Portfolio 2 Submission Instructions

Please follow the submission instructions carefully. A failure to do so will result in mark deductions. Make sure you attempt all questions in Part A and Part B.

1. All questions in Part A submitted via Blackboard's MATLAB grader. Multiple attempts are allowed and your best score will be counted. After submitting an answer to the problem, your grade should appear in My Grades on Blackboard.

2. Solutions to all questions (both Part A and Part B) must also be presented within a single pdf document and submitted via blackboard.

3. The submitted pdf should include your student number in its same (eg. n#######Portfolio2.pdf)

4. Code and working should be simple for your marker to understand.

5. Portfolio 2 is **due at 11:59pm Monday 9th September** and should be submitted through Blackboard. Late submissions will receive a mark of zero. If you make multiple submissions, the most recent on-time submission will be graded.

Part A - For Loops (7 Marks)

Charlie, an avid mountain biker, has purchased a new multisport watch that measures data such as horizontal position, time, heart rate and elevation. The associated software for the watch allows for users to design their own apps that record new measurements. Charlie is interested in measuring their elevation gain and total distance travelled.

1. Write a MATLAB function that recieves vectors for horizontal position and elevation and outputs a plot of elevation vs. horizontal position.

   (1 mark)

2. Write a function that receives the vectors for horizontal position and elevation and outputs total distance travelled. You can assume that each point has been recorded sufficiently close together that a linear approximation incurs insignificant error. Your solution must use a `for` loop and is not allowed to use the in-built `sum` or `diff` functions. **Hint:** Calculate the distance between each coordinate and sum these distances together.

   (3 marks)

3. Elevation gain is a term used to describe the total vertical distance climbed up during uphill sections (downhill elevation changes are ignored). Write a function that receives an elevation vector and calculates the total elevation gain for the trip. Your solution must use a `for` loop and is not allowed to use the in-built `sum` or `diff` functions.

   (3 marks)

Part B - Modelling and Solving First Order ODEs (14 Marks)

Charlie decides to create a theoretical model of his riding velocity to test whether his watch is callibrated properly. To simplify the problem, Charlie decides to test the watch on flat ground. As a further simplification, Charlie decides to start their trial at 10 m/s and then let the bike coast (aka no external force).

1. Given drag force can be modelled with equation $F_d = dv^2$, draw a free body diagram of the bike and show that velocity can be modelled with the ODE:
$$\frac{dv}{dt} + \frac{d}{m}v^2 = 0.$$
(2 marks)

2. If Charlie linearises the ODE about the initial velocity of 10 m/s, show that the approximate velocity, v_a, can be modelled with the ODE:
$$\frac{dv_a}{dt} + \frac{20d}{m}v_a = \frac{100d}{m}.$$
(2 marks)

3. Solve the linearised ODE for v_a given $m = 70\ kg$, $d = 1$.
(4 marks)

4. Solve the original (non-linear) ODE for v given $m = 70\ kg$, $d = 1$.
(4 marks)

5. Plot the solutions for both the linear and nonlinear ODEs over the interval of one minute. Under what conditions does the linearised ODE accurately model velocity? **Hint:** You can adjust the y-axis limits of a plot using the `ylim` function.
(2 marks)

Marking Scheme

Part A

Note: Blackboard's MATLAB grader will not award part marks for Q2 and Q3. The marking scheme for Q2 and Q3 is what the tutors will use if you request by email that they are marked by hand.

1. Correct plot (0.5 marks), includes title and labels (0.5 marks).
2. Correct for loop structure with appropriate vector (1 mark), calculating distance between coordinates (1 mark), correctly summing (1 mark).
3. Correct for loop structure with appropriate vector (1 mark), conditional statement that determines whether elevation is gained (1 mark), correctly summing (1 mark).

Part B

1. Correct FBD (1 mark), correct NSL and algebra (1 mark).
2. Correct linearisation (1 mark), algebra (1 mark).
3. Correct method (1 mark), correct integration (1 mark), correct general solution (1 mark), applying initial condition (1 mark).
4. Correct method (1 mark), correct integration (1 mark), correct general solution (1 mark), applying initial condition (1 mark).
5. Correct plot with labels, legend and appropriate axis limits (1 mark), correct comment (1 mark).