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## CONSTRUCTING PLANE CURVES WITH THE AUTOCAD AND GRASSHOPPER SOFTWARE

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The dynamic development of information technologies, which has taken place in the recent years, has changed and is still transforming the educational system at every level of youths education. These transformations do not always refer to the curricula of the taught subjects, but above all are related to the method of transferring knowledge. The didactic workshop of the university faculty has been expanded to encompass: multimedia presentations, e-learning, a whole range of computer programmes, resources available on-line as well as various ways of remote contacts with students. The faculty staff continue to improve their qualifications and experiment, including new teaching techniques and methods into the process of education.

The construction of plane curves, which is included in the curriculum of the subject of mathematics in the first year of studies at the Faculty of Architecture of Cracow University of Technology, has been given as an example to illustrate the new approach to the realization of didactic issues. This subject matter refers to analytic geometry, the final result of which is a visualization of mathematical contents in the form of a poster made with the application of graphics editors. For many years students realized the task by applying basic AutoCAD commands. Then, following a detailed analysis of the curve description, the method of drawing the curve applying this programme was determined.

An epicycloid and a hypocycloid are considered a rather difficult area of this subject since they are produced by tracing the path of a fixed point of a circle which is rolling on the circumference of another circle which is fixed. The plane motion performed by the rolling circle (usually a smaller one) needs to be divided into separated rotations around the centers of both circles. The correct result is obtained by following the sequence of commands – firstly, by applying the polar array one makes multiple copies of the small circle placing it on the circumference of the large circle (rotation around

the center of the large circle), secondly the point drawing the curve is rotated around the center of the small circle. Since 2015 students have also been drawing curves with the application of the parametric methods available in the AutoCAD software. In that case they make use of the tutorials which introduce the subject of parametric dependencies in this software. In 2017 the Rhinoceros and Grasshopper programmes have been included in the list of tools which are useful in the realization of curves. The construction of a correct algorithm requires that students understand these issues and precisely render solutions. In the case of an epicycloid and a hypocycloid, connecting functionally both circles results directly in the realization of the plane motion. Moreover, the introduction of parameters related to the ratio of radii of both circles as well as the distance of the point drawing the curve from the center of the small circle makes it possible to obtain not one but an unlimited number of combinations of these curves, including ordinary as well as shortened and elongated ones.

Regardless of the kind of software, the work on the subject is carried out in a few stages:

1. Students familiarize themselves with the construction of the curve and determine its approximate shape. They determine the way of drawing the curve with the application of the AutoCAD software.
2. During classes in a computer laboratory they draw the curve applying a selected software (AutoCAD, Grasshopper).
3. For homework, they produce a poster in accordance with the predefined criteria.

Both the AutoCAD and Rhinoceros programmes as well as the Grasshopper addition are software applications used in architectural design, which students have already got acquainted with within the course of Computer-aided Design Techniques. Rhinoceros with the Grasshopper add-in are programmes applied in algorithmic-parametric design, in which graphics are determined by an algorithm with the use of mathematical concepts. Hence, apart from tutorials on plane curves, a lecture has been prepared on vectors and operations on vectors in these programmes, which constitutes an additional illustration of the subject matter taught during the course of mathematics. In spite of the fact that this software is not an easy one, in the academic year 2016/2017 the majority of students chose the Grasshopper programme and constructed plane curves by applying the algorithmic-parametric approach.

The principal purpose of these classes is to familiarize students with plane curves as in the construction and not analytical description. The group of curves, such as: ellipse, parabola, hyperbola, which they will learn about during the course in descriptive geometry, is further expanded by: cycloid, epicycloid, hypocycloid, strophoid, conchoid of Nicomedes, cissoid and other curves. They expand their knowledge on computer programmes, and at the same time learn about the ways of solving non-standard tasks with the application of various graphics editors. The construction of a correct algorithm requires that students understand these issues and precisely render solutions.

The subject of plane curves, covered as in the hereby presented shape, goes beyond the scope of the course in mathematics and, in a sense, interferes with the subject matter of descriptive

geometry and computer techniques. However, this issue brings these subjects closer together and does not separate them. It shows a close connection between descriptive geometry and mathematics in combination with modern computer techniques in the form of graphics editors, which not only leads to an increase in efficiency but above all results in an awareness of the realization of tasks.