EG2040 Wind Power Systems
Comments on Assignment 4 – Blade Design

- They were two possible sets of formulas, depending on whether you used the book or the lecture slides. Both lead to the same results, but you had to be careful about how the twist angle was defined (angle between the chord line and the plane of rotation). This means that the twist angle was, if you used the formulas in the lecture slides, $\theta = \pi/2 - (\gamma + \alpha)$.

- In question 2, some of you did not use the figures given in the assignment at all to determine the design tip-speed ratio and the angle of attack.

- When determining the angle of attack, that you needed to then get the lift coefficient, the right choice was to maximize the lift-to-drag ratio, because we want both to have as much lift as possible and as little drag as possible. We want to maximize the lift force because it is this force that is converted into usable power. We want to minimize the drag force because: 1) drag creates losses and reduces the efficiency of the machine, and 2) when designing a Betz optimal blade, it is assumed that the drag coefficient is zero.

- When determining the design tip-speed ratio, we want to design the blade for the tip-speed ratio that gives the maximum power coefficient. This is because the power coefficient is directly linked to how much power we get out of the turbine. Hence, we want to operate the wind turbine at this maximum power coefficient as often as possible. This is possible if we have wind turbines with variable speed, because when the wind speed changes, the speed of the generator, and hence of the rotor, can be changed accordingly in order to maintain the tip-speed ratio at its optimal value. Some of you argued that we choose the design tip-speed ratio that gives the maximum power coefficient because it will then allow us to operate the turbine at this maximum Cp. But, actually, it is the "other way around". We want to operate the turbine at this maximum Cp, and thus, we design the blades for this value, because this is what is expected the blade will be subjected to during operation.

- In question 3, we want to twist the blade because the apparent wind speed changes along the blade. Since the speed of the sections of the blade increases with the distance from the hub, a section close to the tip will be subjected to a different wind speed than a section close the hub. This means that if we do not twist the blade, the angle of attack will also change. But, when we designed the blades, we assumed that we had a constant angle of attack α for all sections of the blades. This angle of attack was determined to maximize the aerodynamic efficiency of each section of the blade. Hence, keeping this angle of attack constant all along the blade to maximize this efficiency requires that the blade is twisted. The optimal angle of attack is quite small (6 degree in this assignment). So close to the hub, where the blade is mostly subjected to the component of the wind which is perpendicular to the plane of rotation (i.e. not the wind component created by the rotation of the blades), the blade has to be twisted more, and the twist angle decreases as we get closer to the tip, where the main component becomes the one due to the rotation of the blade.

- Be careful when implementing your formulas in Matlab/Excel. Some of you have got the formulas right, but forgot some terms when putting them in Matlab/Excel, thus getting wrong results.