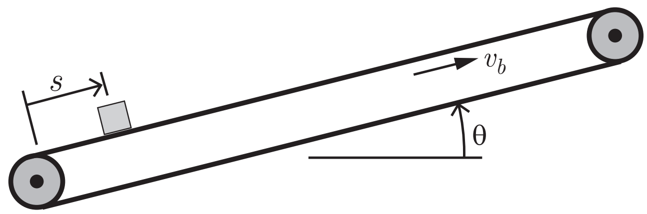
The conveyor belt shown below runs at a constant speed v_b, uphill at an angle θ relative to horizontal as shown in the figure below. A slippery (but not frictionless) block of ice is placed on the belt. At the instant the block is released, it has zero speed. After release, the block of ice begins moving up the belt. Sometime before the block reaches the top of the belt, its speed matches that of the belt.



Suppose that you know the mass of the ice block, m, the angle θ of the belt, the speed of the belt, v_b, and the coefficients of kinetic and static friction, μ_s and μ_k. In answering the questions below, follow the problem solving checklist and the free body diagram checklist. I want you to solve the kinematics of the problem (relationships between position, velocity, and acceleration) by direct integration. Do NOT use so-called kinematics relationships that you learned elsewhere, unless you are willing to derive them from first principles and explicitly justify their use by explaining how their assumptions are satisfied.

1. If the ice block is released at $t = 0$, at what time does the speed of the block match that of the belt?

2. Does your expression for the time that you determined in the question above have the correct sign? Explain.

3. When the speed of the block matches the speed of the belt, how far has it traveled?

4. What is the magnitude of the friction force *after* the block matches the speed of the belt?