PH20105 Experimental Physics & Computing 2: MATLAB assignment

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September 30, 2019

This assignment consists of two parts: Part I requires writing down matlab commands which generate a desired effect, whereas Part II involves writing a short code to analyze a physical problem. Please hand in your answers in a single printed document by using the appropriately marked drawer in the undergraduate lab by 16:00 GMT on 29th of November 2019. Please also use the green cover sheet.

1 Part I

For each of the numbered points below, respond with a single line of MATLAB code only (a single line is defined as a single or chain of commands that are effectively suppressed from being displayed on a computer screen by a single semicolon). It is assumed that, for a given task, all the previous tasks are completed so that the required variables exist in the workspace. Marks corresponding to each of the required commands are given in the square bracket at the end of each point. Note that you can either score the full number of marks or zero, depending on whether the single line of code works or not.

1. Create a variable `x` equal to $\left(20 - (3 - 7e^{2+i\pi\cos\frac{\pi}{3}})\right)$, where i is the imaginary unit. [1]

2. Create a 10-component column vector `v1` containing numbers from 1 to 10 (in an increasing order with 1 in the first row and 10 in the last). [1]

3. Calculate the imaginary part of the 5th component of the sum of `x` and the product of $(2+i)$ multiplied by `v1`. [1]

4. Create a 10-component column vector `v2` such that its j-th component is equal to a square of the j-th component of `v1`. [1]

5. Calculate the scalar product of `v1` and v2. [1]

6. Create a 15x10 matrix `Matrix1` containing random integers between 2 and 10. [2]

7. Calculate the determinant of a 10x10 matrix created from `Matrix1` by cutting off the last five rows. [2]

8. Calculate how many elements of `Matrix1` are greater than 5. [2]

9. Find the greatest value in the third column of `Matrix1`. [2]

10. Plot in red the sine function over a range 0 to 2π using a separation of the grid points of $\pi/100$. [2]

11. Create a variable `Matrix2` equal to a sum of a matrix resulting from truncation of the last five rows of `Matrix1` and a transpose of `Matrix1` with the last five columns truncated. The resulting matrix `Matrix2` should be 10x10. [2]

12. Find the largest in magnitude eigenvalue of `Matrix2`. [2]

13. Using the `trapz` function, calculate the integral $\int_2^5 (1+t)^2 dt$. [2]

2 Part II

For this part of the assignment, provide pieces of code that perform the tasks described below. It is not necessary to code each of the points in one line. Also, treat the code as a single file so that variables created for one of the points can be reused later. Note that some of the points require your comments instead of a piece of code.

2.1 Electric potential and field of a pair of opposite point charges

Consider two charges, $Q_1 = 1\,\mathrm{C}$ and $Q_2 = -1\,\mathrm{C}$, placed at positions $\boldsymbol{r}_1 = (0, 1, 0)$ and $\boldsymbol{r}_2 = (0, -1, 0)$, respectively (components of $\boldsymbol{r}_1$ and $\boldsymbol{r}_2$, as well as all other distances here, are expressed in milimetres).

1. Using the superposition principle, calculate the electric potential $V(\boldsymbol{r})$, where $\boldsymbol{r}$ is the position vector as measured from the centre of the coordinate system, on a grid of points between -4 and 4 along each of the axes x, y and z with a step of 0.1. Assign the result to a variable `Vexact`. [5]

2. What is the location within `Vexact` of the electric potential at a point $(1, -0.8, 3.5)$? [2]

3. Write a piece of code which checks whether any of the entries of `Vexact` are equal to `Inf` or `NaN` and determines their positions (indices of the matrix element). [5]

4. Repeat point 1. but on a grid between -4.05 and 4.05 along x and y and between -4 and 4 along z. Keep the same separation between grid points of 0.1 and assign the result to a variable `Vexact2`. [3]

5. Using the grid from the point above, calculate (and assign to a variable `Vapprox`) the electric potential as given by the formula for an electric dipole. [5]

6. Plot a 3D plot of the difference between `Vexact2` and `Vapprox` in the plane $z = 0$. Explain the main features of the figure in less than 100 words (include the figure in your report). [5]

7. Calculate numerically the electric field components `Ex`, `Ey` and `Ez` due to the potential `Vexact2`. [2]

8. Visualize the electric field in the plane $z = 0$ and for x and y between -1.55 and 1.55 using the command `quiver` (include the figure in your report). [2]