1. Escape (8 points) — *Päivo Simson.*

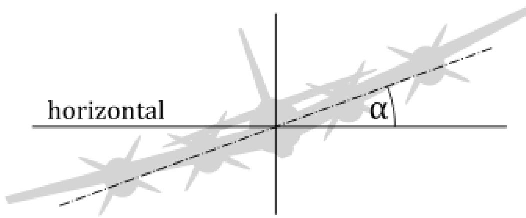
During a nuclear weapon test, a bomb is dropped from an airplane at an altitude of $H = 9\,\text{km}$ and is set to detonate at $h = 500\,\text{m}$ above the ground. The air drag acting on the bomb during the fall is negligible. Immediately after releasing the bomb, the plane starts to escape the explosion. The crew is protected from radiation burst by a protective screen, but the plane is vulnerable to the shockwave and needs to be as far as possible from the detonation point.

i) *(1 point)* The maximum speed of the airplane for a straight level flight (constant altitude) is v_0. What is the maximum diving angle so that the speed does not exceed the speed of sound c? The mass of the airplane is m, the air drag force is $F_d = kv^2$, and the gravitational acceleration is g.

For simplicity, assume from now on that the airplane stays at a constant altitude, flies at a constant speed $v = 190\,\text{m/s}$, and all air maneuvers are limited by the maximum allowed lift-to-weight ratio $n = 2.5$. The gravitational acceleration $g = 9.81\,\text{m/s}^2$.

ii) *(1 point)* After releasing the bomb, how much time does the airplane have before the radiation burst from the bomb hits it?

iii) *(1 point)* What is the smallest possible curvature radius R of the plane's trajectory and the corresponding bank angle α (cf figure) of the plane?



iv) *(3 points)* Suggest a trajectory for the fastest escape. Calculate all the parameters that define the shape of the trajectory and its position relative to the detonation point.

v) *(2 points)* Based on the suggested trajectory, how far is the airplane from the detonation point when the shockwave hits it? It is estimated that the safe distance is 25 km. Is the plane able to escape the explosion? Assume that the average traveling speed of the shock wave is $u = 350\,\text{m/s}$. For this part, if needed, you can use justified approximations to simplify the algebra.