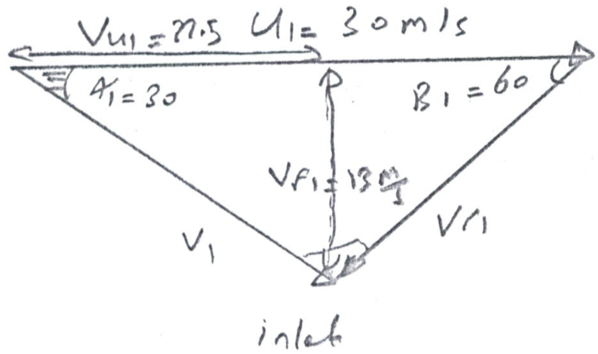
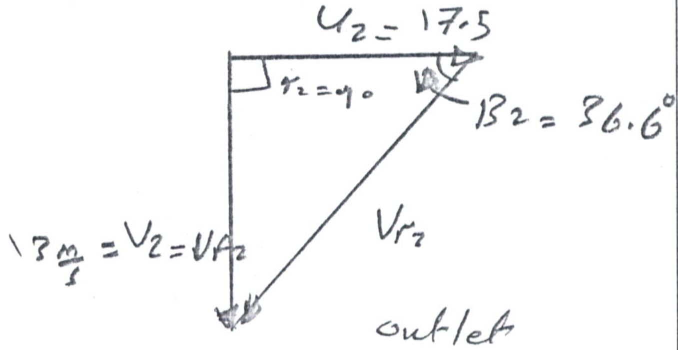
Faculty of Engineering	**Philadelphia University**	Mechanical Eng. Dep.
Course name: hydraulic machines	**Second Quiz**	Course number: 620528
Instructor: Eng. Laith Batarseh	**Thursday 17/4/2018**	Allowed time: 10 minutes

Student Name: **Student ID number:**

Problem: A Frances turbine has an inlet diameter of 1.2m and outlet diameter of 0.7m. if the peripheral speed at the inlet is speed is 30 m/s, the inlet guide vane angle is 30 degree and the inlet blade angle is 60 degree, draw both inlet and outlet velocity triangles. Assume the outlet flow is radial (i.e. zero whirl speed) and the flow velocity is constant. Put all the triangles definitions.

Solution





$$N = \frac{u_1}{D_1} = \frac{u_2}{D_2} \Rightarrow \frac{30}{1.2} = \frac{u_2}{0.7} \rightarrow u_2 = 17.5 \ \frac{m}{s}$$

$$\tan \alpha_1 = \frac{V_{f1}}{V_{u1}}, \quad \tan \beta_1 = \frac{V_{f1}}{u_1 - V_{u1}} \rightarrow V_{f1} = V_{f2}$$

$$\Rightarrow \tan \alpha_1 V_{u1} = \tan \beta_1 (u_1 - V_{u1}) \rightarrow \tan 30 \ V_{u1} = \tan 60 \ (30 - V_{u1})$$

$$\Rightarrow V_{u1} = 22.5 \ \frac{m}{s} \Rightarrow V_{f1} = \tan \alpha_1 V_{u1} \cong 13 \ m/s$$

$$\beta_2 = \tan^{-1} \frac{V_{f2}}{u_2} = \tan^{-1} \frac{13}{17.5} = 36.6^\circ$$

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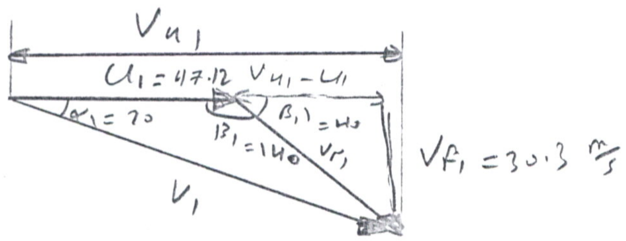
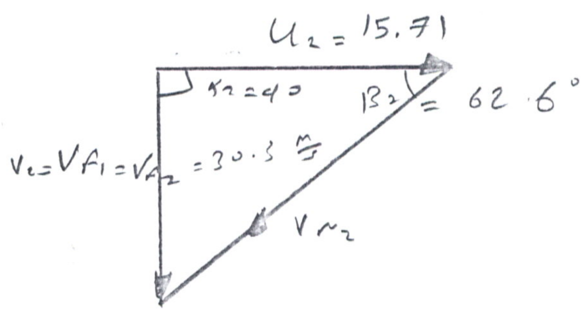
Student Name: Typical Solution. **Student ID number:**

Problem: A Frances turbine has an inlet diameter of 1.5m and outlet diameter of 0.5m. if the rotational speed is 600 RPM, the inlet guide vane angle is 20 degree and the inlet blade angle is 140 degree, draw both inlet and outlet velocity triangles. Assume the outlet flow is radial (i.e. zero whirl speed) and the flow velocity is constant. Put all the triangles definitions.

Solution



Inlet



outlet

$$u_1 = \frac{\pi N D_1}{60} = \frac{\pi (600)(1.5)}{60} = 47.12 \ \frac{m}{s}$$

$$u_2 = \frac{\pi N D_2}{60} = \frac{\pi (600)(0.5)}{60} = 15.71 \ \frac{m}{s}$$

For inlet

$$\tan \beta_1' = \frac{V_{f1}}{V_{u1} - u_1} \ ; \quad \tan \alpha_1 = \frac{V_{f1}}{V_{u1}} \Rightarrow \tan 40 = \frac{V_{f1}}{V_{u1} - 47.12} \ , \quad \tan 20 = \frac{V_{f1}}{V_{u1}}$$

$$\Rightarrow \tan 40 (V_{u1} - 47.12) = V_{u1} \tan 20 \Rightarrow V_{u1} = 83.21 \ \frac{m}{s}$$

$$V_{f1} = 30.3 \ \frac{m}{s} = (\tan 20)(V_{u1})$$

Assume Friction less surface: $V_{r1} = V_{r2}$, or $\beta_2 = \tan^{-1} \frac{V_{f1}}{u_2}$

$$\beta_2 = \tan^{-1}\left[\frac{30.3}{15.71}\right] = 62.6^\circ$$