Grundfos ECADEMY

Impeller and Volute Function

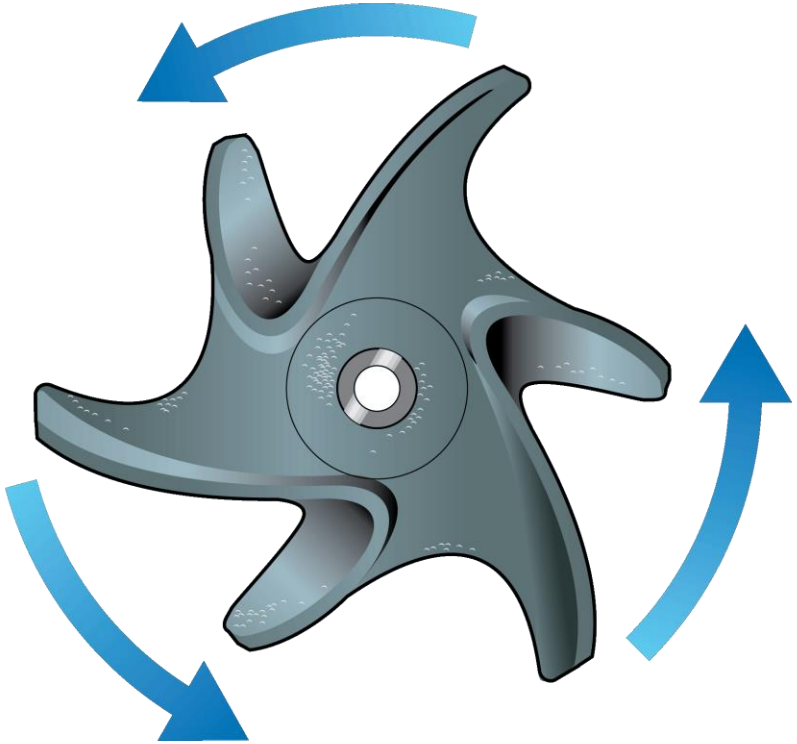
Centrifugal Pump Theory

GRUNDFOS

Possibility in every drop

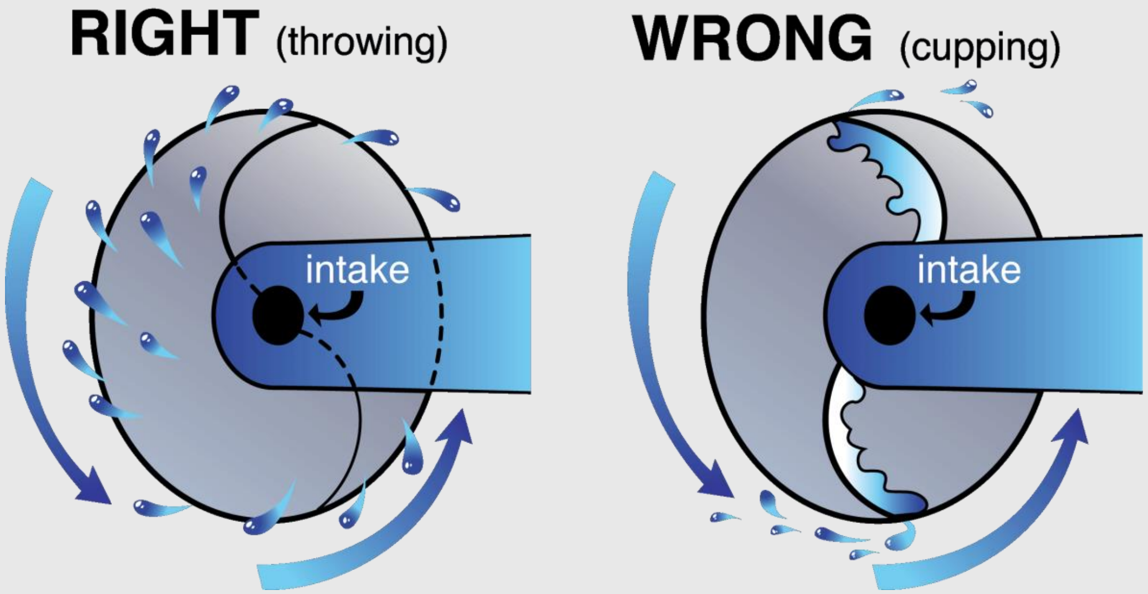
Impeller: Heart of the Pump

- There are many components in regard to impeller design.
- The specific speed, the size, and the style of the impeller
- For this part of the module we will focus mostly on the operation component of the impeller.
- One way to understand how the impeller works is to think of a bucket with a hole in the bottom.
- If the bucket is swung around in a circle the water will fly out of the hole in the bottom.
- The velocity of the bucket determines the velocity at which the water comes out of the hole in the bottom.
- The greater the velocity the bucket is swung, the greater velocity that the water will come out of the hole. The same is true of the impeller.
- This conversion from velocity to velocity head is caused by centrifugal force, which is why these types of pumps are called centrifugal pumps.



Impeller rotation

- The direction of rotation of the impeller and the fact that it slides through the water creating a throwing action.
- The impeller does not cup the water.
- The pump will pump some water when run backwards, but not much.



Impeller, correct rotation

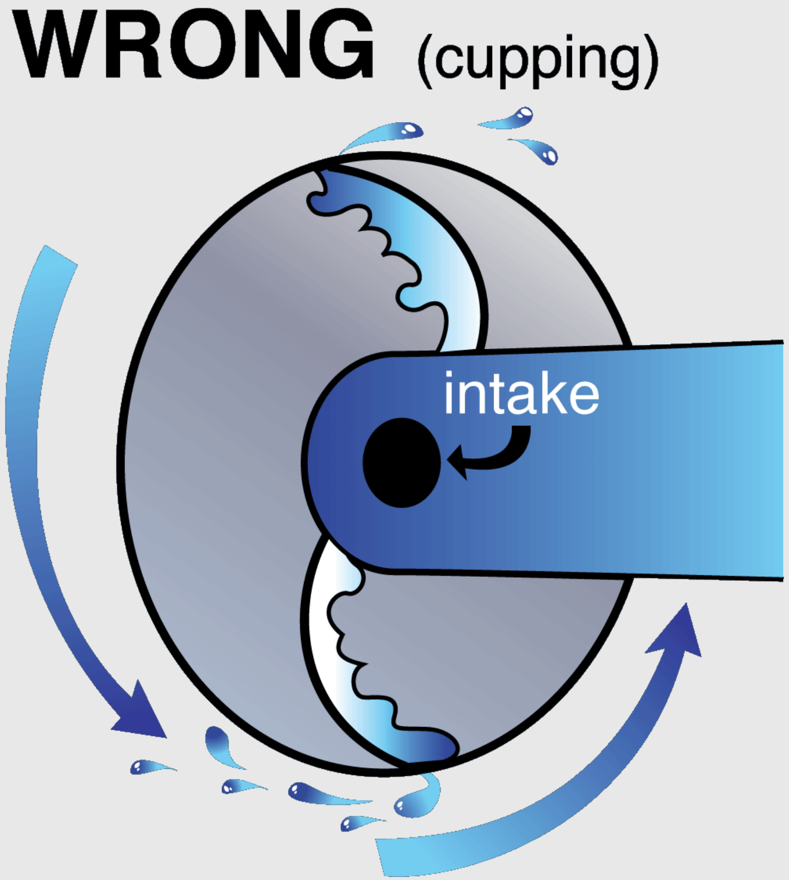
- Click on the related video on the training module page to see a demonstration of how the pump increases pressure and provides flow during correct (Forward) rotation of the impeller.
- With the pump off the systems pressure is at 12.5 PSI and 0 GPM
- Once the pump is up to speed the discharge pressure is up to 25 PSI (12.5 PSI boost) and the flow is up to 14.4 GPM

Impeller, wrong rotation

- Click on the related video on the training module page to see a demonstration of how the pump increases pressure and provides flow during incorrect (Reverse) rotation of the impeller.
- Once again, with the pump off the systems pressure is at 12.5 PSI and 0 GPM
- Now the discharge pressure only goes up to 16PSI (a 3.5 PSI boost) and the flow only goes up to 6.2 GPM which is only 28% of the pressure boost and only 43% of the flow compared to operating correctly.

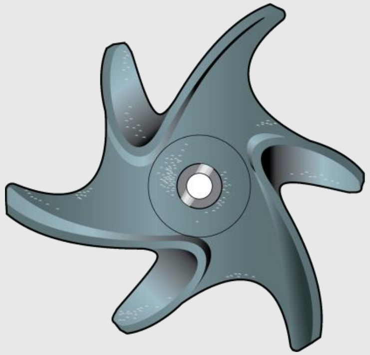
Impeller, wrong rotation

- These are some of the results of incorrect direction of rotation.
    - Reduced Flow and Head
    - Noise
    - Inability to reach shutoff head
    - Decreased pump efficiency
- Incorrect direction of rotation occurs when three phase motors are wired incorrectly.
- Note that with three phase power you can change the rotation by switching any two of the power wires.

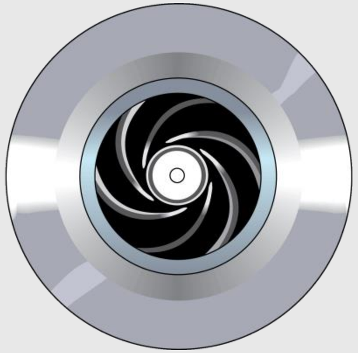


Three types

- The three types are
    - Open
    - Closed
    - Semi-open impellers.
- Common materials that impellers are made out of include: cast iron, bronze, stainless steel, and polymers.



Open

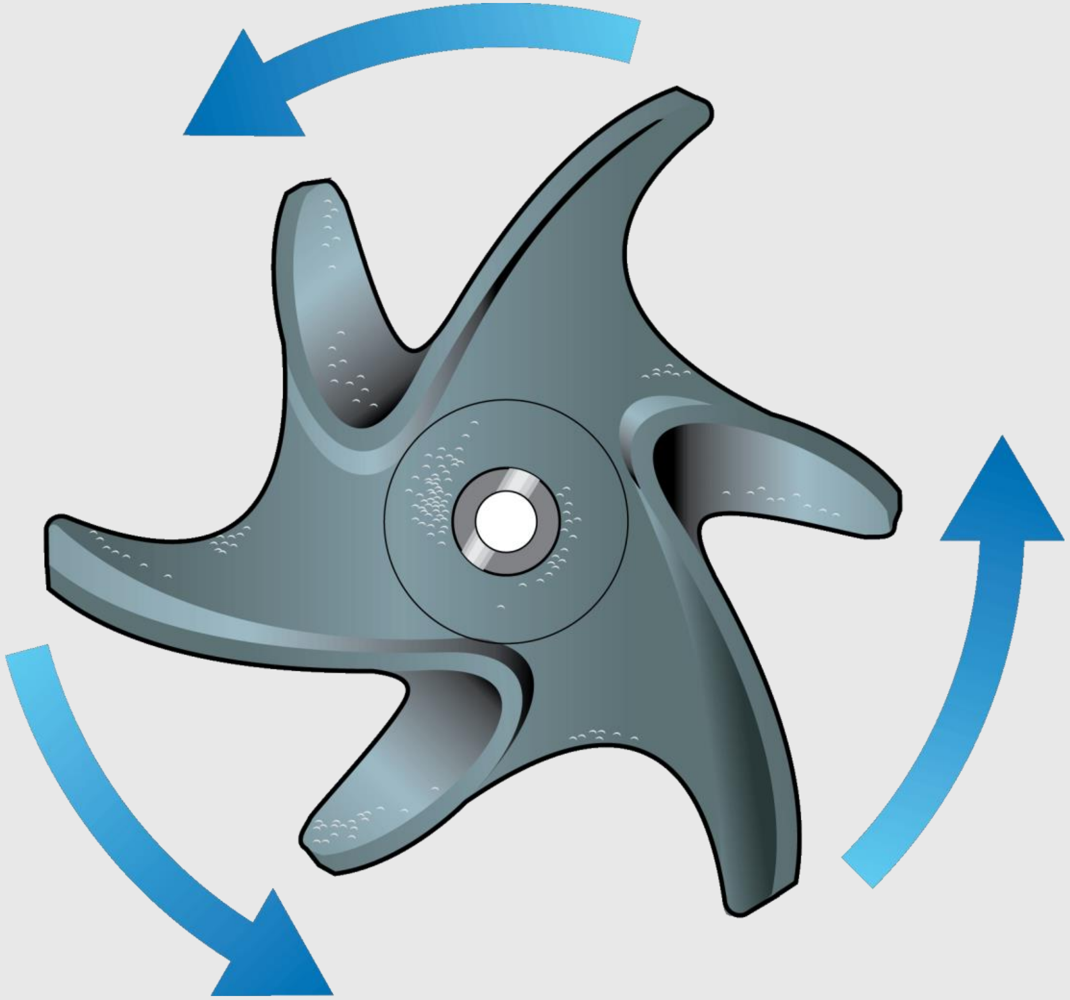


Closed

Semi-open

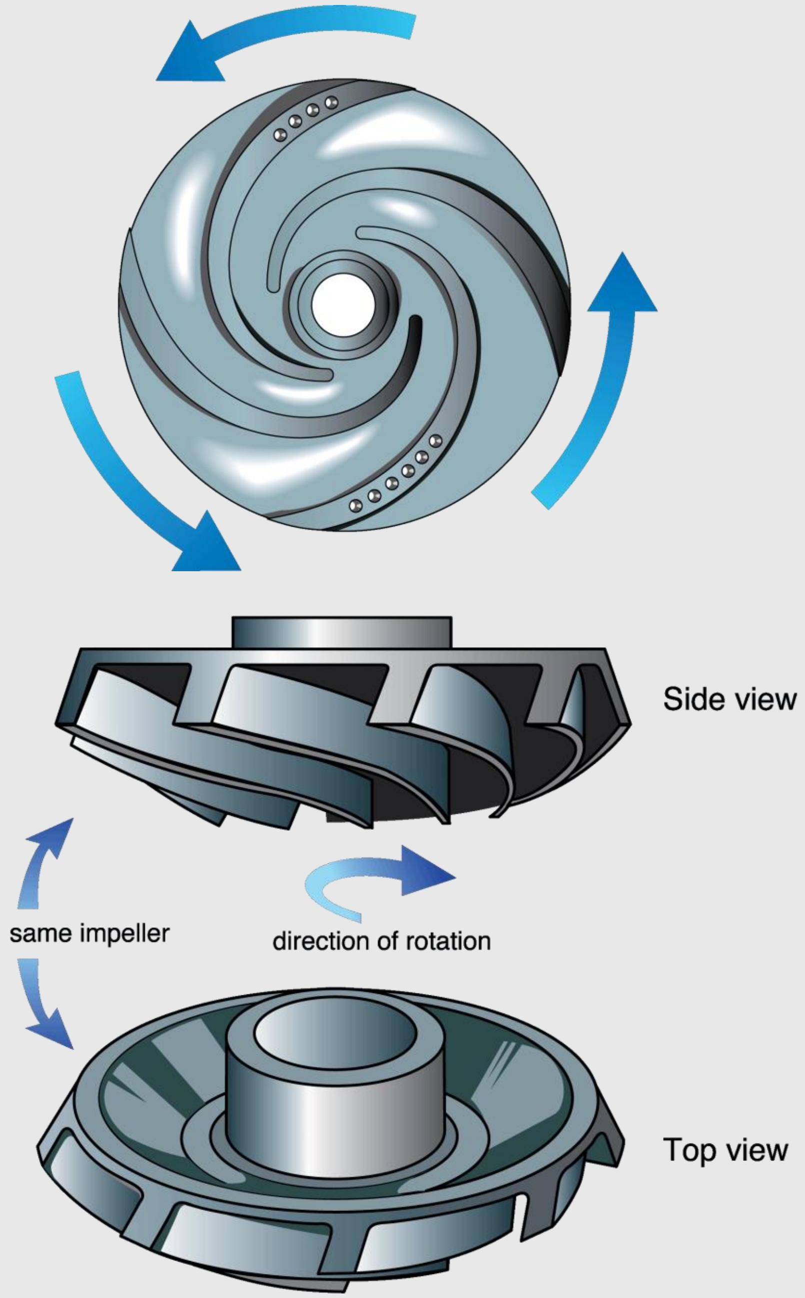
Open Impeller

- The open impeller - High volume, low pressure, low efficiency.
- Pass the largest solids. - note direction of rotation.



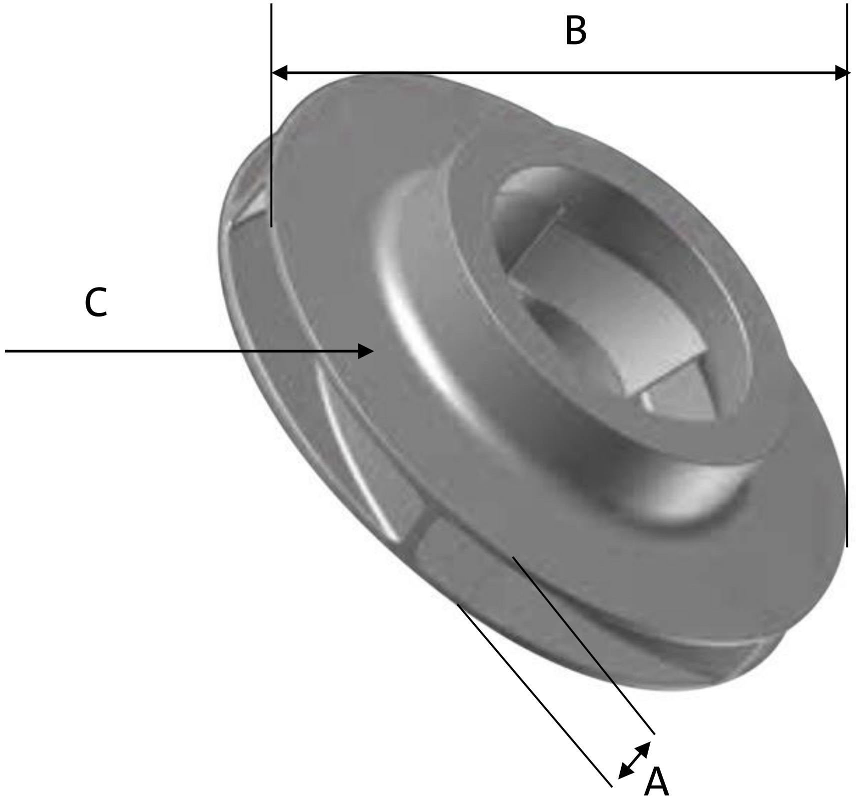
Semi-open Impeller

- It is called semi-open because it has a back shroud.
- Semi-open used medium pressures, medium flows - medium efficiency.
- The two impellers on the bottom are typical of the type and shape of the semi-open impellers used in vertical turbines.



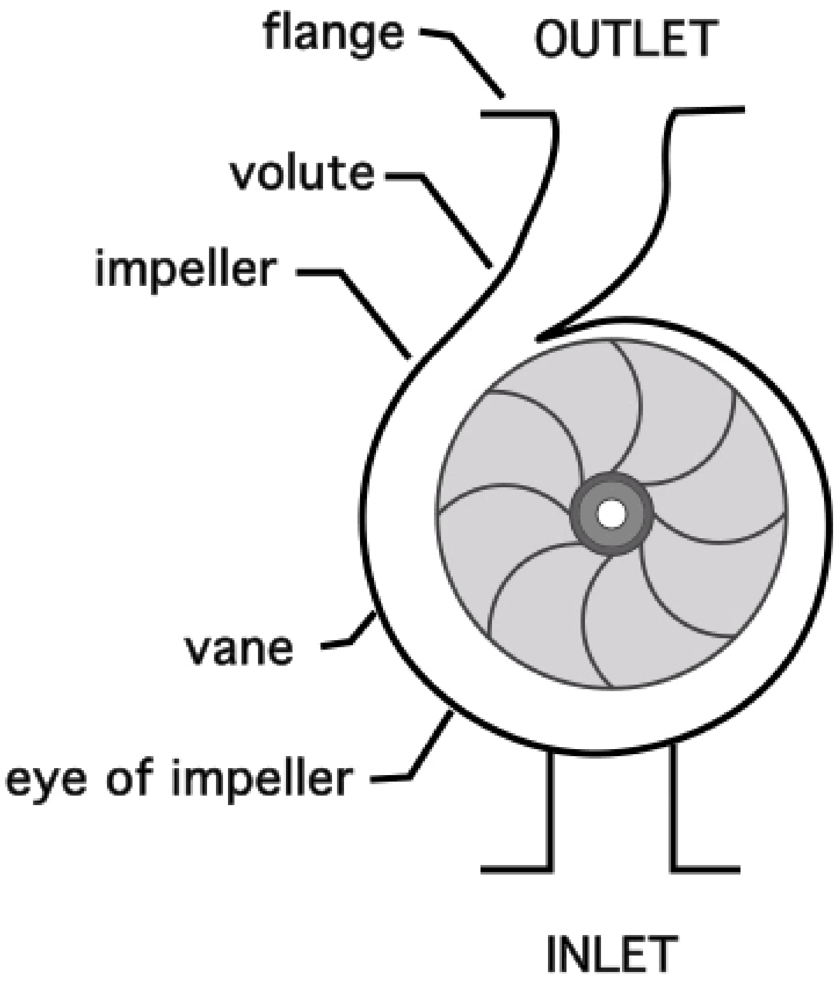
Centrifugal Impeller

- The width (A) of the vanes is the major determining factor in the amount of flow produced by the impeller.
- The head (pressure) produced by an impeller is primarily dependent on its tangential velocity or diameter (B).
- The vane shape (C) is the major influence of an impeller's performance (efficiency).
- Over the years, pump designers have tabulated volumes of data of performance based on these and other design components.
- This information is often associated with a term called “Specific Speed.”



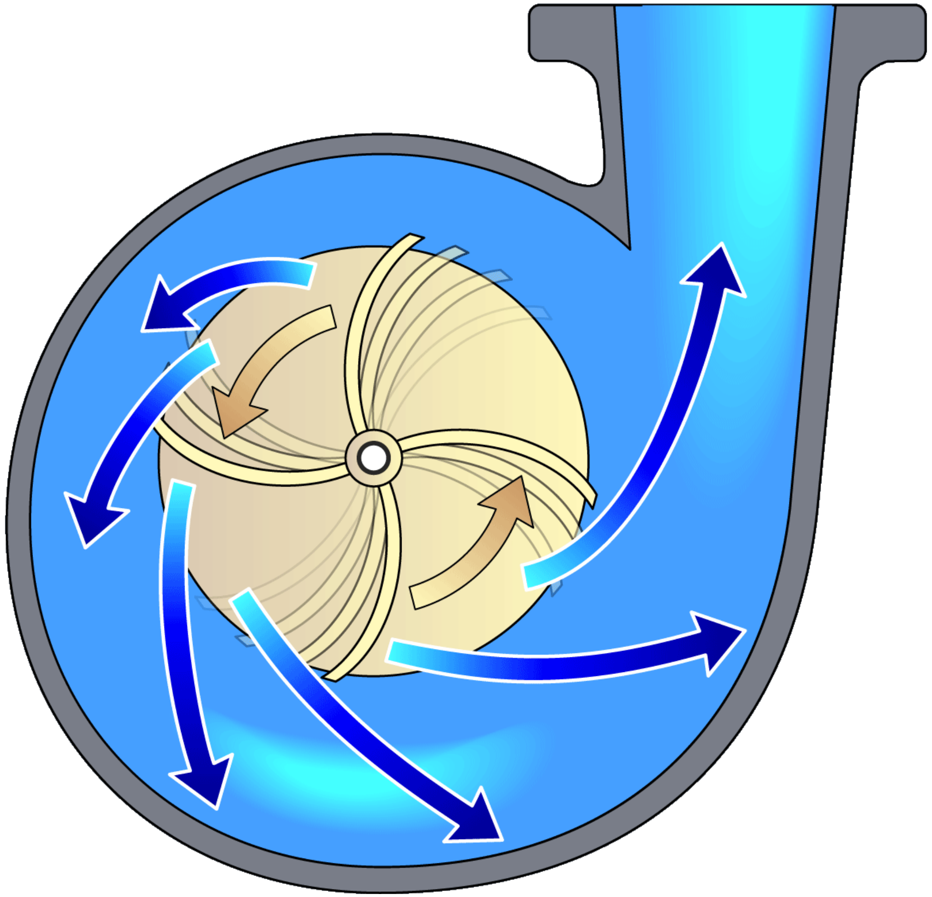
Centrifugal Action

- The fluid enters the pump through the inlet (suction eye) where the impeller adds energy (in the form of velocity) through centrifugal force.
- When the fluid leaves the impeller, there is a decrease in velocity.
- Velocity and pressure are inversely proportional. As velocity increases, pressure decreases, and as velocity decreases, pressure increases.
- The decrease in velocity results in an increase in pressure as the fluid leaves the pump.



Function of the Volute Case

- This brings us back to the other major pump component, the volute case.
- The primary function of the volute case is to transfer velocity head to pressure head.
- This happens because of the shape of the volute case's ever expanding area - Similar to a long funnel, increasing cross sectional area causes, Energy transfer from, Velocity head to pressure head.
- To understand this process -compare two points along the volute case.
- One is near the small end and the other near the large end.
- As water travels along the volute, the cross sectional area increases and so does the volume. But at different rates.



Function of the Volute Case

- Q = liquid flow through a pipe
- V = average velocity of the flow
- A = cross-sectional area of the pipe
- Use the equation Q = VA to explain the result of these different rates of increase.
- Note the quantity increases from 32 to 36 and the area increases from 10 to 18.
- Even though they both increase, the result is a drop in velocity, from 3.2 to 2.

$$Q = V \times A$$

$$32 = 3.2 \times 10$$

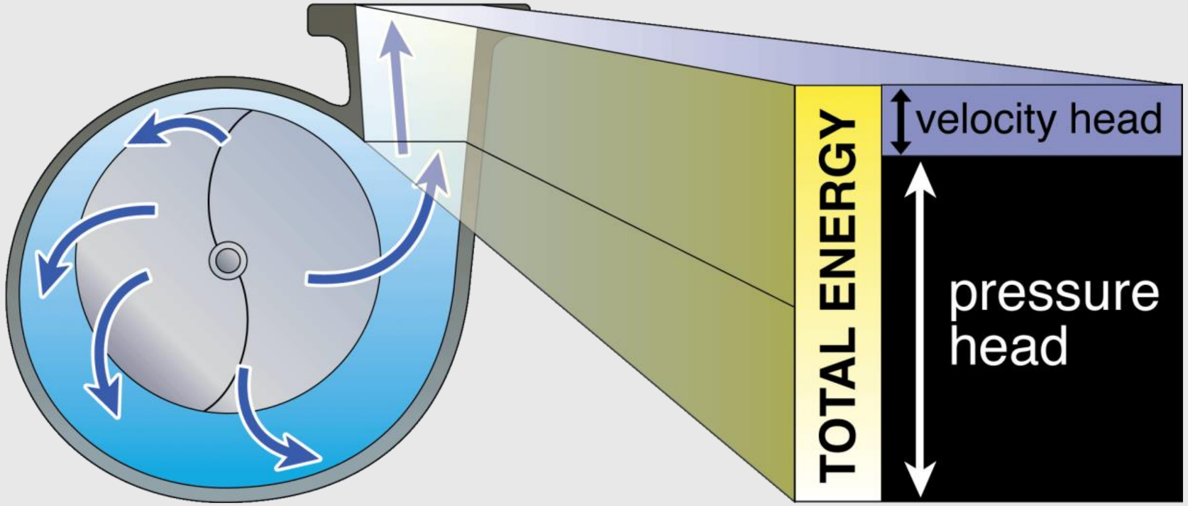
$$36 = 2.0 \times 18$$

Function of the Volute Case

- As the velocity slows, the velocity head (energy) is transferred to pressure head.
- As the water travels around the volute case, this transfer is rather slow.
- Until the water comes to the toe of the volute case - here there is a sudden increase in area and no additional increase in quantity.

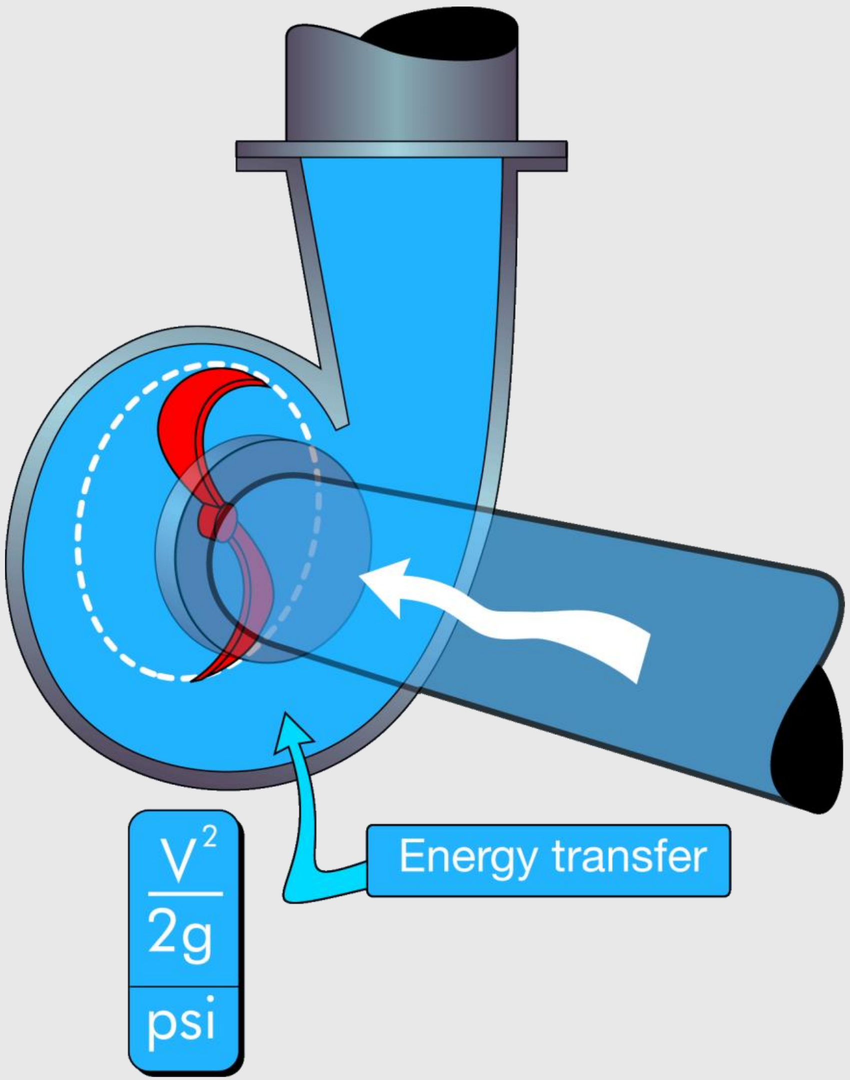
Function of the Volute Case

- The result of this increased area is a sudden drop in velocity head, and an increase in pressure head.
- Also a drop in headloss as a result of a drop in velocity.



Review

- In summary - two theories explain why the pump pumps :
- 1. Energy transfer within the volute as we change from velocity head to pressure head.



Review

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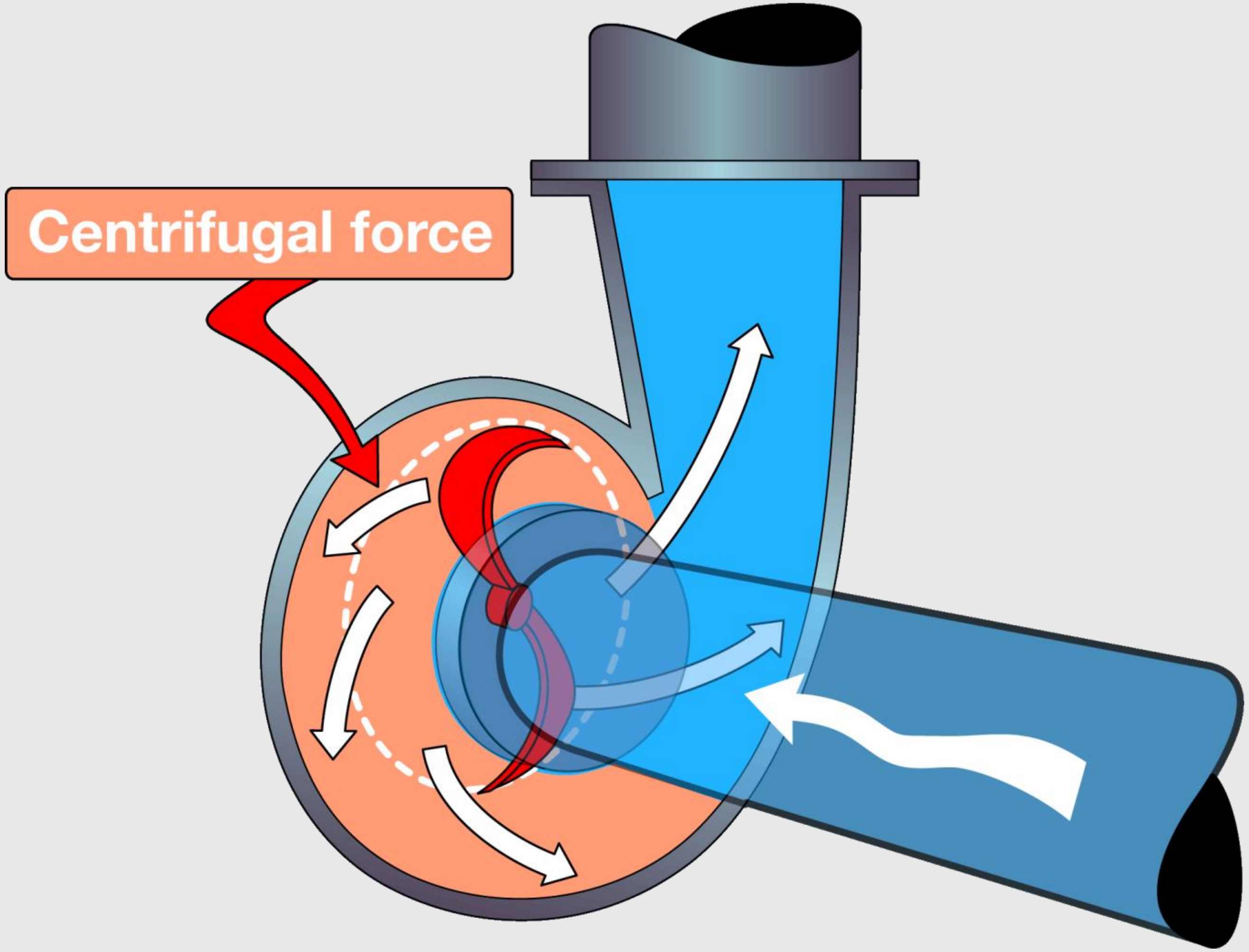
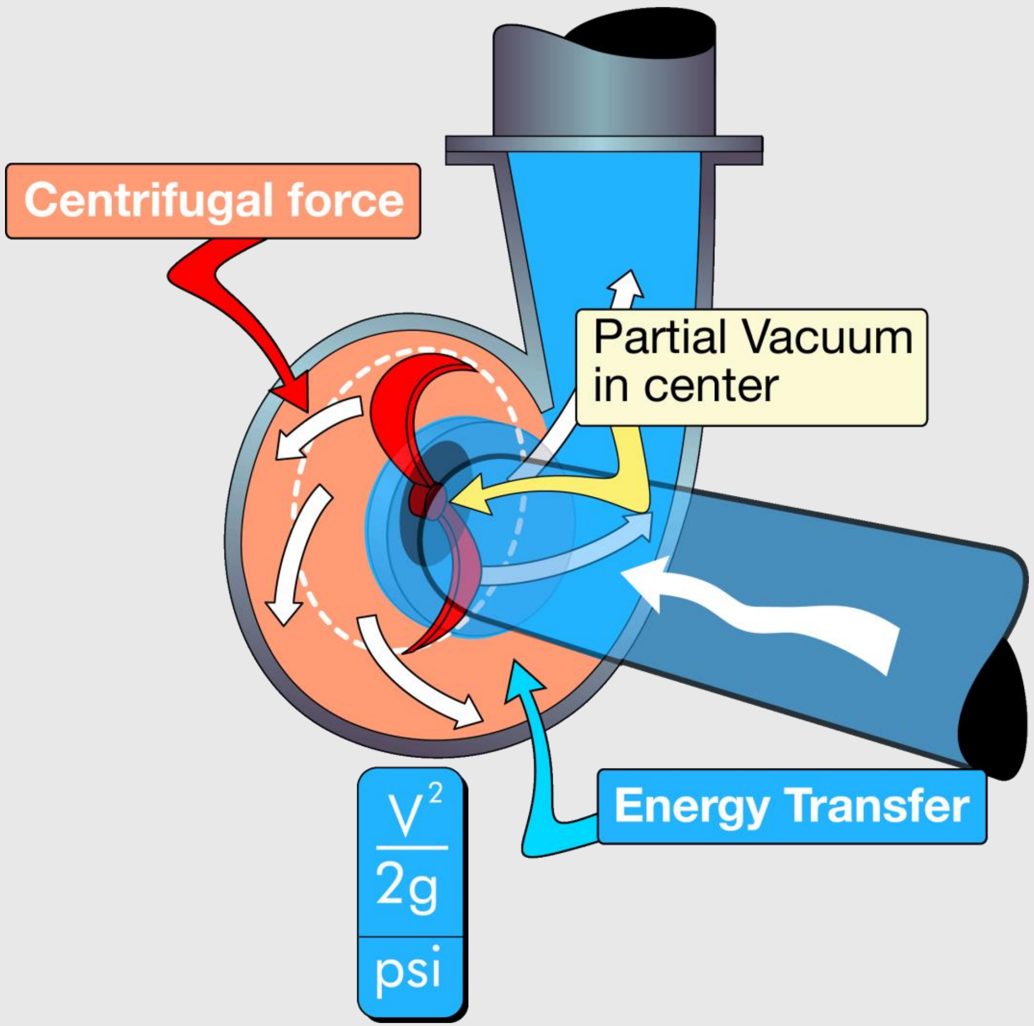
- 1. Energy transfer within the volute as we change from velocity head to pressure head.

- 2. Centrifugal force. The two work together to cause the pump to pump. Centrifugal force throws the water to the outside of the case.



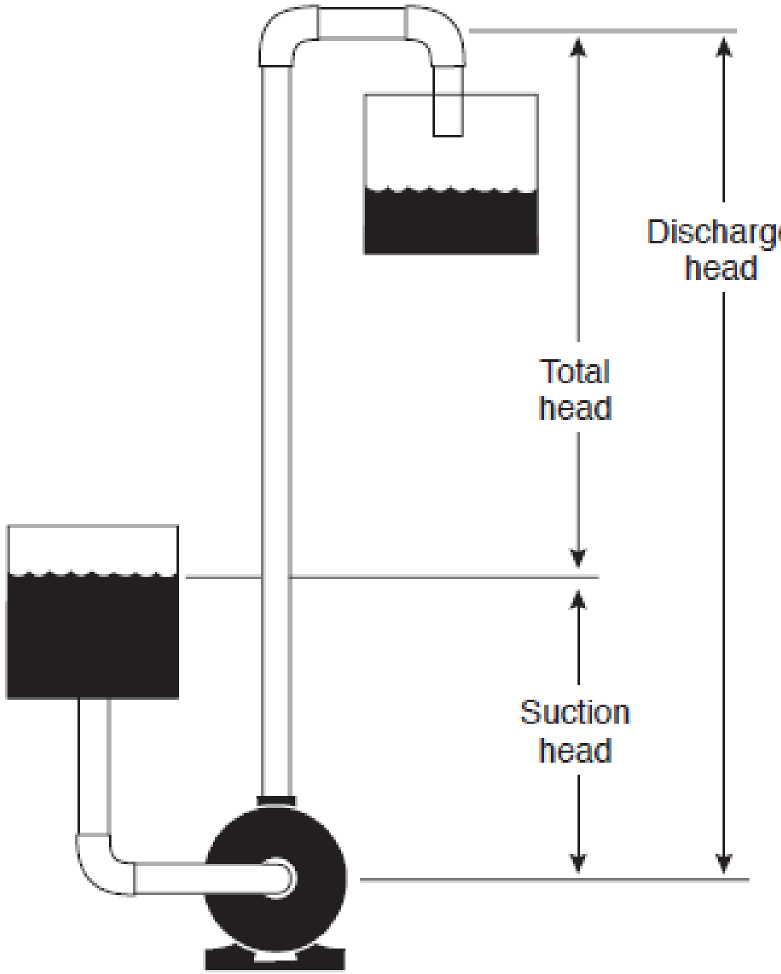
Review

- In summary - two theories explain why the pump pumps :
- 1. Energy transfer within the volute as we change from velocity head to pressure head.
- 2. Centrifugal force. The two work together to cause the pump to pump. Centrifugal force throws the water to the outside of the case.
- The rate that the water travels away from the impeller is greater than the rate it enters the impeller, leaving a partial vacuum at the eye of the impeller.



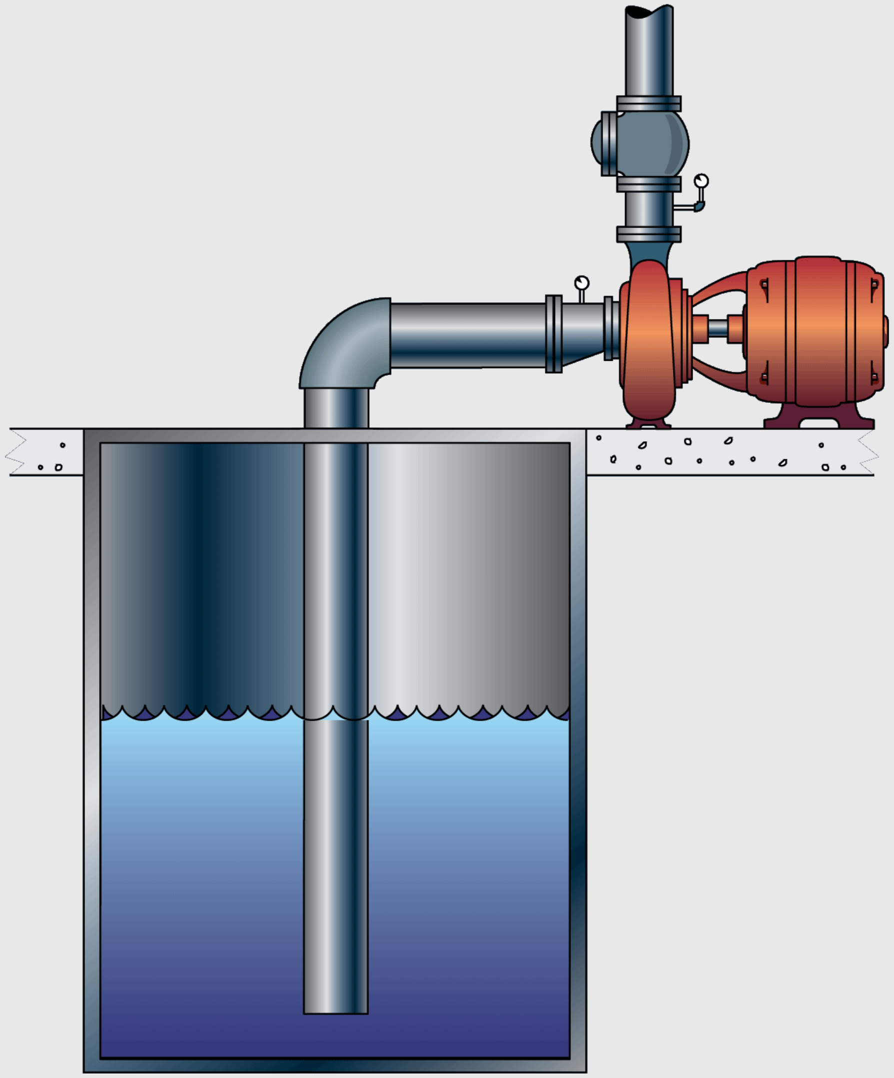
Classification by Suction Condition

- One last component that we will address in this module is the suction condition for the pump.
- If not properly accounted for different suction conditions can greatly affect pump performance.
- Flooded Suction
  - The tank (or fluid) is above the inlet to the pump aids in preventing cavitation of the pump.
  - Also reducing the total head required by the pump.



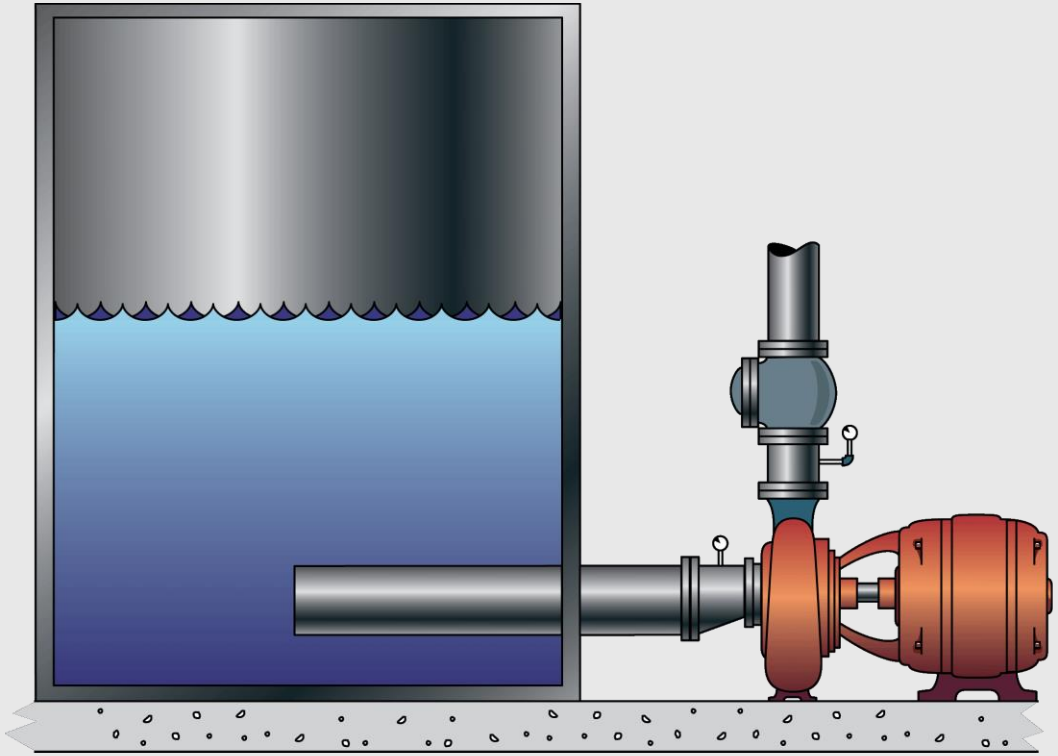
Suction Lift Application

- Here is a picture of a suction lift application.



Flooded Lift Application

- Here is a picture of a flooded suction application.



Summary

You should now be able to:

- Understand the classification of pumps
- Understand the basic operation of a centrifugal pump
- Introduction to the Darcy Weisbach Equation
- Define how a centrifugal pump converts velocity to pressure