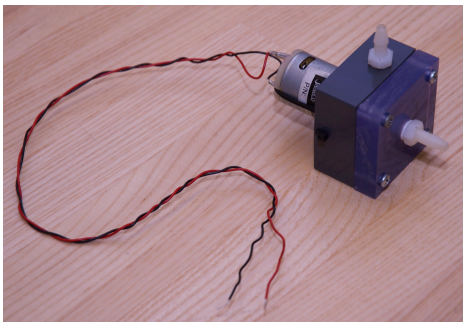
Living with the Lab

Pump Performance Testing



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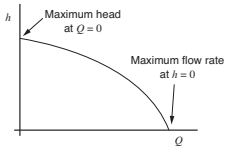
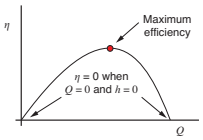
Goal: Measure the pump curve(s)

Head versus flow rate:



Efficiency versus flow rate:



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Pump testing in a nutshell

Prep

1. Make sure the pump works: dry and wet tests.
2. Wire the circuit to measure voltage and current.
3. Configure tubing for the pump test.

Data Collection

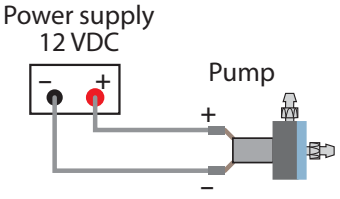
Change height of exit tube. Record mass flow rate, voltage and current.

Make sure the pump works:
Dry and wet tests.

SAFETY

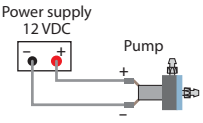
- Keep water away from all electrical equipment except the pump, and do your best to keep the pump motor dry.
- Don't handle the power supply or multimeter(s) with wet hands or wet feet (or when in contact with water).
- Prevent water from splashing onto or near the power supply.
- Wipe up any water that leaks onto the floor.
- Report any problems encountered to your instructor.

Dry Test: Make sure the impeller spins



Don't run your pump too long without water. The purpose of the dry test is to verify that the motor works and that the impeller can rotate freely.

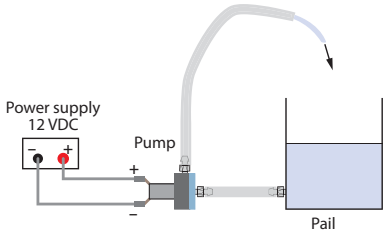
Debugging the dry test



If the impeller does not spin:

- Is the lid so tight that impeller rubs? If so, loosen the screws holding the lid in place.
- Is the motor misaligned? Try wiggling it.
- Are the electrical leads making good contact?
- Is the current limit on the power supply exceeded? Increase the current dial.

Wet Test: Make sure the pump can move water.



SAFETY

- Keep water away from all electrical equipment except the pump, and do your best to keep the pump motor dry.
- Don't handle the power supply or multimeter(s) with wet hands or wet feet (or when in contact with water).
- Prevent water from splashing onto or near the power supply.
- Wipe up any water that leaks onto the floor.
- Report any problems encountered to your instructor.

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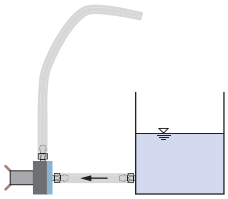
Priming the pump

Priming is the addition of water to the pump cavity so that the impeller can create enough suction to pull water from the supply reservoir.

Use gravity feed from the supply pail to cause water to flow into the pump cavity.



Gravity drives flow into the pump cavity

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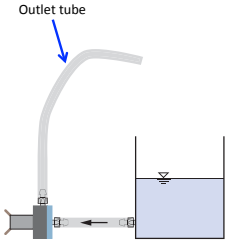
Priming the pump

1. Connect the outlet tube first.



Gravity drives flow into the pump cavity

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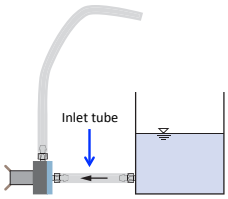
Priming the pump

1. Connect the outlet tube first.
2. Connect the inlet tube from the supply pail.



Gravity drives flow into the pump cavity

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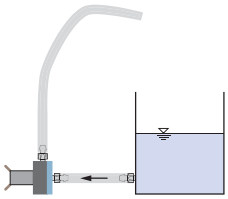
Priming the pump

1. Connect the outlet tube first.
2. Connect the inlet tube from the supply pail.
3. Allow water to flow into the pump cavity.



Gravity drives flow into the pump cavity

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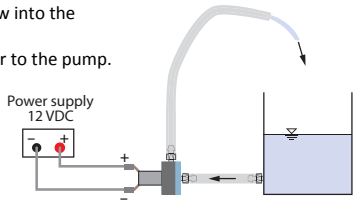
Priming the pump

1. Connect the outlet tube first.
2. Connect the inlet tube from the supply pail.
3. Allow water to flow into the pump cavity.
4. Connect the power to the pump.



Gravity drives flow into the pump cavity

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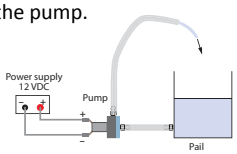
Debugging the wet test

If water is not flowing:

- Are there bubbles in the line between the pail and the pump? If so, tap the lines to move the bubbles.
- Is there water in the pump cavity? If not, make sure the inlet is below the surface of the water in the supply pail, and prime the pump.



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Set up the electrical circuit for measuring pump voltage and pump current.

Do not start the test until you are also ready to measure V and I for the pump!

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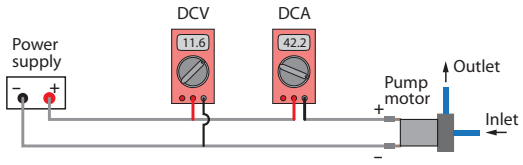
Electrical circuit for pump power measurement

Use your DMM to measure voltage

Use the bench-top DMM to measure current



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Can you make the connections?

Use the DMM on top of the power supply to measure current.

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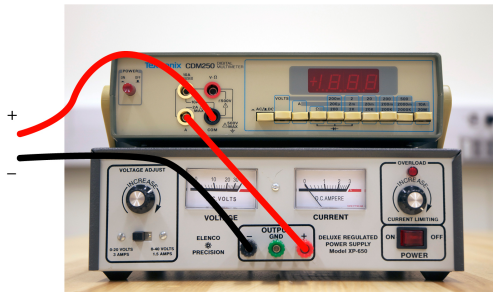
To measure current, the current must flow *through* the DMM: The DMM is in series to measure current



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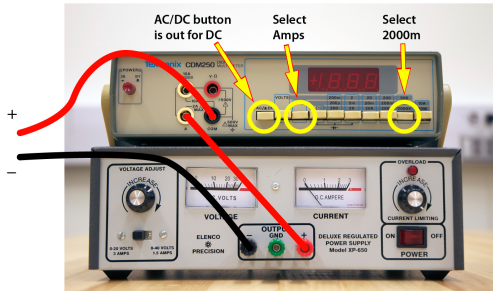
To measure current, the current must flow *through* the DMM, *and* the settings must be correct.



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SAFETY

- Keep water away from all electrical equipment except the pump, and do your best to keep the pump motor dry.
- Don't handle the power supply or multimeter(s) with wet hands or wet feet (or when in contact with water).
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Configure the tubing for measuring the pump curve.

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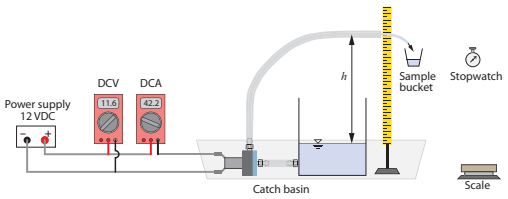
Configure the pump, tubing, meter stick, supply pail, and catch basin for the pump curve measurement



NOTE: h is the distance from outlet of the hose (top) to the free surface in the pail (bottom).

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Preliminary Procedure

1. Fill the supply pail to about one-third of full.
2. IMPORTANT: Align the bottom of vertical scale to the water level in the bucket.
3. IMPORTANT: Set the tare weight of the small bucket.
4. Connect the pump to the supply pail and exit tube.

All steps are important!

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Align the vertical scale to the level of the water surface in the bucket

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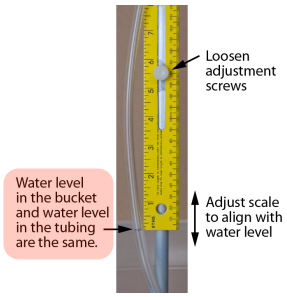
Align the vertical scale to the level of the water surface in the bucket



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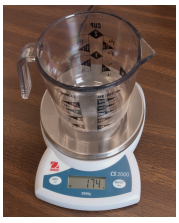
Use the tare function to cancel the dry weight of the pitcher used to collect water samples.


Empty pitcher on the scales


Before clicking "zero"


After clicking "zero"

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Collecting Data: Basic Ideas

1. You choose h, then measure V, I, Δm and Δt
2. Allow Δt of at least 15 seconds. Use longer times at low flow rates.
3. Use strategic selection of the order of h
   - First measure at the extremes: Find the maximum h first.
   - Fill in the middle of the range in random order
4. Use multimeters to measure V and I.
   Do not trust the meters on the power supply

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Collecting Data: Basic Ideas (2)

5. Do not make physical changes (e.g. changing impellers) during a single data set. If you make changes, start over, but keep your data.
6. Do not throw away data. Make notes about suspicious data. Discard measurements only at the analysis stage when you are certain that the data is not valid.

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Data Collection Procedure

Note: Keep the pump running during these measurements.

1. Empty the collection bucket.
2. Move the exit hose to a selected height
   - Water jet should exit the hose horizontally
3. Start the timer as the collection bucket is moved to capture the water
4. Collect "enough" water
5. Record h, Δm, Δt, V and I
6. Repeat for at least 10 settings (10 h values).

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Exit tube should be horizontal

Like this:

Not like this:

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Data sheet

- Label the sheet with team members, date, type of impeller (if more than one is used)
- Make columns of data for h, V, I, Δm, Δt.

h (inch)	V (volts)	I (amp)	Δm (g)	Δt (s)

This is just a sample data sheet. Make your own version on a full sheet of paper. Be prepared to take more data than you will eventually use.

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Strategic data collection:

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Strategic Data Collection

- Take data where it matters.
- There is no reason to use the same Δt for each flow rate measurement.
- The scientifically best procedure is to use longer Δt for lower flow rates. Why?
- There is no reason to use even increments of h.
- The scientifically best procedure is to use a random order of h values. Why?

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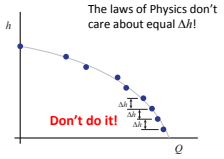
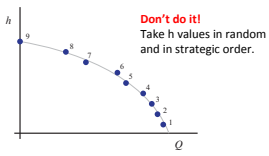
Naive data collection

There is no need to use equal spacing of h values.



There is no need to collect data in order of increasing or decreasing h. In fact, it's a bad idea



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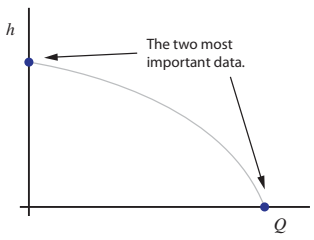
Strategic data collection



First, establish the range of h for your pump. Note that the maximum h may change during the test. Your pump performance will change as you run your pump.

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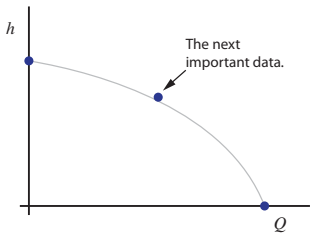
Strategic data collection

The middle value of h determines the curvature of the data set



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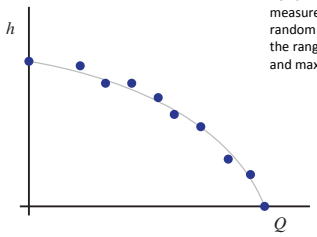
Strategic data collection

Perform the remainder of the measurements by selecting a random order of h values in the range between minimum and maximum h.



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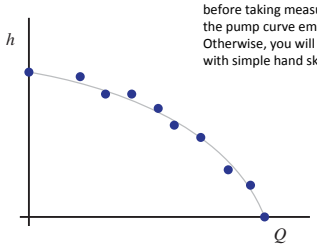
Strategic data collection

If the data reduction spreadsheet is created before taking measurements, you can see the pump curve emerge as data is collected. Otherwise, you will have to visualize the data with simple hand sketches.



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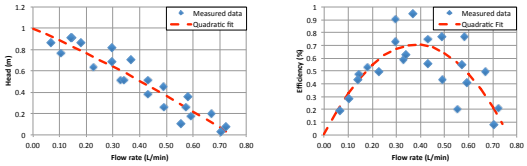
Sample results



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Summary

- Study these slides before coming to lab
- Create a data collection sheet (or spreadsheet) before starting the measurements.
- Use dry and wet tests to debug your pump before setting up your measurements
- Set up the V and I measurements
- Take data strategically