MicroLab for Liberal Arts Colleges and Universities

Computer-Based Data Acquisition Tools and Software for Chemistry

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Some Colleges and Universities Using MicroLab
Research Universities
Auburn University
Kansas State University
Montana State University
North Carolina State University
Northwestern University
Rensselaer Polytechnic Institute
Rice University
University of Georgia
University of Texas El Paso
University of Nevada Las Vegas
University of Western Ontario
University of British Columbia
Comprehensive Universities
California State Bakersfield
California State Stanislaus
California State Northridge
Colorado State - Pueblo
Florida International University
McNeese State University
Missouri Western State University
North Carolina Central University
Prairie View A&M University
SE Missouri State University
University of Alaska Anchorage
University of Michigan, Flint
University of North Carolina Wilmington
University of the Virgin Islands
Youngstown State University
Liberal Arts Colleges
BYU-Hawaii
Carroll University
Eastern Oregon University
Gonzaga University
Hope College
Lake Forest College
Luther College
Manhattan College
Pacific Lutheran University
Spring Arbor University
St. Mary’s University of MN
University of St. Thomas
Valparaiso University
Viterbo University
Two-Year Colleges
American River College
Bismarck State College
Bucks County Community College
Columbia Basin College
Eastfield College
Harold Washington College
Longview Community College
Midland College
Mott Community College
Mt. Hood Community College
North Iowa Area Community College
Pasco-Hernando Community College
Raritan Valley Community College
Rochester Community & Technical College
Salt Lake Community College
San Jacinto College
Santa Barbara City College
Stark State College
Tidewater Community College
UM-Helena College of Technology
University of Wisconsin - Manitowoc
Washtenaw Community College

Students can make almost every instrumental measurement required in general and environmental chemistry and biology with MicroLab’s computer-based **FS-528 FASTspec™ Laboratory Data System**.

Powerful, transparent software engages students in science.

Integrated sensors and sensor amplifiers eliminate clutter from the lab bench, reduce cost, and create low-noise, high resolution measurements. Small changes in chemical and biological systems are clearly visible. Chemical quantities can often be reduced by a factor of ten.

MicroLab’s patented **FS-528 FASTspec™** scanning spectrophotometer opens a new spectrum of useful spectrophotometric applications not possible with traditional spectrophotometer designs.

With quick 360-880 nm scans, it provides simultaneous measurement of Fluorescence, Absorbance, Scatter, Transmission, and Turbidity. **FS-528 FASTspec™** includes software for Beer’s Law, spectrophotometric kinetics, spectrophotometric titrations, fluorescence, scatter and turbidity, and color comparisons.

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**From the front cover** ... This photograph of the 400-700 nm absorption spectra of green food dye, viewed above a white reference spectrum, was taken with MicroLab’s Visual Spectrometer. Note absorption in the violet and red. The **FS-528 FASTspec™** spectrophotometer (page 7) presents both visual and quantitative absorption spectra.
Graduates of the more than 500 U.S. and Canadian 4-year liberal arts colleges and universities contribute inordinately to the professions and to our national leadership. Strong resources and a focus on teaching provide exceptional opportunities for their students.

Four-year liberal arts colleges and universities claim among their strengths small class size, classes and labs taught by full-time faculty, strong student involvement in undergraduate research, and a concern for the overall growth of the student. This is an expensive but successful model. However, the addition of professional programs to the curriculum, increased enrollment, and economic pressures are stretching faculty time and budgets.

Chemistry faculty in these colleges and universities face several problems:

• Lab time is the most expensive instructional time in a college. The pressure is on for more effective use of lab time and reduced material costs. Equipment and software needs to be versatile, extremely reliable, and easy to use.

• Lab safety is becoming a pronounced concern. Smaller sample size made possible by high resolution measurements can reduce risk to students as well as cost.

• NSF and our professional organizations are encouraging us to become serious about developing student inquiry skills and to improve our course content.

• Assessment of student learning has become part of the university funding criteria to meet regional accreditation requirements.

MicroLab can help you use your budget and your lab time and space more effectively to meet these challenges.

With more than 280 years of combined experience in college/university chemistry teaching and research, members of MicroLab’s development team can help you improve your courses and protect faculty time. We have the same graduate training, experience, and concern for students and teaching as you, our colleagues. And we are always available to help.

This Catalog is a Sampler... This is not your usual catalog. It is a very short illustrated story of how MicroLab can help your students – and ours – visualize and understand important chemical concepts. It is a story about how affordable technology and high resolution measurements can reduce the need for expendable chemicals and improve lab safety. It is a story of how software designed for inquiry can engage students in experiment design and fast and accurate data acquisition. Data evaluation and analysis can be done right in the lab with the instructor participating.

This story uses as examples six key experiments from the general chemistry lab curriculum. Please check our web site www.microlabinfo.com or call or write us to obtain specialized mini-catalogs for spectrophotometry and electrochemistry, a full product catalog, pricing, and sample experiments.

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MicroLab’s high quality data and broad range of measurements make it valuable across the four-year chemistry curriculum. One instrument and versatile software can serve lab courses from freshman to senior level.

MICROLAB ADVANTAGES

• Cost-effective: Serves the function of a Spec-20, pH meter, manometer, precision thermometer, conductance meter and more.

• Better use of time: Many measurements can be taken in a short time. Students have time to run an experiment, evaluate it, modify their approach, and try again.

• Immediate feedback: MicroLab’s software plots titration and photometric curves and other data as the student measures them. This immediate feedback greatly enhances the impact of the experiment.

• Communication: Results are displayed in a clear, large format so that students and the instructor can see, discuss, and evaluate.

• Standard electrodes: MicroLab uses standard laboratory electrodes for pH, thermocouple, etc.

• Small footprint: MicroLab instruments are an unobtrusive addition to the bench top. There are no extraneous wires or gadgets on the bench or to store and keep track of.

• High Resolution: Low noise, high resolution data is valued by researchers because it provides a clear view into an experiment. MicroLab provides affordable, research-quality data for students.

• Small Samples: High resolution measurements mean small, low-cost, and safe chemical samples.
Graphing, Gas Laws and Proof-of-Concept Experiments

Boyle’s Law: Proof-of-Concept Experiment

The two graphs to the right illustrate gas pressure – volume data from a pre-written Boyle’s Law “Proof-of-Concept” experiment. This experiment used MicroLab’s internal 0-2 atmosphere pressure sensor and a simple plastic syringe to define sample volume. The left graph shows the pressure-volume relationship while the right graph plots volume vs 1/P, calculated in real time as the data comes in. Both graphs plot simultaneously on the monitor. Eight data points collected in a few minutes enable students to visualize the concept and provide “experimental proof” of the 1/P relationship. Up to four different live graphs may be plotted simultaneously.

Temperature and Pressure: Absolute Zero

This graph shows pressure increase as an air sample in a plastic 10 oz tonic water bottle was heated in a water bath from 28 degrees to 47 degrees. Plotting T vertically and extrapolating the T / P regression line to zero pressure, the intercept predicts a value for absolute zero of minus 269.38 °C. Low noise, high resolution measurements produce a result within 1.3% of the -273.15 °C theoretical value.

Inquiry and Use of Time in a MicroLab Laboratory

Lab should be a place where students learn, not just a place to collect data.

Computers can do a lot more for your lab students than just quickly collect data using small, inexpensive, and safe samples.

Both POGIL and the Science Writing Heuristic advocate an inquiry process that starts with a question about a real chemical system. Students and their instructor turn these questions into an experiment. They conduct the experiment, discuss, analyze and evaluate their results, and use their observations to develop a model of the system.

MicroLab’s software can help students structure their experiment design. They can quickly collect, analyze, and graph high quality data. These graphs, generated immediately and large enough for students and instructor to see, focus in-lab discussion and evaluation of the experiment. Students understand the experiment and the concept when they leave the lab. They have time to revise and run the experiment again if necessary.

A MicroLab experiment is a lot more than just collecting data. Students are involved in all aspects of the process of science, from identification of the problem and design of the experiment, to data collection and analysis, to evaluation and concept development.

PLAN

Identify the problem and devise an experiment to find information needed to solve this.

WORK

Set up the experiment, calibrate sensors if necessary, and collect data.

Organize and analyze the data. Look for concepts and generalizations.

EVALUATE

Evaluate the result and decide if you have a solution to the problem. If not, modify the experiment design and run it again.

MicroLab provides time, in the lab, for instructors to participate in planning and evaluation of the experiment (blue).

Twelve laboratory topics are key to 85 General Chemistry programs recently surveyed by Dr. Steve Brown of the University of Arizona. The MicroLab FS-524 FASTspec™ supports all of the instrumental measurements (green) required for these topics.

Graphing is the underlying analysis skill used in all of these experiments.

Experiments are available for no-cost download from the MicroLab website. Faculty can easily adapt existing experiments for MicroLab.
Acid-Base Chemistry: Titration Curves and Inquiry

Turning Proof-of-Concept into Inquiry Experiments

There is a lot more information available in titration curves than is provided by a simple indicator end-point titration.

MicroLab makes it easy for students to plot volume with respect to pH, temperature, or other solution properties, as the titration proceeds. Instead of just looking for a numeric answer, they can ask “How does this system work?”.

This phosphoric acid / NaOH example illustrates identification of buffer regions, calculation of pKa, and the use of derivative plots to accurately locate end-points. Students can also use titration curves to match chemical indicators to equivalence point pH.

None of these concepts can be developed easily with manual titrations.

Counting Drops

Drop counters and an inexpensive drop dispenser are a useful and cost-effective alternative to burettes. They will not break and their resolution is about 50% better than a burette. And they do not get tired or distracted. A drop counter is calibrated by counting the number of drops required to fill a 10.00 mL graduated cylinder.

MicroLab’s formula tool is used to convert drops directly into volume during the titration.

mL = (drops)*(mL/drop).

MicroLab’s patented Model 226 Drop Counter uses a reflective infra-red sensor. A background correction circuit measures and subtracts background light making the unit immune to changes in room lighting. An internal circuit inserts a 25 millisecond “dead time” at the detection of each drop, eliminating false counts from fragmented drops.

Creating Constant Volume Drops

Accurately counting drops is only half of the task. Equally important is a source of repeatable, constant volume drops. A burette, because of its large pressure head change during a titration and relatively large drop size (0.05 mL), is a poor choice for a drop dispenser. Both drop size and drop rate are dependent on a drop dispenser’s pressure head.

MicroLab’s new precision Model 154 Constant Volume Drop Dispenser has a 50 mL titrant reservoir and will deliver 30 mL with a 1 cm change in pressure head - about 3% the pressure head change of a burette. Drop rate is easily controlled by a multi-turn needle valve, and a stopcock controls on/off after drop rate is set.

Drop volume is about 0.034 mL, and a volume / drop count graph is linear with five 9’s in its correlation coefficient. Because of its extremely constant flow rate, the Model 154 Drop Dispenser can also be used for timed titrations without a drop counter.

Weak Acids and pKa’s

The phosphoric acid titration graph shown here illustrates the quality of data this system will produce. Removal and neutralization of the first and second hydrogens show clearly as inflections in the graph. A first derivative plot identifies the end points – one can match the maximum derivative value and pH with volume to calculate end point to a titrant volume within 0.034 mL. pKa values – the pH at the center of the each of the buffer regions – can be observed in the data table and estimated on the graph.

Heat of Reaction

The blue line in this phosphoric acid titration data shows the importance of high resolution, low noise temperature measurements. The rate of temperature change (slope) during neutralization of the first hydrogen is greater than that for the second. Removal of the first hydrogen has a greater heat of reaction than the second. The total temperature change in this experiment was only about 0.9 degrees C. The titration was run in a Styrofoam cup. It used 20 mL of titrant.

Low noise, high resolution measurements mean small sample sizes and experiments that don’t have to be repeated. Careful experiments give text-book results.
New Tools for Electrochemistry

Electrochemistry is somewhat of a step-child in the general chemistry curriculum. Often left for quick treatment at the end of the semester, “hands-on” electrochemistry labs are thought difficult and expensive. This need not be true. Here are some new tools that use small samples and will make electrochemistry understandable, affordable, easy and fun to teach – and to learn!

The MicroLab 528’s black and red “Voltage” banana jacks play double duty. For spontaneous electrochemical experiments such as the electrochemical series and the Nernst equation, they measure DC voltage ± 2500 mV with a resolution of ± 0.076 mV. For forced electrochemical experiments such as electroplating, these banana jacks provide an adjustable regulated 0-5 volt DC power supply delivering up to 750 mA.

Spontaneous Electrochemical Reactions:
Oxidation/Reduction • Half Cell Reactions • The Electrochemical Series • The Nernst Equation

MicroLab’s Model 152 Mult-EChem Half Cell Module has space for eight metal/ion electrochemical half cells, each equally accessing a central aqueous salt bridge through a replaceable porous cylinder. Small (3 mL) samples provide extremely stable electrochemical cell voltage measurements.

The order of elements and the voltage difference between elements in the electrochemical series is the same regardless of choice of reference half-cell. Voltages on the right used a Pb / Pb²⁺ reference half cell. Voltages on the left refer to a standard hydrogen half-reaction. Electron motion in a Zn/Cu cell is illustrated in red.

MicroLab’s half-cell display shows direction of electron motion and identifies the oxidation and reduction reactions, as well as displaying cell voltage.

Forced Electrochemical Reactions: Electroplating • Coulometry

- Electroplating experiments - demonstration of electrochemical reduction and its industrial applications.
- Electro-gravimetric experiments - including determination of Avogadro’s number, ionic charge, and atomic mass.
- Coulometric titrations that generate the titrant through electrochemical oxidation or reduction in a solution.
- MicroLab’s Coulometry software integrates current over time to calculate coulombs of charge or moles of electrons delivered.

Cyclic Voltammetry

MicroLab’s affordable Model 170 Cyclic Voltammetry Module uses inexpensive Pine Instrument disposable screen-printed electrodes (10 included). It connects to the FS-528’s Port A multipurpose input, will scan with 1-20 mV steps, and can plot current vs applied voltage or current vs voltage referenced to an Ag/AgCl electrode.

Cyclic voltammogram of a phthalocyanine compound with a Pine Instruments screen printed electrode.

–Data by Dr. Erin Anderson, National Cancer Institute.

All MicroLab data may be exported into Excel for further analysis with a simple mouse click.
More Spectrophotometry with MicroLab: Molecular Absorption Spectra and FS-528 FASTspec™

Absorption spectrophotometry is the workhorse of analytical chemistry. Measurements are quick, accurate, inexpensive, and usually take little sample preparation. However, although spectrophotometry is based on color, it is almost always taught with instruments that present a sterile black-and-white view of a colorful and interesting science.

Students can use MicroLab’s Model 141 Visual Spectrometer and our MicroLab FS-528 FASTspec™ scanning spectrophotometer to bridge the gap between visual observation and quantitative measurement of absorption spectra.

If you place a vial of colored liquid in the Visual Spectrometer and look at a white light source (the sky, or an incandescent white light bulb), you can view the absorption bands together with a continuous white reference spectrum (right). This food dye sample looks green because it absorbs blue/violet and red light. The absorption bands are real and highly visual.

Working from measured absorbance data, MicroLab’s FS-528 FASTspec™ scanning spectrophotometer creates the same visual display (below, with the blank now on top) to provide students both visual and quantitative display of absorption spectra with every scan.

Beer’s Law – Selection of an Analytical Wavelength

Selection of a wavelength for Beer’s Law experiments is counter-intuitive. Students find it hard to understand because it is the light that is absorbed that counts, not what comes through the colored sample. Conventional wisdom is to choose green light for a green sample. What is going on here? You have to think absorbance. Here’s how it works with MicroLab:

These four figures represent spectral scans of the five green food dye samples pictured above, using MicroLab’s FS-528 FASTspec™ scanning spectrophotometer.

The difference between these graphs is the choice of analytical wavelength, which determines the molar absorptivity constant of the sample. The slope of the Absorbance / Concentration graph is determined by the molar absorptivity constant and the path length. Path length is held constant by using the same diameter vials.

The first graph violet has a greater slope and thus greater analytical sensitivity than the blue measurement because the molar absorptivity is greater at the violet wavelength.

Note the quality of the data: The correlation coefficient of the Beer’s Law line is 0.9994.

The green measurement has the least sensitivity because the absorbance of the sample is least in the green region.

The red measurement illustrates the effect of deviations from Beer’s Law at high absorbance. When absorbance is high, very small amounts of stray light become significant and lower the observed absorbance at the detector. A non-linear curve fit works for concentration, though the errors in measuring an unknown become much greater as the curve flattens out. All of this can be explored easily with a few mouse clicks.
MicroLab’s FS-528 FASTspec™

NEW 5th Generation Features!
- Constant Temperature Heater System
- Sample Illumination
- Rotating Field Magnetic Stirring
- Real-time Tactile Control
- Regulated Electroplating/Coulometry Power Supply
- Cyclic Voltammetry
- FASTspec™ Scanning Spectrophotometry 360-880 nm
  - Patented FASTspec™ Technology
  - Fluorescence
  - Absorbance
  - Scatter
  - Transmission
  - Beer’s Law
  - Kinetics
  - Spectral Profiles
  - Color Comparison
  - Turbidity / Nephelometry
  - Backscatter Turbidity
  - Spectrophotometric pH/Indicator Titrations

Basic Measurements
- pH/Redox /DO
- Gas Pressure
- Temperature
- Light Conductance
- Voltage/Electrochemistry
- Time
- Counts/drops
- Thermocouple
- Volts/Millivolts
- Milliamperes

PLUS, MicroLab’s advanced software operates at four levels:
- Prewritten programs provide quick, accurate data for proof-of-concept experiments.
- Instrument programs provide intuitive display of complex spectrophotometric and electrochemical data.
- Drag-and-Drop Experiment design tools encourage inquiry experiments.
- Advanced programming tools support original research.

Software
- All MicroLab products include software and a FREE site license. You can place copies of the software on all your departmental computers, at common access points for students, or even make copies for students for their personal PC’s.

Warranty
- MicroLab equipment is designed and manufactured in the US. We stand behind the quality of our product and provide a five year warranty on all MicroLab products. If you ever have a problem with a piece of MicroLab equipment, call us and make it our problem.

Welcome to MicroLab
- Most of us who teach college and university chemistry are running a balancing act. We have more students, many more in some cases. Our lab space is limited. The pressure is on for shorter lab periods, reduced costs and chemical use, and improved safety.
  - At the same time, we are encouraged to improve our course content and to be serious about developing inquiry skills.
  - MicroLab can help you use your lab time and space more effectively to meet these challenges.
  - With more than 280 years of combined experience in research and in college and university teaching, members of MicroLab’s team have the same graduate training, experience, and concern for students and teaching as you, our colleagues.
  - MicroLab can make lab a place where students learn, not just a place to collect data. Both proof-of-concept and inquiry experiments can be carried through to their conclusion in a 2-3 hour lab period.
  - With three U.S. patents recently granted, MicroLab’s technology and software are at the cutting edge. MicroLab’s instruments are versatile, rugged, and quick to learn. They will serve lab courses from freshman to senior, and undergraduate research.
  - We look forward to visiting with you about your laboratory and curriculum needs, and to meeting you at an ACS or 2YC3 meeting.

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