CONTACT INFORMATION

- **Instructor:** Dr. Hartwig Peemoeller; office: Physics, room 366  
  email: peemoell@uwaterloo.ca
- **Office hours:** Mondays, 10:30-11:30 am
- Please include the text “phys242” in the subject of any emails.
- There will be one Teaching Assistant marking the PHYS 224 assignments. All questions relating to the marked assignments (e.g., concerns about mark addition, appropriateness of mark assignment to components of problem solutions) should be directed at the course instructor.

COURSE DESCRIPTION:

- **Calendar course description:**
  **PHYS 224 LEC,TUT 0.50**  
  Course ID: 013965
  **Electricity and Magnetism for Life and Medical Physics**  
  Coulomb's law, electric field, Gauss' law, potential, current, resistance, electromotive force, D.C. circuits, magnetic fields, induced electromotive forces; applications include cell membrane potentials, action potentials, role of charge in structure and function of DNA, basis for the magnetoencephalogram and biomedical instrumentations. [Offered: F]  
  **Prereq:** PHYS 112 or 122; one of MATH 118, 119, 128, 138, 148.
  **Antireq:** PHYS 222, 223, 241, 242, 252, 253

- **Detailed Course Content:**

  Includes ALL material covered in the following:
  1) lectures
  2) lecture notes/slides on LEARN (some updates will be added throughout term)
  3) textbook material (as detailed in the section “Detailed PHYS 224 Course Content F14” at the end of this Course Outline).
  4) assignments

  A detailed course content is given at the end of this Course Outline.
• Lectures:

PHYS 224 lecture format:
- power point (PP) slides+ blackboard
- generally PP slides presented in class will be placed on LEARN before the material is presented in class

- the solutions to problems/examples done in class will not be available on LEARN (only the example/problem statements are placed there).

- none of the solutions for problems/examples considered in the tutorials will be placed on LEARN (only the example/problem statements are placed there).

Lectures are an integral part of PHYS 224 and attending lectures is a course requirement

• Tutorials:

Wednesdays, 5:30-6:30 pm, in room physics 308, except for November 6th when it will be from 5:00-6:00 pm in room physics 308.

• Assignments:

There will be 9 assignments:
(The schedule given here assumes that the midterm test can in be held October 14 or 15. If the test date needs to be changed due to conflicts that are unknown at the time of publication of this course outline, the assignment schedule may have to be adjusted as well.)
Assignment #1: handed out September 11; due 4 pm, September 18
Assignment #2: handed out September 18; due 4 pm, September 25
Assignment #3: handed out September 25; due 4 pm, October 2
Assignment #4: handed out October 2; due 4 pm, October 9
Assignment #5: handed out October 15; due 4 pm, October 24
Assignment #6: handed out October 24; due 4 pm, November 3
Assignment #7: handed out November 3; due 4 pm, November 12
Assignment #8: handed out November 12; due 4 pm, November 21
Assignment #9: handed out November 21; no due date, not marked

-- (absolutely no late submissions will be accepted, except for medical reasons)

The drop-off box for assignments is just outside (on right hand side) of physics room 211A (opposite to room 204).
Assignments will be posted on LEARN at least one week before the due date. Solutions for all assignments will be posted on LEARN.

**Note re assignment returns:**

The assignments will be marked and returned to you (normally in a week) by being placed inside cardboard boxes outside room 366 in physics. Marked assignments will be left outside of room physics 366 for no longer than two weeks. Students who prefer an alternative return method must so advise the instructor (HP) by email by September 19, 2014 and staple an appropriately sized stamped self-addressed envelope to each assignment submitted, so that it may be returned by mail.

**Unclaimed assignments:** Unclaimed assignments will be retained until one month after term grades become official on Quest. After that time, they will be destroyed in compliance with UW’s confidential shredding procedures.

- **Midterm Test:**
  
  October 14, 6:30-8:00 pm in room physics 313.
  
  Only “pink tie” or “blue goggle” calculators permitted.

- **Final Exam:**
  
  There will be a 150 minute exam to be scheduled by the registrar. The exam schedule should be available near the end of October.
  
  Only “pink tie” or “blue goggle” calculators permitted.

**LEARNING OBJECTIVES:**

- In PHYS 224 you will learn the fundamentals of Electricity and Magnetism at a 2nd year level. During the course, the various discussions will lead to Maxwell’s equation which you will learn to apply to solve numerous problems of practical interest. Of particular emphasis will be applications in the biophysical and biomedical areas. It is expected that by the end of the course you will have clear insight into the essential role Electricity and Magnetism plays in the functioning and the very existence of a variety of bio systems.

**RESOURCES:**

- **Textbook:**
  
  One of
  
  “Essential University Physics” by Wolfson
  
  “Physics for Scientists and Engineers 7th or newer edition” by Serway and Jewett
“Fundamentals of Physics” by Halliday, Resnick and Walker
“Physics with Mastering Physics” by Walker
“University Physics 13th edition” by Young and Freedman

- Lecture slides, assignments and solutions to assignments and midterm test will be placed on LEARN.

ASSESSMENT:

- Course mark:

  The greater of a) Assignments (20%) + Midterm Test (20%) + Final Exam (60%),
  or      b) Assignments (20%) + Final Exam (80%).

- Policy regarding missed graded elements:

  In general there will be no make-up exam, make-up test or make-up assignments for PHYS 224. Exceptions due to illness or death will be considered on an individual basis and are also considered under the heading "OTHER COURSE RULES/CONSIDERATIONS" below.

ACADEMIC INTEGRITY:

- Office of Academic Integrity provides relevant information for students, faculty and staff.
  - Academic Integrity: In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility.
  - Grievance: Students, who believe that a decision affecting some aspect of their university life has been unfair or unreasonable, may have grounds for initiating a grievance. Students should read Policy #70, Student Petitions and Grievances, Section 4. When in doubt, students must contact the department’s/school’s administrative assistant who will provide further assistance.
  - Discipline: Students are expected to know what constitutes academic integrity, to avoid committing academic offenses, and to take responsibility for their actions. Students who are unsure whether an action constitutes an offense, or who need help in learning how to avoid offenses (e.g., plagiarism, cheating) or about ‘rules’ for group work/collaboration should seek guidance from the course instructor, academic advisor, or the Associate Dean of Science for Undergraduate Studies. For information on categories of offenses and types of penalties, students should refer to Policy #71, Student Discipline. For information on typical penalties, students should check Guidelines for the Assessment of Penalties.
**Appeals**: A decision or penalty imposed under Policy 33 (Ethical Behavior), Policy #70 (Student Petitions and Grievances) or Policy #71 (Student Discipline) may be appealed, if there is a ground. Students, who believe they have a ground for an appeal, should refer to Policy #72 (Student Appeals).

**OTHER COURSE RULES/CONSIDERATIONS:**

- **Exam Period Travel:**
  - On-campus F14 examinations begin Dec 4, 2014
  - On-campus F14 examinations end Dec 19
  - For F14 exam dates, it is recommended that you start checking the registrar’s web site toward the end of October for posted exam dates
  - Student travel plans are not considered acceptable grounds for granting an alternative examination time.

- **Make-up exam, test, assignments**: In general there will be no make-up exam, make-up test or make-up assignments for PHYS 224. Exceptions due to illness need to be considered on an individual basis; also see Verification of Illness form (VIF) or other compelling documentation below.

- **Students with Disabilities**:
  - AccessAbility Services, located in Needles Hall, Room 1132, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If students require academic accommodations to lessen the impact of their disability, they should register with AccessAbility Services at the beginning of each academic term.

- **Changes to Course Outline**:
  - Revised course outlines will be posted/provided, if course details change (e.g., topics covered, emphasis on certain topics, etc.)
  - Course elements that will not change are:
    - Grading scheme
    - Course elements related to evaluation.

- **Verification of Illness form (VIF) or other compelling documentation**:

  If students experience an illness that notably interferes with their ability to complete assignments, attend required classes, attend required labs, write tests or write exams, they are to notify the instructor before or within 24 hours of the course element and submit a completed Verification of Illness (VIF) form, within 48 hours. Exceptions may occur when students are very ill and/or hospitalized. This form is available from the Health Services web site (http://info.uwaterloo.ca/infoheal/_StudentMedicalClinic/VIF.html).

  Students are to obtain their VIF from Health Services, when it is open - https://uwaterloo.ca/health-services/student-medical-clinic/hours.
There are exceptions to requiring VIFs to come from Health Services:
  - Health Services is closed (e.g., weekends; after hours) or fully booked (in this latter case, students should obtain written verification from Health Services that they tried to be assessed by Health Services)
  - Students are out of town
  - Students are receiving ongoing care from a family physician or specialist

Information should include:
  - Date(s) of physician assessment(s)
  - Date(s) of illness
  - Level of incapacitation
  - Basis of the assessment (i.e., physician’s examination or strictly the student’s description)

This policy will also apply to non-Science students taking Science courses.

- Some other important dates:

  September 26: Deadline to drop or withdraw from courses with 100% tuition refund

  October 24: Deadline for 50% tuition refund

  November 14: Drop, penalty 1 period ends: *WD (Withdraw, no credit granted) grade assigned for course(s) dropped*

  November 15: Drop, penalty 2 period begins: *WF (Withdraw/Failure, no credit granted, value 32) grade assigned for course(s) dropped* *(Engineering students: Visit course load and withdrawal in the calendar for specific regulations.)*

  December 22: **Unofficial Grades** begin to appear in **Quest**: *Beginning this date, registered students can view their unofficial term grades in Quest (not all grades may appear on this date).* Note that PHYS 224 grades may be available at a later date.

**DETAILED PHYS 224 COURSE CONTENT F14:**

**I Electric charge, force, field, potential**

1 Coulomb’s Law and Electric Field Intensity

Properties of Electric Charges
Charging Objects by Induction
**Coulomb's Law** (also 3D problem)
**The Electric Field** (also 3D problem)
Electric Field Lines
Review of 1st year Discussion about Electric potential and finding E from V - re lab
Electric Dipole
Force between red blood cells
Electric force between DNA nucleotides

2 Electric Field of Continuous Charge Distributions

E due to Various distributions (line, ring, disk, plane
Motion of a Charged Particle in a Uniform Electric Field
Oscilloscope

3 Electric potential (also 3D problem)

Electric potential energy
Electrostatic potential energy of a human DNA molecule
Electric potential
Electric potential and field of electric dipole in spherical coordinates
Cell membrane /potential/ions; axon/action potential
Current dipole
Myocardial cells
The heart, depolarization wave, electric dipole, measurement of ΔV due to dipole

4 Gauss’ Law

Electric flux
Gauss’ Law, spherical, cylindrical and planar symmetries
E associated with myocardial cell
Conductors in electrostatic equilibrium
E of a solid, charged insulating sphere surrounded by a conducting shell

5 Some additional examples involving V and E

Potential inside and outside uniformly charged sphere
Potential inside and outside parallel plate capacitor
Finite line charge, ring, disk

II Capacitance, RC Circuits, Dielectrics

1 Capacitance and Capacitors

Calculate C for parallel plate capacitor, two concentric spherical shells
Calculate C for myocardial cell
Energy stored in Capacitor
Defibrillator
Circuits with capacitors in series, parallel
2 RC Circuits (series)
Charging, discharging
Electric circuit model of pacemaker cell

3 Dielectrics
Polarization, bound and free charge/densities
Polarized rod, sphere
Electric Displacement, susceptibility
Single cell bacteria with sticky dielectric shell
E, D, P and bound charge density for membrane

III Current, Resistance, DC Circuits
Electric Current, current density

1 Ohm’s Law
Resistance of skin versus body

2 Review of DC Circuits
Kirchhoff’s Rules
3-loop problems

IV Magnetic Force, Field, Induction

1 Magnets, Magnetic Fields and Forces
Magnetic Fields
F=qvxB
Cyclotron
Velocity selector
Mass spectrometer
F=IlxB
Monitoring blood flow in open-heart surgery
Torque on current loop, on magnetic dipole
NMR, concepts, relaxation times, gradients MRI

2 Sources of Magnetic Fields
Charged particle in motion
Biot-Savart Law
Straight wire, loop
Forces between two wires
Ampere’s Law
In and around solid wire, solenoid, toroid, Tokamak
Magnetism in matter, paramagnetism, diamagnetism, ferromagnetism
Earth’s magnetic field
Magnetic blood pump
Effects of large magnetic fields on health (ion movement)

3 Magnetic Induction

Magnetic flux
Faraday’s Law
Patient breathing monitor
Faraday’s Law and motional emf
Lenz’s Law
Induced emf and Electric Field
Basis for magnetoencephalogram
E inside and outside solenoid
Induction and multi-loop problem
Faraday’s disk
Eddy currents
Self inductance
Charging/discharging RL circuits
Very large voltage developed due to self inductance
Magnetic energy density
MRI scanner disaster
Effects of large transient magnetic fields on health (induced currents in brain)