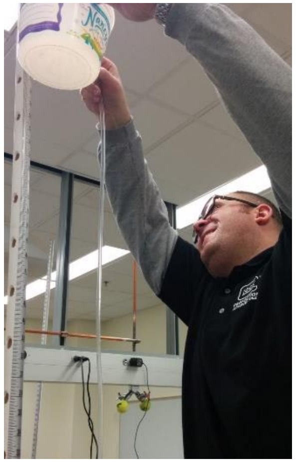
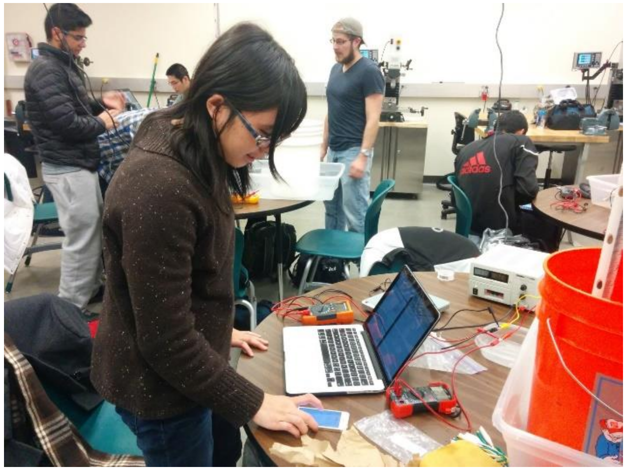
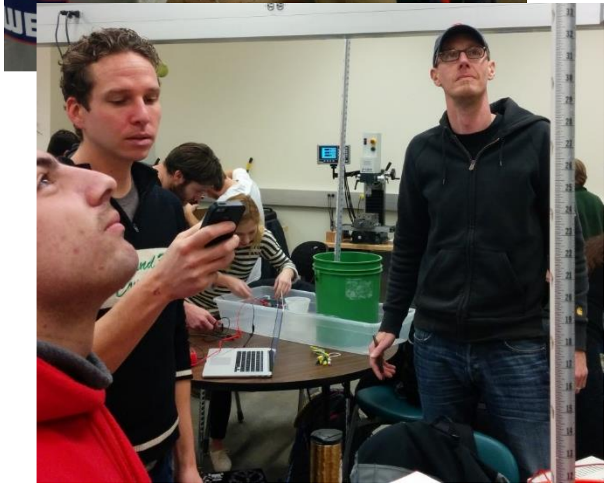


Pump Performance





ME 120

Pump Performance

The pump converts electrical power into fluid motion.

Engineers have a common language and analytical models to describe pump performance:

1. Flow rate
2. Pump Head
3. Efficiency

1.Flow rate

Volumetric Flow Rate:

$$\boxed{\overset{\text{m}^3/\text{s}}{Q} = \overset{\text{m/s}}{v}\overset{\text{m}^2}{A}}$$

where v is the average fluid velocity in the outlet tube, and A is the cross-sectional area of the tube.

Mass Flow Rate:

$$\boxed{\overset{\text{kg/s}}{\dot{m}} = \overset{\text{kg/m}^3}{\rho} Q = \rho v A}$$

where ρ is the fluid density.

We also know that:

$$\boxed{\dot{m} = \frac{\Delta m}{\Delta t}}$$

where Δm is the mass accumulated in time Δt

2. Pump Head

Pump Head:
It is a measure of how high the pump can push the fluid.

If the friction losses in the inlet and outlet tubes can be neglected,

$$\boxed{head = h}$$

where h is the height of the free end of the hose above the free surface of the supply reservoir.

Each pump has a characteristic relationship between head and flow rate.
Procedure to determine $h = f(Q)$:

- Measure Q with the outlet held at different heights, h
- Plot $h = f(Q)$
- Obtain a least square curve fit to $h = f(Q)$

3. Pump Efficiency

Each pump has an optimal operating point, i.e., an optimal (*Q, h*) that yields maximum efficiency, η.

$$\boxed{\eta = \frac{desired\ outcome}{cost\ of\ obtaining\ the\ outcome} = \frac{output}{input}}$$

Each device has a conventional definition of output and input. For a pump:

- $output$ = power delivered to the fluid
- $input$ = power consumed by the motor

The units of output and input should be the same. η is dimensionless.

$$\boxed{output = \dot{m}gh + \frac{1}{2}\dot{m}v^2}$$

where g is the acceleration of gravity in m/s^2

$$\boxed{input = VI}$$

where V is the voltage and I is the current supplied to the motor.

Summary

At each height of the outlet tube, you have measured:

- h = pump head = distance the water stream is elevated
- Δm = mass accumulated in time Δt
- Δt = time allowed for mass accumulation
- V = voltage applied to pump motor
- I = current drawn by pump motor

For each height of the outlet tube, you can compute:

- $\dot{m}$ = mass flow rate
- Q = volumetric flow rate
- v = fluid velocity in the tubing
- η = pump efficiency