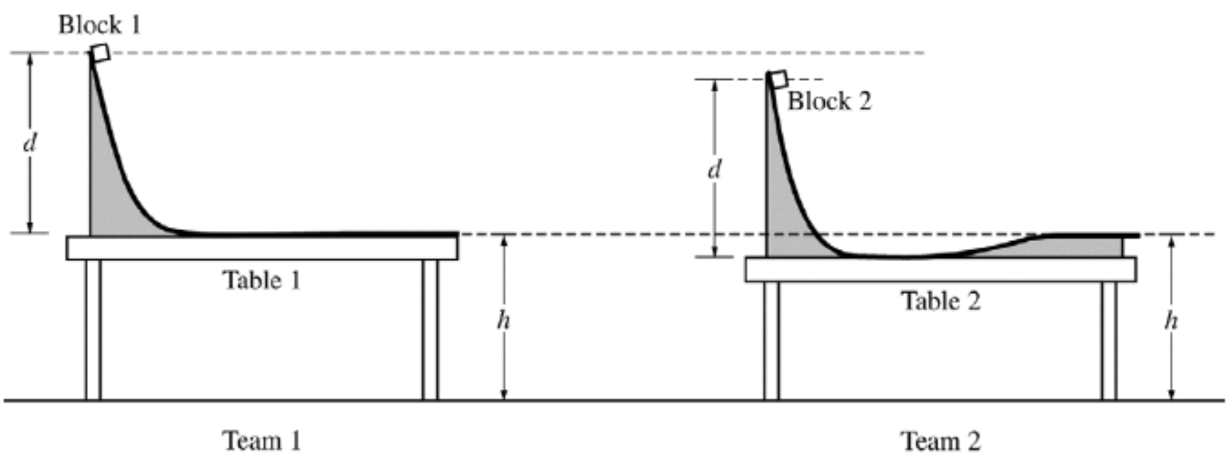
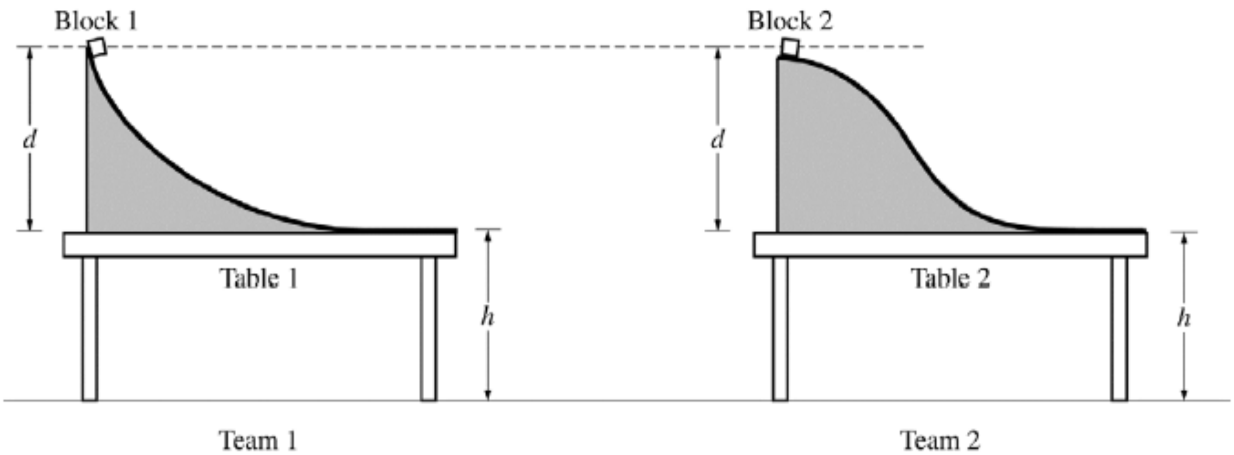
Problem 17-4: Consider the low-friction slide launches shown below. A block will be placed at the top of each and released from rest. The slides are identical starting *d* units above each tabletop. As Table 2 is physically lower than Table 1, a rise is constructed so the a block leaving that table will leave at the same height h for both cases.



a.) If both blocks are released from rest, will the blocks leave their respective tables and land the same distance out on the floor. Justify your response without deriving mathematical relationships.

--the velocity of each block at they leave their respective tables will be dependent upon the amount of energy each has at the take-off point;
--both blocks start from rest;
--both blocks have gravitational energy at their release point;
--a body's potential energy is a function of its distance above its zero-potential energy level (it's y = 0 level);
--block 1's net y-displacement (it's drop distance) before leaving its table is greater than the net y-displacement of block 2 before leaving its table;
--this means block 1's take-off velocity will be greater than block 2's;
--with a greater take-off velocity (with each leaving their table moving horizontally), block 1 with its greater velocity will travel the farthest in the x-direction over the free fall.

b.) In a second experiment, low friction slides with the same height are used again but with different shapes.



i.) Which block, if either, lands farther from its respective table? Briefly explain your reasoning without manipulating equations.

--with no friction, the two blocks should have the same velocity at the bottom of their slides;
--with both blocks moving in the horizontal as they leave the table, with the same velocity, they should travel the same distance in the x-direction during free fall.

ii.) Which block, if either, hits the floor first? Briefly explain your reasoning without manipulating equations.

--the block that hits the floor first will be the block that gets to the bottom of its slide first;
--table 1's block will experience a quick acceleration at the beginning, which means its velocity will increase immediately;
--table 2's block will experience a slow acceleration at the beginning, so although it will pick up speed quickly at the end, it will take more time;
--conclusion: the block on table 1 should hit the floor first.

iii.) Assume now that both slides are frictional with the same coefficient of friction. Explain why it might be difficult to predict without doing the math which block will be moving the fastest at the bottom of their respective slides?

--before, the problem was a straight conservation of energy with both bodies starting from rest and both "dropping" the same distance;
--with friction included, extraneous work is introduced into the system, pulling energy out of the system as the bodies move down the slide;

--frictional forces are proportional to the normal force;
--for table 1:
    --the initial normal force is small so the initial frictional effect will be small;
    --as the mass on table 1 will pick up speed quickly due to the initial slope, it will reach a large velocity quickly;
    --what makes the problem difficult for table A is that at the bottom of the arc where the body is traveling fast fairly fast, the normal force won't just equal to a component of gravity, you also have to include the centripetal effect (mv^2/R) in the normal force calculation;
    --the normal force larger than it expected, the frictional force may slow the body substantially;
    --the only way to determine how much is to do the math;
--as for table 2:
    --the initial formal force will be large, so the frictional force will be large making that mass's initial velocity increase even smaller than it had been;
    --once over the hump, though, the normal force will diminish considerably and the drop will be nearly friction-free, so the velocity increase will be large;
    --once at the bottom, though, again a centripetal effect should take over increasing the normal force beyond a component of mg, and slowing the body more than it would have been;
--bottom line: without the centripetal effect, it doesn't appear that the mass on table 2 would be moving as fast as the mass on table 1 at the bottom of their respective ramps;
        --problem is, centripetal force is a function of velocity squared, so that retarding frictional quantity is going to be larger for the faster moving mass on table 1 at the bottom of its ramp, which means the frictional effect may slow that mass down to the speed of the mass on table 2 . . . maybe;
--it seems the only way to know for sure would be to do the math;

iv.) Let's assume the curvature of the ramp on table 1 is actually a quarter circle, and some enterprising soul decides to calculate how much work friction does the mass as it moves from rest to the bottom of that ramp. Explain how she would go about doing that?

--work calculations when the force is varying require the evaluation of the integral of the force (written in general) along the line of motion dotted into a displacement along that line, or F(Rdp), where R is the radius of the arc and p is the angle between the normal and the vertical;
--using a free body diagram, it can be seen that the force function doing the work will be the component of gravity along the arc minus the frictional force, or "mgsin(p) - (mu)N";
--because the body is following a curved path, the sum of the forces in the radial direction will be centripetal, so summing the forces in that direction will yield the difference between the normal and component of mg perpendicular to the

motion, equaling mv^2/R . . . except, if we assume the body is traveling with very small velocity, that acceleration term can be ignored . . . ;

--solving for N from the radial direction, substituting it into the tangential force relationship to get the work-producing force, then integrating over an angle of p = 0 to pi/2 will yield the appropriate work quantity.