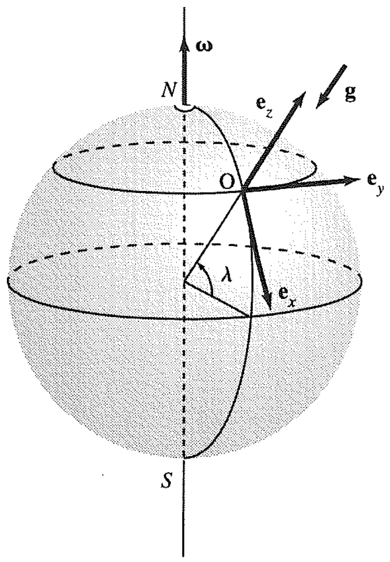
CLASSICAL PHYSICS TFY 4345 – COMPUTATIONAL EXERCISE 2

This is the second compulsory exercise, return by November 1st at 13:00 in Blackboard. You may work either alone or in pairs. Refer to your partner while returning. Everyone must return a report due to bookkeeping purposes (the same report for pairs). Prepare your report using LaTeX. Pay special attention on the quality of figures as these are the most important content (are the labels visible, is the line thickness appropriate, etc.). Do not attach the source code in your report. You may program in any language as long as you prepare your own code from scratch.

Assessment: Accepted (1) or requires a revision (0)

1. Paris Gun and the Coriolis effect

Based on the previous assignment calculate the Coriolis effect on projectile motion. We shall consider here the Paris Gun from WW1. During 1918, the new type of long-range siege gun was fired from a hill (Le mont de Joie) near Crépy and was used to shell Paris at a range of 120 km. It took several days for the French military to find out what was going on and where the gun was positioned.



Now, you will need to describe the **situation in 3D**. Select the local coordinate system as shown here (East along y-axis). Include the calculation of the relevant **vector cross-product** in your code. The rotation velocity of Earth is 7.29 x 10^{-5} s^{-1}. Radius of Earth: 6371 km.

Calculate the **shooting direction (azimuth)** in your local coordinate system based on the coordinates:

- Crépy (origin, 49°36'18"N 3°30'53"E)
- Paris (48°51'24"N 2°21'03"E)

First, determine the **shooting angle** for reaching the 120-km range **without the Coriolis effect**. Note that Paris does not correspond to $z = 0$ in your local coordinate system. Earth is round, not flat!

Second, **switch on the Coriolis effect** and observe **what is the effect on trajectory**? What is the range and how much (and which direction) does it differ from the previous case? What is deflection angle with respect to the original shooting direction? How much is the highest point of the trajectory affected?

Initial conditions: Initial speed of the cannon shell, v_0 = 1640 m/s; projectile mass m = 106 kg

Air drag model: Ratio of the drag force ($F_g = -B_2v^2$) parameter over mass, $B_2 = 2 \times 10^{-3}$ kg/m (Appendix, slide 8); this is the same B_2 as previously in the computational assignment 1.

Air density corrections: Adiabatic model (see Appendix, slide 9), whenever the equation becomes negative at high altitude replace it by zero to cut out the artificial "boost" effect.

Note: Use ***3D linear interpolation*** to determine the landing point of the cannon shell by interpolating between the last point above ground and the point that would have been below ground (when distance from the center of Earth is less than 6371 km). See the Appendix, slides 7-9. The equations of air drag and air density correction models are also available therein.