1. Wind on roof

A \( m = 2 \text{ kg} \) object is sitting at a bottom of a roof, which is inclined at \( \theta = 30^\circ \), and ends \( H = 4 \text{ m} \) vertically above this level. We shove the object toward the top of the roof, giving it the initial speed of \( v_0 = 10 \text{ m/s} \). There is also horizontal wind (parallel to the ground), blowing in the back of our object, acting on it with the force of \( F_0 = 2 \text{ N} \).

(A) What is the minimal coefficient of kinetic friction \( \mu_k \) so that this doesn’t fly off of the roof?

(B) But if the roof is wet, that friction coefficient is only \( \mu_k = 0.05 \). What is the acceleration now?

(C) In the previous case, with what speed does the object reach the top of the roof, shooting off?

2. To push or to pull?

We want to move a box across the floor. The coefficient of kinetic friction between them is \( \mu_k = 0.4 \). The mass of the box is \( m = 2 \text{ kg} \). We want to expend as little energy as possible.

(A) We push it with the force of \( F_0 = 20 \text{ N} \), but at the angle of \( \theta = 10^\circ \) with the horizontal. What is the acceleration of the box?

(B) If we pull it instead, walking in front of it, but under the same angle with the horizontal, how much force do we need to achieve the same acceleration? Explain briefly why this force is different.

(C) As we go, we pull more and more vertically: at what angle do we lift the box off of the ground? (⋆) What is the optimal angle – to give maximum acceleration with a given force? [Optional.]

3. Two blocks, a very light cord, and a little pulley.

We have two blocks, and a light, unstretchable cord to connect them. We also have a very light pulley, which spins without any friction. We take a flat board, and mount the pulley on one end. Then we lay this board horizontally, and place one block, of mass \( m_1 = 3 \text{ kg} \), on it. We connect via the cord the other block, of mass \( m_2 = 2 \text{ kg} \), with it, run the cord over the pulley, and let this other block hang freely off of the other end of the cord. See figures below. The coefficient of kinetic friction between the board and the block is \( \mu_k = 0.6 \).

(A) We let go; they start moving. What is the acceleration of the box? The tension in the cord?

(B) Now we raise the end of the board with the pulley, inclining the board so much as to make sure that the box on it starts sliding downward, while the other one is coming straight up. We estimate that the angle is \( \theta = 45^\circ \). What is the acceleration now?

(C) Now we remove the hanging mass completely, and start reducing the angle, to stop the acceleration of our system. At what angle does it stop accelerating?