Dynamics Final Exam

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Problem 1. (45 pts)

Answer these questions briefly.

(1) Derive the principle of work and energy from newton's second law. (10 pts)

(2) Derive the principle of impulse and momentum from newton's second law. (10 pts)

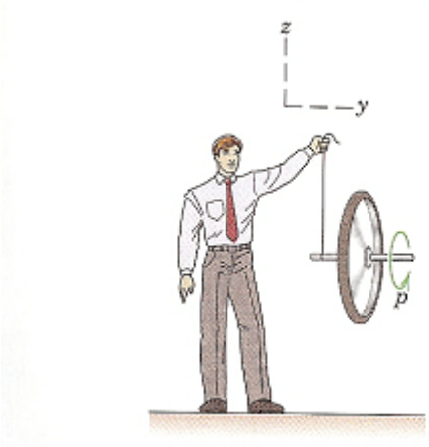
(3) i) Explain d'Alembert's principle. (5 pts)

ii) How is it used to solve problem? (5 pts)

(4) A rapidly spinning wheel is suspended with a string attached to one end of its horizontal axis.

i) Draw a FBD of the wheel and describe the precession motion of the wheel. (10 pts)

ii) Describe why precession occurs and which direction the wheel rotates. (5 pts)

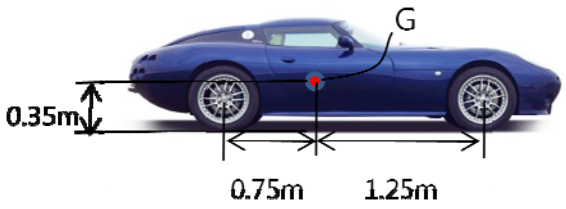


Problem 2. (15 pts)

The sports car has a mass of 1500 kg and a center of mass of G. The coefficient of static friction between the wheels and the road is $\mu_s = 0.2$. Neglect the mass of the wheels for calculation. Determine the shortest time it takes for it to reach 100 km/h, starting from rest,

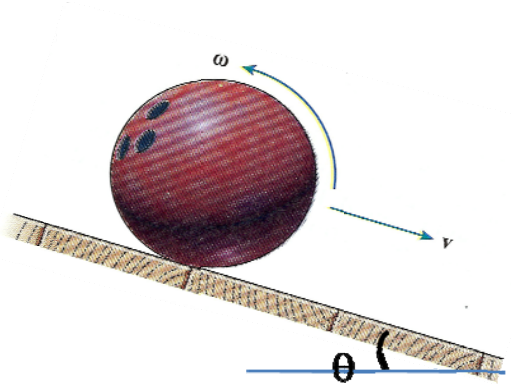
(a) If the engine only drives the rear wheels. (10 pts)

(b) Compare the above with the cases where the engine only drives the front wheels or the engine drives all four wheels. Which method takes the least time to reach 100 km/h? (No calculation is needed.) (5 pts)



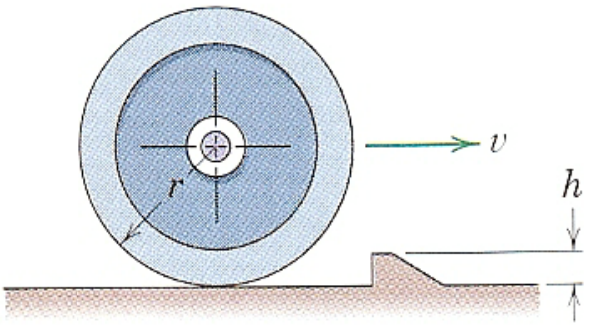
Problem 3. (20 pts)

The 200-mm-diameter bowling ball shown in the figure has a mass of 5 kg. The instant that the ball comes in contact with the surface, it has a forward velocity of v of 10 m/s and a backspin of 5 rad/s. The surface is angled at θ=30 degrees. If the kinetic coefficient of friction between the ball and the surface is 0.3, determine the elapsed time and the distance traveled before the ball begins to roll without slipping.



Problem 4. (20 pts)

Determine the minimum velocity *v* which the wheel must have to just roll over the obstruction. The centroidal radius of gyration of the wheel is *k*, and it is assumed that the wheel does not slip.



Problem 5. (40 pts)

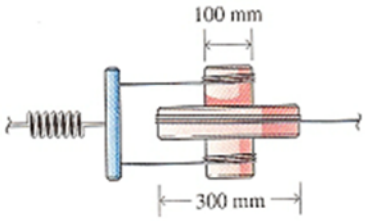
The stepped cylinder C in the figure consists of a 5 kg cylindrical annulus (300 mm outer diameter and 100 mm inner diameter) and a 7 kg cylindrical axle of 100 mm diameter. A spring with a spring constant of 2 kN/m is attached to cords wrapped around the axle. A second cord is wrapped around the center of the cylinder, passes over a small frictionless pulley, and is attached to a 15 kg crate A. If the crate has a speed of 1.5 m/s downward when the spring is stretched by 100 mm and the cylinder rolls without slipping, determine

(a) Calculate the mass moment of inertia of the stepped cylinder, I_c. (10 pts)

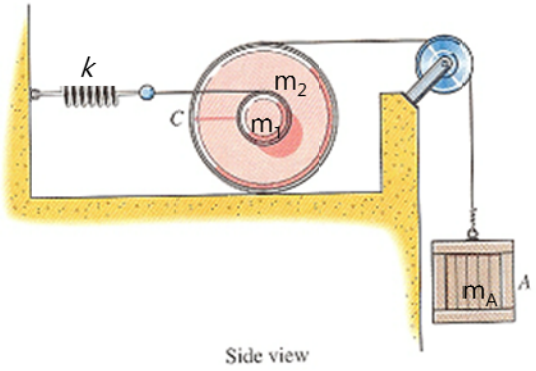
(b) The maximum distance that the crate will drop. (10 pts)

(c) The speed and the angular velocity of the cylinder and the speed of the crate when the stretch in the spring is zero. (10 pts)

(d) The maximum distance that the crate will rise above its initial position. (10 pts)

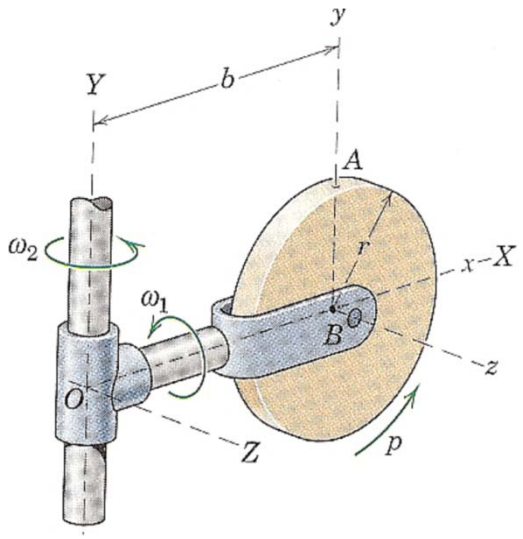


Top view



Side view

Problem 6. (40 pts)



The thin circular disk of mass *m* and radius *r* is rotating about its z-axis with a constant angular velocity *p*, and the yoke in which it is mounted rotates about the *X*-axis through OB with a constant angular velocity ω_1. Simultaneously, the entire assembly rotates about the fixed *Y*-axis through O with a constant angular velocity ω_2. The disk passes the position shown where the *x*-*y* plane of the disk coincides with the *X*-*Y* plane. The *x*-*y*-*z* axes are attached to the yoke.

(a) Determine the kinetic energy T of the disk at the instant shown. (14 pts)

(b) Determine the velocity *v* of point A on the rim of the disk. (13 pts)

(c) Determine the acceleration *a* of point A on the rim of the disk. (13 pts)