Water Pumps

Chapter 5 - STUDENT OUTCOMES

1. Describe the operational difference between **centrifugal pumps** and other types of pumps.
2. Define and use **pump characteristic curves.**
3. Describe the operation of **pumps** in **pipelines, branching systems**, and **pipe networks**.
4. Explain **series** and **parallel pump** configurations.
5. Understand the concepts of **cavitation, specific speed**, and **pump similarity.**
6. Recognize how **pump selection** is accomplished.
7. **Calculate solutions to various pump analysis and design problems involving these concepts.**

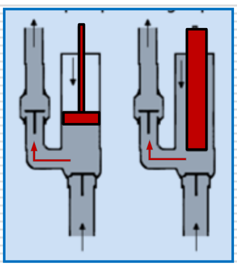
Description of Pumps and Pump Types

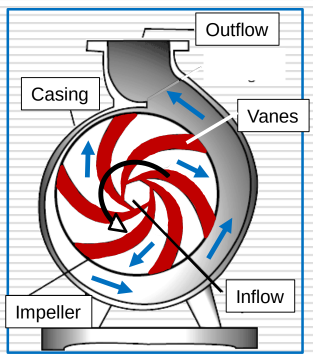
(Definitions and Visualization)

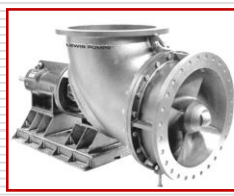
Pump:

Turbo-hydraulic: fluid moved by rotating vanes or another moving fluid (e.g., centrifugal, jet, and propeller pumps)

Positive displacement: fluid moved by precise machine displacements (e.g., screw and reciprocal pumps)







Q: Guess these pump types.

Centrifugal (Radial Flow) Pumps
(Visualization and Flow Principles)

Q: Will water be ejected from the pipe T if we spin it?

A:

Q: What principle of physics is being utilized to move water?

A:

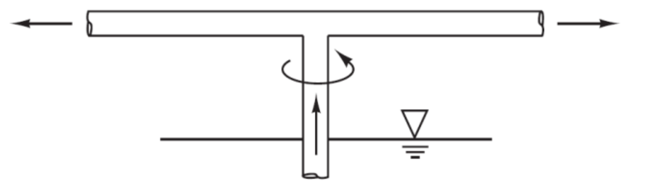
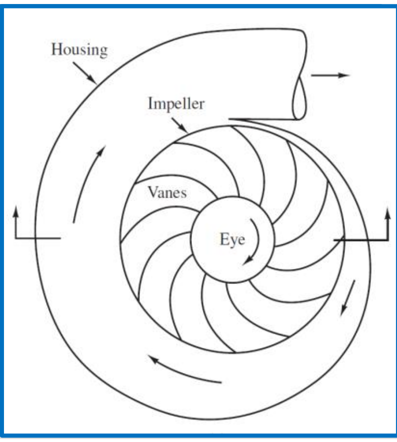


Figure 5.1 Demour's centrifugal pump

Centrifugal (Radial Flow) Pumps
(Visualization and Derivation of Power Input)

From Newton's 2nd Law, derive the impulse momentum eq'n:

F = $\quad$ = $\rho Q(V_o - V_i)$ ➔ **from Chap 3**



Q: What is the relationship between force and torque (T)?

applied to impulse-momentum:

$T = \rho Q(r_o V_o \cos\alpha_o - r_i V_i \cos\alpha_i)$

Also, Power (P) =

So the **Pump Power Input** is:

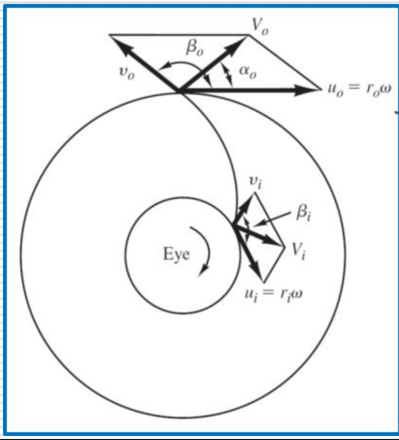
$P_i = \rho Q\omega(r_o V_o \cos\alpha_o - r_i V_i \cos\alpha_i)$

Centrifugal (Radial Flow) Pumps

(Power Input Equation: Variable Definitions)

Q: Explain the meaning of the variables u_o and v_o.

A:



Q: Define the variable V_o?

Q: How can the radial velocities (V_{ro} & V_{ri}) found given Q?

Centrifugal (Radial Flow) Pumps

(Equations for Power Output & Efficiency)

Q: Does energy increase on the output side of the pump?
. If so, in what form? Does the flow rate increase?

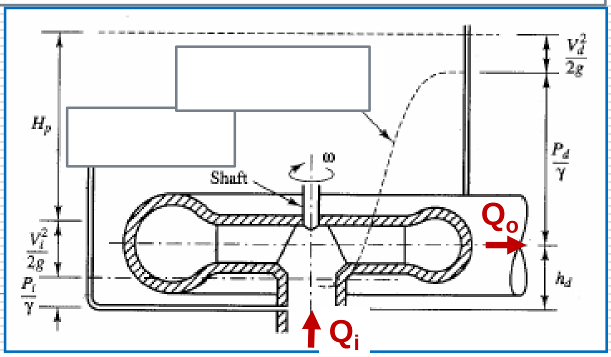
A:
.

Pump Power Output:
$P_o = \gamma Q H_p$

Pump Efficiency:
$e_p = P_o/P_i$

Motor Efficiency:
$e_m = P_i/P_m$

Overall Efficiency:



Centrifugal (Radial Flow) Pumps

(Pump and Motor Selection Example Problem)

A centrifugal pump is required to lower the stormwater depth in a 12 ft by 10 ft rectangular sump at the rate of 1 foot every minute. The pump must overcome a lift of 20 feet. If the overall efficiency rating of the pump is 75%, select the appropriate pump (flow rate in gpm) and motor (power in kW). Assume pipeline losses are negligible.

Ans. **Q** =

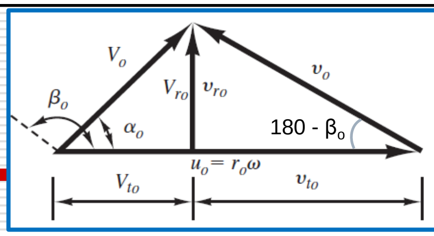
P_o =

P_o =

$\mathbf{P_m}$ =

Centrifugal Pumps

(Example Problem)



Find: Pump power input (P_i).

Given: Pump impeller thickness = 30cm; diameters (D_o = 150 cm, D_i = 50 cm), V_i = 17.7 m/sec, α_i = 45°, β_o = 150°, rotation speed (ω) = 100 rad/sec, and Q = 5.89 m³/sec.

Ans. $P_i = \rho Q\omega[r_oV_o\cos(\alpha_o) - r_iV_i\cos(\alpha_i)]$; → u_o =

υ_{ro} =

υ_{to} =

V_o = $= [(4.17)^2 + (75 - 7.22)^2]^{\frac{1}{2}}$ =

α_o = $= 3.52°$; substituting $\mathbf{P_i}$ = **28,100 kW**

Homework Problems: