ENGS9BB.F TURBULENCE AND WIND ENERGY

ENGS9BB.F **Turbulence and wind energy**	**Credits : 2 ECTS** **Duration : 21 hours**	**Semester : S9**

Persons in charge:

Emmanuel Plaut, professor

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Keywords: deterministic models, stochastic models

Prerequisites: fluid dynamics elementary course

Objective: learn advanced turbulence modeling, with a focus on 1/ CFD 2/ Wind energy systems, that always operate under turbulent conditions.

Program and contents:

1. ***Reynolds Averaged Navier-Stokes (RANS) approach and models***

   We study ***turbulence modelling for computational fluid dynamics*** (CFD) by focusing on the ***RANS approach and models***. The RANS approach is indeed closely linked to the ***statistical theory of turbulence***, which is quite relevant. The RANS approach is basically interesting to characterize and gain some understanding on ***turbulence phenomena***. Finally, RANS models are still, today, the preferred choice for engineering studies. After a brief discussion of ***Reynolds stress equations*** and ***models***, the focus is on ***eddy-viscosity* 2*-equations models***, namely, the $k-$ and $k-$ models.

   Using a *problem-based learning approach*, studies of the ***Direct Numerical Simulations*** (DNS) database of Lee & Moser (2015) will be performed with **Matlab**.

2. ***Stochastic models, especially, in the context of wind energy***

   This second part of the module is focused on the ***wind energy sciences***. Knowing that the wind in the atmospheric boundary layer is always turbulent, the ***small scale statistics of turbulent flows*** is reviewed, with a focus on the ***intermittency phenomena*** and ***extreme events*** like ***`wind gusts'***. The ***principles of wind energy conversion*** and the ***aerodynamics*** of wind turbines are also presented. The International Electrotechnical Commission (IEC) standards to evaluate ***power curves*** and ***annual energy production*** of a given wind turbine is introduced. The limitations of this approach are discussed and more accurate *stocha stic* approaches are introduced, which lead for instance to the notion of ***`Langevin power curves'***.

   The students will use the **statistical computing software R** to study various ***`turbulence experimental databases'***.

Please check the web page of this module on **http://emmanuelplaut.perso.univ-lorraine.fr/twe :** it sketches the planning of this module, gives instructions and files, etc...

Abilities:

Levels	Description and operational vocabulary
Know	Hybrid RANS - LES methods. Be aware of current research in the domain of CFD of turbulent flows
Understand	The RANS approach - the LES approach - Strengths and weaknesses of each approach The notion of intermittency and extreme events
Apply	The RANS approach - the LES approach
Analyze	The RANS approach - the LES approach Analyze a velocity time series: be able to extract mean and standard deviation values, a PDF of the velocity and of the velocity increments, etc... Analyze a wind time series: construct the IEC power curve
Summarize	
Assess	Choose a good approach - model to solve numerically a given turbulent flow problem

Evaluation:

☑ Written test	☑ Continuous assessment	☐ Oral presentation	☐ Project	☑ Written report