# NDnano Undergraduate Research Fellowship (NURF)
# 2012 Project Summary

1) Student name: John McPhee
2) Faculty mentor name: Gyorgy Csaba, Wolfgang Porod
3) Project title: Building a Kerr Effect Device for Nanomagnet Measurements

4) Briefly describe any new skills you acquired during your summer research:
This majority of this project focused on optics. I learned how to design an optical system and how to determine the polarization and intensity of light at any point in the system using Mueller matrices and Stokes vectors. I also learned how a photoelastic modulator and lock-in amplifier work together to detect very small changes in light with large amounts of noise.

5) Please briefly share a practical application/end use of your research:
This instrument will be used for nanomagnet research. By plotting the intensity of the laser versus magnetic field strength, hysteresis curves can be plotted to observe how the nanomagnets are behaving.

Project summary:
Computers use magnetics for data storage, but primarily rely on electronics for information processing. Nanomagnetic logic is an emerging technology that could allow computers to use magnetic nanostructures to process information. An efficient method of studying how magnets behave on the nanoscale is essential in the development of nanomagnetic logic devices. Traditionally, most nanomagnetic devices have been studied using magnetic force microscopy (MFM). MFM has very high resolution but takes measurements very slowly and may inadvertently change the magnetization state of the magnets. This motivated my research to implement an optical method for imaging the magnets.

When polarized light reflects off of a magnetic surface, a phenomenon called the magneto-optic Kerr effect (MOKE) occurs. The magnetic field affects the ellipticity and the polarization state of the reflected light beam. The small changes in the reflected beam's polarization are proportional to the strength and direction of the magnetization. In this project I designed and built an instrument that records hysteresis loops using the Kerr effect. I modified an unused ellipsometer by adding a photodetector, photoelastic modulator and lock-in amplifier. Initial tests of the instrument have shown the expected magnetic signals.

Publications (papers/posters/presentations):
Building a Kerr Effect Device for Nanomagnet Measurements (poster)
MOKE Manual (user guide)