

Problem 1.5 10 points:

Based on Reynolds number dependency of DNS meshing requirements provided in the notes, **derive** and plot:

a) Mesh size dependence on Reynolds number for **3D simulation** (5 points)

b) Time-dependent computational cost dependence on Reynolds number. Assume that the time step is proportional to the mesh spacing ($\Delta t \sim \Delta x$) (5 points)

Assume that mesh size of $Re = 10^4$ is **one non-dimensional unit**. Computation cost of this simulation is also **one unit** with the same Re . Provide plots for both a) and b) with Re up to 10^5 . Use both linear and log-scale representations.

Note 1: in your plot, the spacing on x axis should be $\Delta x = 10^4$, and $y=1$ corresponds to computational cost of $Re = 10^4$.

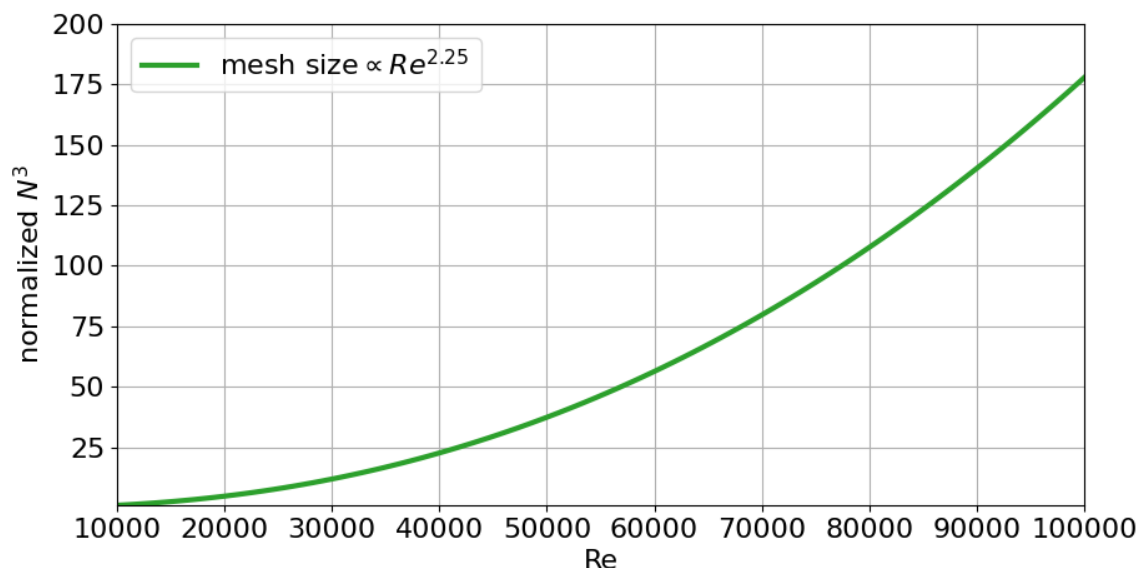
Note 2: hand-drawn plots are not accepted.

Note 3: mesh size is the total number of cells in the domain.

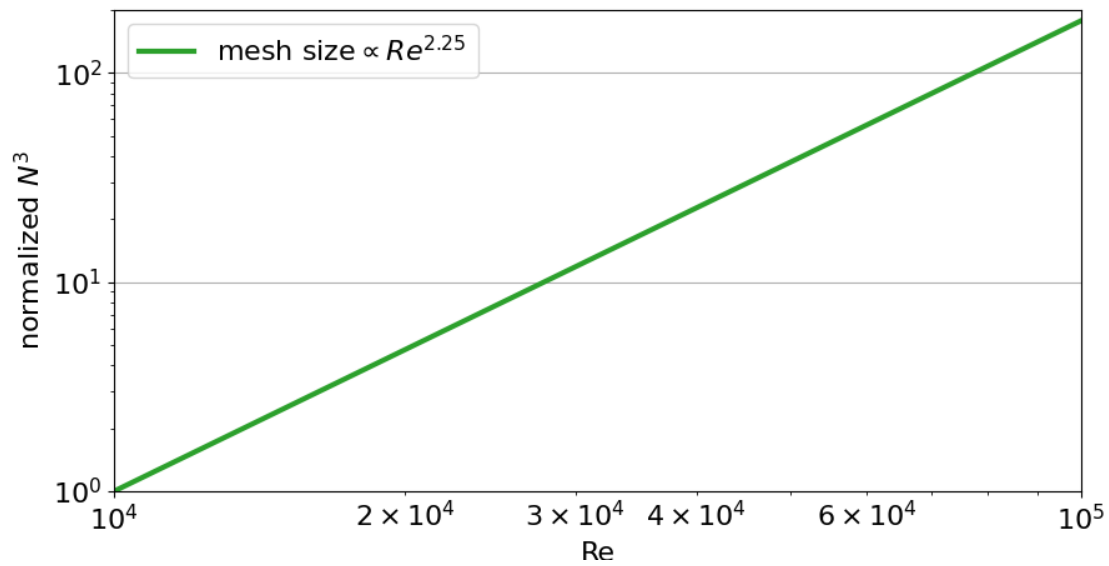
Solution:

a) The mesh size for a 3D DNS is proportional to $Re^{2.25}$:

$$N^3 \propto Re^{2.25}$$

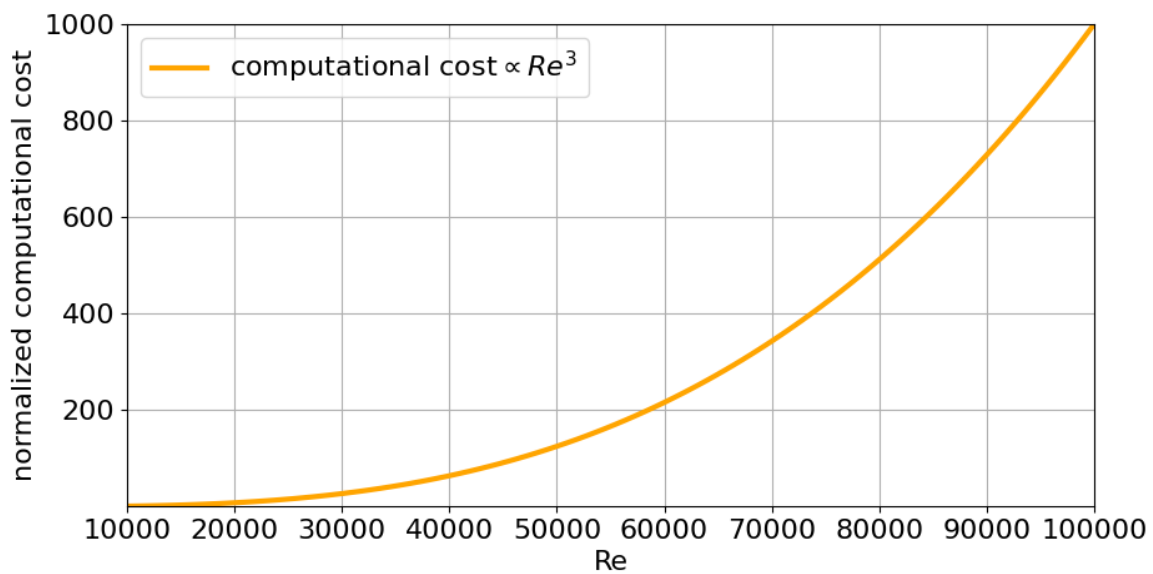


In log scale:



b) With the assumption that time step size is proportional to the mesh size, the computational cost for DNS over the same time span is then:

$$cost \propto N^4 = Re^3$$



In log scale:

