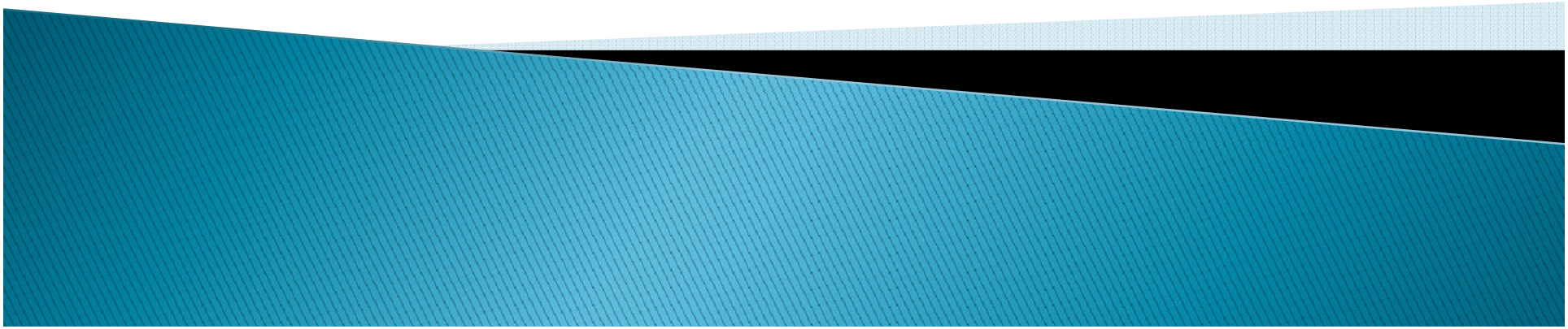
Actuator Disk Theory

A simple but strong model



The test exam question

- Tentamen mt527 – Jan 17 2011
- Vraag 2a t/m c
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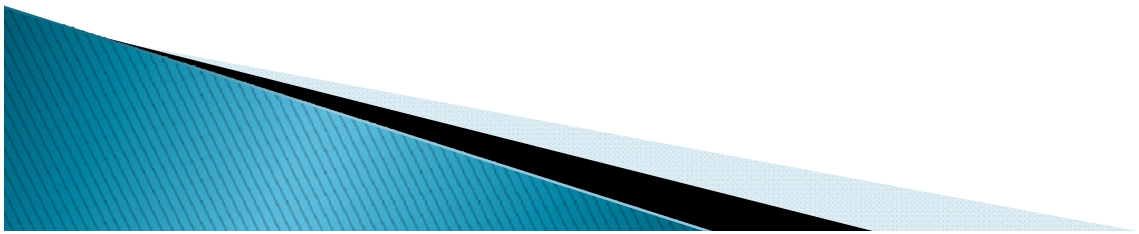
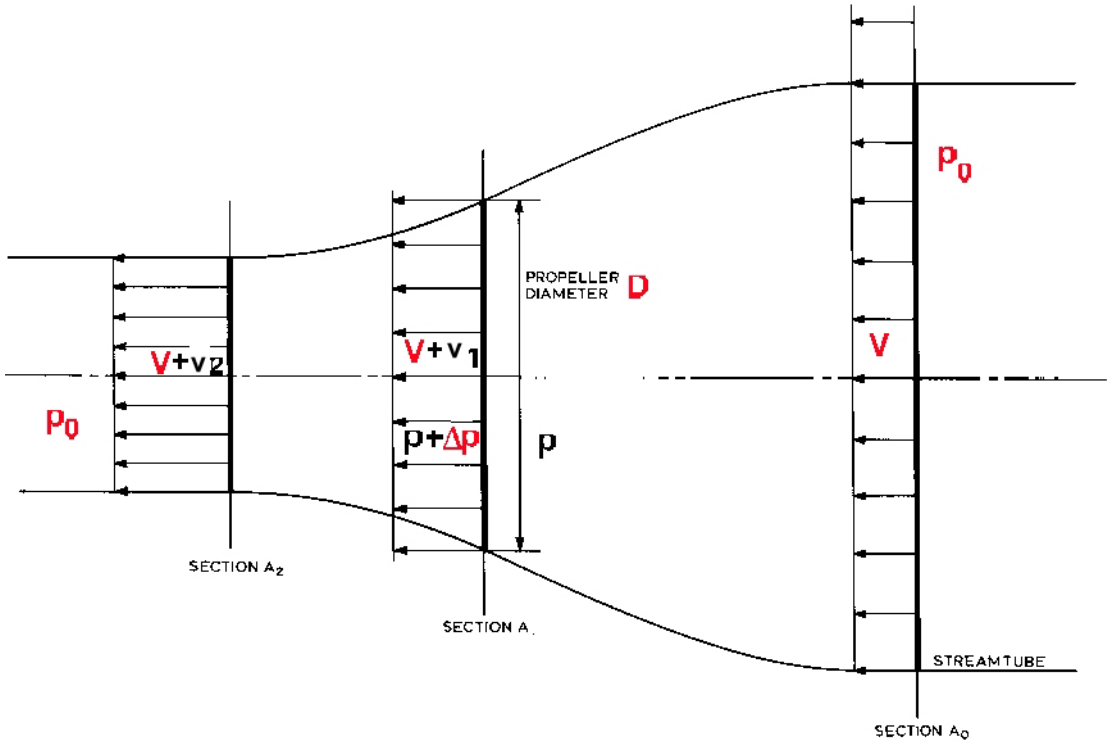


Actuator disk

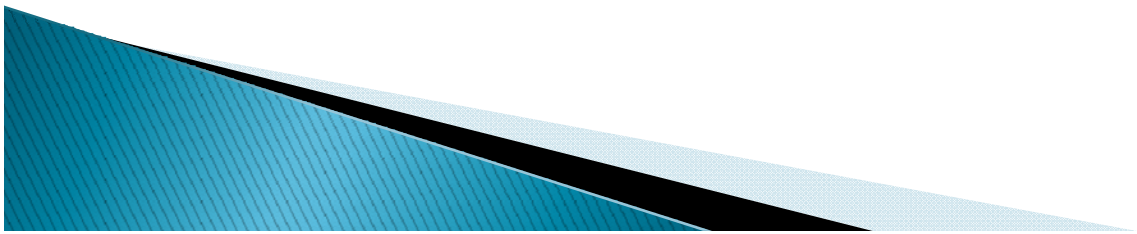
as a model of the propeller



Fundamentals of Actuator disk theory

Conservation laws:

- Mass (Continuity eq.) $\int \overline{u_n}.\overline{n}\,dA$
- Momentum $\sum \overline{F} = \int \rho\left(\overline{u}.\overline{n}\right)\overline{u}dA$
- Energy (used for Bernoulli eq.) $p + \frac{1}{2}\rho v^2 - \rho g z = c$



Actuator Theory: Assumptions and simplifications

Assumptions

- Thrust is uniformly distributed over propeller disk
- Uniform inflow and outflow velocity fields

Simplifications

- Inviscid flow
- Infinite number of blades
- no rotational kinetic and viscous energy losses

Consequences

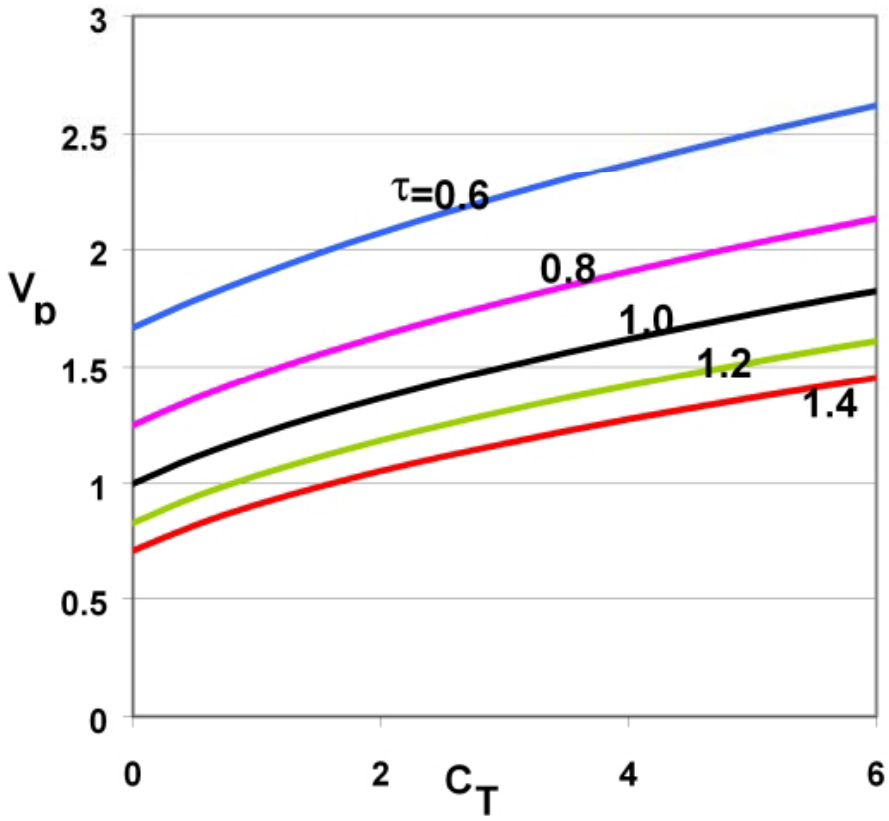
- only axial kinetic energy losses are accounted for
- Rotational, viscous and non-uniformity losses are not accounted for
- most ideal situation

Assumptions

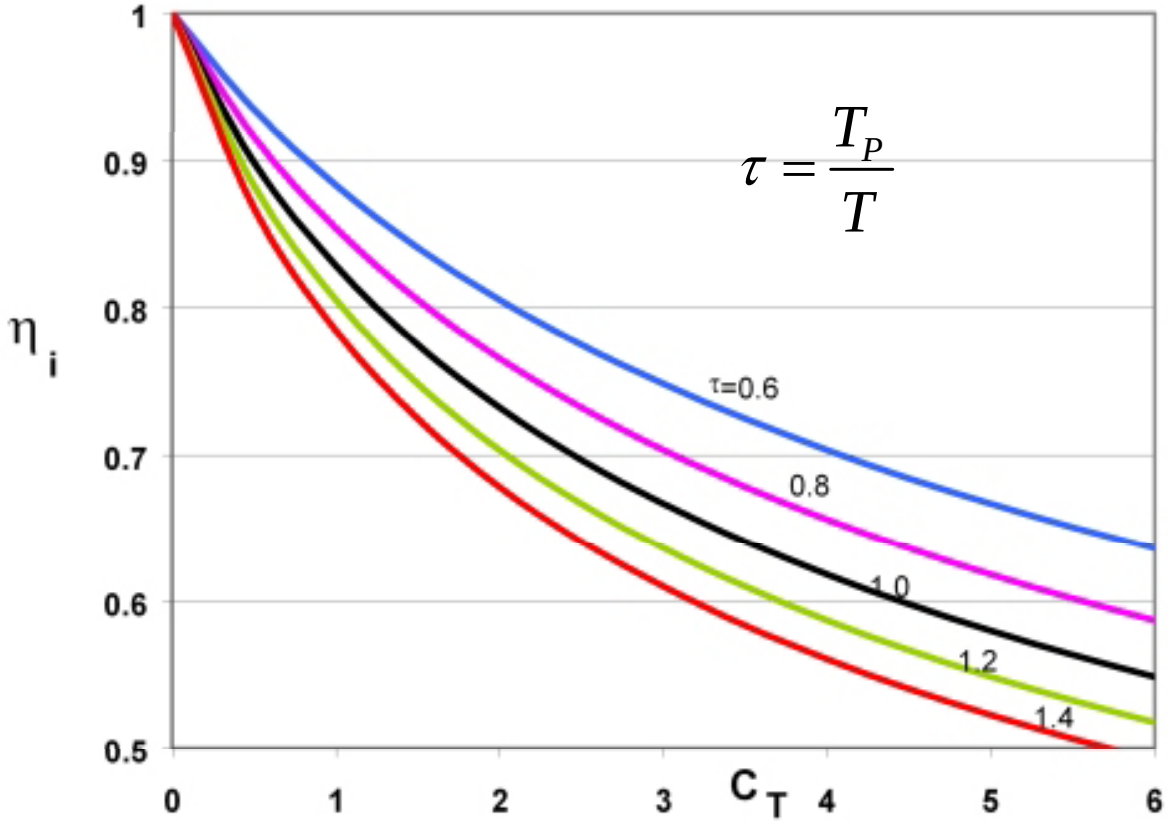
Simplifications

Total axial velocity in propeller plane

$$\tau = \frac{T_P}{T}$$



Ideal efficiency as a function of propeller loading



- Propeller eff decreases with increasing loading C_T
- Propeller eff increases with increasing duct thrust