First perform the lab according to the lab manual, and become an expert at running the machine. (Plot Mechanical Power vs. Vane Position at a fixed Pump and Load setting). The basic experiment is OK, but as an engineer in charge of a hydraulic power plant you would be requested to adjust the turbine's parameters to achieve various levels of power at a given river condition, or output a constant level of power despite changing river conditions. **There for I have added the following "Real Life" part to the experiment:**

1) Vary your power plants output to match power demand. At a constant pump setting of 4.0, and wide open pressure valve adjust the vanes and load on the turbine to achieve a mechanical power (+/-3%) of: 80, 90 and 100W.
2) Try to maintain a constant level of power output despite changing river conditions. Achieve a mechanical power output of 80W (+/-5%) at the following pump settings: 3.5, 4.0, 4.5, with a wide open pressure valve.

For each set of data record: Variable Type:
     Pump setting   INPUT
     Vane Position   INPUT
     Speed of the Turbine   OUTPUT
     Torque of the Turbine   OUTPUT
     P1, P2, P3   OUTPUT
     Flow Rate   OUTPUT

Calculate the following for each setting:
     Hydraulic Power
     Mechanical Power
     Overall Efficiency

Write up:
     In engineering communications are very important. Either you will be following some one else's work, or some one will be following your work, or more likely both. What ever you do, it is important to communicate it CLEARLY so that others can understand what you have done, even if they come from a different background.
     There are a few fundamentals you must have in your write up. First you must answer the basic questions: Who, What, When, Why, Where, How? Some of these may be obvious (ie. Like the work was done in the lab), but it is relatively quick to answer the questions, so do it. Also any process consists of **INPUT** variables, **OUTPUT** variables and **UNCONTROLLED** Variables. Every time you make a measurement you need to communicate what was the state of each variable (input and output), and any calculation must be presented clearly enough to check your final results.
     My guidelines for writing up a lab report are simple: Make sure that someone can reproduce your work, and understand it based only on things which are stated as "GIVEN" and your report, that's it.
     For this lab you can assume that the test apparatus is GIVEN and understood. Apart from that you are responsible for communicating exactly how to reproduce your work, and what ever analysis and results you attained.

FINAL NOTE: The "Torque" transducer reads in Nm, and does not "Zero" at 0, instead it reads about 0.64 Nm when it is unloaded. Make sure you correct for this in your data.

Bernoulli Saves The Day!
Application of Bernoulli's Equation to Fluids Lab

$$\frac{1}{2}\rho V^2 \; + \; \rho gh \; + \; P \; = \; constant$$

where ρ = density of water,
V = velocity of water.
g = acceleration due to gravity.
h = elevation (height) of water.
P = pressure of water.

Bernoulli's equation is basically an energy balance. The units on each factor are Energy/Volume, and the terms are Kinetic, Potential, and Pressure respectively. This is the guiding equations behind the two turbine labs.

IMPULSE TURBINE

With this system the incoming and exiting water stream (jet) are both at atmospheric pressure, and the same height. The only term in Bernoulli's equation that is changing upon impact with the turbine is the velocity (ie. Kinetic energy), which is changing direction. This is imparting the kinetic energy to the turbine to run the generator (or whatever).
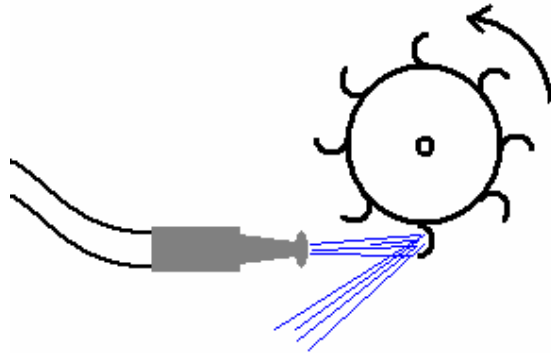
REACTION TURBINE

In this system the dominant change in the water stream is a pressure drop across the turbine. If Pressure is Energy/Volume then Power is Energy divided by Volume/Time, or Flow Rate (Q). The Power extracted by the turbine is then Q(P1-P2) where P1 is the Pressure before the Turbine, and P2 is the pressure after the turbine. What happens if P1-P2 is very small? There is almost no pressure drop (ie. resistance) across the turbine, so the flow (Q) will be maximized, but the power of the turbine will be very small. If P1-P2 is maximized, (ie. large pressure drop across turbine) the flow rate will be reduces as the resistance to flow has increased, and again we will have a low power output.
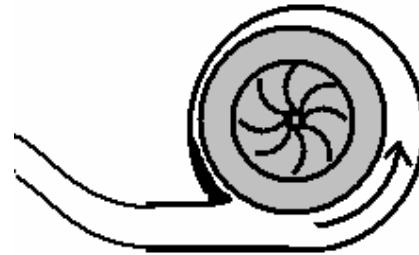
Power will be maximized when the pressure drop is approximately ½ of the overall pressure of the system. This is analogous to the mechanical power of the turbine.

TURBINE POWER

The mechanical power of the turbine (or any rotating equipment) is equal to its rotating speed (in rad/sec) times its torque (in Nm): Power = Torque x Speed

If the turbine is run unloaded it operates at its highest speed, the "No Load" speed. No Power can be extracted at this speed as the torque is zero. The Maximum Torque occurs when the turbine is "stalled", ie. when the speed is zero. Again no power is extracted when the turbine is stalled. The maximum power occurs when the turbine is running at about ½ the "No-Load" speed.