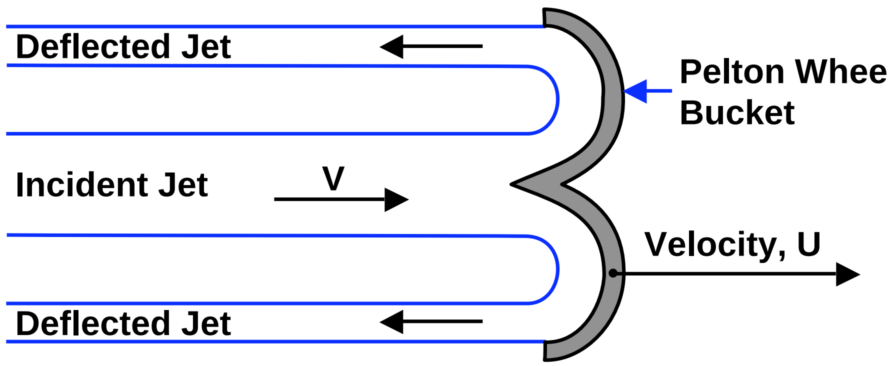
Problem 220I

The nozzle of a Pelton turbine produces a steady jet of water (density, ρ) of cross-sectional area, A, and velocity, V. This jet impinges on a Pelton wheel bucket which is travelling at a steady velocity, U, in the same direction as V ($V > U$); the jet is deflected by the bucket and emerges in a direction parallel to the incident jet:



Assuming the pressures in all the jets to be the same as the surrounding atmosphere and neglecting gravity and viscous losses, find the force on the bucket in terms of ρ, A, V and U. [Hint: consider the problem in a frame of reference that is moving with the bucket. The flow is unsteady in any other frame of reference.]

What is the rate of work that the turbine can deliver (the output horse-power) in terms of ρ, A, V and U?

The speed, U, of the bucket will depend on the resistance of the machinery that the turbine is driving. Sketch the form of the characteristic of the turbine, namely the graph of the rate of work delivered (the output power) plotted against the shaft speed as represented by U for given values of ρ, A, and V. At what U/V is the output power a maximum?

If the input power to the turbine is estimated to be given by $\rho A V^3$ what is the efficiency, η, of the turbine? Sketch the graph of η as a function of U. What is the efficiency at maximum power delivery?