# Projects

During the next half of the course, you will form teams of 2-3 students and explore a project of your choice. The project should relate to oscillations and waves, but beyond that you have a lot of freedom to choose or come up with a project. Ideally the project has some “wow” factor.

At the end of the semester you and your team will present a poster to other students and faculty from the department on **Wednesday April 29 from 4-7 pm.** Please note this date. You will also write a research paper based on your project, its results, and your findings.

Below are some ideas and examples for final projects:

1. **Wind instruments**: Explore the physics of wind instruments by measuring the spectrum of various instruments. Build your own instrument to try to replicate the sound. Understand the effects of transients, which are responsible for some of the acoustic “character” of the instrument.
2. **String instruments**: How does the method of playing an instrument affect its tone? Use a high speed camera to understand why bowing a violin string produces a different sound from plucking it.
3. **Speckle interferometry**: When you look closely at a laser beam spot, you can see a speckle pattern with some very unique properties. What is the nature of this pattern and how can you use it for imaging and measuring small motions?
4. **Sagnac interferometry**: The Sagnac effect arises in a Mach Zender interferometer which is rotating. Commercial airlines and submarines navigate using such a gyroscope. How does it work? Can you build one sensitive enough to measure the rotation of the Earth?
5. **Digital Holographic microscope**: Build a digital holographic microscope that can capture the 3D motion of a tiny moving object such as a swimming bacterium.
6. **Optical tweezers**: Use a laser beam to trap and manipulate a particle. Such traps are used with ultracold quantum gases, and in biological and soft matter applications.
7. **Beam shaping**: How can you shape a beam of light using a spatial light modulator? Make an optical vortex or a donut-shaped beam, and explore what happens when you put a small particle in it.
8. **Sound interference and meta-materials**: Make a material which is an ‘invisibility cloak’ for sound. How can you engineer a material which can focus acoustic waves to a point?
9. **Nonlinear oscillators and chaos**: Nonlinear oscillators can be highly unpredictable. Explore the motion of the chaotic pendulum and understand the origin of classical randomness. Or investigate how resonance can be sustained in nonlinear oscillators without feedback, a phenomenon called *autoresonance.*
10. **Quantum mechanics in bouncing drops**: Build an apparatus in which drops of oil bounce along a liquid surface, guided by their own waves. Explore how these "wave-particles" diffract and interfere.
11. **Advanced holography**: Explore different geometries for making holograms. How can you make a color hologram that does not show dispersion?

12. **Computer-generated holograms**: Use your understanding of zone plates to make computer-generated holograms. You can display them on the spatial light modulator and make a holographic movie.