

Engineering Student Technology Committee

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College of Engineering

Colorado State University

1. Title of Proposal: *Integrating Data Acquisition into the Undergraduate Geotechnical Engineering Laboratory*

2. Proposal Participants: *Christopher Bareither and Joseph Wilmetti*

Primary Contact for Proposal

Name: Christopher Bareither

E-Mail: christopher.bareither@colostate.edu

Department/Major: Civil and Environmental Engineering

Check One: **Faculty** **Staff** **Student**

Additional proposal participants

Name: Joseph Wilmetti

E-Mail: joseph.wilmetti@colostate.edu

Department/Major: Civil and Environmental Engineering

Check One: **Faculty** **Staff** **Student**

3. Proposal Abstract (limit to 100 words):

Introduction to Geotechnical Engineering Laboratory (CIVE 356) is a required 1-credit laboratory course for all Civil Engineering undergraduate students. This course focuses on experiential learning to teach fundamentals of soil property measurement, data analysis, and report writing. The objective of this project is to integrate computer-based data acquisition into CIVE 356 to enhance the laboratory experience. Students will learn fundamentals of a data acquisition system, how to interface between physical and digital platforms, how to calibrate electronic sensors, and how to incorporate data acquisition into conventional geotechnical experiments.

4. Proposal Budget

List of items to purchase and cost of each

The Fu Hua Chen Geotechnical Teaching Laboratory includes six fully-equipped stations that have the required materials and equipment to complete all laboratory exercises in CIVE 356, Introduction to Geotechnical Engineering Laboratory. The focus of this proposal is to upgrade the existing equipment with data acquisition capabilities. Data acquisition equipment that will be purchased for this proposed project is included in Table 1. Each laboratory station will be equipped with a Microsoft Windows-based laptop, National Instruments DAQ board, 12-V external power supply, two linear variable displacement transducers (LVDT), and a load cell with signal conditioner. This equipment will provide the necessary measurement capabilities to support testing for the evaluation of engineering properties of soils.

Table 1. Data acquisition equipment to be purchased for the proposed project.

Item	Source	Cost per Unit (USD)	Units	Subtotal
Laptop PC (ThinkPad X131e)	ENS at CSU	\$539	6	\$3,234
NI USB 6009 DAQ board	National Instruments	\$324	6	\$1,944
External 12-V power supply	Circuit Specialists	\$19	6	\$113
25-mm stroke length DC LVDT	Novotechnik	\$175	12	\$2,100
2000-lb S-type load cell	Interface	\$370	6	\$2,220
In-line signal conditioner	Interface	\$260	6	\$1,560
Protective case for equipment	Pelican Products, Inc.	\$88	6	\$528
Total =				\$11,669

Dollar or percentage amount requested from ESTC: \$11,669

5. Full description of proposal:

The undergraduate Civil Engineering curriculum requires students to take Introduction to Geotechnical Engineering Laboratory (CIVE 356), a 1-credit companion course to CIVE 355, Introduction to Geotechnical Engineering. The laboratory course is structured around a 3-hr laboratory session where students complete fundamental experiments to measure soil characteristics (e.g., composition, specific gravity) and engineering properties (e.g., shear strength). These exercises provide unique, hands-on learning opportunities that allow students to learn techniques in laboratory measurement, data analysis, and report writing while reinforcing and expanding on content covered in lecture (i.e., CIVE 355). During the fall semester of 2013 there were 33 students enrolled in CIVE 356 and there are currently 46 students enrolled for the spring 2014 semester. Thus, on an annual basis approximately 80 students can be expected to benefit from the proposed technology upgrade.

The focus on experiential learning in the laboratory course is highly beneficial to all Civil Engineering undergraduates. Laboratory exercises in CIVE 356 related to engineering property measurement currently rely on manually reading dial-gage indicators to assess soil deformation and loading (normal and shear) during testing. Although this technique is functional for collecting data during testing, modern geotechnical engineering laboratories incorporate state-of-the-art data acquisition and control systems. The objective of this proposal is to integrate data acquisition (DAQ) into CIVE 356 to expose and teach students fundamentals of DAQ and enrich their laboratory-based experiential learning.

Data acquisition (DAQ) will be integrated into CIVE 356 such that the DAQ equipment proposed for purchase in this proposal will be used during half of a semester. The proposed laboratory schedule for CIVE 356 as well as the conventional schedule that has been implemented for the past few years is in Table 2. An introduction to DAQ laboratory session will be created and cover an overview of DAQ equipment, system connection and performance considerations (e.g., measurement accuracy), and sensor calibration. During the introductory laboratory session, each student group will learn how to connect sensors and create a DAQ interface between the laptop, DAQ board, and sensors in LabVIEW. One of the key deliverables

for this introductory session will be the creation of calibration curves for all sensors that the students will use in the subsequent exercises (e.g., consolidation, direct shear, unconfined compression).

A proposed short design project will be implemented at the end of the course that will allow students to create a basic hypothesis, design an experiment to test their hypothesis, and implement testing and analysis over a two-week period. The design project will be based on evaluating engineering properties of soils such that DAQ equipment will be used throughout the project. Incorporating a design project that integrates state-of-the-art DAQ equipment will further enhance experiential learning and provide students a unique opportunity to create, test, and evaluate a hypothesis.

Table 2. Traditional and proposed CIVE 356 laboratory exercise outlines.

Week	Traditional Laboratory Exercise Outline	Proposed Laboratory Exercise Outline
1	Lab introduction	Lab introduction
2	Soil identification & weight-volume relationships	Soil identification & weight-volume relationships
3	Mechanical sieve & specific gravity	Mechanical sieve & specific gravity
4	Hydrometer	Atterberg limits
5	Atterberg limits	Compaction
6	Compaction	Hydraulic conductivity
7	<i>Break</i>	<i>Break</i>
8	Relative Density	Intro to Data Acquisition
9	Hydraulic conductivity	Consolidation I
10	Consolidation I	Consolidation II
11	Consolidation II	Direct shear
12	Consolidation III	Unconfined compression
13	Direct shear	Design project
14	Unconfined compression	Design project
15	<i>No Labs</i>	<i>No Labs</i>
16	<i>No Labs</i>	<i>No Labs</i>

Subject:notebook for the new lab

Date:Wed, 19 Feb 2014 10:27:48 -0700

From:Ryan Medhurst <medhurst@engr.colostate.edu>

To:joseph.wilmetti@colostate.edu

Cart details

Quantity	Part number	Description	Availability	Item price	Line total
1	3368CTO	ThinkPad X131e - 1 Year Depot Warranty	Ships in 5-7 days	\$539.00	\$539.00
		Processor	Intel Core i3-3227U Processor (3M Cache, 1.90 GHz) on Mother Board		
		Operating System	Windows 8 64		
		Operating System Language	Windows 8 64 English		
		Display Type	11.6" W HD (1366 x 768)LED, Anti-Glare, Midnight Black (w/WWAN), 720p HD Camera		
		System Graphics	Intel GMA HD Gfx 4000, Intel Core i3-3227U ULV Processor (1.9GHz, 3MB L3, 1600MHz DDR3)		
		Total Memory	4 GB DDR3 - 1600MHz (1 DIMM)		
		Keyboard	Keyboard US English		
		Hard Drive	500GB Hard Disk Drive, 7200rpm		
		Battery	6 Cell Lithium Battery (X131e)		
		Power Cord	65W AC Adapter - US (2pin)		
		Integrated WiFi			
		Wireless LAN Adapters	ThinkPad a/b/g/n Wireless BT Combo (2x2 ABGN & BT4.0)		
		Integrated Mobile Broadband	Mobile Broadband upgradable		
		Language Pack	Language Pack Win8 US English		
		Warranty	1 Year Depot/Express Warranty		

Subtotal: **\$539.00**

[USXDISCOUNT] **-\$26.95**

Estimated total:

...



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NI USB-6009

14-Bit, 48 kS/s Low-Cost Multifunction DAQ

- 8 analog inputs (14-bit, 48 kS/s)
- 2 analog outputs (12-bit, 150 S/s); 12 digital I/O; 32-bit counter
- Bus-powered for high mobility; built-in signal connectivity
- OEM version available
- Compatible with LabVIEW, LabWindows™/CVI, and Measurement Studio for Visual Studio .NET



Overview

The NI USB-6009 provides basic DAQ functionality for applications such as simple data logging, portable measurements, and academic lab experiments. It is affordable for student use and powerful enough for more sophisticated measurement applications. For Mac OS X and Linux users, download the NI-DAQmx Base driver software and program the USB-6009 with NI LabVIEW or C.

To supplement simulation, measurement, and automation theory courses with practical experiments, NI developed a USB-6009 Student Kit that includes a copy of LabVIEW Student Edition. These kits are exclusively for students, giving them a powerful, low-cost, hands-on learning tool. See the Resources tab for more details.

For faster sampling, more accurate measurements, calibration support, and higher channel count, consider the NI USB-6210 and NI USB-6211 high-performance USB DAQ devices.

USB DAQ modules are compatible with the following versions (or later) of NI application software: LabVIEW 7.x, LabWindows/CVI 7.x, or Measurement Studio 7.x. USB DAQ modules are also compatible with Visual Studio .NET, C/C++, and Visual Basic 6.0.

The mark LabWindows is used under a license from Microsoft Corporation. Windows is a registered trademark of Microsoft Corporation in the United States and other countries.

Specifications

Specifications Documents

- Specifications (2)
- Data Sheet

Specifications Summary

General

Product Name	USB-6009
Product Family	Multifunction Data Acquisition

Form Factor	USB
Part Number	779026-01
Operating System/Target	Mac OS , Pocket PC , Windows , Linux
DAQ Product Family	B Series
Measurement Type	Voltage
Isolation Type	None
RoHS Compliant	Yes
USB Power	Bus-Powered
Analog Input	
Channels	4 , 8
Single-Ended Channels	8
Differential Channels	4
Resolution	14 bits
Sample Rate	48 kS/s
Throughput (All Channels)	48 kS/s
Max Voltage	10 V
Maximum Voltage Range	-10 V , 10 V
Maximum Voltage Range Accuracy	7.73 mV
Minimum Voltage Range	-1 V , 1 V
Minimum Voltage Range Accuracy	1.53 mV
Number of Ranges	8
Simultaneous Sampling	No
On-Board Memory	512 B
Analog Output	
Channels	2
Resolution	12 bits
Max Voltage	5 V
Maximum Voltage Range	0 V , 5 V
Maximum Voltage Range Accuracy	7 mV
Minimum Voltage Range	0 V , 5 V
Minimum Voltage Range Accuracy	7 mV

Update Rate	150 S/s
Current Drive Single	5 mA
Current Drive All	10 mA
Digital I/O	
Bidirectional Channels	12
Input-Only Channels	0
Output-Only Channels	0
Timing	Software
Logic Levels	TTL
Input Current Flow	Sinking , Sourcing
Output Current Flow	Sinking , Sourcing
Programmable Input Filters	No
Supports Programmable Power-Up States?	No
Current Drive Single	8.5 mA
Current Drive All	102 mA
Watchdog Timer	No
Supports Handshaking I/O?	No
Supports Pattern I/O?	No
Maximum Input Range	0 V , 5 V
Maximum Output Range	0 V , 5 V
Counter/Timers	
Counters	1
Buffered Operations	No
Debouncing/Glitch Removal	No
GPS Synchronization	No
Maximum Range	0 V , 5 V
Max Source Frequency	5 MHz
Pulse Generation	No
Resolution	32 bits
Timebase Stability	50 ppm
Logic Levels	TTL

Physical Specifications

Length 8.51 cm

Width 8.18 cm

Height 2.31 cm

I/O Connector Screw terminals

Timing/Triggering/Synchronization

Triggering Digital

Synchronization Bus (RTSI) No

Pricing

NI USB-6009 Complete Package

Each NI USB-6009 requires:

Roll over icons above to learn why you need each item in the package.

NI USB-6009 Software

NI USB-6009 and Accessories

NI USB-6009 - 779026-01 Qty \$ 289 each

Recommended Accessories

Connectivity Accessory - USB 6008/09 Accessory Kit - 779371-01 Qty \$ 35 each

Optional Accessories

USB 6000 Series Prototyping Accessory - 779511-01 Qty \$ 36 each

Hardware Subtotal: \$ 324

Software

Note : You should only purchase this device without software if you already own compatible application software. [\[View Full List\]](#)

LabVIEW Base Development System for Windows (English) , 1 year SSP - 776671-35 Qty \$ 999 each

Change Software

Learn about all compatible software and get recommendations based on your needs.

Software Subtotal: \$ 0

Estimated Shipping Days: 5 - 10

Package Price: \$ 324

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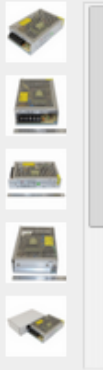
Resources

Additional Product Information

- [Dimensional Drawings](#)
- [Product Certifications](#)

Related Information

- [NI USB DAQ for OEM](#)
- [Download NI DAQ Drivers](#)
- [NI SignalExpress Interactive Data-Logging Software](#)
- [NI USB-6009 Student Kit](#)



12 Volt Power Supply - 5.0 Amp Single Output

Item no. PS1-60W-SL12

1	\$19.950
10	\$18.900
100	\$18.150

Qty

96 In Stock

[Manual](#)
 [Spec sheet](#)
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 [ROHS statement](#)

12 Volt Power Supply - 5.0 Amp Single Output

A 60W 12V/5A Highly Reliable, Universal AC input/full range single output power supply. They have the approval of UL and CE and come 100% full load burn-in tested and are protected with overload/over and voltage/short circuit. Also included is a 2 year manufacturer's warranty. Dimensions: 6.4 x 3.92 x 1.56"

- Brand: PowerSupply1
- Complies with RoHS Directive
- AC Input Voltage Range: 85-264VAC
- Input Frequency: 47-63Hz
- Inrush Current: Cold Start, 20A/115V, 40A/230V
- Input Leakage Current: <0.7mA/230V
- Line Regulation (Full Load): <± 0.5%
- Output Voltage Adj. Range: ± 10%
- Output Overload Protection: 110-150%
- Output Over Voltage Protection: 115-150%
- Withstand Voltage: I/P-O/P: 3.0KVAC/1 min; I/P-F/G: 1.5KVAC/1 min; O/P-F/G: 0.5KVAC/1 min
- Rise Time: 50ms@full load (typical)
- Hold Up Time: 20ms@full load (typical)
- Operating temp.& humidity: -10°C to 50°C (14°F - 122°F), 20%-93%RH (non-condensing)
- Storage temp.& humidity: -20°C to 85°C (-4°F - 185°F), 20%-93%RH (non-condensing)
- MTBF: 100,000 hours
- UL Ref. Number: E258719
- EMC Standards: GB9254, EN55022 classB, EN55024, EN61000-3-2,3, EN61000-4-2,3,4,5,6,8,11
- Cooling Method: Convection

[Spec Sheet](#)



Our 12 volt power supply selection

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155 Northboro Road
Southborough, MA 01772
Telephone: (508) 485-2244
FAX: (508) 485-2430
E-Mail: info@novotechnik.com

DATE: 2/20/14

TO: Colorado State Univ

ATTENTION: Christopher Bareither

PHONE:

FAX:

FROM: Brenda Bourgeois

PAGES: _____ Including Cover

FAX LOG #:

Dear Christopher,

The following is the information you requested on our TRS Series Transducers currently available from Novotechnik U.S. Incorporated.

<u>DESCRIPTION</u>	<u>QUANTITY</u>	<u>PRICE</u>
TRS25	12	\$175.00 each

Units are in stock.

If you have any questions or concerns after reviewing this information, please feel free to contact us at anytime.

Best Regards,

Brenda Bourgeois, Customer Service

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SSM / SSM2 Sealed S-Type Load Cell

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- Proprietary Interface temperature compensated strain gages
- Environmentally sealed
- 0.02% nonrepeatability
- 0.0008%/°F (0.0015%/°C) temp. effect on output
- 0.025% creep
- Tension and compression

20 kN

- English standard
- Metric standard

Part number	Capacity	Description	Price	Qty
SSM-AJ-50	50 lbf	Sealed S-type load cell with 10-ft integral cable	\$290.00	<input type="text" value="1"/> Add to cart
SSM-AJ-100	100 lbf	Sealed S-type load cell with 10-ft integral cable	\$290.00	<input type="text" value="1"/> Add to cart
SSM-AJ-250	250 lbf	Sealed S-type load cell with 10-ft integral cable	\$290.00	<input type="text" value="1"/> Add to cart
SSM-AJ-2000	2,000 lbf	Sealed S-type load cell with 10-ft integral cable	\$370.00	<input type="text" value="1"/> Add to cart
SSM-AJ-3000	3,000 lbf	Sealed S-type load cell with 10-ft integral cable	\$370.00	<input type="text" value="1"/> Add to cart
SSM-AJ-5000	5,000 lbf	Sealed S-type load cell with 10-ft integral cable	\$415.00	<input type="text" value="1"/> Add to cart
SSM-AJ-500	500 lbf	Sealed S-type load cell with 10-ft integral cable	\$290.00	<input type="text" value="1"/> Add to cart
SSM-AJ-1000	1,000 lbf	Sealed S-type load cell with 10-ft integral cable	\$290.00	<input type="text" value="1"/> Add to cart

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In-Line Millivolt to Analog Converter

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- ✓ DC powered
 - ✓ ±5 VDC or 4-20 mA
 - ✓ Small size
 - ✓ Ultra-stable electronics
- Small, DC powered in-line signal conditioner with 9-pin connectors, +/-5V and 4-20mA outputs and 1000Hz bandwidth.

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This product is manufactured in metric standard capacities only. Refer to metric tab above.

Accessories

500-4-10 Small, DC powered in-line signal conditioner with 9-pin connectors, +/-5V and 4-20mA outputs and 1000Hz bandwidth. \$260.00 Add to cart

- Interface UK
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You Pay: \$88.12

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Ratings: 17 reviews write a review

Product Highlights

- Watertight, Dustproof Case Made of Ultra High Impact Copolymer Three-piece Foam Set Automatic Pressure Equalization Valve Easy-open Double Throw Latches Stainless Steel Padlock Protectors Folding Handle Lifetime Guarantee of Excellence

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The Pelican 1450 Case with Foam (Orange) is an unbreakable, watertight, airtight, dustproof, chemical-resistant and corrosion-proof hard case used to carry any kind of equipment that needs to be protected from the elements. It is made of Ultra High Impact structural copolymer that makes it extremely strong and durable. It includes a 0.25" (6.4 mm) neoprene o-ring, easy-open double throw latches that seal perfectly, and an automatic pressure equalization valve for quick equalization after changes in atmospheric pressure. The case has a comfortable rubber over-molded handle.

This case includes a 3-piece foam set.

Construction

- Ultra High Impact structural copolymer Watertight, crushproof, and dustproof Foam interior Open cell core with solid wall design Stainless steel hardware

Three-piece foam set that consists of 1 "egg crate" foam upper section, 1 Pick 'N' Pluck foam section and one 1.0" blank bottom foam section

Automatic pressure equalization valve

0.25" (6.4mm) neoprene o-ring

Essential Accessories

Inserts & Foams

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Pelican - 1451 Foam Set Price: \$24.99

Desiccant



Pelican - Silica Gel Price: \$9.95

Trolley Systems



Norris - 90-2E Cart - 250 lbs Capacity Price: \$64.99

Usually ships in 7-14 business days

Related Accessories

Easy-open double throw latches with stainless steel padlock protectors

Temperature rating -40 to +210°F (-40 to +95°C)

Comfortable rubber over-molded handle



Pelican - 1453 O-Ring
Price: \$2.95

Certifications

- IP67 (Ingress Protection) = 1 meter submersion or 30 minutes
- MIL C-4150J (Military Standard)
- Defense standard 81-41/STANAG4280

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