Physics 271, Sections H1 & H2 — Thursday, Oct 2, 2014

Problems #4 — Force & Motion [II]

1) Consider two masses m_1 and m_2, one on an inclined plane with an angle θ and the other one connected to it by a string over a frictionless pulley. The inclined plane is actually a triangular mass M sitting on a scale. The coefficient of static friction between M and the scale is μ_S and the coefficients of static and dynamic friction between m_1 and M are μ_{s1} and μ_{k1}.

a) Find the conditions on μ_S and μ_{s1}, so that nothing moves.
b) If m_1 and m_2 are moving, what is the condition on μ_S so that the M does not move?
c) M is not moving. What is the weight that the scale measures?

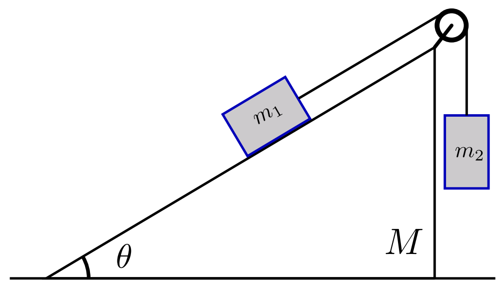

Figure 1: An inclined plane.

2) Consider a sleigh on ice with mass M and a box with mass m on top of it. The coefficients of static and kinetic friction between the box and the sleigh are μ_s and μ_k. The friction between the sleigh and ice is negligible.
a) We apply a horizontal force on the box. What is the maximum force so that the box and the sleigh do not move relative to each other? Call this force F_c. Find the accelerations of box and sleigh when applied force is smaller than F_c. Find the accelerations when the applied force is bigger than F_c.
b) Solve previous part if we apply the force on the sleigh instead of the box.

3) A car is turning on a road which is part of a curved surface of a cone. See fig. 2. The car is going with constant velocity v on a circle with radius r. The angle between the road and horizontal plane is θ. The coefficient of static friction between the car and the road is μ_s.
a) What are the condition[s] that the car does not slip.
b) What is the magnitude of the normal force on a driver with mass m.

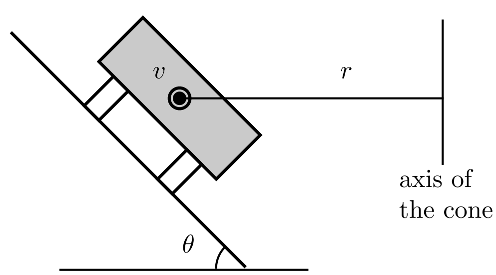

Figure 2: A car turning on a curved surface of a cone.

4) You throw a baseball right up to the sky. It takes the baseball the time t_1 to reach the highest point in the sky, and it takes it the time t_2 to come down.
a) If the drag force is $\mathbf{f} = -k\mathbf{v}$, find $v(t)$. Also write down expressions for t_1 and t_2, i.e. you do not need to calculate the integrals.
b) If the drag force is $\mathbf{f} = -kv\mathbf{v}$, find $v(t)$. Also write down expressions for t_1 and t_2, i.e. you do not need to calculate the integrals.
c) Draw a qualitative velocity graph, $v(t)$. Is $t_1 > t_2$ or $t_1 < t_2$? Use the graph to argue.

5) You went skiing. In a downhill with an angle θ, where the coefficient of kinetic friction is μ_{k}. You mass is m, effective area is A, the density of the air is ρ, and the drag coefficient is C.
a) Find the terminal speed.
b) How much the terminal speed changes if you squat and halve the effective area.
c) How much the terminal speed changes if there is a wind with velocity v_{w} in the direction of skiing.