# Méthodes Multi Échelles :

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The course is finished, but the subject is maybe not. It was just an introduction and a review of classical fluid mechanics with the small parameters point of view : all is $\varepsilon$.

As it is well known that in France *everything ends by songs*, so I propose a song clearly devoted to Fluid Mechanics and Multiple Scales, the Song of Asymptotics (not to be confused with the famous "song of silence", nice as well, but centred on acoustics).

The song starts by a clear reference to the random walk, which leads to the diffusion equation which is every were in Mechanics and Physics (chapters on heat equation, and selfsimilar solutions, finite elements). Then clear reference to aerodynamics (boundary layer) and hydrodynamics (KdV, Airy wave theory), two domains with lot of asymptotics. The cannonball refers to the singular problem associated in the chapter of MAE. The high Reynolds flow over bumps (or mountains) with Hilbert transform is clearly mentioned ("blowing velocity"). Note the reference to granular media (porous flows and homogenisation) and the clear reference to the problem of erosion with multiple time scales, at least the time scale of the currents and the time scale of erosion (Exner law). Note reference to electromagnetism and propagation of light (Eikonal and WKB expansion). Note references to acoustics, biomechanics of flying bodies ($\partial$'Alembert's paradox), astronomy (initial science of asymptotics, so do not "don't look up"). Note in this song from Bob Dylan references to other Nobel price (for literature 2016) winners (Feynman 1965, Haroche 2009, Parisi/ Hasselmann/ Manabe 2021).
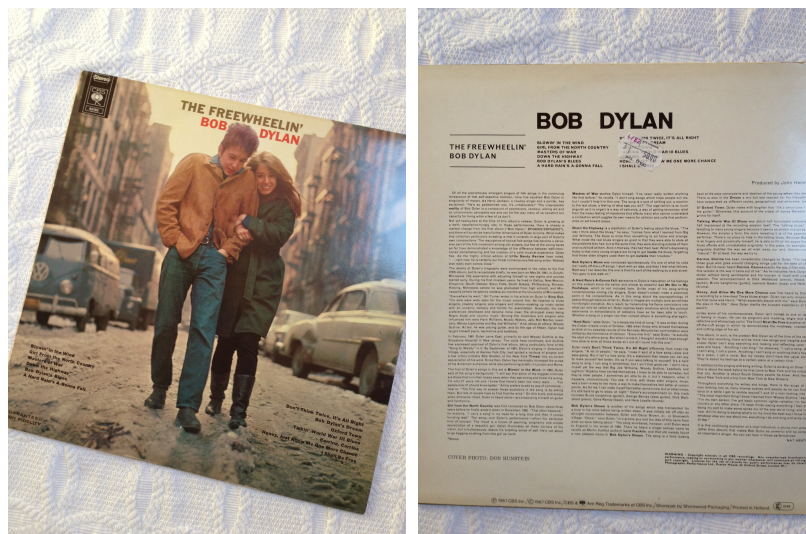


FIGURE 1 – PYL, personal collection, circa 1982.

How many roads must a man walk down
Before you call him a man ?
Yes, 'n' how many seas must a white dove sail
Before she sleeps in the sand ?
Yes, 'n' how many times must the cannonballs fly
Before they're forever banned ?
The answer, my friend, is blowin' in the wind
The answer is blowin' in the wind
How many years can a mountain exist
Before it's washed to the sea ?
Yes, 'n' how many years can some people exist
Before they're allowed to be free ?
Yes, 'n' how many times can a man turn his head
Pretending he just doesn't see ?
The answer, my friend, is blowin' in the wind
The answer is blowin' in the wind
How many times must a man look up
Before he can see the sky ?
Yes, 'n' how many ears must one man have
Before he can hear people cry ?
Yes, 'n' how many deaths will it take till he knows
That too many people have died ?
The answer, my friend, is blowin' in the wind
The answer is blowin' in the wind

of course think to the message of this song fo mankind, note final references to $\partial$'Alembert, "le siècle des lumières", freedom for people through knowledge, and make it yours.

# Références

[1] Bob Dylan (1962)
http://www.bobdylan.com/us/songs/blowin-wind

[2] M. Van Dyke, Perturbation methods in Fluid Mechanics (1975)

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