MECH230 - Fall 2024
Recommended Problems - Set 07

Theresa Honein

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Friction Forces

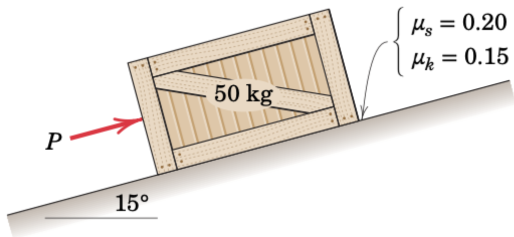
- Static friction is unknown but satisfies that static friction criterion $||\mathbf{F}_f|| \leq \mu_s ||\mathbf{N}||$.
- Kinetic friction is prescribed according to Coulomb's friction model to be $\mathbf{F}_f = -\mu_k ||\mathbf{N}|| \frac{\mathbf{v}_{rel}}{||\mathbf{v}_{rel}||}$.

where μ_s and μ_k are the static and kinetic friction coefficients respectively. $\mathbf{v}_{rel}$ is the relative velocity between the two contacting surfaces. When friction is static, $\mathbf{v}_{rel} = \mathbf{0}$.

These problems are taken from J. L. Meriam, L. G. Kraige, and J. N. Bolton (MKB), Engineering Mechanics: Dynamics, Ninth Edition, Wiley, New York, 2018.

1. [MKB 03-002] In choosing your coordinate system, think about the advantages of taking $\{\mathbf{E}_x, \mathbf{E}_y\}$ to point along and perpendicular to the incline, respectively, rather than along the horizontal and vertical.

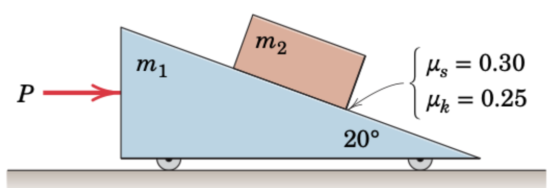
3/2 **The 50-kg crate is stationary when the force P is applied. Determine the resulting acceleration of the crate if (*a*) $P = 0$, (*b*) $P = 150$ N, and (*c*) $P = 300$ N.**



PROBLEM 3/2

2. [MKB 03-030] In this problem, you will apply the 4 steps twice. First, consider the combined system of the two blocks. The static friction forces at the block-wedge interface are internal to this system and are thus not included in the free body diagram. Then consider the system of mass m_2 alone. The static friction force acting on m_2 is now external to the system and points along the incline. It is convenient to define a unit vector $\mathbf{u}$ along the inline and to project the balance of linear momentum of m_2 along $\mathbf{u}$. Use the static friction to determine a range for P as required by the problem statement.

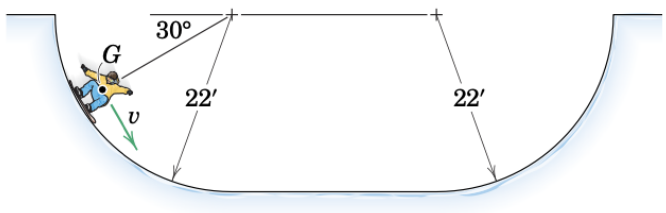
3/30 **Determine the range of applied force P over which the block of mass m_2 will not slip on the wedge-shaped block of mass m_1. Neglect friction associated with the wheels of the tapered block.**



PROBLEM 3/30

3. [MKB 03-047]

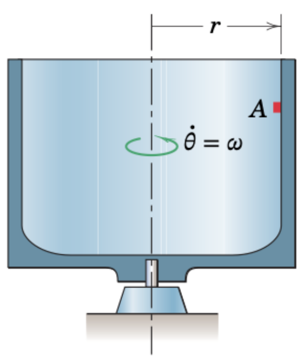
3/47 A 180-lb snowboarder has speed $v = 15$ ft/sec when in the position shown on the halfpipe. Determine the normal force on his snowboard and the magnitude of his total acceleration at the instant depicted. Use a value $\mu_k = 0.10$ for the coefficient of kinetic friction between the snowboard and the surface. Neglect the weight of the snowboard and assume that the mass center G of the snowboarder is 3 feet from the surface of the snow.



PROBLEM 3/47

4. [03-049] Set up a cylindrical polar coordinate system with origin at the base of the cylinder axis. Take your system to be the small object A and apply the 4 steps on it. When prescribing the normal and friction forces, note that A is a particle moving on a cylindrical surface.

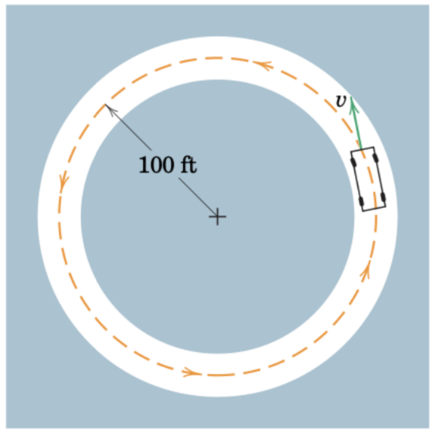
3/49 A small object A is held against the vertical side of the rotating cylindrical container of radius r by centrifugal action. If the coefficient of static friction between the object and the container is μ_s, determine the expression for the minimum rotational rate $\dot{\theta} = \omega$ of the container which will keep the object from slipping down the vertical side.



PROBLEM 3/49

5. [03-050]

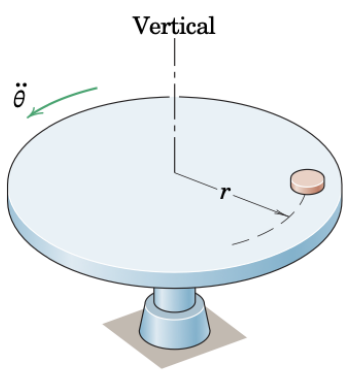
3/50 The standard test to determine the maximum lateral acceleration of a car is to drive it around a 200-ft-diameter circle painted on a level asphalt surface. The driver slowly increases the vehicle speed until he is no longer able to keep both wheel pairs straddling the line. If this maximum speed is 35 mi/hr for a 3000-lb car, determine its lateral acceleration capability a_n in g's and compute the magnitude F of the total friction force exerted by the pavement on the car tires.



PROBLEM 3/50

6. [03-071] Use a polar coordinate system whose origin is taken to be at the center of the disk.

3/71 A small coin is placed on the horizontal surface of the rotating disk. If the disk starts from rest and is given a constant angular acceleration $\ddot{\theta} = \alpha$, determine an expression for the number of revolutions N through which the disk turns before the coin slips. The coefficient of static friction between the coin and the disk is μ_s.



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