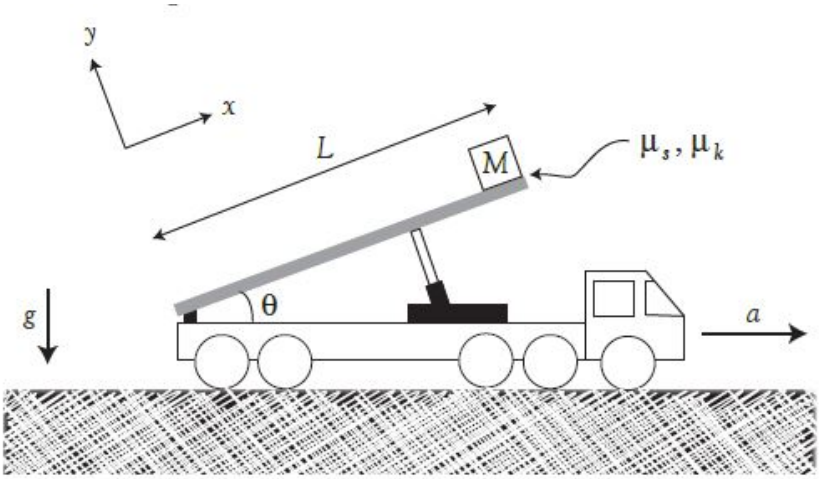
FP15

A crate of mass M, which contains an expensive piece of scientific equipment, is being delivered to Caltech. The delivery truck has a freight bed of lenth L (see the figure), with a coefficient of static friction μ_s and a coefficient of kinetic friction μ_k. Rather than move the heavy crate himself, the driver tilts the truck bed by an angle θ and then drives the truck forward with increasing acceleration a, until the crate begins to slide.



For this problem, use the x, y coordinate system shown in the figure. These coordinates are fixed with respect to the truck's bed, **not** to the ground.

a) (2 points) Draw a free-body force diagram for the crate in the truck's frame of reference.

b) (3 points) Write down Newton's second law for the motion of the crate in the $x-$ and $y-$ directions, just before it begins to slip.

c) (2 points) Determine the minimum acceleration a_{min} for which the crate will begin to slip. Express your answer in terms of the constants shown in the figure.

When the truck reaches a_{min} and the driver notices the crate beginning to slide, he continues at that constant acceleration.

d) (3 points) Find the speed of the crate along the $x-$ direction when the crate leaves the truck bed. Neglect the size of the crate. You may leave your answer in terms of a_{min}.