# Can a Skier Outrun an Avalanche?
## Force Decomposition
### Read-ahead

**Introduction**

A free body diagram is a pictorial device used by physicists and engineers to analyze the forces acting on an object, with the aim to predict and explain the motion of the object. Often these forces are not in the same direction as the motion, in which case they need to be "resolved", i.e., broken down into components parallel to the motion and components perpendicular to the motion. In this set of problems, you will apply the method of force decomposition to answer the question of whether a snowboarder can outrun an avalanche.

**Instructions**

Your first step for this module should be to watch the two video clips linked from the Canvas site. The first is a worked example involving a block on an inclined plane, in which the basics of force decomposition are explained. The second clip is from the movie "xXx: Avalanche"; in this scene the main character tries to stay ahead of an avalanche he has deliberately triggered with explosives. After reading through *Can a Skier Outrun an Avalanche?* context and questions below, you should complete the reflection assignment in Canvas. Note: *you will have a chance to talk further with your coach before answering the questions below in detail*. The point of this read-ahead and the reflection is to "prime the pump" for further conversations with your coaches.

**Force Decomposition**

A snowboarder is trying to keep ahead of an avalanche, which is thundering down the mountain at 200 mph. Consider the free-body diagram of the snowboarder shown in Figure 2 below, in which the various forces are labeled.

Figure 1: Still from the movie

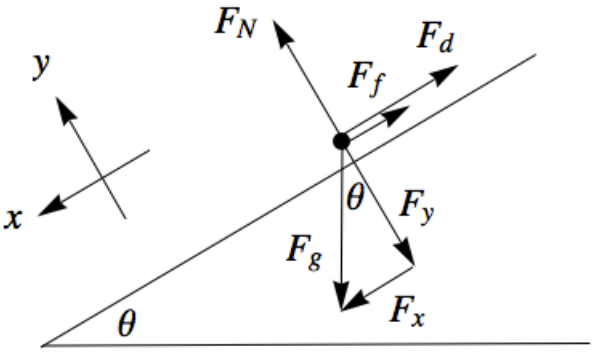


Figure 2: Free-body diagram of snowboarder

$F_g$ is the force of gravity, which is $mg$, where $m$ is the mass of the snowboarder and $g$ is the gravitational constant 9.8 m/s$^2$. This force can be decomposed into a force parallel to the slope, labeled $F_x$ in the diagram, and a force perpendicular to the slope, labeled $F_y$. The force due to friction is labeled $F_f$, and

the drag force due to air resistance is labeled $F_d$.

**Questions**

1. Find expressions for $F_x$ and $F_y$ in terms of $m, g$, and the angle $\theta$.
2. The normal force $F_N$ is the force of the ground pushing back on the snowboarder, which must equal $F_y$ since the snowboarder's motion is parallel to the slope. The force of friction is $F_f = \mu F_N$, where $\mu$ is the coefficient of friction. The drag force is $F_d = \frac{1}{2}\rho C_D A v^2$, where $\rho$ is the density of air, $C_D$ is the drag coefficient, $A$ is the cross-sectional area of the snowboarder, and $v$ is the snowboarder's velocity. Suppose $m$ is 80 kg, $\rho, C_D$, and $A$ are all equal to 1, $\theta$ is 45 degrees, and $\mu$ is 0.03. Suppose that the snowboarder has reached terminal velocity $v_t$ and is no longer accelerating. This implies that the sum of all of the components of forces parallel to the slope is zero. Use this to calculate the terminal velocity $v_t$, both in m/s and in mph.
3. Assuming the other parameters stay the same, how small would the snowboarder need to make his cross-sectional area $A$ in order to keep ahead of the avalanche?

**Instructions, part deux**

After reading and reflecting on these questions, complete the pre-read assignment on Canvas. This will give your coach some insight on your thinking in order to best help you before you are required to formally answer these questions.