The University of Western Ontario  
Schulich Faculty of Medicine and Dentistry  
Department of Medical Biophysics

BIOPHYS 9665 A – Advanced MRI Physics

Fall Semester 2018

**Instructors:**
- Jean Theberge (Course coordinator)  jtheberge@lawsonimaging.ca  
- Keith St. Lawrence  kstlaw@lawsonimaging.ca  
- Tim Scholl  scholl@uwo.ca  
- Terry Thompson  thompson@lawsonimaging.ca  
- Corey Baron  cbaron@robarts.ca  
- Ravi Menon  rmenon@imaging.robarts.ca  
- Neil Gelman  ngelman@lawsonimaging.ca  
- Francisco Martinez Santiesteban  fmartine@imaging.robarts.ca  
- Jonathan Thiessen  jthiessen@lawsonimaging.ca

**Course Objective:**

The purpose of this course is to provide an understanding of advanced magnetic resonance pulse sequences and specialized methods used in current clinical and research settings. This course will assume an understanding of the concepts covered in BIOPHYS 9663 and 9662.

The course will explore pulse sequence design, typical artifacts, rudimentary data analysis and typical applications for several MR acquisition techniques including:

1. Rapid scanning techniques (RARE, HASTE, EPI) (Corey Baron)
2. BOLD fMRI (Ravi Menon)
3. Perfusion MRI (DCE, ASL) (Keith St. Lawrence)
4. Flow compensation and MR angiography (Francisco Martinez)
5. Diffusion MRI and DTI (Jean Théberge)
6. Magnetic Resonance Spectroscopy (Terry Thompson)
7. Parallel MRI (Charles McKenzie)
8. Relaxation mechanisms & Relaxometry (Neil Gelman)
9. Magnetization Transfer Imaging (Jonathan Thiessen)
10. Susceptibility-Weighed Imaging (Francisco Martinez)
11. Hyperpolarized MRI (Tim Scholl)
12. Fat suppression and Dixon imaging (Charles McKenzie)
13. MRI site planning and metallic implant safety evaluations (Jean Théberge)
14. Hybrid MRI/PET imaging (Jonathan Thiessen)

(2 lecture hours per week, half-course).

**Learning Outcomes:**

- Trainees will understand the pulse sequence design principles that make MRI sensitive to a wide range of physiological phenomena.
- Trainees will acquire knowledge and achieve understanding of the typical MRI artifacts associated with advanced pulse sequences and learn mitigation approaches.
- Trainees will understand post-processing of advanced MRI pulse sequences data in sufficient detail to generate basic image reconstruction pipelines.
Trainees will be familiar with fundamental principles in a number of state-of-the-art MRI applications:
- Rapid scanning techniques
- BOLD fMRI
- Perfusion MRI
- Flow compensation and MR angiography
- Diffusion MRI and Diffusion Tensor Imaging
- Magnetic Resonance Spectroscopy
- Relaxation mechanisms & Relaxometry
- Magnetization Transfer Imaging
- Susceptibility-Weighed Imaging
- Hyperpolarized MRI
- MRI site planning and metallic implant safety evaluations
- Hybrid MRI/PET imaging

**Course Prerequisites:**
BIOPHYS 9663 or BIOPHYSICS 9650 are preferred but if you would like to take this course without these prerequisites, please consult and obtain permission in writing from Dr. Théberge to assess equivalency. Knowledge of basic calculus is assumed. If there are any questions, seek advice from the instructor.

**Course Time and Location:**
Tuesdays and Thursdays: 9:30-10:30 am (MSB - Rm493).

**Instructor, Office hours:**
Instructor office hours vary. Please contact the appropriate instructor by email to schedule an appointment.

**Textbook(s):**
There is no formal textbook for the course. Materials will be provided as necessary throughout.

However the textbook recommended for previous course in this series (see reference below), MBP9663, contains material covering a large proportion of what will be covered in this course.


## 2018 - MBP 9665 – Advanced MRI Physics

<table>
<thead>
<tr>
<th>Date &amp; Time</th>
<th>Location</th>
<th>Instructor</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Sep 4th 9:30 to 10:30 am</td>
<td>MSB493</td>
<td>Théberge/Baron</td>
<td>Course Overview. K-Space Refresher</td>
</tr>
<tr>
<td>2 Sep 6th 9:30 to 10:30 am</td>
<td>MSB493</td>
<td>Baron</td>
<td>Intro to rapid scanning techniques (RARE, HASTE, EPI)</td>
</tr>
<tr>
<td>3 Sep 11th 9:30 to 10:30 am</td>
<td>MSB493</td>
<td>Martinez</td>
<td>Flow compensation and MR angiography 1</td>
</tr>
<tr>
<td>4 Sep 13th 9:30 to 10:30 am</td>
<td>MSB493</td>
<td>Théberge</td>
<td>Diffusion MRI and DTI 1</td>
</tr>
<tr>
<td>5 Sep 18th 9:30 to 10:30 am</td>
<td>MSB493</td>
<td>Martinez</td>
<td>Flow compensation and MR angiography 2</td>
</tr>
<tr>
<td>6 Sep 20th 9:30 to 10:30 am</td>
<td>MSB493</td>
<td>Théberge</td>
<td>Diffusion MRI and DTI 2</td>
</tr>
<tr>
<td>7 Sep 25th 9:30 to 10:30 am</td>
<td>MSB493</td>
<td>McKenzie</td>
<td>Parallel Imaging and array coils 1</td>
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<tr>
<td>8 Sep 27th 9:30 to 10:30 am</td>
<td>MSB493</td>
<td>McKenzie</td>
<td>Parallel Imaging and array coils 2</td>
</tr>
<tr>
<td>9 Oct 2nd 9:30 to 10:30 am</td>
<td>MSB493</td>
<td>Menon</td>
<td>BOLD fMRI 1</td>
</tr>
<tr>
<td>10 Oct 4th 9:30 to 10:30 am</td>
<td>MSB493</td>
<td>Menon</td>
<td>BOLD fMRI 2</td>
</tr>
<tr>
<td>11 Oct 9th 9:30 to 10:30 am</td>
<td>MSB493</td>
<td>St. Lawrence</td>
<td>Perfusion MRI 1</td>
</tr>
<tr>
<td>12 Oct 11th 9:30 to 10:30 am</td>
<td>MSB493</td>
<td>St. Lawrence</td>
<td>Perfusion MRI 2</td>
</tr>
<tr>
<td>13 Oct 16th 9:30 to 10:30 am</td>
<td>MSB493</td>
<td>McKenzie</td>
<td>Fat suppression and Dixon imaging</td>
</tr>
<tr>
<td>14 Oct 18th 9:30 to 10:30 am</td>
<td>MSB493</td>
<td>Thompson</td>
<td>Magnetic Resonance Spectroscopy 1</td>
</tr>
<tr>
<td>15 Oct 23rd 9:30 to 10:30 am</td>
<td>MSB493</td>
<td>Thompson</td>
<td>Magnetic Resonance Spectroscopy 2</td>
</tr>
<tr>
<td>16 Oct 25th 9:30 to 10:30 am</td>
<td>MSB493</td>
<td>J. Thiessen</td>
<td>Magnetization Transfer Imaging 1</td>
</tr>
<tr>
<td>17 Oct 30th 9:30 to 10:30 am</td>
<td>MSB493</td>
<td>J. Thiessen</td>
<td>Magnetization Transfer Imaging 2</td>
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<td>18 Nov 1st 9:30 to 10:30 am</td>
<td>MSB493</td>
<td>Gelman</td>
<td>Relaxation mechanisms &amp; Relaxometry 1</td>
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<tr>
<td>19 Nov 6th 9:30 to 10:30 am</td>
<td>MSB493</td>
<td>Gelman</td>
<td>Relaxation mechanisms &amp; Relaxometry 2</td>
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<td>20 Nov 8th 9:30 to 10:30 am</td>
<td>MSB493</td>
<td>J. Thiessen</td>
<td>MRI/PET</td>
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<td>21 Nov 13th 9:30 to 10:30 am</td>
<td>MSB493</td>
<td>Martinez</td>
<td>Susceptibility-Weighted Imaging Quantitative</td>
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<td>22 Nov 15th 9:30 to 10:30 am</td>
<td>MSB493</td>
<td>Scholl</td>
<td>Hyperpolarized MRI 1</td>
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<tr>
<td>23 Nov 20th 9:30 to 10:30 am</td>
<td>MSB493</td>
<td>Martinez</td>
<td>Susceptibility Mapping</td>
</tr>
<tr>
<td>24 Nov 22nd 9:30 to 10:30am</td>
<td>MSB493</td>
<td>Scholl</td>
<td>Hyperpolarized MRI 2</td>
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<td>25 Nov 27th 9:30 to 10:30am</td>
<td>MSB493</td>
<td>Théberge</td>
<td>MRI site planning</td>
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<tr>
<td>26 Nov 29th 9:30 to 10:30am</td>
<td>MSB493</td>
<td>Théberge</td>
<td>Metallic Implant Safety Evaluations</td>
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<td>27 Dec 4th 9:30 to 10:30am</td>
<td>MSB493</td>
<td>Multiple</td>
<td>Pre-exam Review and Q&amp;A</td>
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<td>28 Dec 6th</td>
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<td>No Class during exam week</td>
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<tr>
<td>29 Dec 11th</td>
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<td>No Class during exam week</td>
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<tr>
<td>30 Dec 13th 1:00 to 4:00 pm</td>
<td>TBA</td>
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<td>Final Exam</td>
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### Key dates of UWO Academic calendar for fall 2018

- Sept. 4<sup>th</sup> - first day of classes,
- Nov 30<sup>th</sup> - last day of classes,
- Dec. 3<sup>rd</sup> - exams start,
- Dec. 21<sup>st</sup> - exams end
**Evaluation:**
The final mark in the course will be distributed as follows:

1. Final exam 50%
2. Assignments 50%

**Final Exam:**
There will be one Final exam. The Final exam will be of 3 hours in duration and scheduled in the afternoon of Dec 13th (typically 1-4pm, room to be announced). Six exam topics will be selected among the course topics and will be the focus of six corresponding sections on the exam. The final mark will be based on the best five sections out of six. The selected sections will be announced by the time of the Pre-exam review class at the latest.

**Assignments:**
Assignments will be handed out in class or electronically via the course website and will normally be due back the following week. There will typically be one assignment every other lecture week. Topics that are not evaluated through an assignment will be examined in the final exam.

Students are encouraged to work together on the assignments, although each student must hand in their own work.

**Attendance Policy:**
All classes, laboratories, and tutorials are mandatory, unless otherwise stated. Any student who, in the opinion of the course co-ordinator is absent too frequently from class or laboratory periods in any course, will receive a failing grade after due warning has been given in writing from the course co-ordinator and Graduate Chair.

**Cheating and Plagiarism Policy:**
Students are encouraged to work together, but each student must take total responsibility for his/her submitted work. Students must write their laboratory reports and final projects in their own words. Whenever students take an idea, or a passage from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. University policy states that cheating, including plagiarism, is a scholastic offence. The commission of a scholastic offence is attended by academic penalties which might include expulsion from the program. If a student is caught cheating, there will be no second warning.

All written reports and projects may be subject to submission for textual similarity review to commercial plagiarism detection software under license to the University for the detection of plagiarism. All reports will be included as source documents on the reference database for the purpose of detecting plagiarism of papers subsequently submitted to the system. Use of the service is subject to the licensing agreement, currently between the University of Western Ontario and Turnitin.com (http://www.turnitin.com).

See the School of Graduate and Postdoctoral Studies Scholastic Offence Policy:
http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_grad.pdf

**Use of Electronic Devices Policy:**
No electronic devices (e.g., cell phones, MP3 players) may be used during lectures or examinations. The use of non-programmable calculators is permitted during examinations; programmable calculators are prohibited during examinations.

**OWL Internet/Bulletin Board Policy:**
It is the student’s responsibility to read the course website posted on Western’s on-line learning management system, OWL (https://owl.uwo.ca/portal). This includes the course bulletin board and all information and/or assignments posted about the course. If the student fails to act on information that has been posted on the course site and does so without a legitimate explanation (i.e., those covered under the illness/compassionate form), then there are NO grounds for an appeal.

**Request for Assignments Extensions:**

Students are advised to inform the course co-ordinator as soon as possible regarding an extension for assignment submissions due to medical reasons or other compassionate reasons. Extensions will only be granted by the course coordinators at their discretion.

**Absence Due to Medical Illness:**

Students must familiarize themselves with the Policy on Accommodation for Medical Illness: https://studentservices.uwo.ca/secure/index.cfm. If you are unable to meet a course requirement due to illness or other serious or compassionate circumstances, you must provide valid medical or other supporting documentation to the course co-ordinator immediately. It is the student's responsibility to make alternative arrangements with the co-ordinator to complete missing course requirements.

A student requiring academic accommodation due to illness, should use the Student Medical Certificate: http://www.uwo.ca/univsec/pdf/academic_policies/appeals/medicalform.pdf when visiting an off-campus medical facility or request a Record's Release Form for visits to Student Health Services. The form is available at: http://www.health.uwo.ca/services/students/policies.html. The release form will allow the course co-ordinator to confirm with Student Health Services that a student’s absence from regular attendance or inability to meet scheduled course commitments is due to medical reasons. The nature of the illness will not be divulged by Student Health Services.

**Graduate Students’ Mental Health and Physical Wellness:**

As part of a successful graduate student experience at Western, students are encouraged to make their health and wellness a priority. Western provides several on campus health-related services to help you achieve optimum health and engage in healthy living while pursuing your graduate degree. For example, to support physical activity, all students, as part of their registration, receive membership in Western’s Campus Recreation Centre: http://www.uwo.ca/campus_life/athletics.html

All facets of extracurricular campus life in which graduate students can participate are available on this URL: http://www.uwo.ca/campus_life/arts_culture.html

Information regarding health and wellness-related services available to students may be found at http://www.health.uwo.ca. Students seeking help regarding mental health concerns are advised to speak to someone in whom they feel comfortable confiding, such as their graduate supervisor, their program director (Graduate Chair), or other relevant administrators in their unit. Campus mental health resources may be found at: http://www.health.uwo.ca/mental_health/resources.html

**Accessibility to the Course and Course Materials:**

Please contact the course co-ordinator if you require material in an alternate format or if you require any other arrangements to make this course more accessible to you. You may also wish to contact Services for Students with Disabilities (SSD) at 661-2111 x 82147 for any specific question regarding an accommodation.