

Uncertainty in Meter Readings

Objective: To learn how to determine uncertainty of meter readings.

Equipment: 1 D-cell battery per table
Pasco analog voltmeter (one for two tables)
DMM (one for two tables)
2 banana plug connecting wires per table

Explanation: The accuracy of an analog ammeter or voltmeter is usually stated as a percent of the full-scale reading. The Pasco analog meters used in this course are accurate to $\pm 2\%$ of the full scale reading. Thus for a reading of 1.00V on a 3 volt scale, the uncertainty is $\pm 0.06\text{V}$. A reading of 1.0V on the 30 volt scale will have an uncertainty of 0.6V.

For a digital multimeter (DMM), accuracy is usually specified as a percent of the reading, not the full scale reading. So a meter with a specification of 1% of the reading will read an actual value of 100.0V as something between 99.0V and 101.0V. Also, most manufactures specifications include a range of digits to the right of the percentage, e.g., $\pm(1\%+2\text{digits})$. This gives an indication of how many counts the last digit on the right can vary. So if a meter rated at $\pm(1\%+2\text{digits})$ measures an actual value of 100.0V, the indicated display could be anything from 98.8V to 101.2V.

For the BK 2703B DMM used in our labs, the accuracy of the DC voltage readings for all scales is $\pm(0.5\%+1\text{ digit})$. Thus for a reading of 3.57 volts on the 20 volt scale, the accuracy is

0.5% of the reading	$\pm 0.02\text{ V}$	(this value was rounded to one significant digit because the meter reading is to the hundredth of a volt. We can not be more certain of our uncertainty than we are of the measurement.)
+1 digit implies	$\pm 0.01\text{ V}$	

Total estimated uncertainty = $\pm 0.03\text{ V}$, and we would record our value as $3.57 \pm 0.03\text{ V}$. The same principles apply to other types of measurements made with meters.

This semester you are expected to include uncertainty estimates with all measurements. For meter readings, you will determine the uncertainties using the methods practiced today.

In the exercise today, you will measure voltage of a D cell battery and determine the uncertainty of your measurement. You will use both an analog voltmeter and a DMM. One of each type of meters has been located on the two adjoining tables. You will work in groups of two and share the meters between the two tables. One team can start with the analog meter and the other team with the DMM and then switch. Each of you should take turns reading the meters.

Name: _____

Five points will be deducted for each significant figure error.

1. (30 points) Using the Pasco analog voltmeter, connect one lead wire between the COM (common) terminal of the analog voltmeter and the bottom of the D-cell. Connect another wire between the 30-volt maximum terminal of the voltmeter and the top of the D-cell. Record the measured voltage with an error estimate. Remember our analog meters the error estimate is $\pm 2\%$ of the full scale reading.

V = _____ volts

Calculate the fractional error, $\Delta V / V * 100\%$. ΔV is the uncertainty in voltage V. (Be careful with significant figures in the fractional error). Show your steps.

Move the wire from the 30-volt terminal to the 15-volt terminal of the voltmeter and connect to wire to the top of the D-cell. Record the measured voltage with an error estimate.

V = _____ volts

Calculate the fractional error.

Move the wire from the 15-volt terminal to the 3-volt terminal of the voltmeter and connect to wire to the top of the D-cell. Record the measured voltage with an error estimate.

V = _____ volts

Calculate the fractional error.

2. (30 points) Using the DC voltmeter function of the DMM using the 200 volt scale, connect one lead wire between the COM (common) terminal of the DMM and the bottom of the D-cell. Connect another wire between V Ω terminal and the top of the D-cell. Record the measured voltage with an error estimate using the specifications of the BK2703B DMM. (Use these specifications even if your meter is not a BK2703B.)

V = _____ volts

Calculate the fractional error, $\Delta V / V * 100\%$. ΔV is the uncertainty in voltage V. (Be careful with significant figures in the fractional error). Show your steps.

