MATH36032 Project 2 - deadline 12th April 2021, time 1100hrs.

In this project, the dynamics between a fox and a rabbit will be investigated, by solving differential equations modelling their positions at different times. The initial configuration is shown in Figure 1, where the fox starts chasing the rabbit while the rabbit tries to escape from its predator and moves towards its burrow instantaneously. The fox, initially located[1] at $(250, -550)$, pursues the rabbit with the initial speed $s_{f0} = 16m/s$ in one of the following two possible ways:

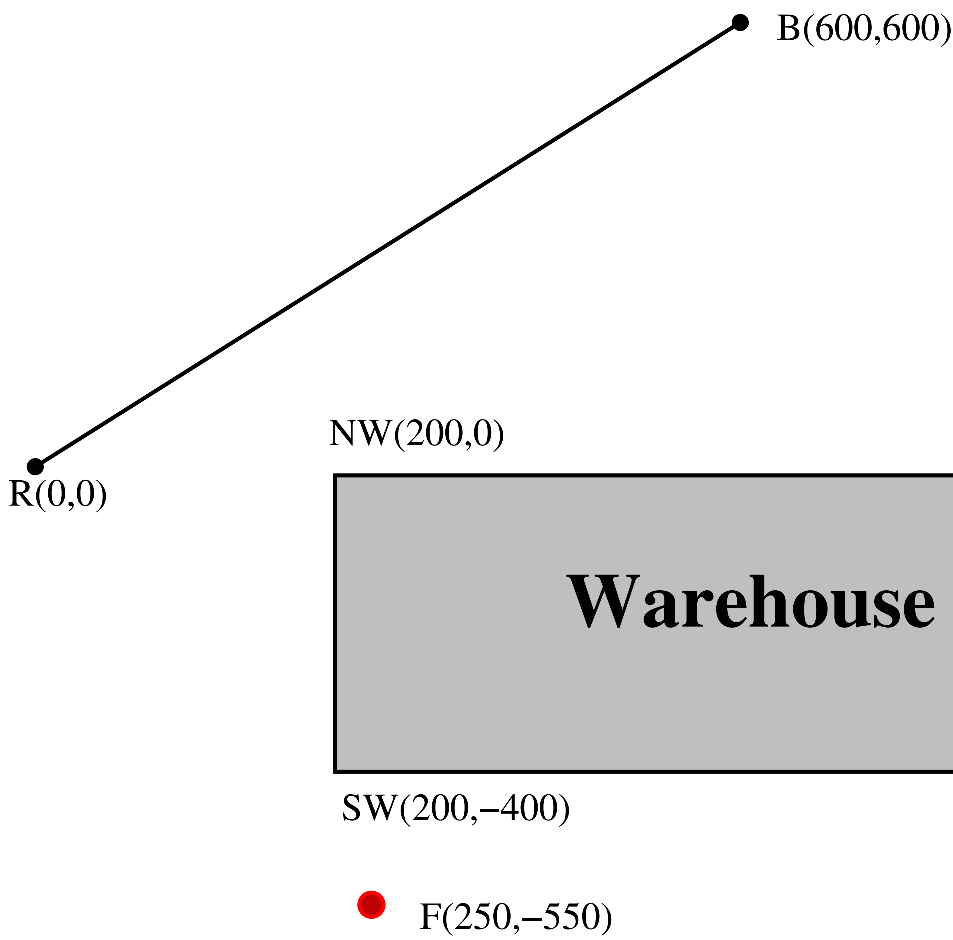

Figure 1: Coordinates (in metres) of the fox (F), the rabbit (R) and its burrow (B) and the two corners (SW,NW) of the warehouse.

- if the rabbit is in sight, the fox's attack path points directly towards the rabbit (the direction of the velocity vector of the fox is exact from the fox to the rabbit);
- if the view of the rabbit is blocked by the corner SW of an impenetrable warehouse (assuming that the warehouse is extended indefinitely to the east), then the fox runs

[1]The subscripts f and r denote the fox and rabbit respectively. The units of the coordinates are metres.

directly towards this corner. If the rabbit is still not in sight when the corner is reached, then the fox moves parallel to the NW-SW perimeter of the warehouse until it sees the rabbit.

The rabbit, initially located at the origin $(0, 0)$, runs towards its burrow at $(600, 600)$ in a straight line with initial speed $s_{r0} = 13m/s$.

Question 1: Constant speeds.. Assuming that both the fox and the rabbit run with constant speeds $s_{f0} = 16m/s$ and $s_{r0} = 13m/s$ respectively, determine whether the rabbit can be captured before it reaches its burrow. The rabbit is considered to be captured by the fox, if the distance between them is smaller than or equal to 0.1 meter.

Question 2: Diminishing speeds. Let us consider a more realistic scenario, when the hungry fox meets the tired rabbit. Because neither the fox nor the rabbit are in their best conditions, their chasing/escaping speeds diminish in time, according to the amount of distance (starting from the time they find each other and start running) they have travelled so far. More precisely, their speeds at time t are given by

$$s_f(t) = s_{f0}e^{-\mu_f d_f(t)}, \quad s_r(t) = s_{r0}e^{-\mu_r d_r(t)},$$

where $s_{f0} = 16m/s$ and $s_{r0} = 13m/s$ are the same initial speeds as above, $\mu_f = 0.0002m^{-1}$ and $\mu_r = 0.0008m^{-1}$ are the rates of the diminishing speeds, $d_f(t)$ and $d_r(t)$ are the distance they have travelled up to time $t(> 0)$. Determine whether the rabbit can be captured before it reaches its burrow. (You may assume that this diminishing speed starts from $t = 0$).

Outputs required You are required to submit a report (maximum 8 pages including any appendices) in pdf form via the submission box on Blackboard. Additionally you need to submit your m-files used for the MATLAB codes.

Additional information and guidelines

1. All coding must be done in MATLAB.
2. Treat both the fox and the rabbit as points, without worrying about their finite sizes (as in most models).
3. The questions can be answered with different approaches, but the preferred way is to use the built-in ODE solver `ode45` discussed during the lectures.
4. Avoid using hard-coded numbers. Any number in your code should either be given as initial condition, or be derived from these conditions.
5. Keep to the page length not exceeding eight A4 pages, and there is no need for a title page or abstract for a relative short report like this. Font sizes should be no smaller than 11 point, and page margins no smaller than 2cm.
6. List the complete code of the whole function at the end of each question, or in an appendix. Make your source code more readable, by keeping the indentation and

stylistic features, and can be copied from your submitted. Your published results should be reproducable from the code attached.

7. Have a look at the generic rubric about how your report will be marked, and also the intended learning outcomes about what you are expected to achieve in the end.

8. Avoid copying (too many) sentences directly from the project description, and try to restate the problem with your own words or examples if possible.

9. You may use your report in the future as evidences of written work, so take it seriously.

10. Your target audience is a fellow student on your course: explain the questions so that the report can be understood without this project description and your approach could be implemented in another computer language like Python. The report should indicate to the reader how well you understand the problem and the approach you took. Your goal will be to communicate your solutions to another person rather than to show you've completed the assignment.

11. Balance the explanation of the approach and the comments in the code. Avoid under-commenting and over-commenting.

12. Aim for precision and clarity of writing.

13. Since there is no final exam, you are advised to spend at least 15 hours on each project, with additional self-study if you are less experience with computer programming. Remember for a 10 credit module like this one, you are expect to spend $100 = 10 \times 10$ hours in total (including lectures, labs, self-study and coursework).

14. Please do not put any personal information on the report, only your student ID number.

15. The submission for each project will be open two weeks before the deadline. Only your last submission will be marked, and anything submitted after the deadline will be treated late and any penalty will be applied by the Teaching and Learning Office in June according to the Undergraduate Student Handbook.