Physics 3150 Final Project Information, 2016

Several ideas are listed below, trending somewhat toward the ambitious side of the spectrum of possible projects. Many students choose to do something different — you are really limited only by your imagination and the available time. In planning your project, keep in mind that we have access to several National Instruments computer interface units that make it relatively easy to control experiments or acquire data using LabView or, for simple tasks, National Instruments Signal Express. We also have access to self-contained single-chip microcontrollers and the facilities to program them, and in Lab 10 we will learn the basics of this process.

To keep the projects on track, I will be asking for the following during the semester:

- (a) An initial concept, to be chosen **by March 11** and finalized shortly after the spring break. You should choose something that seems feasible and captures your interest.
- (b) Discussion. You must discuss the idea with me to make sure it is not too easy, too hard, or too expensive. The design can be based partially on reference circuits from the web or publications, but it should be more than just a copy of a simple circuit example or kit. The TAs and I can also refine your idea and suggest alternate approaches.
- (c) A block diagram and/or program flowchart for implementing your idea.
- (d) A detailed circuit with a complete parts list. We need this early in the process if any parts must be ordered. If you buy all the parts, you can keep your project. Otherwise we will keep them for use by the next class.
- (e) Construction. You have to build the gadget.
- (f) Demonstration. The last few class periods, you will show off your project to your peers.
- (g) A short written report to be turned in **by May 2** at latest, including basic design information, a full schematic drawing including pin numbers for any integrated circuits, and listings of any computer programs used in your work.

Some possibilities

- 1. Build a clock. This could be anything from a time-of-day clock built using simple counters and logic chips, to a precise microcontroller-based timer for photogate-based physics experiments, to a homemade GPS receiver that uses the time signals from a GPS chip.
- 2. Magnetic levitation using active feedback to a magnetic coil, using a Hall sensor and a small permanent magnet to detect the position.
- 3. Digital Vernier caliper. Although it would be possible to emulate the capacitance grid used for inexpensive commercial calipers, it is probably easier and more fun to print an optical grid, using a photodiode with an optical mask for Vernier (or in this case, Moiré pattern) detection.
- 4. Automatic gain control/audio compressor (make your own elevator music!?)
- 5. Build a circuit that implements the logistic equation, and map the resulting chaotic behavior. There's lots of information available on this subject in the literature and on the web.
- 6. Automated magnetic field cancellation using a Hall effect sensor and a small magnetic coil.
- 7. Use a power MOSFET or H-bridge together with a pulse-width modulator to build a 'Class D' audio power amplifier with very high efficiency while maintaining reasonably low distortion.
- 8. A resonant seismometer using a magnet on a pendulum, with a Hall sensor.
- 9. Measure daily tidal fluctuations in the gravitational field by building a gravimeter using a piece of resistive compressible foam, possibly with a microcontroller to sample and store the data.
- 10. Use a microcontroller, sensor, and LCD display to construct a complete portable instrument such as a digital thermometer or hygrometer.
- 11. Use a microcontroller and appropriate analog circuitry to build an arbitrary waveform generator.

- 12. Build a small frequency-synthesized keyboard with a microcontroller and/or phase-locked loops (PLLs). Can you find a way to make it play more than one tone at a time?
- 13. Noise cancelling earbuds.
- 14. Devise and build an apparatus to measure Johnson noise in a resistor, using a commercial or homemade "lock-in amplifier" to eliminate excess low-frequency noise.
- 15. Laser beam position detector with quadrant photodiode and lock-in detector
- 16. Build a temperature controller (PID or other types, continuous or pulse-width modulated). This can be done as an analog circuit or by using a microcontroller to implement the control loop as a computer program.
- 17. Use an accelerometer chip and a hobbyist-type servo motor to build a self-leveling table (probably with only a single axis). Alternatively, use a photocell and a servo to build a light-following arm.
- 18. Frequency modulation/demodulation using a phase-locked loop (PLL).
- 19. AM or phase modulation of a laser diode and transmission on an optical fiber, a model system for optical communication.
- 20. Audio spectrum analyzer or graphic equalizer.
- 21. Computer design and simulation of active filter circuits using commercial design software, followed by construction and testing of the finished designs.
- 22. Motorized position controller, or a model car with "follow me" capability.
- 23. Computer-based printed-circuit board layout (for any circuit of moderate to medium complexity).
- 24. Computer interfacing projects using the computational power of a full PC with LabView or Signal Express; for example,
 - (a) Basic computer vision/control—ideally, picking up an object by using a small CCD camera and a positioner with a servo or stepper motor.
 - (b) A crude inertial guidance system using a 3-axis accelerometer.