<table>
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<tr>
<th>Module level</th>
<th>Credits</th>
<th>Language</th>
<th>Return</th>
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<tr>
<td>Master</td>
<td>6</td>
<td>English</td>
<td>Annual</td>
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**Module designation**

**Rotor Aerodynamics**

**Course(s)**

**Rotor Aerodynamics**

**Person responsible for the module**
Prof. Dr.–Ing. Martin Lawerenz

**Lecturer**
Prof. Dr.–Ing. Martin Lawerenz,
M. Sc. Irfan Ahmed

**Workload**
180 h
(42 h lecture, 42 h exercises, 21 h online sessions, 75 h examination preparation)

**Relation to curriculum**
Specialist studies, simulation and structural technology, elective

**Type of teaching, contact hours**
Online unit, telephone, Adobe Connect, telephone, digital communications

**Requirements according to examination regulations**
Module Fluid Mechanics

**Recommended prior learning**
Modules Theoretical Fluid Mechanics and Computational Fluid Dynamics

**Module objective / intended learning outcomes**
Upon completion of the course, students will have ability to assess and analyze the flow field of wind turbine rotors and will be able to perform basic aerodynamic design of the blades.

- **Knowledge**: Aerodynamics of wind turbine rotor
- **Skills**: Performance estimation of wind turbine, aerodynamic design of rotors, numerical simulation–methods.
- **Competencies**: Analysis and assessment of wind turbine flow–field, and the corresponding energy transmission.

**Content**

1) Introduction.
2) Basic Aerodynamics.
   - Coordinate System & Velocity Triangle.
   - Aerodynamic Variables.
   - Dimensionless Parameters.
   - Conservation Laws.
3) Wind Turbine Model.
   - D Representation of Wind Turbine Flow–Field.
   - Betz’s Law of Maximum Power.
   - Extensions for Vortical Flow.
4) Blade Element Method.
   - Classical Blade Element Method.
5) Airfoil Aerodynamics.
   - Potential Flow.
   - Streamline Curvature Method.
   - Stream–Function Method.
- Viscous Flow.
  - Boundary Layer Concept.
  - Laminar and Turbulent Boundary Layers.
  - Loading of Boundary Layer & Separation.
- Aerodynamic Losses.
  - Definition.
  - Losses in 2-D Flow.
  - Losses in 3-D Flow.

6) Boundary Conditions.
- Inflow Wind.
- Wind Shear.
- Gust Loads.
- Flow near the Tower.

- Objectives.
- Constraints.
- Optimization Methods.
- Optimization of Wind Turbine Rotor.

8) Numerical Simulation of Wind Turbine Flow (Examples).
- Steady-state Navier–Stokes Simulation.
- Unsteady Navier–Stokes Simulation.
  - Rotor–Tower Interaction.
  - Dynamic Inflow.

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<tr>
<th>Study and examination requirements and forms of examination</th>
<th>Written Test (60min) or online oral examination (30 min.)</th>
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<tr>
<td>Media employed</td>
<td>Online script</td>
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Reading list
ASME Press, 2009