Mathematics 9161A Differential Geometry
(Curvature in Mathematics and Physics)
Sept-Dec 2019, Western University
Instructor: Masoud Khalkhali

Course outline: The idea of *curvature* plays an important role in many areas of mathematics and physics. In this course we shall look at some of its definitions and manifestations in geometry, topology, and mathematical physics. Notice: this is a mathematics course and no familiarity with physics will be needed. Similarly, no knowledge of differential geometry will be assumed. I shall provide all the necessary background. The following topics will be covered.

1) Gauss's theorema egregium and what it means for mankind. Riemann curvature tensor and its shadows (Ricci and scalar curvature), sectional curvature. An analysis of Riemann's 1854 paper. Connections on the tangent bundle, Levi-Civita's theorem. Connections on principal G-bundles and on vector bundles. Chern-Weil and Chern-Simons theories. Gauss-Bonnet theorem.

2) Bi-invariant metrics on Lie groups and Maurer-Cartan equations.

3) Einstein-Hilbert action and Einstein's field equations in general relativity, special solutions, introduction to black holes.

4) Gauge theory and Yang-Mills equations, Higgs mechanism, applications to elementary particle physics.

Textbook: Curvature in Mathematics and Physics, by Shlomo Sternberg (Dover Publication, 2012; also available on author's website). There are many other good texts-I shall introduce them as we move on.

Time and place: M 9:30-11:30, W 10:30-11:30; MC 108.

Grading: %60 take home assignments (2 sets of assignments), %40 presentation.

- **Conflict exams: If you have a conflict with one of the exam times, please consult the Faculty of Science policy on missed course work. Based on that, if you think your situation qualifies you to take the conflict exam, please contact me as soon as possible, no later than a week before the exam in question.**

- **Medical accommodations: If you are unable to meet a course requirement due to illness or other serious circumstances, you must provide valid medical or other supporting documentation to the Dean's Office as soon as possible and contact me immediately. It is your responsibility to make alternative arrangements**

with me once the accommodation has been approved. In the event of a missed final exam, a "Recommendation of Special Examination" form must be obtained from the Dean's Office. For further information, please consult the University policy on medical accommodation.

- Missed homework: Late homework will not be accepted. Homeworks can always be submitted in advance. For extended absences or medical emergencies, these are handled the same way as for exams. In that case, a homework grade could be dropped; there will be no make-up homework.

- Academic integrity: Working on homework with your peers is allowed, in fact encouraged. However, each student must write their own solutions. Handing in suspiciously similar solutions will be considered an instance of cheating. Scholastic offences are taken seriously and will not be tolerated. For more information, please consult the University policy on scholastic discipline.

- Accessibility: Please consult Services for Students with Disabilities (SSD) regarding accessibility services on campus. Please contact me if you require material in an alternate format or other accommodations to make this course more accessible to you.