Note: All the following problems were conceived by the students of PREP Physics 7A as an exercise. Any impossible situations are the result of unrestrained creativity. If you need clarification or see an issue with a given problem set up, consult the group that designed the problem.

Problem 1: Tomo is standing on the Campanile at height $h$ above the ground. He throws a Stanford student at angle $\theta$ above the horizontal into a trash can on the ground a distance $d$ away from the Campanile’s base.

a) What initial throwing speed $|v_0|$ is required in order for the Stanford student to land in the (padded) trash can?

b) Describe the position, velocity, and acceleration vectors at time $= t$.

c) Find the student’s final velocity $v_f$ upon hitting the trash can at an angle of $\phi$.

d) After the Stanford student lands in the can, the can, resting at the top of a slope of decline $\alpha$ below the horizontal, begins to slide. The coefficient of friction between the trash can and the ground is $\mu_k$. Find how far the can slides before the force of friction mercifully ends the student’s nightmare.
Problem 2: It was a dark and stormy night, and mad scientist Tom Zajdel laughed manically at the top of the Campanile – his rocket was ready to be launched! It misfires, however, and he falls of the Campanile, holding the rocket horizontally, just barely managing to fire his parachute. His henchman Tomo sees and decides to bicycle to his rescue, jumping off a ramp with angle $\theta$ to the horizontal and coefficient of friction $\mu_k$ (assume the bicycle acts as a point mass). At what distance $d_0$ from the Campanile must Tomo leave the ramp in order to catch Tom in midair, most majestically and heroically, winning his heart forever?

a) Find the net force on Tom.

b) Find Tomo’s velocity when leaving the ramp.

c) Find $d_0$. 
**Problem 3:** Thor, a legendary demigod, is in Jovenheim, battling Frost Giants. He needs his hammer, Mjolnir, to fight them. He swings his hammer counterclockwise vertically to create wind power and push them away. His hammer and rod grip (consider it all as a point particle) has a mass $m$ and his strap (consider it as an ideal string) with which it swings in a circle has length $R$. The maximum tension which the strap can maintain without breaking is $T$. Assume gravity on Jovenheim is $g = 9.81 \text{m/s}^2$.

a) What is the maximum linear speed that Mjolnir can move at until the strap breaks?

b) At what point in the circular path of the hammer would the strap break, assuming that it is just exceeding the maximum linear speed.

c) Define the velocity vector of the hammer at the moment the strap breaks.

d) The strap breaks at a velocity $v_0$ at an angle $\theta$ above the horizontal due to a delayed snap. The hammer is at a height $h_0$ above the ground when it snaps. What is the maximum height above the ground that the hammer will reach before it starts its trajectory downwards? Assume $g = 9.8 \text{m/s}^2$ and all godly powers are removed on Jovenheim.

e) Loki, Thor’s evil brother, is a certain distance away from the hammer’s launch point, tinkering with the Tessaract, a source of unlimited power. How far does Loki have to be for Mjolnir to fall on him? Assume Loki is at ground level (i.e. his head is at ground level and his body is submerged in a trench below ground).
Problem 4: It is Stephen Hawking’s 75th birthday and out of the goodness of his heart, Tomo offers to give him a ride down Campanile hill. Tomo ($m_2$) lays on his belly at the top of the hill and Hawking ($m_1$) sits on Tomo’s back. Campanile hill is frictionless and air resistance is negligible. Tomo and Hawking are released from rest and as they slide down the hill, two black holes appear at the tip of the Campanile (but manage to avoid consuming the famous clock tower). The hill breaks at an upturned ramp and since Stephen Hawking is unaffected by the black holes, he just misses them (via Hawking radiation), while unfortunately, Tomo gets sucked into an infinite dimensional loop.

If Hawking is then in freefall and uses his skis to continue down the hill, what is his final velocity at the bottom of the hill?