Mathematics summer projects for undergraduate students

We offer summer research projects for undergraduate students, whereas the student studies a mathematical topic outside of the standard mathematics curriculum at QUB. These projects lead to potential original research or to the acquisition of useful mathematical skills, and are conducted under the supervision of an academic staff member. If you are interested in studying any of them, please approach the respective lecturer.

Available sample projects:

Title: ***Towards groups***
Supervisor: Dr David Barnes
Description: We're all familiar with the notion of symmetries of an object (such as a square or a cube). Describing the properties of symmetries (such as how to compose them) leads to the idea of mathematical groups.

Topic: ***Graphs and algorithms***
Supervisor: Dr David Barnes
Description: Graph theory is one of the most applicable areas of pure mathematics. In particular it has produced many algorithms used to solve real-world problems. Examples include: finding the shortest path, finding the best delivery route or solving scheduling problems.

Topic: **Fractals**
Supervisor: Dr David Barnes
Description: Some of the most beautiful images created by mathematics are representations of fractals: a mathematical set that exhibits a repeating pattern that displays at every scale. Modern mathematical language gives a precise formulation of this idea and provides tools to study fractals. Once a mathematical rule for the fractal is found, computers can be used to draw these fractals and allow us to visualise them.

Title: **Integral points in polytopes**
Supervisor: Dr Thomas Huettemann
Description: Polytopes are geometric objects like polygons (in the plane), cubes and pyramids in 3-space. It is often interesting to cound how many integral points lie in a polytope; this seemingly simple question leads to beautiful results which can be explored quite hands-on by explicit examples.

Topic: **Curves in the plane**
Supervisor: Dr Thomas Huettemann
Description: An ellipse is defined as the collection of points in the plane that have a constant sum of distances from two given points. What happens if you replace "sum" here by "difference", or "product", or "ratio"? One can discover beautiful geometric objects by exploring questions like these.

Topic: **Convex figures in the plane**
Supervisor: Dr Thomas Huettemann
Description: A convex figure is one that has the following property: given two points in the figure, the line segment joining these two points is entirely inside the figure too. Some convex figures can "rotate" within a square while always touching all four sides; the circle is an obivous example, but there are others to be discovered as well.

Topic: **Continuous functions**
Supervisor: Dr Ying-Fen Lin
Description: A function from real numbers to the real numbers is called continuous if, roughly speaking, there is no “gaps” in its graph. The precise definition can be given in various ways and the concept of continuous functions can be defined in more general (abstract) settings, which play an important role in research in mathematical analysis.

Topic: **p-adic numbers**
Supervisor: Dr Ying-Fen Lin
Description: The rational numbers are dense in the real numbers, and their usual arithmetic extends to the well-known addition and multiplication of real numbers. Another interesting, but very different, way to extend the rational numbers and their arithmetic, which is relevant to other areas of mathematics, such as number theory and algebra, is given by the so-called p-adic numbers.

Topic: **Continued fractions**
Supervisor: Professor Ivan Todorov
Description: Decimal expressions of real numbers are well-known and very practical for life within and outside Mathematics. In this project we will have a look at another useful way to express reals - the so-called continued fractions - which allow us to represent real numbers as infinite sequences of integers and to perform approximations by rationals in a straightforward and elegant way.

Topic: **Fractional graph theory**
Supervisor: Proessor Ivan Todorov
Description: A graph consists of nodes, some pairs of which are linked: imagine points on the plane some pairs of which are connected with a straight line (and some not). To colour a graph means to assign colours to its nodes so that linked nodes are assigned different colours. Can we colour a graph with 2.5 colours?