Topics – Second part

Note that the descriptions are not limiting. They are a guide to start the research process.

101. **Pythagorean theorem.** History and proofs of the Pythagorean theorem.

102. **Mathematical induction.** Explanation of proofs by induction. Should include some examples.

103. **Proofs by contradiction.** What is a proof by contradiction? Should include examples.

104. **Graphs.** A lot of mathematical problems concern mathematical graphs. The notion of Eulerian path, their existence, is one of the problems which could be discussed via the famous problem "Seven Bridges of Königsberg".

105. **Ptolemy's theorem.** How can we check that a quadrilateral can be inscribed in a circle? This is the object of Ptolemy's theorem. This talk should contain a proof of the theorem.

106. **Voting paradox.** Depending on countries there are several ways to organize elections. Is there a way which is better than others? This talk should present several protocol and explain which are the advantages of each of them with mathematical arguments.

107. **Computing π.** This talk will explain methods to get good approximations of π. It will also explain why it is impossible to hope for an exact value. It should contain explicit examples.

108. **Spherical geometry.** Let us replace the blackboard by a ball and try to do geometry on it. What will change? What is the shortest point between two points?

109. **Linear dynamical systems – Predator-prey model.** Suppose that we put a certain quantity of rabbits and foxes on an isolated island. What will happen after a while? Can it be predicted? Only rabbits? Only foxes? Some balanced situation?

110. **Crystal structure in daily life.** We all know how a pile of oranges as a natural tendency to get arranged. Why is that? The aim of this topic is to understand what geometrical properties of a crystal structure make it more or less likely to happen. It is possible to relate this to chemistry.

111. **Pythagorean triples.** We consider a right-angled triangle with sides of integer lengths. What can be these lengths? The aim is to show the formula giving these length (to prove how to find such triples of integers but also to prove that there are no other than the one given by the formula).

112. **Famous computable sums.** The aim is to prove several formulas for computing sums of numbers. For example, what is the value of $1+2+\cdots+n$, or $1^2+2^2+\cdots+n^2$, or $2^1+2^2+\cdots+2^n$? There are several possible proofs. It includes elegant geometrical argument and inductive proofs.

113. **About magic squares.** A magic square is a 3×3 matrix that has the property that the sums of its entries on each row, column and diagonal are equal. Can we find all these magic squares? What are the possible variants?

114. **Platonic solids.** This is the other name of regular polyhedrons. How many are they? How to prove that these are the only ones? These will be some of the questions that will be answered.

115. **The problem of shortest path.** How does a famous website choose for us the best possible travel between two locations? The main aim will be to introduce Dijkstra's algorithm which permits to solve this problem. The talk should contain some examples of computations.