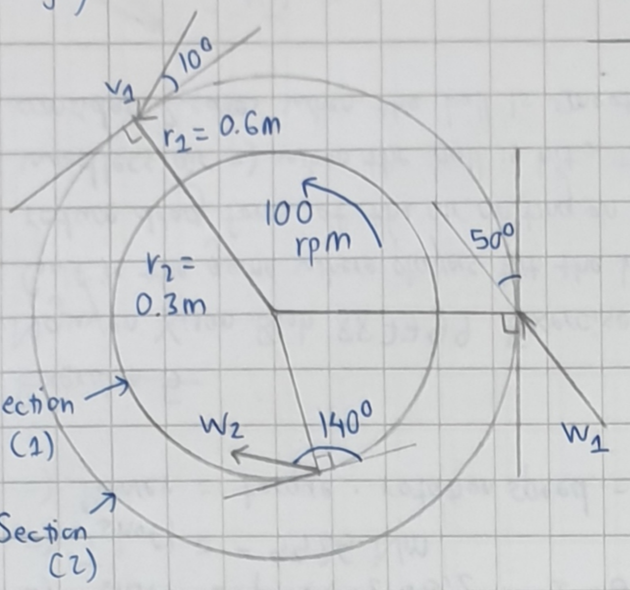
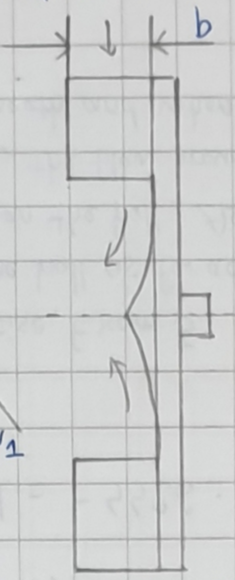
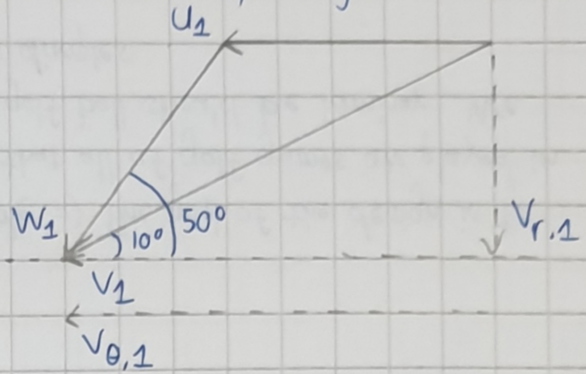
Nguyen Xuan Binh 887799 Exam Question 4





$\uparrow Q = 1 m^3/s$

We have velocity triangle at the inlet



Law of cosine; $\frac{U_1}{\sin 40^\circ} = \frac{V_1}{\sin 130^\circ}$

$\Rightarrow V_1 = U_1 \frac{\sin 130^\circ}{\sin 40^\circ}$

(100 rpm = 10.47 rad/s)

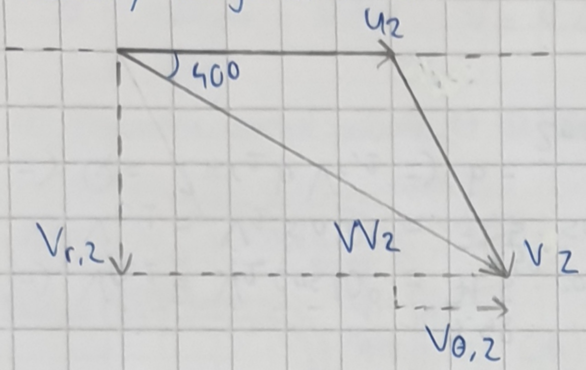
We have $U_1 = r_1 \omega \Rightarrow V_1 = r_1 \omega \frac{\sin 130^\circ}{\sin 40^\circ} = 0.6 \cdot \underset{10.47}{\cancel{100}} \cdot \frac{\sin 130^\circ}{\sin 40^\circ} = \underset{7.48}{\cancel{71.5}}$ m/s

$\Rightarrow V_{\theta,1} = V_1 \cos 10^\circ = \overset{7.48}{\cancel{71.5}} \cdot \cos 10^\circ = \cancel{70.41 \text{ m/s}}$ 7.37 m/s

$V_{r,1} = V_1 \sin 10^\circ = \overset{7.48}{\cancel{71.5}} \cdot \sin 10^\circ = \cancel{12.41 \text{ m/s}}$ 1.29 m/s

$\Rightarrow Q = 2\pi r_1 b V_{r,1} \Rightarrow b = \frac{Q}{2\pi r_1 V_{r,1}} = \frac{1}{2 \cdot 3{,}14 \cdot 0.6 \cdot 1.29} \approx 0.2m$ (blade height answer) (0.206)

Velocity triangle at outlet



We have $U_2 = r_2 \omega = 0,3 \cdot 10,47 = 3,14 \; m/s$

Flow rate is the same at inlet and outlet

$\Rightarrow Q = 2\pi r_2 b V_{r,2} = 2\pi r_2 b W_2 \sin 40^0$

$\Rightarrow W_2 = \dfrac{Q}{2\pi r_2 b \sin 40^0} = \dfrac{1}{2\pi 0.3 \cdot 0,2 \sin 40^0}$

$W_2 = 4.12 \; m/s$

$V_{\theta,2} = U_2 + W_2 \cos 140^0 = 3,14 + 4,12 \cdot \cos 140^0 \approx -0.016 \, m/s$

$\Rightarrow T_{shaft} = \rho Q (r_2 V_{\theta,2} - r_1 V_{\theta,1}) = 1000 \cdot 1 \cdot (0,3 \cdot -0,016 - 0,6 \cdot 7.37)$

$\Rightarrow T_{shaft} = -4426 \; Nm$

$\Rightarrow$ Power = torque · rotation speed $= -4426 \cdot 10.47 \approx -46.34 \; kN$ (answer)