Activity 12

LE SAUT QUANTIQUE
CENTRE D'INNOVATION PÉDAGOGIQUE
EN SCIENCES AU COLLÉGIAL

Speed Limits

Activity developed at Cégep régional de Lanaudière
à L'Assomption
by **ARIEL FRANCO**

Activity 12

Speed Limits

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Scientific Discipline

Mathematics

Average Age of Students

17-18 years old

Course Title and Number

Differential Calculus (201-NYA-05)

Duration of Activity

2 weeks

NOTE

In this document, the masculine is used without discrimination and solely to make the text easier to read.

Appendices are available in PDF and Word format on the CD provided with this document.

In addition, an instructional analysis of the activity is available in the pedagogical treasures section (*Trésors pédagogiques*) on the Saut Quantique Web site at: **http://www.apsq.org/sautquantique**.

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Speed Limits

Description of Activity

OVERVIEW

At the end of the *Differential Calculus* course, the teacher presents a problem situation that deals with the motion of two cars over time. This activity brings students to integrate the fundamentals of the course (definition of a function, derivative of a function and continuity of a function) by applying them to real-life situations.

Students must solve this problem situation with the *Maple* software program.

Basically, the problem to be solved is as follows:

> Last week, on his way to college, Bernard was stopped by the police for speeding while, according to the radar data, he was driving at 88.1 km/h in a 70-km/h zone. Bernard believes that the police committed an injustice towards him. The officer who gave him his ticket said that any vehicle that exceeded the allowable speed limit by 5 km/h or more was automatically stopped. Now, when he stopped at the traffic light, Bernard saw Ariel, one of his friendly colleagues, driving at about 10 m in front of him. At the green light, the two cars took off and Bernard never passed Ariel over the 437.5-meter distance that he drove before he was stopped by the police. Yet the police never stopped Ariel. Is it unfair? Did the police officer lie? Was this a setup? It is up to you to shed some light on the mystery!

Knowing the mathematical function that describes the position of Ariel's car versus time, students must determine the mathematical function that gives the position of Bernard's car versus time, by fulfilling several requirements with regard to the position, speed and acceleration of both cars, as well as the continuity of these functions at any point.

This activity was adapted from pedagogical support material in mathematics, in the *International Baccalaureate* program.

RELEVANCE AND ORIGINALITY OF ACTIVITY

Since this is a real-life and believable situation, students are eager to solve the problem.

This activity integrates physics and mathematics concepts.

Objectives and Relation to the Program

PEDAGOGICAL OBJECTIVES OR TARGETED COMPETENCIES

- Describe a car's position, speed and acceleration using a piecewise function.
- Use these functions to make various calculations.
- Use the definition of the derivative to find the function that gives a car's speed and acceleration.
- Describe a car's behaviour in words, where the functions are known, stating its position, speed and acceleration.
- Use the concept of continuity of a function at a point to determine the conditions required for the continuity of a piecewise function.

- Use the *Maple* software program to solve a linear equation system and plot the graph of a function.

LINK BETWEEN THE ACTIVITY AND THE PROGRAM

General Program Goals Targeted

This activity targets the following general goals of the *Science* program:

- To take a systematic approach to problem solving;
- To use the appropriate data processing technologies;
- To reason logically;
- To communicate effectively;
- To work as members of a team.

Link with Course

This activity is the last assignment given to students in the *Differential Calculus* course. It is submitted to them towards the end of the semester (12th or 13th week), as it provides a complete review of the fundamentals discussed in the course (definition of a function, derivative of a function, continuity of a function).

Link with Other Courses

Since the activity involves a real-life situation about the motion of two cars over time, it addresses the concepts of position, speed and acceleration seen in the *Mechanical Physics* course.

Number of Students and Educational Support

APPROXIMATE NUMBER OF STUDENTS IN CLASS

The number of students is of little importance as the activity takes place outside of the classroom.

NUMBER OF STUDENTS PER TEAM

2 people

EDUCATIONAL SUPPORT

The teacher first familiarizes himself with the problem situation (see Appendices S.1, T.1 and T.2).

After handing the problem situation to students (Appendix S.1), he acts as guide, suggesting a review of specific concepts based on student questions.

He must also provide specific support and assistance for the use of *Maple*, as students often need help with command syntax.

Conducting the Activity

CONDUCTING THE ACTIVITY AND TIME REQUIRED TO COMPLETE EACH STEP

Before

The teacher must make sure he addresses all relevant concepts in class (piecewise, derivative and continuity functions).

He must also introduce students to the *Maple* software program via an activity or laboratory session.

During

The teacher submits the problem situation (Appendix S.1). Students work in teams of two, at their own pace, in class during exercise periods or outside of class. They have two weeks to complete the assignment.

After

The teacher does a review in class based on the graph describing the position of Ariel's car versus time (see Appendices T.1 and T.2). He facilitates a discussion on the possible alternatives with regard to this function.

Evaluation and Required Material

SUGGESTED EVALUATIONS

This activity is worth between 2% and 5% of the final course grade.

The teacher must stringently correct this activity (especially the notation), since it is an assignment.

For the *Maple* portion, it is important to ask students to insert a text line before each command line to explain the command and, at the same time, to personalize their work in order to avoid plagiarism.

REQUIRED MATERIAL

Maple software program

APPENDICES

Teacher

Appendix T.1: Activity Solution (Written Part, Word File

Appendix T.2: Activity Solution (*Maple* Part Word and *Maple* Files)

Students

Appendix S.1: Activity (Word File)

Note:

Appendices are available in PDF and Word format on the CD provided with this document.

Other Suggestions and Media Directory

OTHER IDEAS TO EXPLORE

The activity can be adapted to the group's abilities (by providing more or less clues on the function to be found). The version provided is for a group with poor abilities.

It would also be interesting to complete the description of the behaviour of Bernard and Ariel's cars by asking students to plot three graphs in a single *Maple* worksheet:

- The first representing the position of Bernard and Ariel's cars;
- The second representing the speed of these cars;
- The third representing the acceleration of these cars.

In the graph that represents the speed of the cars, you notice that Ariel's car never exceeds the speed limit allowed, while Bernard's car exceeds it after 17.48 s.

The graphs that represent the cars' speed and acceleration provide a great opportunity to review the concepts of continuity and derivability. Thus, students could, for example, be asked to explain why the acceleration of Ariel's car is not defined at $t = 6$ s.

MEDIA DIRECTORY

BRADLEY, G. L. and K.J. SMITH (2001) *Calcul différentiel*, ERPI, 280 p.

FRANCO, Ariel and Bernard MARCHETERRE (2001). *Maple et le calcul différentiel*, ERPI, 132 p.