

11.90 An idealized radial turbine is shown in Fig. P11.90. The absolute flow enters at 25° with the blade angles as shown. The flow rate is $8 \text{ m}^3/\text{s}$ of water at 20°C . The blade thickness is constant at 20 cm. Compute the theoretical power developed at 100% efficiency.

Solution: The inlet (2) and outlet (1) velocity vector diagrams are shown at right. The normal velocities are

$$V_{n2} = Q/A_2 = \frac{8.0}{2\pi(1.2)(0.2)} = 5.31 \text{ m/s}$$

$$V_{n1} = Q/A_1 = \frac{8.0}{2\pi(0.8)(0.2)} = 7.96 \text{ m/s}$$

From these we can compute the tangential velocities at each section:

$$u_2 = \omega r_2 = 80 \left(\frac{2\pi}{60} \right) (1.2) = 10.1 \text{ m/s};$$

$$u_1 = \omega r_1 = 80 \left(\frac{2\pi}{60} \right) (0.8) = 6.70 \text{ m/s}$$

$$V_{t2} = V_{n2} \cot 25^\circ = 11.4 \text{ m/s}; \quad V_{t1} = u_1 - V_{n1} \tan 30^\circ = 2.11 \text{ m/s}$$

$$P_{\text{theory}} = \rho Q(u_2 V_{t2} - u_1 V_{t1}) = 998(8)[10.1(11.4) - 6.7(2.11)] \approx \mathbf{800,000 \text{ W}} \quad \text{Ans.}$$

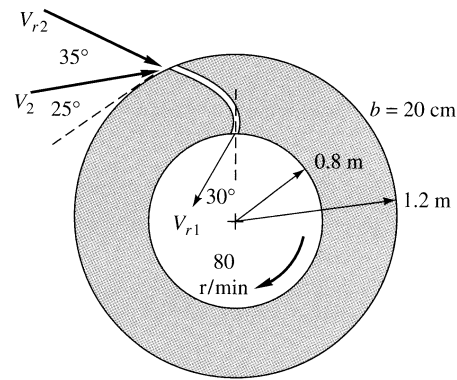
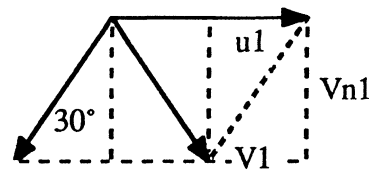
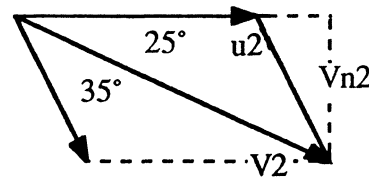


Fig. P11.90



11.91 The flow through an axial-flow *turbine* can be idealized by modifying the stator-rotor diagrams of Fig. 11.12 for energy absorption. Sketch a suitable blade and flow arrangement and the associated velocity vector diagrams. For further details, see Chap. 8 of Ref. 25.

Solution: Some typical velocity diagrams are shown on the next page, where $u = \omega r =$ blade speed. The power delivered to the turbine, at 100% ideal shock-free flow, is

$$P_{\text{ideal}} = \rho Q(u_1 V_{t1} - u_2 V_{t2})$$

where $V_{t1,2}$ are the tangential components of $V_{1,2}$