Exercise problems

1. (a) An axial turbine rotor is prescribed with rotor inlet and outlet flow in radial equilibrium. The whirl component of the flow is designed to vary radially as : $C_{w1} = a.r - b/r$; and $C_{w2} = a.r + b/r$
Where, a and b are constants. Find the inlet and outlet axial velocities (C_{a1} and C_{a2}) from above.
[$C_a^2 = K - 2.a^2 [(r^2-1) - 2(b/a)\ln r]$ & $C_{a1} = C_{a2}$ axially]
(b) It is prescribed that at mean radius = 0.3 m , axial velocity=150 m/s, degree of reaction R_x = 0.5, blade loading coefficient, $\psi_{rotor} = H_0/U_{tip}^2$. Rpm=7640 Hub/tip ratio of the rotor =0.5. At 80% rotor radius, find the rotor relative flow inlet and outlet angles.
[43.2^0 and 10.4^0]

2. Hot gas exits from a turbine stator-nozzle at a radially constant angle, α_2 . The gas is also prescribed to be in radial equilibrium. Axial velocity variation at that station is given as :

$$C_{a2}.r^{\sin^2 \alpha_2} = const$$

For a turbine in which the axial velocity at radius 0.3m is 100 m/s. If the turbine, as stated above, is designed with constant $\alpha_2 = 45^0$, find the axial velocity at that station at 0.6 m radius.

[70.7 m/s]

Prof. Bhaskar Roy, Prof. A M Pradeep, Department of Aerospace, IIT Bombay

3. An axial flow turbine is designed with free-vortex at stator-nozzle exit and zero whirl at rotor exit. For the following operating condition, T_{01} = 1000 K, $\dot{m}$ = 32 kg/s, r_h = 0.56 m, r_t = 0.76 m, rpm = 8000, R_x = 0.5 at tip and C_a=const=183 m/s. and C_1= C_3. Find :

a) C_2 , nozzle exit velocity
b) M_{max} in the stage
c) R_x at the root
d) Power output of the stage
e) T_{03} and T_3 at stage exit.

[a) 480 m/s; b) 0.818; c) 0.08; (d) 3.42 MW; e) 907 K & 892 K]