

# SYLLABUS

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**Title:** Practical Neutron Scattering for the Sciences and Engineering at a Steady State Neutron Source

**Course Number:** Topics

**Meeting time/day/place:** TBA/Mon and Fri/Physics building and MURR

**Instructor Name:** Wouter Montfrooij

## COURSE DESCRIPTION-

**Summary:** This lecture/lab course will cover the basic principles and practices of neutron scattering for a broad student audience using the unique on-campus facilities at the MU reactor. A combined Problem Based Learning/Writing Intensive approach will be used. This course is the first of the three core courses that are part of the IGERT (Integrative Graduate Education and Research Traineeship) curriculum "IGERT: Neutron Scattering for the Science and Engineering of the 21st Century".

**Details:** This MU lab course will cover the basic principles and practices of neutron scattering for a broad student audience. The on-campus facilities at MURR present a unique opportunity to provide trainees with direct access to neutron spectrometers as part of their course work. Trainees will gain a practical understanding of the information that can be obtained from neutron scattering measurements through numerous "hands-on" examples of applications in various areas of chemistry, biology and physics.

Trainees will perform basic measurements on multiple spectrometers at MURR—one of the powder diffractometers, the reflectometer, and the triple-axis spectrometer TRIAX. Triple-axis spectrometers are one of the primary workhorses in experimental condensed matter physics because of their ability to pick (within broad ranges) arbitrary incident and final neutron energies and momenta. This flexibility also makes them an ideal tool for demonstrating scattering concepts like momentum and energy transfer, instrument resolution, etc. TRIAX is the only triple-axis spectrometer in operation at a U.S. university and shares the same operating software as all spectrometers at Oak Ridge's HFIR. The basic scattering concepts learned on TRIAX can carry over directly to the more specialized instruments, which are optimized for specific kinds of experiments.

Trainees will work in groups during many experiments to foster teamwork and improve communication skills. Each trainee will also complete simple activities individually to learn to operate each major piece of scattering and imaging equipment. The hands-on work will consist of modules to be completed separately; the modules will be chosen to match the individual trainee's interests as well as to broaden his/her interdisciplinary understanding across the fields of physics/biology/engineering etc. All modules are based on the **Problem Based Learning (PBL)** approach.

**Prerequisites:** Intro Modern Physics or comparable course. Contact the instructor by end of December 2011 if this prerequisite is not met in order to set up a plan of study to fill in the gaps.

## COURSE LEARNING GOALS

Upon completion of the course the trainee can expect to have acquired the following “sophisticated neutron scattering user” abilities:

- Functional understanding of the principles of using scattering to learn about materials.
- Ability to apply neutron scattering to the trainee’s future research, and understanding of what neutron scattering can contribute to the trainee’s field of study.
- Ability to carry out a neutron scattering experiment including the following: selection of instrument and sample environment, writing of beam time proposals, experimental planning and analysis of the results.

### **INSTRUCTOR INFORMATION**

Address: 418 physics building

[montfrooijw@missouri.edu](mailto:montfrooijw@missouri.edu) (preferred)

phone: 573-639-0104

### **TA INFORMATION**

There will be no TA’s, but various points of contacts will be given pertinent to the modules that we will be completing.

### **REQUIRED TEXTBOOK**

**Required:** G.L. Squires: *Introduction to the theory of thermal neutron scattering* (Dover publications).

Note, you should order this book well in advance as it is not always in print, and the bookstore will NOT carry it.

#### **Suggested:**

##### **Physics angle:**

- Steven W. Lovesey, *Theory of Neutron Scattering from Condensed Matter, Vols. 1 and 2* (Clarendon Press, 1984)
- Gen Shirane, Stephen M. Shapiro, John M. Tranquada: *Neutron Scattering with a Triple-Axis Spectrometer* (Cambridge, 2002).
- G.E. Bacon: *Fifty years of neutron diffraction* (Hilger, 1987)

##### **Biology angle:**

- Chick Wilson: *Single Crystal Neutron Diffraction from Molecular Materials* (World Scientific, 2000)

- S.J. Perkins: *High Flux X-ray and Neutron Solution Scattering*, in *Methods in Molecular Biology Volume 22*, C. Jones; B. Mulloy; A.H. Thomas, editors (Humana Press, 1994)
- *Neutrons in Biology*, edited by Schoenborn and Knott (Plenum 1996)

#### Chemistry angle:

- G.E. Bacon: *Neutron Scattering in Chemistry* (Butterworths, 1977)
- B.J.M. Willis: *Chemical Applications of Neutron Scattering* (Oxford University Press, 1973)
- R.H. Ottewill, *Small Angle Neutron Scattering*, in *Colloidal Dispersions*, J.W. Goodwin (editor), Special Publication No. 43, Royal Society of Chemistry, 1982

#### Books accompanying schools:

- *Neutron and Synchrotron Radiation for Condensed Matter Studies*, Baruchel ed. (Hercules school, Springer Verlag 1991)
- R.J. Newport; B.D. Rainford; R. Cywinski (editors): *Neutron Scattering at a Pulsed Source* (Adam Hilger, 1988)

### COURSE POLICIES

Trainees are expected to attend lectures, and it is mandatory to participate in the lab part of the course during the scheduled part of the course. **The lab part will have NO make-up possibilities** as the course is scheduled around ongoing experiments that are using the same equipment.

### ASSIGNMENTS

The trainee's grade will be based on homework assignments, lab work (modules) and final project. Note that 70% of the grade is based on hands-on lab work.

There will be 6 homework assignments (30%)

There will be six lab modules that will count towards the final grade (30%)

There is one final project in lieu of a final exam (40%)

**Homework:** The six homework assignments serve to bolster the trainee's understanding of the concepts learned in lecture by solving specific problems, and they prepare the trainee for the upcoming module. Homework assignments will need to be completed before the start of the lab module.

**Lab modules:** The lab modules are problem based learning modules that will familiarize the trainee with the various spectrometers and basic elements of neutron scattering experiments and equipment. The modules will be assigned and tweaked based upon the trainee's interests and research plans (if any).

**Final project:** Trainees are expected to complete a final project that comprises all the steps of an actual neutron scattering experiment. The project will cover the selection of an instrument, writing of a beam time proposal, selection of sample environment equipment, completion of an experiment of the beam port floor of MURR, analysis of the results and writing a scientific report on the results.

### GRADING SCALE

A: > 80%    B: 70-80%    C: 60-70%    D: 40-60 %    F: <40 %

### SEQUENCE OF TOPICS

Topic	PBL lab module	Duration (approx.)
Using the wave properties of particles to learn about materials through scattering.	Light diffraction, location: physics building	1 week
Properties of the neutron; Bragg scattering; Bolts and pieces of spectrometers.	Counting chain, location: physics building	2 weeks
determination of the structure of a material, part 1: perfect structure, global perspective. Nuclear and Magnetic structure.	2 axis diffractometer, location: MURR beam port floor	2 weeks
determination of the structure of a material, part 2: detailed structure, deviation from perfect structure, non-periodic structures.	powder diffractometer, location: MURR beam port floor	3 weeks
Layered structures (Membranes, surfaces, semiconductors...)	Reflectometer, location: MURR beam port floor	2 weeks
Movement within a structure. Inelastic and quasi-elastic scattering. Collective excitations.	Triple axis spectrometer, location: MURR beam port floor	4 weeks

### ADA STATEMENT

If you need accommodations because of a disability, if you have emergency medical information to share with me, or if you need special arrangements in case the building must be evacuated, please inform me immediately. Please see me privately after class, or at my office.

To request academic accommodations (for example, a notetaker), students must also register with Disability Services, AO38 Brady Commons, 882-4696. It is the campus office responsible for reviewing documentation provided by students requesting academic accommodations, and for accommodations planning in cooperation with students and instructors, as needed and consistent with course requirements.

## **UNIVERSITY POLICY ON ACADEMIC DISHONESTY**

Academic honesty is fundamental to the activities and principles of a university. All members of the academic community must be confident that each person's work has been responsibly and honorably acquired, developed, and presented. Any effort to gain an advantage not given to all students is dishonest whether or not the effort is successful. The academic community regards academic dishonesty as an extremely serious matter, with serious consequences that range from probation to expulsion. When in doubt about plagiarism, paraphrasing, quoting, or collaboration, consult the course instructor.

Academic Dishonesty includes but is not necessarily limited to the following:

- A. Cheating or knowingly assisting another student in committing an act of cheating or other academic dishonesty.
- B. Plagiarism which includes but is not necessarily limited to submitting examinations, themes, reports, drawings, laboratory notes, or other material as one's own work when such work has been prepared by another person or copied from another person.
- C. Unauthorized possession of examinations or reserve library materials, or laboratory materials or experiments, or any other similar actions.
- D. Unauthorized changing of grades or markings on an examination or in an instructor's grade book or such change of any grade report.

Academic Integrity Pledge:

Students are expected to adhere to this pledge on all graded work whether or not they are explicitly asked in advance to do so: "I strive to uphold the University values of respect, responsibility, discovery, and excellence. On my honor, I pledge that I have neither given nor received unauthorized assistance on this work."

The University has specific academic dishonesty administrative procedures. Although policy states that cases of academic dishonesty must be reported to the Office of the Provost for possible action, the instructor may assign a failing grade for the assignment or a failing grade for the course, or may adjust the grade as deemed appropriate. The instructor also may require the student to repeat the assignment or to perform additional assignments. In instances where academic integrity is in question, faculty, staff and students should refer to Article VI of the Faculty Handbook. Article VI is also available in the M-Book. Article VI provides further information regarding the process by which violations are handled and sets forth a standard of excellence in our community.

In the event of a suspected incident of misconduct, the instructor plans to use option B (M-book, page 11: <http://www.missouri.edu/~mbook/mbook.pdf>)