- worksheet: positron.hep.upenn.edu/p8/files/ws13.pdf
- 4 problems + 1 XC. All friction where F^{normal} is tricky.
- No video for this Wed. Expect 2 ch11 videos for next week.
- I'll bring last Wednesday's hands-on stuff back this Wednesday, for people who were out last Wednesday.
- Email **in advance** & file a CAR if you need to miss class.

$$F^K = \mu_K F^{\mathrm{normal}} \qquad F^S \le \mu_S F^{\mathrm{normal}} \qquad W = \vec{F} \cdot \Delta \vec{r}$$

F^{normal} is perpendicular to the surface and is as large as it needs to be to prevent the object from passing through the surface

In today's problems, you usually need either to decompose gravity into "downhill" and "perpendicular" components, or else to decompose the pushing/pulling force into horizontal and vertical components. Remember that for an object that is either at rest or moving at constant velocity, forces along each axis sum (with proper signs) to zero. A careful FBD often helps.

Physics 8, Fall 2021, Worksheet #13.

Upload PDF (smartphone scan or tablet edit) to Canvas at or shortly after end of class on Mon, Oct 18, 2021.

Problems marked with (*) must include your own drawing or graph representing the problem and at least one complete sentence describing your reasoning.

Discuss each problem with your teammates (usually groups of 3), then write up your own solution. Be sure to compare final results with your teammates, as a way to catch mistakes. It can also be very interesting when you and a teammate use different methods to arrive at a result! Do not hesitate to ask for help from other students, from Melina, or from Bill.

1. The coefficient of static friction of tires on ice is about 0.10. (a) What is the steepest driveway on which you could park under those circumstances? (b) Draw a free-body diagram for the car when it is parked (successfully) on an icy driveway that is just a tiny bit less steep than this maximum steepness. (You might want to do (b) before you do (a).)

2. A woman applies a constant force to pull a 62 kg box across a floor at constant speed. She applies this force by pulling on a rope that makes an angle of 30° above the horizontal, and for the box-floor interface, $\mu_k = 0.18$. (a) Find the tension in the rope. (b) What is the work done by the woman as she moves the box 8.0 m?

3*. A janitor is pushing a 15 kg trashcan across a level floor at constant speed. The coefficient of friction between can and floor is 0.11. (a) If he is pushing horizontally, what is the magnitude of the force he is exerting against the can? (b) If he pushes not horizontally but rather at an angle of 36.9° down from the horizontal, what must be the magnitude of his pushing force to keep the can moving at constant speed?

4. A resort uses a rope to pull a 52 kg skier up a 35° slope at constant speed for 82 m. The tow rope is parallel to the ski slope. (a) Find the tension in the rope if the snow is slick enough to allow you to ignore any frictional effects. (b) How much work does the rope do on the skier? (c) Now find the tension in the rope if the coefficient of kinetic friction between snow and skis is $\mu_k = 0.15$. (d) Now how much work does the rope do on the skier?

5*. Optional / extra-credit. A book of mass m is resting on a table. You push down on the book with a force directed at an angle φ w.r.t. vertical. (So in this case $\varphi = 0$ would mean pushing vertically, and $\varphi = 90^\circ$ would mean pushing horizontally.) The coefficient of static friction bewteen the book and the table surface is μ_S. If φ is smaller than some minimum value $\varphi_{\min}$, you cannot get the book to slide no matter how hard you push. What is that minimum angle?

Hint: If you consider where static friction "just barely lets go" (ie use an "$=$" sign in the static-friction equation), then consider the mathematical limit $F^{\rm push} \to \infty$, the result is an expression giving a particular value for φ that may look familar.