angles, locate the instantaneous center of zero velocity of bar BD and describe the type of motion of bar BD (rectilinear translation, curvilinear translation, rotation about a fixed axis, general plane motion).



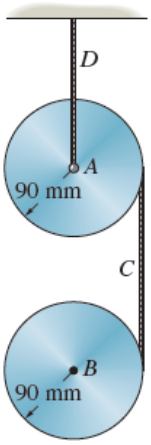
Q8. The 20-kg punching bag has a radius of gyration about its center of mass G of k_G=0.4m. If it is initially at rest and is subjected to a horizontal force F=30N, determine the initial angular acceleration of the bag and the tension in the supporting cable AB.



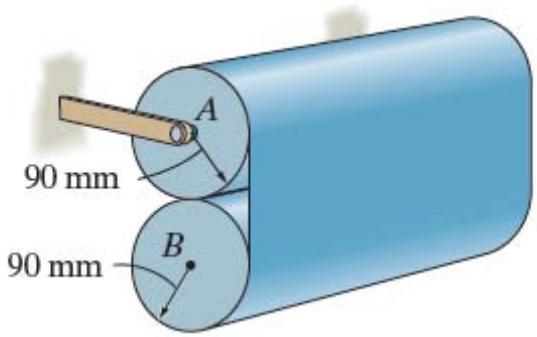
Q9 The 30-kg slender rod AB rests in the position shown when the horizontal force P=50 N is applied. Determine the initial angular acceleration of the rod. Neglect the mass of the rollers.



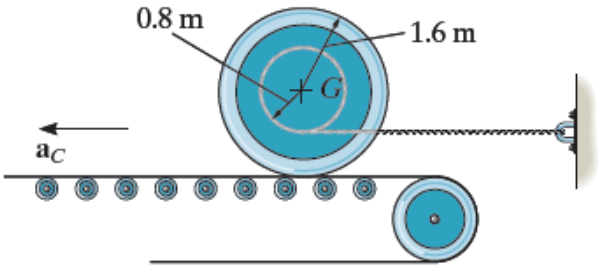
Q10 A cord C is wrapped around each of the two 10-kg disks. If they are released from rest, determine the tension in the fixed cord D. Neglect the mass of the cord.



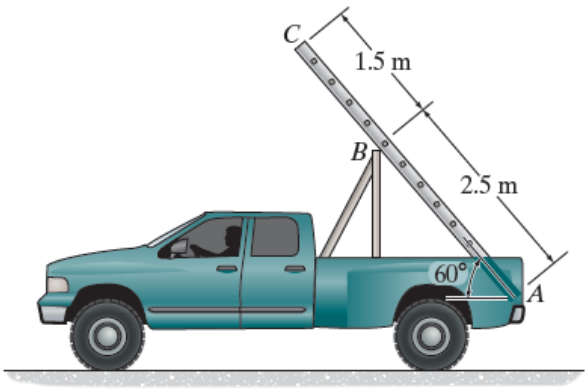
Q11 A long strip of paper is wrapped into two rolls, each having a mass of 8 kg. Roll A is pin supported about its center whereas roll B is not centrally supported. If B is brought into contact with A and released from rest, determine the initial tension in the paper between the rolls and the angular acceleration of each roll. For the calculation, assume the rolls to be approximated by cylinders.



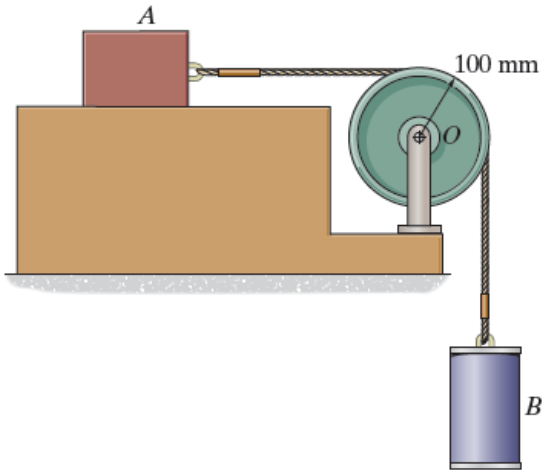
Q12 The spool has a mass of 500 kg and a radius of gyration k_G=1.30 m. It rests on the surface of a conveyor belt for which the coefficient of static friction is μ_s=0.5. Determine the greatest acceleration a_C of the conveyor so that the spool will not slip. Also, what are the initial tension in the wire and the angular acceleration of the spool? The spool is originally at rest.



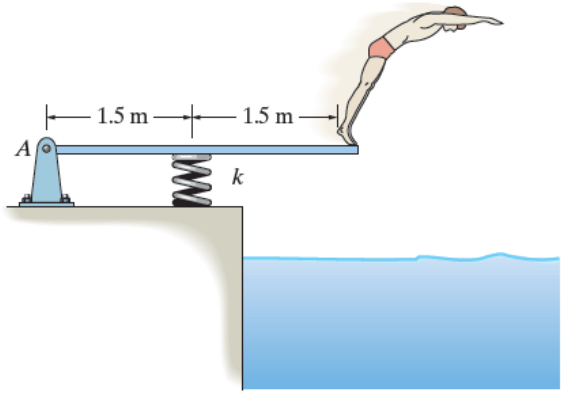
Q13 If the truck accelerates at a constant rate of 6 m/s^2 starting from rest, determine the initial angular acceleration of the 20-kg ladder. The ladder can be considered as a uniform slender rod. The support at B is smooth.



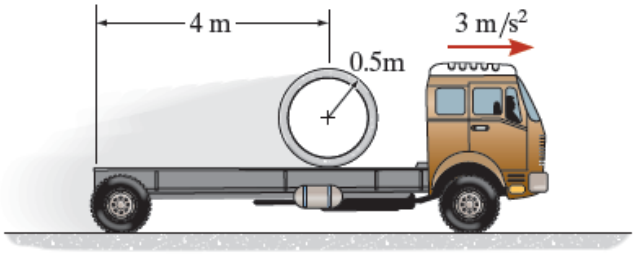
Q14 The 15-kg block A and 20-kg cylinder B are connected by a light cord that passes over a 5-kg pulley (disk). If the system is released from rest, determine the cylinder's velocity after its has traveled downwards 2 m. The coefficient of kinetic friction between the block and the horizontal plane is μ_k = 0.3. Assume the cord does not slip over the pulley.



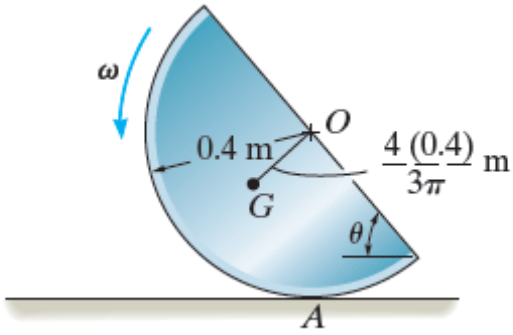
Q15 Determine the angular acceleration of the 25-kg diving board and the horizontal and vertical components of reaction at the pin A the instant the man jumps off. Assume that the board is uniform and rigid, and that at the instant he jumps off the spring is compressed a maximum amount of 200 mm, and the board is horizontal. Take k = 7 kN/m.



Q16 The 500-kg concrete culvert has a mean radius of 0.5 m. If the truck has an acceleration of 3 m/s^2, determine the culvert's angular acceleration. Assume that the culvert does not slip on the truck bed, and neglect its thickness.



Q17 The semicircular disk having a mass of 10 kg is rotating at $\omega = 0.5$ rad/s at the instant $\theta = 60°$. If the coefficient of static friction at A is $\mu_s = 0.5$, determine if the disk slips at this instant



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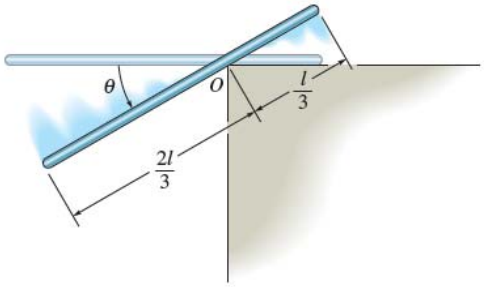
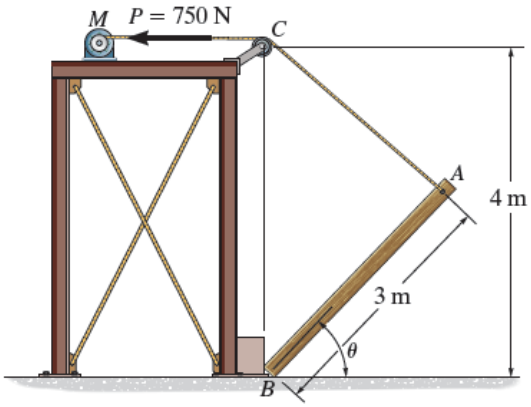
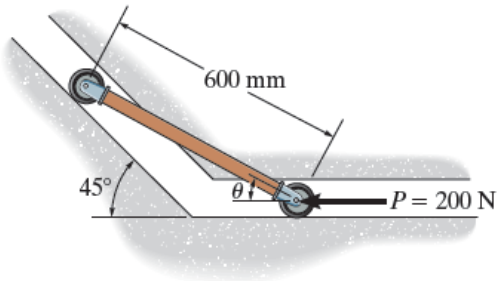
Q18 The uniform bar has a mass m and length l. If it is released from rest when θ=0 determine the angle θ at which it first begins to slip. The coefficient of static friction at O is $\mu_s = 0.3$.



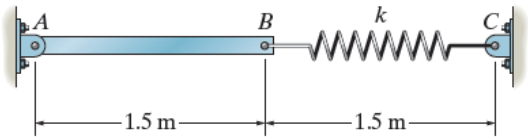
Q19 Motor M exerts a constant force $P = 750$ N of on the rope. If the 100-kg post is at rest when θ=0, determine the angular velocity of the post at the instant θ=60, Neglect the mass of the pulley and its size, and consider the post as a slender rod.



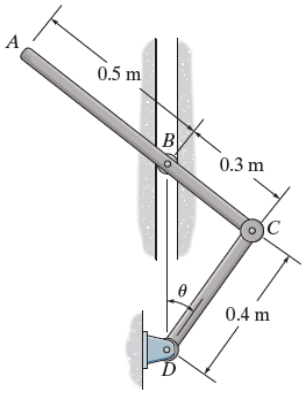
Q20 If P = 200 N and the 15-kg uniform slender rod starts from rest at θ=0, determine the rod's angular velocity at the instant just before $\theta = 45°$.



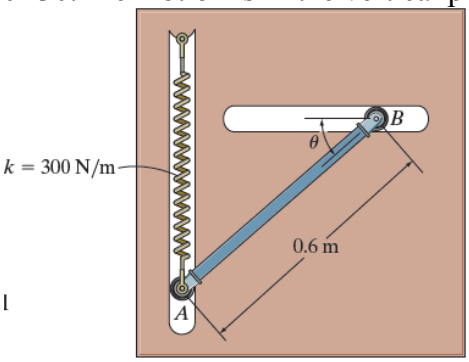
Q21 When the slender 10-kg bar AB is horizontal it is at rest and the spring is unstretched. Determine the stiffness k of the spring so that the motion of the bar is momentarily stopped when it has rotated clockwise 45°.



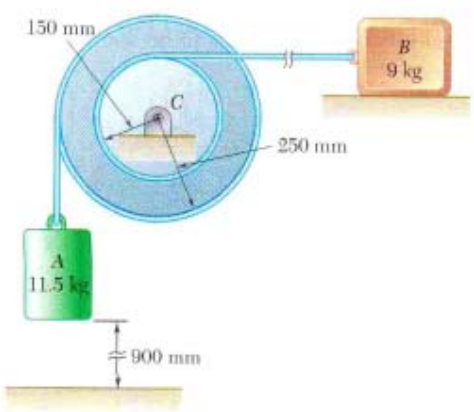
Q22 The 6-kg rod ABC is connected to the 3-kg rod CD. If the system is released from rest when θ=0, determine the angular velocity of rod ABC at the instant it becomes horizontal.



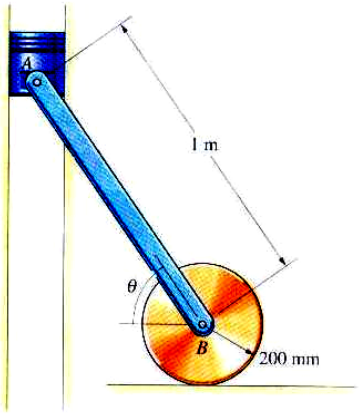
Q23 A spring having a stiffness of k = 300 N/m is attached to the end of the 15-kg rod, and it is unstretched when θ=0. If the rod is released from rest when θ=0, determine its angular velocity at the instant θ=30.The motion is in the vertical plane.



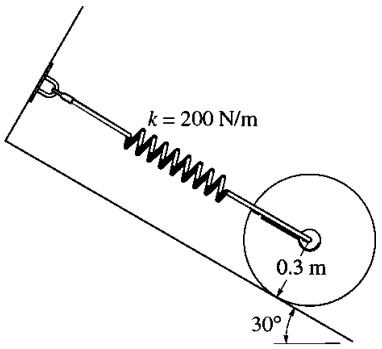
Q24 The double pulley shown has a mass of 14 kg and a moment of inertia of I_C= 0.4 kg.m^2. Cylinder A and block B are attached to cords that are wrapped on the pulleys as shown. The coefficient of kinetic friction between block B and the surface is 0.25. Knowing that the system is released from rest in the position shown, determine:
(a) the velocity of the cylinder A as it strikes the ground,
(b) the total distance that block B moves before coming to rest.
Hint: Use the principle of work and energy.



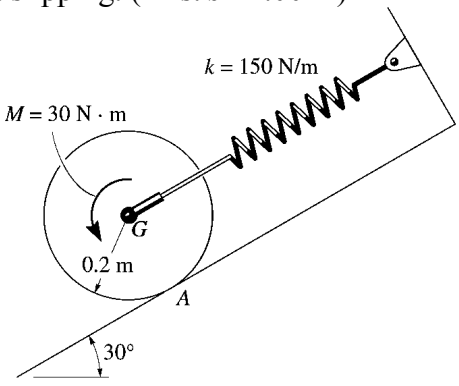
Q25 The 4-kg slender bar is pinned to a 2-kg slider at A and to a 4-kg homogeneous cylindrical disk at B. Neglect the friction force on the slider and assume that the disk rolls. If the system is released from rest with θ = 60°, what is the bar's angular velocity when θ = 0°?



Q26. At the instant the spring becomes undeformed; the center of the 40-kg disk has a speed of 4 m/s. From this point determine the distance d the disk moves down the plane before momentarily stopping. The disk rolls without slipping. (Ans: d = 3.38 m)



Q27. The 20-kg disk is originally at rest, and the spring holds it in equilibrium. A couple moment of M = 30 N.m is then applied to the disk as shown.
a)- Determine its angular velocity at the instant its mass center G has moved 0.8 m down along the inclined plane. The disk rolls without slipping. (Ans: ω = 11.0 rad/s)
b)- Determine how far the center of mass of the disk travels down along the incline, measured from the equilibrium position, before it stops. The disk rolls without slipping. (Ans: s =2.00 m)



Q28. At the instant shown, the 50-kg bar is rotating downward at 2 rad/s. The spring attached to its end always remains vertical due to the roller guide at C. If the spring has an unstreched length of 1m and a stiffness of k=240N/m, determine the angle θ, measured below the horizontal, to which the bar rotates before it momentarily stops.