ASPE Student Challenge 2025

Revision date: Sep 9, 2025

Sponsored by

Some aspects may be modified

Overview

This year's Student Challenge involves recording music on a 50 mm diameter 3 mm thick acrylic disc using a diamond cutting tool and an air-bearing spindle, see Figure 1(a). In preparation for the final event at the ASPE annual meeting at San Diego, your task is to implement a low-velocity position feedback control for a flexure stage shown in Figure 1(b and c). for a travel range of ±2.5 mm. This stage will feed the cutting tool transversely (x) relative to the spindle axis (z) using a voice-coil actuator with its translation in x measured using an optosensor that will be calibrated against a micrometer. Details about a Z-stage to be mounted on the X-stage will be provided soon. This stage will comprise a cutting tool holder and an adjustment mechanism to set the depth of cut. At the final event, you will record a 45-second song played at 33 rpm. During recording, the air-bearing spin can spin at a minimum of 3.3 rpm (one-tenth of playing speed), and a typical groove spacing on the disc is 125 μm, which corresponds to X-stage travel speed of 6.7 μm/s.

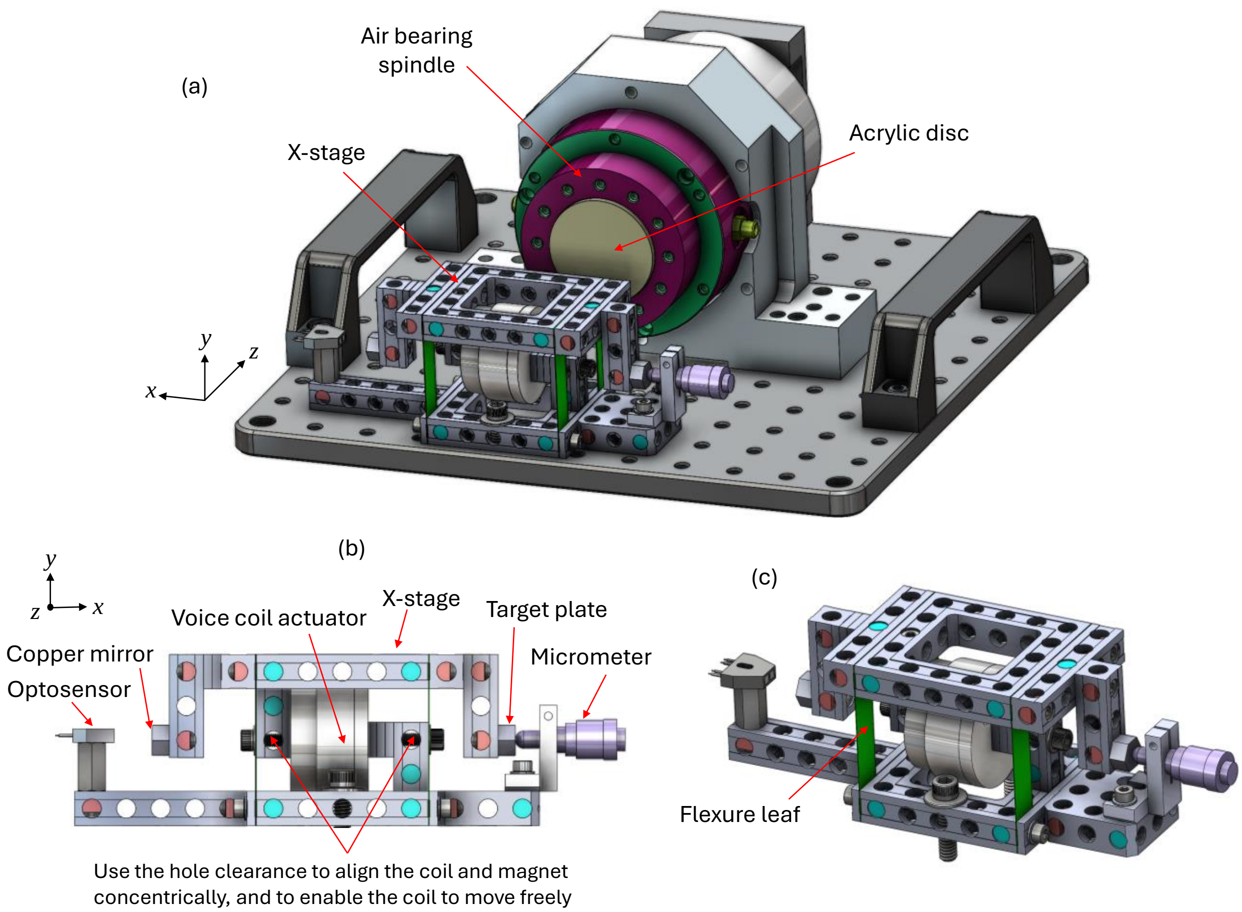


Figure 1: (a) Solid model of the air-bearing spindle and the Flexure-based X stage, (b) Front view and (c) isometric view of the X-stage with its sensor and actuator.

Committee-provided components

Teams will receive the following X-stage components (by Sept. 15), also see

Figure 3.

1. Leaf flexures and 'mechblocks' from Motus Mechanical, and CAD model for assembly (Github).
2. NI myRIO-1900 FPGA microcontroller (provided based on request).
3. Voice-coil actuator, optosensor, and micrometer (for displacement control and calibration).
4. 'Control box' with 16-bit ADCs and DACs, and 1.5 A transconductance amplifiers.
5. LabVIEW project (GitHub) with examples .vi's including myRIO–control box communication.

Optosensor calibration and feedback control of the X-stage

Assemble the X-stage components on your own optical breadboard or by any other suitable means. The mechblocks have 0.5 in. hole spacing and can accommodate either ¼-20 or M6 screws. Once assembled, calibrate the optosensor voltage as a function of micrometer displacement for a ±2.5 mm travel by maintaining contact with the 'target plate'.

- +X direction: rotate micrometer clockwise to push the target plate; record signal.
- –X direction: rotate counter-clockwise and use the voice coil actuator to contact the micrometer tip; record signal.
- Apply a curve fit to the recored signal to account for sensor nonlinearity.
- After calibration, implement feedback control to follow a ±2.5 mm amplitude triangle wave at 6.7 µm/s for one period, see Figure 2 . To generate this signal, a LabVIEW file, Triangle wave signal.vi is provided in the LabVIEW project.

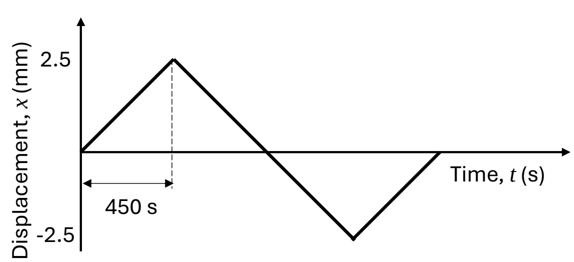


Figure 2: Triangle wave to follow using feedback control

These are all the experiments you are expected to perform prior to bringing your apparatus to the final event at San Diego. A representative X-stage mechanism exhibits a natural frequency of 17 Hz and a damping ratio of 0.09, as determined from a step response using the voice coil actuator. Teams may implement passive damping, provided it can be easily removed from the mechblocks before returning them to the committee.

Please contact the committee if you wish to use any additional components not provided by us. Use of components without approval will unfortunately result in a penalty.

Cuttting the musical record

At the Final event, teams will integrate the X-stage with the committee-supplied Z-stage and spindle to cut records. The song signal will be superimposed onto the voice coil actuator drive signal. It will be up to each team to create a control strategy to either feedback control or open-loop control to follow the song's signal content. Each team will have its own setup and numerous attempts until midnight on Monday, Nov 3rd. Record player(s) will be available for testing. In the event of unexpected equipment failure, or limited availability, teams are expected to share spindles and other essential equipment.

Milestones

- **Preliminary presentation on Zoom (mid-Oct.):** Grading will be based on progress report, effort, and a preliminary error budget. Committee feedback will be provided to enhance the performance.
- **Project report (Friday Oct. 31 midnight):** Submit findings, implementation details, and final error budget in less than 2 pages.
- **Final event (Monday Nov. 3, 6 pm)**: The Student Challenge room (Salon E) would typically be open for the participants to setup their apparatus by noon.
- **Rapid-fire presentations (Wednesday Nov. 5, lunch):** Present results, error budget, and play your record. Each team will have 5 minutes total, including audience questions.

Resources

GitHub

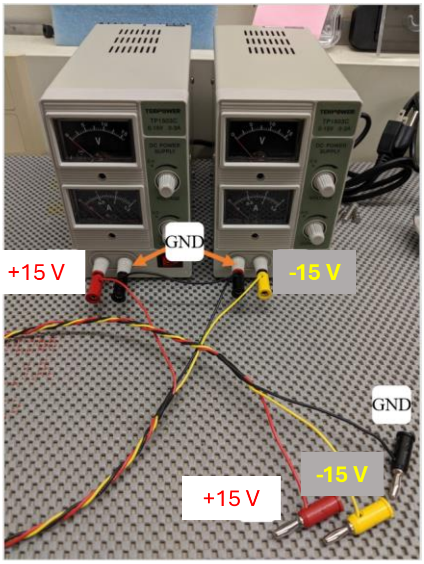
https://aspe.net/2025-student-challenge/

https://mail.google.com/chat/u/1/#chat/space/AAQAXU64Upk

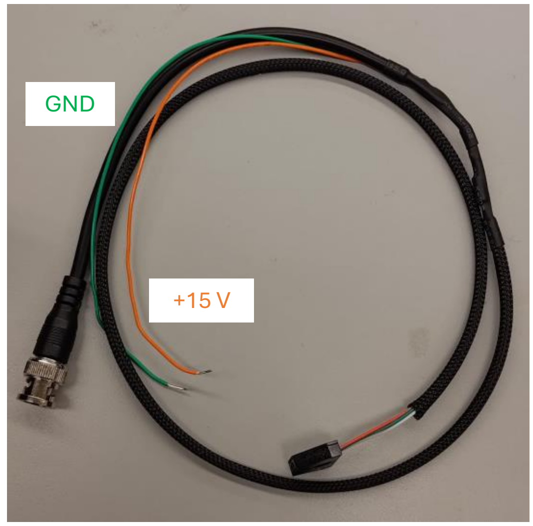
aspe.challengecommittee@gmail.com

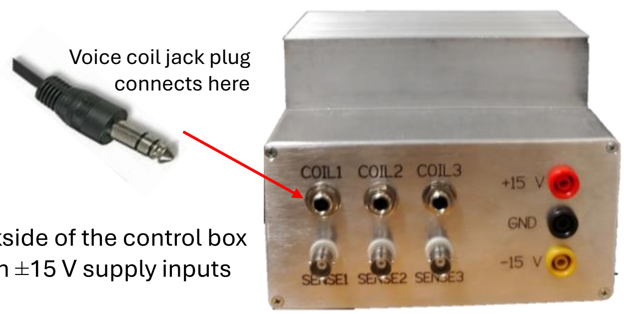
Electrical hardware provided

Two 15 V, 3 A power supplies



Optosensor





Backside of the control box with ±15 V supply inputs

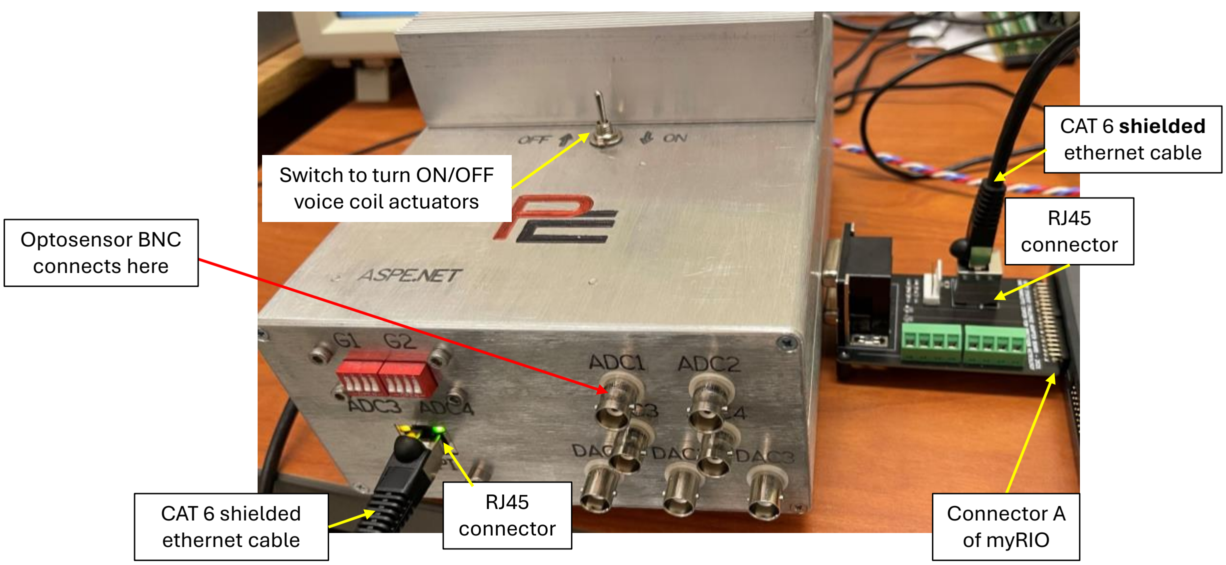


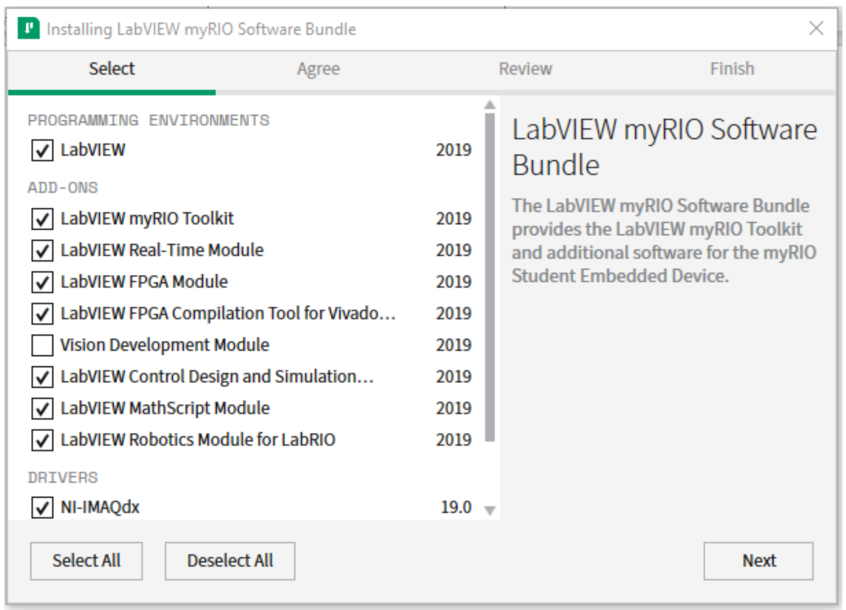
Figure 3: Hardware provided by the committee

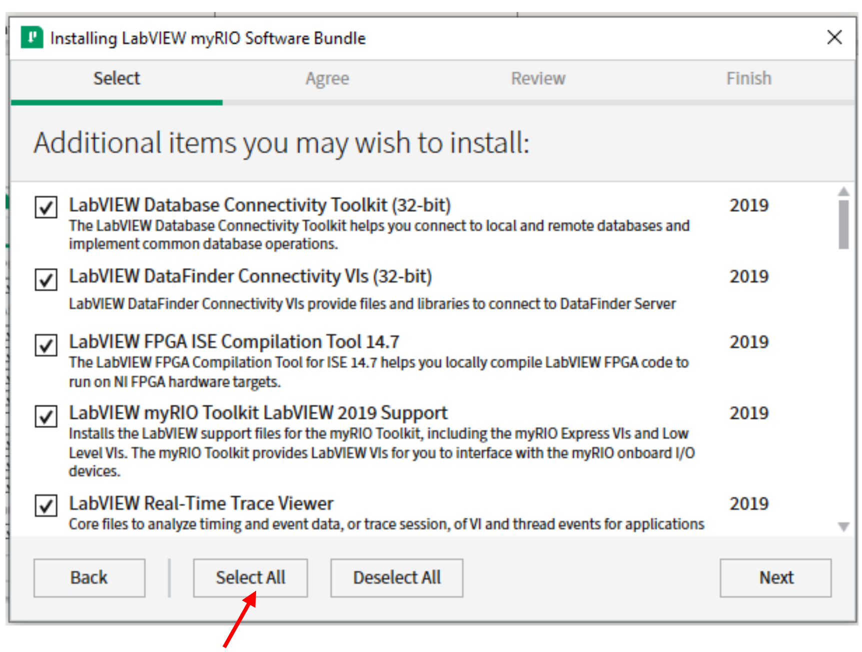
LabVIEW installation

(courtesy: Dr. Lei Zhou)

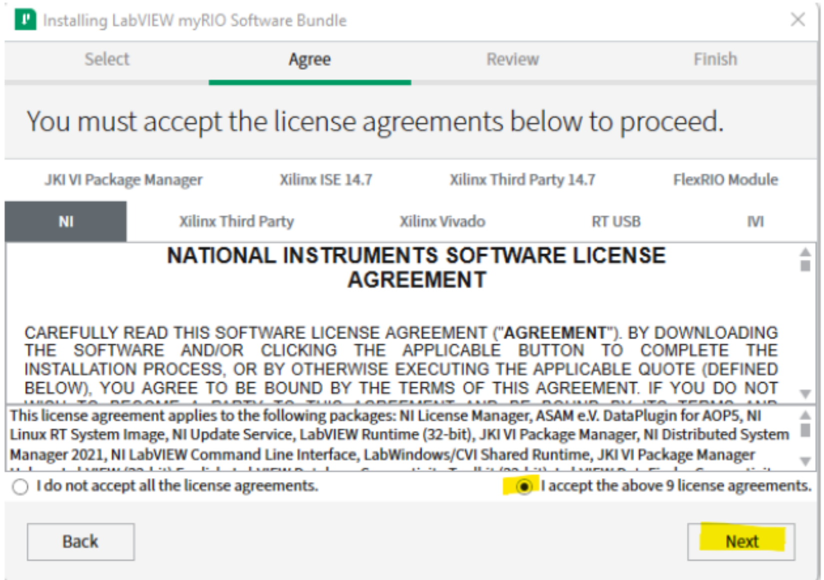
Please make sure to download and use the **LabVIEW 2019** myRIO software bundle from here, which includes the myRIO toolkit, realtime module, and FPGA module necessary for the Student Challenge purposes.

During installation select all exept for Vision development module, as shown below.

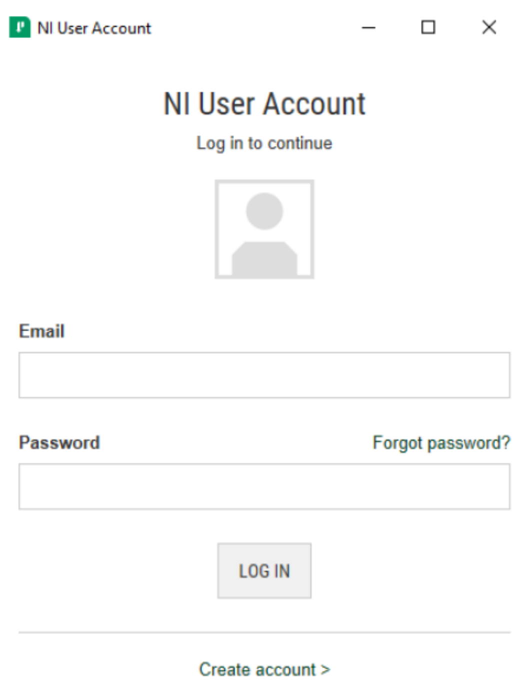




- You will need to accept multiple license agreements for each module.



- The installation process may take one hour. Your computer may need a restart at the end of the installation.
- Once the installation is close to finish, it pops licensing wizard as the screenshot below:

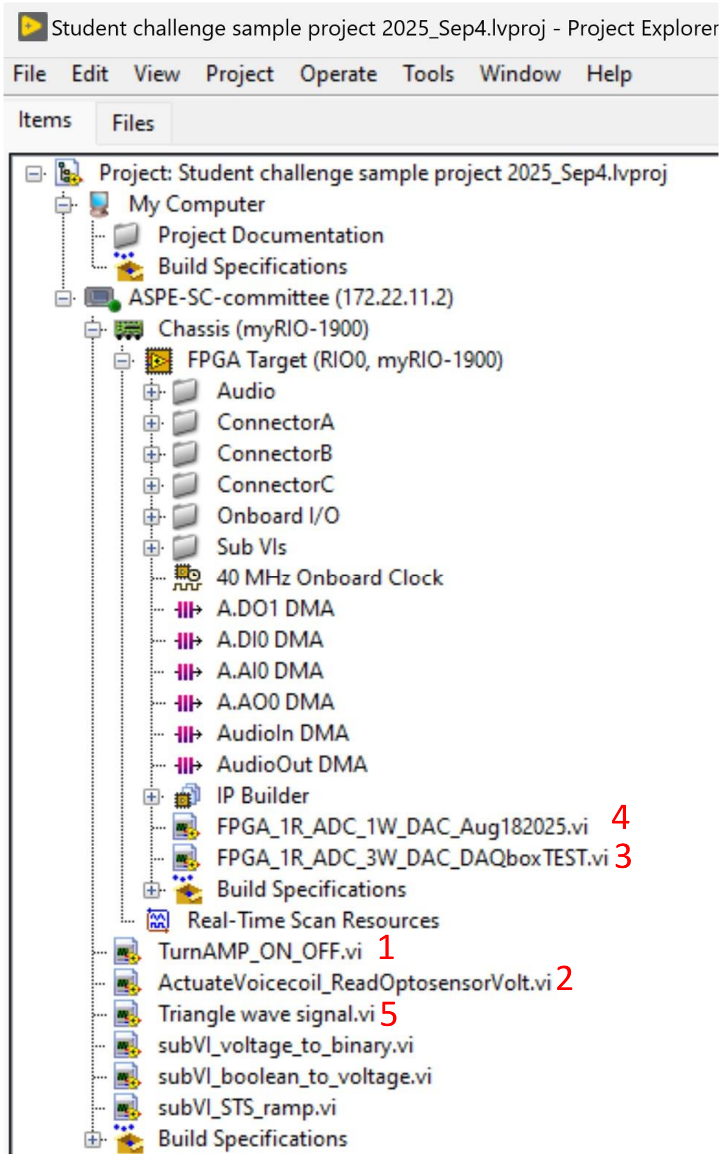


If your school does not have a serial number, LabVIEW lets you evaluate for 7 days, and later for 45 days. Please let us know if you have issues.

If your myRIO has a different firmware version, follow the instructions here.

LabVIEW project file

The project file can be found in Github which contains the .vi's that interact with the hardware provided via NI-myRIO, see image below.



- Before turning on (off) the power supply and flicking the switch (on/off) on top of the control box, use program (1) to send 0 V input to the DACs connected to the amplifiers in the control box
- Program (2) sends a voltage input to amplifier channel 1 to actuate the voice coil, and read the optosensor voltage.
- Program (5) generates a triangular wave.
- Integrate (2) and (5) to your feedback control algorithm to track the triangular waveform.