EG2040 Wind Power Systems
Assignment 4 – Blade design

Deadline for full credits: Friday 11 April, 15.00

The assignments should be completed individually and the report containing all solutions should be submitted in the blue box marked EG2040, outside the student room at Teknikringen 33. If Matlab is used for completing the assignment the code should be included with the report.

Solutions to the assignments should be well motivated and explained in detail. All equations used should be written clearly and all variables clarified. Figures and tables should be properly scaled and have captions. Write your name and student number on the front page of the assignment.

The teaching assistant will be available to answer questions during the scheduled course assistance hours.

In this assignment, we want to design the Betz optimum blade for a two- and a three-bladed machine. The same airfoil was chosen for both machines. The lift-to-drag ratio and the lift coefficient of the airfoil against the angle of attack are given in figure 1 below, and the exact values from these curves can be found in table 1. The curves giving the power coefficient against the tip speed ratio for typical two- and three-bladed machines can be found in figure 2. Chapter 3 from the book by Manwell et al. can be of help for this assignment.

Questions

1. Give formulas (you do not need to derive them) for calculating the chord length and the twist angle of the Betz optimum blade. The twist angle is here defined as the angle between the chord line and the plane of blade rotation. Assume a pitch angle of zero. Explain all introduced symbols and quantities that appear in the formulas and draw a figure explaining the angles.
2. Apply the formulas to a three- and a two-bladed machine for blades with radius $R = 30+C$ (where C is the last two digits of your personal number divided by 10) and a pitch angle of zero: explain how you select the values of the parameters appearing in the formulas, and fill in the table below, with r being the distance from the hub along the blade in meter.
3. Explain why the blades have to be twisted.

		Three bladed		Two bladed	
r/R	r [m]	$c(r)$	θ_T [deg]	$c(r)$	θ_T [deg]
0.1					
0.2					
0.3					
0.4					
0.5					
0.6					
0.7					
0.8					
0.9					
1.0					

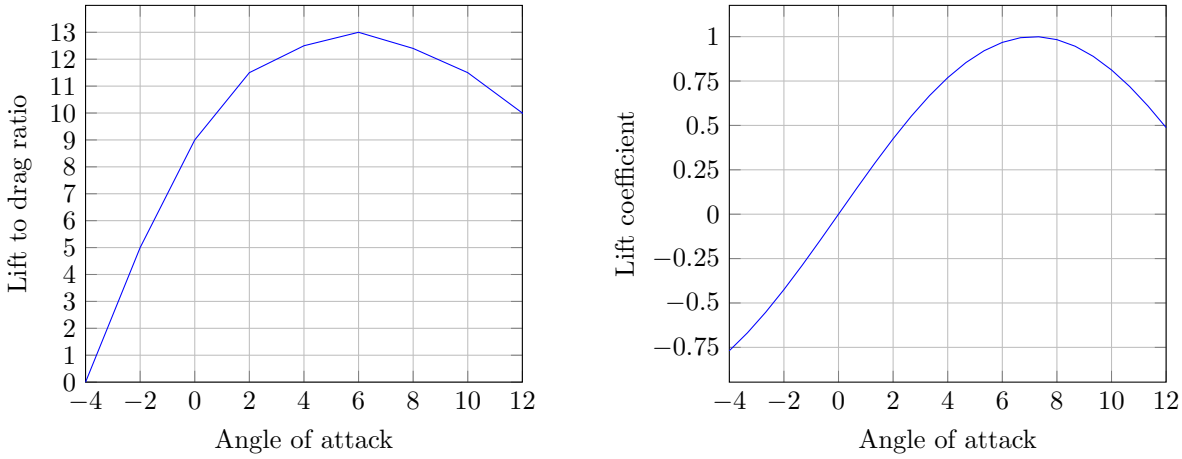

Figure 1: Lift-to-drag ratio and lift coefficient against angle of attack

Table 1: Some values from the curves in figure 1

Angle of attack [deg]	Value of the lift to drag ratio	Value of the lift coefficient
-4	0	-0.7690
-2	5	-0.4247
0	9	0
2	11.5	0.4247
4	12.5	0.7690
6	13	0.9677
8	12.4	0.9832
10	11.5	0.0.8125
12	10	0.0.4879

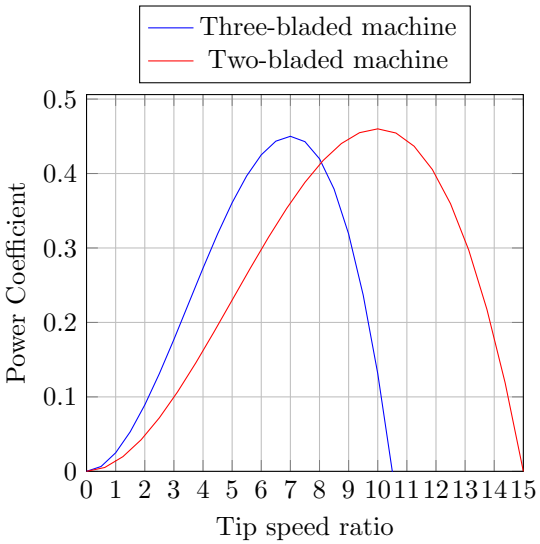

Figure 2: Power coefficient against tip speed ratio