Danmarks Tekniske Universitet / Technical University of Denmark

Written examination:

Date: May 28 2024

Page 1 of 3 pages

Course title: Wind Turbine Aeroelasticity

Course number: 46310

Aids allowed: All

Exam duration: 4 hours

Weighting: Indicated at the questions

Q#1: (30%) Use your script for the 5DOF system including controller and set wind speed to 8 m/s (turbulent). Specify the initial rotational speed to ω=0.7 rad/s and the pitch angle as θp=0 degrees. Assume that the generator torque is lost at t=100s so that the generator torque suddenly becomes M_G=0 Nm. For a maximum allowable pitch angle of 45 degrees plot as function of time the rotational speed, the pitch angle, the thrust and the tip deflection in both y and z direction. Also make a PSD plot of the time history of the tip deflection in the z-direction after it has settled to something periodic. Explain from the graphs what is happening.

Q#2: (30%) Now assume that the pitch actuator is malfunctioning so that the pitch remains at θ_p=0 degrees. Simulate again the sudden loss of the generator at t=100 s. Plot $\omega(t)$, thrust T(t), flapwise bending moment $M_y(t)$ and tip deflection in z -direction. Compare with the results from Q#1.

Q#3: (20%) A simple 2 DOF mechanical system for a wind turbine blade is shown in Figure 1. The first part of the blade is stiff and rigidly clamped. At x=L and x=2L there is a torsional spring of stiffness k_1 and k_2, respectively. All the mass in the beam is concentrated at x=1.5L and x=2.5L. Define the DOFs and derive the mass and stiffness matrix.

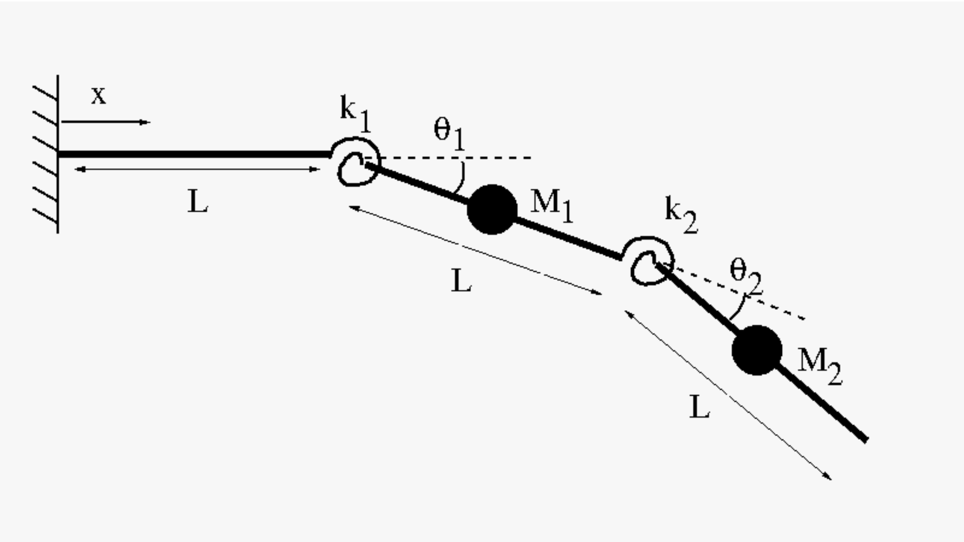

Figure 1: A simple 2-DOF mechanical system simulating a cantilever beam

Q#4: (20%) To experimentally simulate the dynamics and aerodynamic damping of edgewise blade vibrations an airfoil is put in a wind tunnel and suspended in a spring that allows the airfoil to vibrate in the x-direction only, see Figure 2. The airfoil is mounted at a geometrical attack of α_g and has a mass of M, a chord of c and a width of b. The airfoil data are known as $Cl(\alpha)$ and $Cd(\alpha)$. Set up the equation of motion and explain how it can numerically be solved.

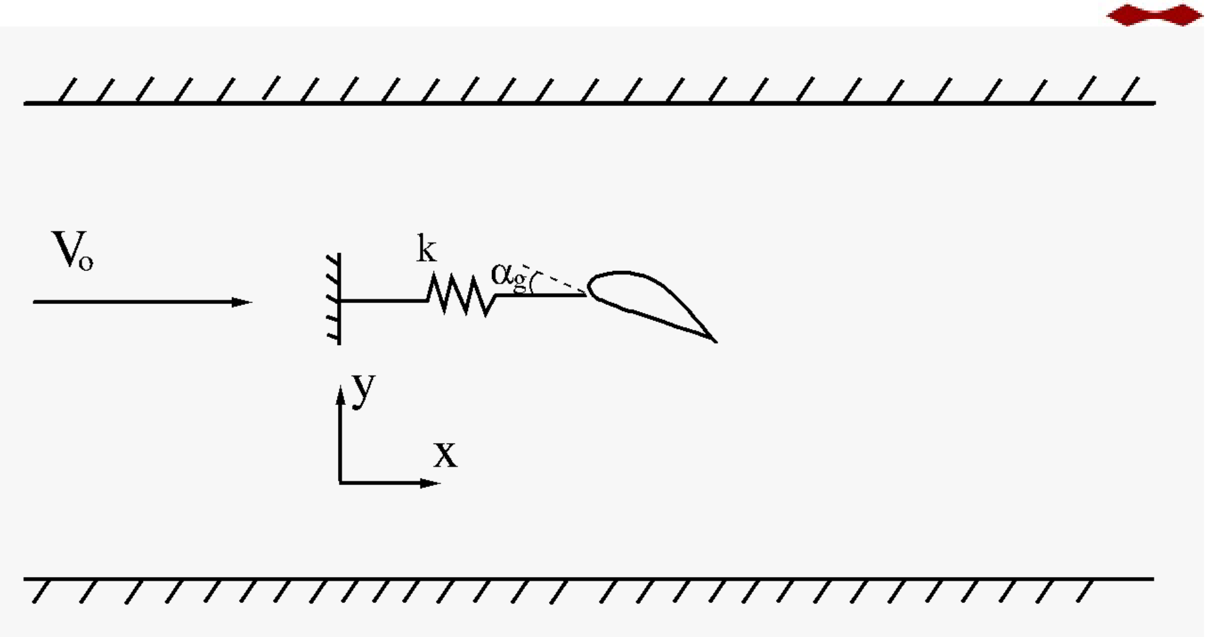

Figure 2: An airfoil with known airfoil data Cl(α) and Cd(α) of chord c and a with w=b is suspended in a spring in a wind tunnel and free to vibrate in the x-direction.

The wind velocity is $\begin{pmatrix} V_{o,x} \\ V_{o,y} \end{pmatrix} = \begin{pmatrix} V_o \\ 0 \end{pmatrix}$