Please read the following instructions carefully

1. Please do not indulge in any unfair means. Any students caught indulging in any unfair means will be reported to ADAC.
2. Please switch off your mobile phones and other electronic items and keep them in a bag in the front of the room.
3. You are not allowed to keep any books, notebooks, notes, papers, etc. You should keep pens or pencils only to write your report on the sheets provided.
4. Sharing any material or discussing any thing with any student in not allowed.
5. Write your name and roll number clearly on the answer sheet provided.
6. The Moodle page will stop accepting submissions at 5:00PM. Upload your files as soon as you finish answering a question. Do not wait until the last minute.
7. Upload all your files: AMPL models, PYTHON routines, data, plots or any other file that is required to run your program or to obtain your output.
8. Return your answer script before you leave.
9. There are two questions, each worth 15 marks. Upload answers to questions 1 and 2 separately, in the spaces provided on Moodle.
10. All questions marked **[R]** should be answered clearly in the answer sheets provided. Do not re-write your program or AMPL model in the answer sheet.
11. Clearly write any assumptions that you make.

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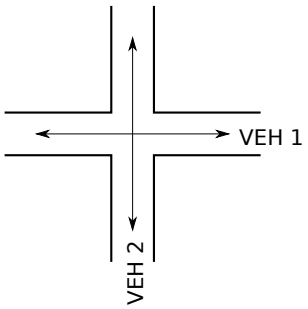
1. Suppose there are two pickup vehicles that serve two mutually perpendicular lanes in a warehouse. The two lanes intersect at a point (say origin), and the two vehicles are initially located here. Each vehicle makes a random move in its lane after every two minutes. The distance it moves is uniformly random between 0 and k ($k = 2$) meters in either direction. The speed of the vehicle is quite fast, so you may assume that the movements are instantaneous. We would like to answer the following questions based on simulation of the above system. You may assume that the length of the lanes is infinite in either direction.

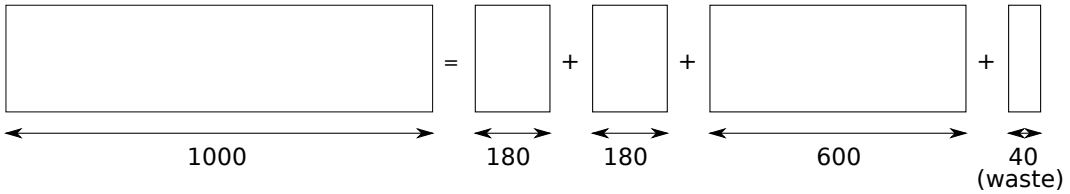


   (a) Write a program to find out when are the two vehicles expected to meet again. We will say, that they meet when the distance between the two is less than or equal to 1cm.

   (b) **[R]** Explain the logic of your program and how you ran your program to reach your conclusion. Do not write the program in your report.

   (c) **[R]** Experimentally deduce how the expected time until the vehicles meet again changes as a function of k?

2. Powai Cutters is in the business of cutting large sheets (called rolls) of high-grade steel in to smaller plates that are used in making transformers. They get 1000-inch long rolls of steel as raw material. They need to cut them into plates of four different sizes: 180 inch, 245 inch, 360 inch, 420 inch and 600 inch. They can cut the plates in any pattern. For example, a 1000-inch roll can be cut into two 180-inch plates and one 600-inch plate, the remaining 40 inch of metal is waste. We may assume that width of the roll and all plates is the same. Also assume that the rolls are cut along the length.



Suppose Powai Cutters needs to supply 2350 plates of length 180 inches, 970 plates of length 245 inches, 6100 of 360 inches, 3950 of 420 inches and 2110 of 600 inches. We want to find the minimum number of 1000-inch rolls that they need to buy in order to satisfy their demand. They can possibly produce more than the demand.

(a) [**R**] First find how many patterns of 180, 245, 360, 420, 600 can be made from the roll of length 1000. Find only the 'efficient' patterns, i.e. those patterns that can not be extended to obtain a valid pattern. For instance, $2\times180+0\times245+1\times360+0\times420+0\times600$ is not an efficient pattern, because more plates can be cut from the remaining portion. Write all these efficient patterns in your report. How many are there?

(b) [**R**] Using these patterns, write an optimization problem to find the best solution. Clearly define the variables and constraints in your report.

(c) Solve this problem using a suitable solver.

(d) [**R**] Report the number of rolls required for each pattern (report only nonzero values) in your optimal solution.

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