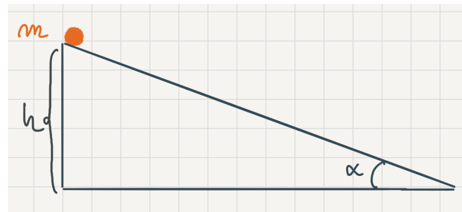
Exercises

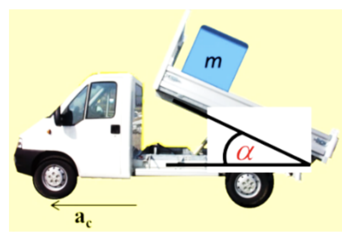
Exercise 1



A mass m is placed at the top of an inclined plane at an angle α to the horizontal. Initially, friction is neglected. All calculations will be made using forces. m is released with no initial velocity.

1) Calculate the velocity and position of m as a function of time.
2) Calculate the time taken by m to reach the bottom of the plane, as well as the speed of m at the bottom, as a function of h, α, and g.
3) Compare with the values obtained for a free fall from a height h.
4) Now assume that there is friction, and that α is greater than the limit value allowing the mass to slide. The coefficient of kinetic friction is μ_c. Repeat the calculations for questions 1 and 2.
5) Verify that if $\mu_c = 0$, we obtain the same result without friction.

Exercise 2 *Pas la benne d'aller vite*

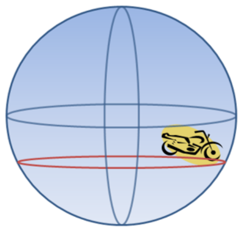


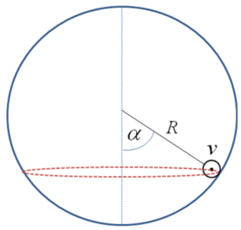
A truck driver forgot to lower the dump bed of his truck. The dump bed forms an angle α with the horizontal (see diagram). A package of mass m, initially at rest due to static friction, is located at the top of the dump bed (we denote the coefficients of static and dynamic friction by μ_s and μ_d, respectively).

a) Determine the limiting angle α, when the truck is stationary, so that the package does not slide.

b) We assume that angle is less than the critical angle. Determine the minimum norm of the horizontal acceleration a_c of the truck that will cause the package to start moving relative to the dump truck (package release). Assume that the package remains in contact with the dump truck at all times.

Exercise 3 *The ball of death*



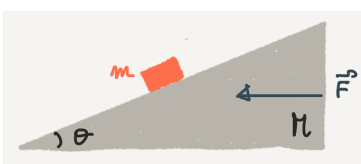


An attraction sometimes found at funfairs involves a motorcyclist entering a spherical "cage" and spinning around faster and faster. At the start of the rotation, the rider is at the bottom of the sphere, then, as the speed increases, he "climbs" up. He can thus reach the middle of the sphere. In this situation, the rider's body is horizontal (α=90°). Consider a spherical cage with radius R, and a motorcyclist (on his motorcycle) that we will consider as a material point, with mass m, in a gravitational field $\vec{g}$. We will neglect friction.

a) Calculate the speed v of the motorcyclist based on the angle α (see figure) corresponding to a state of equilibrium (uniform circular motion and he does not fall).

b) Using a diagram showing the forces, show without calculation that α cannot be greater than 90°.

Exercise 4 *Hold your position*



A small block (with mass m) is placed on the sloping side of a triangular block (with mass M) which is itself placed on a horizontal table. Assuming there is no friction on these surfaces, determine the force that must be exerted on M so that m remains in a fixed position relative to the triangular block (i.e., it does not slide down the slope).