SYMMETRY

Vancouver Summer Program
July 13 – August 13, 2019

Monday-Friday, 9:00 AM - 12:00 PM

Text: There is no required text for this course. Readings and worksheets can be found on the course's Connect site.

Instagram: http://instagram.com/symmetry330A

Course Description:

Symmetry is present all around us - in the forms of plants and animals, in patterns and shapes of art and architecture, and in the structures of materials from simple molecules to complex proteins and minerals. The principles of symmetry play important roles in physics, chemistry, mineralogy, mathematics, biology, astronomy, and many other sciences. We can even hear symmetry in music. In this course, we will discuss basic principles of symmetry such as mirror reflections, rotations, and repetition, how different symmetries combine into symmetry groups in two and three dimensions, and how we can recognize different kinds of symmetry in shapes and patterns. Next, you will use your understanding of symmetry to discover how it appears in different parts of science and art.

In-class activities and discussions will be used to develop an understanding of fundamental principles, and group presentations will form a major component of student activities in this course. The course will culminate with a group presentation on symmetry.

Course Learning Objectives:

By completion of this course, you will:

- Gain an appreciation of the fact that symmetry is all around us;
- Be able to critically discuss the symmetry of objects and patterns;
- Experience interactive and group learning;
- Gain an in-depth understanding of selected topics in symmetry;

Topics:

In class we will focus mostly on the symmetry of physical objects and patterns, but other aspects of symmetry will arise as part of your independent research and class discussions.

Main topics include:

- Symmetry of objects in two- and three-dimensional space, e.g. point groups;
- Symmetry of repeated patterns in two dimensions, e.g. friezes and wallpaper groups;
- Symmetry of repeated patterns in three dimensions, e.g. space groups and crystallography;
- X-ray diffraction, i.e. the application of crystallographic symmetry in mineralogy and biological sciences;
- Group theory, i.e. a basic introduction to the mathematical theory of symmetry.

Though we touch on some very mathematical topics, no calculations or proofs are required for this course.

Outline:

1. Introduction to Symmetry
2. Point groups in two dimensions
3. Group concepts
4. Frieze groups: translation in one direction
5. Plane groups: translation in two directions
    a. Lattices in two dimensions
    b. Wallpapers
6. Point groups in three dimensions
    a. Simple 3D point groups
    b. Inversions and rotoinversions
    c. Cubic point groups
    d. Special kinds of polyhedra
7. Spiral symmetry
8. Crystallography in three dimensions
    a. Sphere packings
    b. Lattices in three dimensions
    c. Space groups
9. Applications of symmetry: X-ray diffraction and crystal structures
10. Quasicrystals *
11. Fractals and scale symmetry *
12. Antisymmetry and colour symmetry *
13. Symmetry in physics *
14. Group Theory *

* time permitting

Graded Activities:

Name	% of Total Grade
Plane Groups Quiz	10
Point Groups Quiz	10
Found Symmetry Presentation	15
Topics in Symmetry Poster Project	20
Short Assignments	10
Participation	5
Final Exam	30

Plane Groups Quiz - Group, In-Class (10% of course grade)
The class will be divided into groups, and each group will determine the plane group symmetry of a number of 2D patterns. Each group will see the same patterns.

This assignment is designed to meet the following objectives:
- Being able to critically discuss and demonstrate the symmetry of 2D patterns;
- Further developing skills for group work and presentation.

Point Groups Quiz - Group, In-Class (10% of course grade)
The class will be divided into groups, and each group will determine the point group symmetry of a number of objects. Each group will see the same objects. This will be a timed activity.

This assignment is designed to meet the following objectives:
- Being able to critically discuss and demonstrate the symmetry of objects;
- Developing skills for group work and presentation.

Found Symmetry AKA The Symmetry Scavenger Hunt - Group, In and Out of Class (15% of course grade)
The class will be divided into groups, and each group will be responsible for preparing a presentation with photographs of objects and patterns from the local environment (no images from books), with their point and plane group symmetries identified. Marks will be awarded based on the inclusion of a variety of different symmetries (i.e. the objects belong to a variety of different point or plane groups) and correctly identifying point and plane groups

This assignment is designed to meet the following objectives:
- Gaining an appreciation of the fact that symmetry is all around us;
- Further developing skills for group work and presentations

Topics in Symmetry Poster Project - Group, In and Out of Class (20% of course grade)
The class will be divided into groups, and each group will be responsible for preparing a poster discussing a topic in symmetry. The poster will be presented as part of an in-class poster

session. Some possible topic ideas include:

- Symmetry in Art
- Scale Symmetry in Fractals
- Quasicrystals
- Symmetry of Snowflakes
- Symmetry in Architecture
- Symmetry of Growth
- Symmetry in Music
- Symmetry in Organisms
- Symmetry in Physics
- Symmetry of Your Favourite Group of Minerals, Crystals, Viruses, Proteins, etc.

This assignment is designed to meet the following objectives:

- Connecting concepts of symmetry that were learned in class with the outside world;
- Designing a scientific poster and gaining presentation skills.

In addition, each member of a group project will evaluate the individual participation and contribution of every member of their group (including themselves). This evaluation will include a numerical score as well as written comments. Particularly strong or weak group participation by individuals should stand out, and we reserve the right to scale an individual's project grade. Clearly, we expect you to resolve contribution issues within your groups before it comes to this, and we encourage you to come to us if you are having problems doing so. We will discuss the details of this grading in class.

This assignment is designed to meet the following objectives:

- Encouraging participation in class discussions
- Encouraging participation in group activities
- Acknowledging individual contributions to group efforts

Short Assignments - Individual, In and Out of Class. (10% of course grade TOTAL) Short individual activities, readings, or worksheets meant to practice one or more concepts related to symmetry. These will usually be worth 1-2% each.

Participation - Individual and Group, In Class. (5% of course grade)
Each student is expected to play an active role in the discussions and activities that take place in class. We will make a subjective assessment of student's involvement in the general activities of the class, and we will assign a score out of 5 to each student to reflect this assessment.

Final Exam - Individual (30% of course grade) The exam will review all the main components of the course, including identifying point groups of 3D objects and plane groups of wallpapers. Most questions will be short answer. More details will be discussed in the final week of class.