Online Lab Sections with the IOLab & Remotely Operated Experiments in 1st yr. Physics

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KPU Physics

Overview

<u>The Course</u>
PHYS 1100 is a one-semester algebra-based course with mechanics and E & M.

<u>Format</u>: students take (any permutation)

Lecture		Lab
• on campus	&	• on campus
• online		• online (this poster)
• hybrid		

<u>Online Labs (9 total) – avail. since 2017</u>

- 7 using IOLab
- 2 remotely operated
- content & sequence parallel on-campus sections

Weekly Cycle

<u>Pre-lab Assignment</u>

- Available Sunday, due Wednesday
- Equips students with theory, orientation and analysis tools

<u>Lab Experiment & Report</u>

- Available upon pre-lab submission
- due Sunday
- Students make prediction, perform experiment, write discussion incl. uncertainty

<u>Learning Progression</u>

Early Labs

- Student lab reports are heavily guided

Later Labs

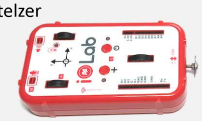
- progressively freer in format
- progression in student expectations

The Labs

#	Topic	Experiment	mode	Pre-lab activity	Lab activity	Other Skills	Notes
1	Uniform Motion	Students explore motion in one dimension and its graphical representation.	IOLab	1. Explore x(t) graphs of objects in motion 2. Install the IOLab software on own device 3. Explore the basic functions/sensors of IOLab	Given sketches of x(t) graphs 1. reproduce graphs by moving IOLab accordingly.	Connecting physical motion to its graphical representation and vice versa.	This pre-lab is longer than most and is spread over 2 weeks.
2	Acceleration	Students explore how position and velocity change with time for various types of motion in 1D.	IOLab	1. Match a described motion with x(t) and v(t) graphs 2. Introduction to measurement uncertainties and their propagation	Students push the IOLab up a ramp to 1. produce x(t) and v(t) graphs 2. determine the acceleration and ramp angle	Comparing obtained graphs with prediction. Start work with uncertainties.	Students construct/improvise a ramp with household items.
3	Freefall	Students send IOLab in freefall. Graphical analysis yields g.	IOLab	1. Tutorial on data tables, graphing with error bars and interpreting linear graphs 2. Setting up the freefall experiment with IOLab	1. Drop IOLab onto a cushion from different heights 2. Measure time of freefall using accelerometer to plot a graph whose slope is predicted to be g/2	Constructing data tables Graphing with error bars Interpreting linear graphs	Students write discussion by filling in blanks as prompted.
4	Projectile Motion	Students launch IOLab over edge of table.	IOLab	1. Explore projectile motion from a horizontal platform using a simulation 2. Prepare and practice launching IOLab from table while taking data	1. Predict projectile range from table height and IOLab's speed at launch 2. Measure range from landing location	Uncertainty propagation Do measured result and prediction agree within uncertainty?	Students write discussion by filling in blanks as prompted.
5	Acceleration on an Incline	Students roll cart down inclined track using remote control.	remote	1. Simulation assisted tutorial to derive "a = g sin θ", with uncertainties 2. Tutorial on operation of remote equipment	1. Predict acceleration from height and length of track 2. Measure acceleration from slope of v(t) graph	Uncertainty propagation Do measured result and prediction agree within uncertainty?	Students write discussion from scratch, based on experience with prior labs.
6	Uniform Circular Motion	Students swing IOLab around in circle on a string while force sensor measures tension.	IOLab	1. Simulation assisted tutorial on uniform circular motion 2. Tutorial on using IOLab force sensor	1. Measure period and radius to calculate speed, centripetal acceleration and force. 2. Measure centripetal force using force sensor	Uncertainty propagation Do measured result and prediction agree within uncertainty?	Decreasing guidance given. Students have opportunity to discuss many potential sources of error.
7	Impulse and Momentum	Students bounce IOLab cart w/ spring bumper off a solid object.	IOLab	1. Students prepare and practice the collision while taking data	1. Change in velocity is compared to the area under F(t) graph	Interpreting v(t) and F(t) graphs for momentum and impulse	Students perform calculations and write discussion independently.
8	Conservation of Mechanical Energy	Students roll IOLab as a roller coaster.	IOLab	1. Roller coaster simulation, with friction 2. Students prepare a roller coaster-like track for IOLab	IOlab is sent down track and 1. calculate total energy from height and speed data	Performing relevant calculation and comparisons with minimal guidance	Energy is usually not conserved, as seen in pre-lab simulations.
10	Electron charge-to-mass ratio (e/m)	JJ Thomson's e/m experiment is performed by remote control.	remote	1. Orientation of equations used for analysis 2. Tutorial on operation of remote equipment	1. Measure accelerating voltage and Helmholtz coil current 2. Work out a value for e/m	Writing entire report from scratch, based on experience with prior labs.	Students given two weeks to complete this lab.

What is IOLab?

Invented by physicists Mats Selen & Tim Stelzer



Built in sensors include:

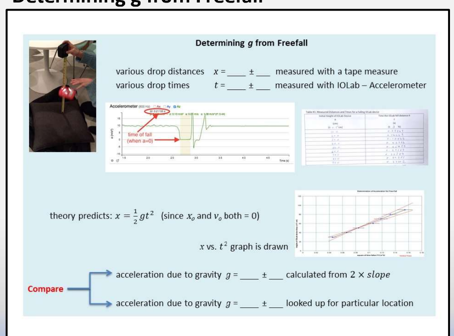
- 3D accelerometer
- 3D magnetometer
- 3D gyroscope
- Optical encoder wheel (rolls as cart)
- Force probe
- Light intensity sensor
- Atmospheric pressure sensor
- Temperature sensor
- Microphone

Also:

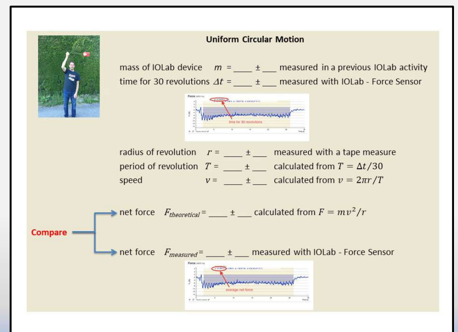
- 6 analog inputs
- 6 digital inputs
- DC coupled high gain differential amp
- DAC output

Sample IOLab Expts

Determining g from Freefall



Uniform Circular Motion



Future Plans

Encourage more interaction

- Peer-to-peer (e.g. online forum)
- Student-instructor (videoconference)

Building own *CloudLab* units

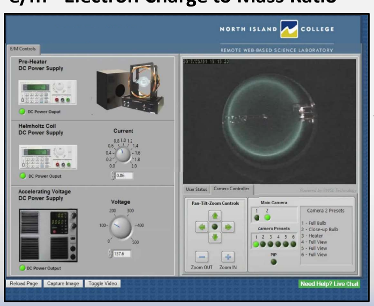
- Expts that work better as remote

New partner institutions

Library handles lab kit loans

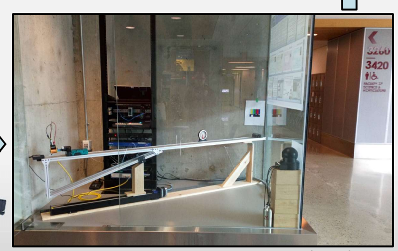
CloudLabs

e/m - Electron Charge to Mass Ratio



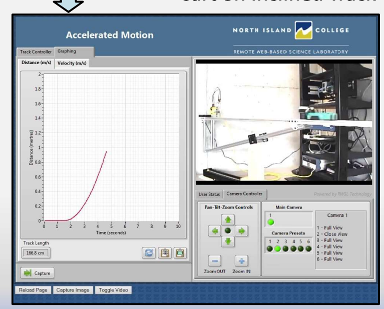
Equipment located 150 km away at North Island College (Comox, BC) are operated remotely by students through the internet.

RWSL/NANSLO facility includes lab equipment for Physics, Chemistry & Biology and are described further at
http://www.nic.bc.ca/rwsl and
http://www.wiche.edu/nanslo



This unit is located at KPU-Richmond (new)

Cart on Inclined Track



Thanks

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Resources & Contact

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Handouts, lab manuals and more at
http://www.kpu.ca/physics/sato/CAPHalifax

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