Recitation Questions
17 February

Note: Remember that all Newton's-second-law problems can and should be solved by this pattern:

1. Draw force diagrams of the object or objects whose motion you care about
   (a) Decide on a coordinate system for the problem
   (b) Resolve the forces into x- and y-components
2. Write down $\sum F = ma$ for the object(s), in both x- and y-directions if necessary
3. Ask a question concerning the algebraic quantities (for instance, "If static friction has its maximum value of $\mu_s F_N$, for what value of θ does $a = 0$?")
4. Do the algebra, solving a system of equations if need be

1. Wheeled vehicles accelerate themselves forwards or backwards by turning their wheels using an engine or a brake. This force is called *traction*, and is a special case of static friction (if the wheels do not slip on the pavement. Just like the force of static friction has a maximum value $F_{f,stat,max} = \mu_s F_N$, the maximum force of traction $F_{tr,max} = \mu_s F_N$. This means that, no matter how powerful the engine or the brakes in a car, its acceleration (forward or backward) is limited by the maximum traction of the wheels.

   Consider a vehicle with the following parameters:

   - The total mass of the vehicle is m
   - The engine is in the front, making that end heavier. The normal force on the front two wheels is $F_{N,f} = 2/3\, mg$, while the normal force on the rear two wheels is $F_{N,r} = 1/3\, mg$.
   - The coefficient of static friction between the tires and the pavement is μ_s. On dry pavement the value is 1, while on snow the value is 0.3.

   Find:

   (a) the maximum forward acceleration of the vehicle, if it is front-wheel drive, driving on dry pavement

(b) the maximum forward acceleration of the vehicle, if it is front-wheel drive, driving on snow

(c) the maximum forward acceleration of the vehicle, if it is rear-wheel drive, driving on snow

(d) the maximum backward acceleration of the vehicle, if brakes are attached to all four wheels, and it is on snow

(e) Two-wheel-drive pickup trucks are often rear-wheel-drive. Drivers will often load the bed of these trucks with snow or sand when driving on mud or snow. Why do they do this?

2. A book rests on a table that can be tilted. The coefficent of static friction between the book and the table μ_s is 0.5, while the coefficient of kinetic friction μ_k is 0.4.

   You observe the following:

   - If the tilt angle (between the table and the horizontal) is less than some critical angle ϕ, then the book will not fall. If it is pushed, then it will move a small distance and come to rest again.
   - If the tilt angle is greater than ϕ, but less than another angle ψ, then the book will not fall on its own. However, if it is pushed downward just a bit, then it will continue to slide all the way down the table.
   - If the tilt angle is greater than ψ, it will slide down on its own without being pushed.

   (a) Describe in words why you think this happens. Can you reproduce this with things around your classroom? (desks, books, objects placed on books, objects placed on desks)?

   (b) Find ϕ and ψ.