Exercises

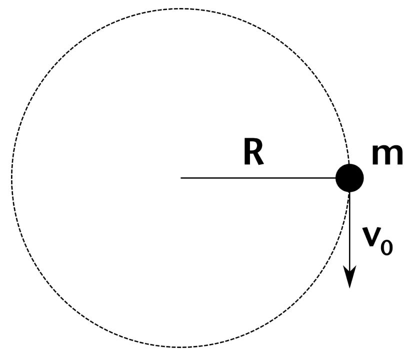
Exercise 1 *Don't be so rigid*

A mass m is suspended from a string which is fixed at the other end. We want to make it rotate in a vertical plane. We throw it downwards when the string is horizontal with a velocity v_0. We neglect the mass of the string.

What is the minimum value of v_0 for the mass to describe a complete circle

— if the string is rigid?

— if the string is flexible?



Exercise 2 *Pédaler dans la choucroute*

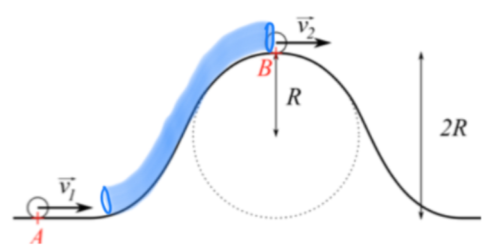
A cyclist can descend a slope forming an angle α with the horizontal at a speed of 6.0 km/h without pedaling. By pedaling vigorously, he can also descend this slope at a constant speed of 40 km/h. With the same power, how fast could he climb this slope? We assume that the friction force is directly proportional to the speed v, i.e., $F_f = \eta v$, where η is a constant.

Exercise 3 *Hole in one!*

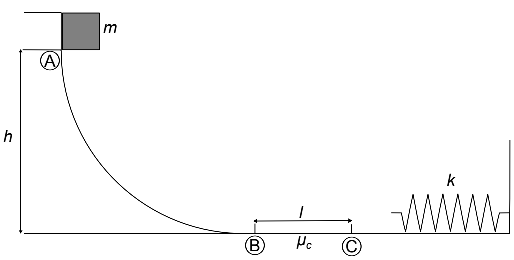
On a mini golf course, a ball of mass m_1 must pass over a bump-shaped obstacle, shown in the opposite diagram : the bump has a radius of curvature R at its peak, and its height is equal to $2R$. Friction forces are ignored. The ball is guided through a tube to the peak.

a) The ball leaves point A located before the bump with a velocity $\vec{v}_1$. Calculate the velocity $\vec{v}_2$ of the ball when it reaches the top of the bump (point B).

b) Calculate the maximum velocity $\vec{v}_1$ at point A so that the ball does not take off when it reaches the top of the bump.



Exercise 4 *Let it go !*

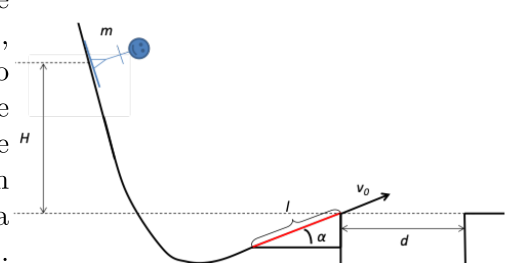


A block of mass m, initially at rest, is dropped from point **A** from a height h. The track is considered frictionless, except for the portion between **B** and **C**, which has a length l. The block travels along the track, strikes a spring with a stiffness constant k, and compresses it by a distance d from its equilibrium position. What is the value of the coefficient of kinetic friction μ_c between the block and the rough surface between points **B** and **C** ?

For the numerical application, we will take $m = 10$ kg, $h = 3$ m, $l = 6$ m, $k = 2250$ N $\cdot$ m^{-1} and $d = 0.3$ m.

Exercise 5 *Bob reaches new heights*

Bob, the crazy snowboarder, wants to perform the jump of the century over a crevasse ! To do this, he imagines a ramp of length l at an angle α to the horizontal in front of the crevasse. We assume that the altitude of the landing point is the same as that of the top of the ramp and that the length of the crevasse is d. Bob then climbs the slope to a height H above the top of the ramp (see diagram). Bob's mass is m.



a) At first, Bob covered the ramp with snow and we consider the friction forces to be zero along the entire path. Knowing that Bob starts at height H with zero velocity, express the magnitude of his velocity v_0 at the moment he leaves the ramp.

b) Obviously, the jump is successful if its range is greater than the length of the crevasse d. Calculate the minimum value of the height H that Bob must climb in order not to fall into the crevasse.

c) After several jumps, the snow on the ramp disappears. We consider that there is now dry kinetic friction with a constant μ_c along the entire length of the ramp (length l, section shown in red in the diagram). Calculate the new velocity v_f at the end of the ramp.