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Prereq: Familiarity with the basic abstract differential geometry.

Class schedule: Monday–Wednesday, 9:00–10:20, in MC 5403.

Course Description: Beginning about 40 years ago was a remarkably fruitful interaction between physicists and mathematicians. Ideas from physics had profound implications in geometry (algebraic and differential) and topology, and vice-versa. At this intersection lies gauge theory, which for mathematicians is roughly the study of bundles and additional structures on them, most notably connections.

This course covers some of the basic ideas and tools of gauge theory. Our aim will be to understand the objects and part of the methods used to prove exciting results about geometry and topology of low-dimensional manifold: possible intersection forms of 4-manifolds (Donaldson), genus of embedded surfaces in projective plane (Kronheimer–Mrowka), obstructions to existence of Einstein metrics (LeBrun).

Topics will include: vector bundles, principal bundles, connections and covariant derivatives, curvature and characteristic classes; the space of connections and gauge equivalences; the Yang–Mills equation, the ASD equation, the Seiberg–Witten equations, and relevant moduli spaces; etc.

Textbook and additional references: There are no perfect textbook for this class, and therefore my course will be based on a number of sources. There are no required textbook. There are however a number of reference texts in which you can find a lot of good stuff. None cover all we will cover.

- Shōshichi Kobayashi and Katsumi Nomizu, Foundations of differential geometry, Volume 1, John Wiley & Sons 1963. (Available for 1 day loan on the library course reserve.)
- John W. Milnor and James Stasheff, Characteristic classes, Annals of mathematics studies no. 76, Princeton University Press, 1974. Available for 1 day loan on the library course reserve.)
- Robert Friedman and John W. Morgan, eds., Gauge theory and the topology of four-manifolds, IAS/Park City Mathematics Series Volume 4, 1997. (Of particular interest are Morgan’s lectures An introduction to gauge theory which contain many exercises. Available for 1 day loan on the library course reserve.)
- Norman Earl Steenrod, The topology of fibre bundles, Princeton mathematical series 14, 1951. (Available for 1 day loan on the library course reserve.)
- Stephen Bruce Sontz, Principal bundles: the classical case, Springer, 2015. (available online through the library)
- Clifford Henry Taubes, Differential geometry: bundles, connections, metrics and curvature, Oxford Graduate Texts in Mathematics 23, 2011. (Available for 1 day loan on the library course reserve, or for purchase as softcover, hardcover or ebook Amazon.ca, Indigo.ca.)

Marking Scheme: There will be four or five assignments, for a total of 70 points, and a final project and presentation, for a total of 30 points. Subjects for final project and presentation must be chosen with permission of instructor.
**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.

**Academic Integrity Office (UW):** A resource for students and instructors

**Grievance:** A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Students who decide to file a grievance should refer to University of Waterloo Policy 70 (Student Petitions and Grievances). When in doubt please be certain to contact the department’s administrative assistant who will provide further assistance.

**Discipline:** A student is expected to know what constitutes academic integrity, to avoid committing academic offences, and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (e.g., plagiarism, cheating) or about “rules” for group work/collaboration should seek guidance from the course professor, academic advisor, or the Associate Dean. When misconduct has been found to have occurred, disciplinary penalties will be imposed under the University of Waterloo Policy 71 (Student Discipline). For typical penalties check the Guidelines for the Assessment of Penalties.

**Grievance:** A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. For students who decide to file a grievance, students should refer to University of Waterloo Policy 70 (Student Petitions and Grievances).

**Appeals:** A decision made or penalty imposed under Policy 70, Student Petitions and Grievances (other than a petition) or Policy 71, Student Discipline may be appealed if there is a ground. A student who believes he/she has a ground for an appeal should refer to Policy 72 (Student Appeals).

**Note for students with disabilities:** The AccessAbility Services (AS) Office, 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 you require academic accommodations to lessen the impact of your disability, please register with the AS Office at the beginning of each academic term.