ANALYSIS OF RANDOM VARIABLES

It is required to create a GUI-based tool that allows a user to:
1) Enter a single random variable and results in the statistics of such variable.
2) Enter multiple random variables and results in their joint statistics.
3) Enter functions of random variables and generate their probability distributions.

The GUI can be built using Matlab or any other software package.

GUI Description

The GUI should do the following:
1) **Section 1: Random Variables**
   - Allow the user enter a random variable in the form of its sample space.
     An example .m file of the sample space is attached.
   - Allow the user to perform and display the following:
     – Plot the probability distribution and the CDF of the random variable.
     – Display the mean, the variance and the third moment of the random variable
     – Plot the MGF $M(t)$ vs $0 < t < t_{\max}$, where $t_{\max}$ is set by the user.
     – Plot the first and the second derivatives of $M(t)$, and calculate their values at $t = 0$

2) **Section 2: Joint Random Variables**
   - Allow the user enter two random variables in the form of sample pairs.
     An example .m file of the sample space is attached.
   - Allow the user to perform and display the following:
     – Find and plot the joint probability distribution of the two random variables.
     – Find and plot the marginal probability distributions.
     – Calculate the covariance of the two random variables.
     – Calculate the correlation coefficient of the two random variables.

3) **Section 3: Functions of Random Variables**
   - Allow the user enter two random variables, X and Y, in the form of sample pairs.
     An example .m file of the sample space is attached.
   - Allow the user to perform and display the following:
     – **Bonus** Allow the user to define Z and W as functions of X and Y.
     – Plot the probability distribution of $Z = 2X - 1$.
     – Plot the probability distribution of $W = 2 - 3Y$.
     – Plot the joint probability distribution of Z and W.

Testing your GUI

Test your GUI for the following:

1) Testing Section 1
   a) The RV in the sample file.
   b) X_2 is a RV, where $X_2 \sim \mathcal{U}(-5, 2)$.
   c) X_3 is a RV, where $X_3 \sim \mathcal{N}(3, 4)$.
   d) X_4 is a RV, where $X_4 \sim \mathcal{B}in(5, 0.3)$
   e) X_5 is a RV, where $X_5 \sim \mathcal{P}oisson(10)$
2) Testing Section 2 and Section 3
   a) The two RVs in the sample file.
   b) The random variables X_2 and Y_2, where $X_2 \sim \mathcal{N}(3, 4)$ and $Y_2 \sim \mathcal{N}(-5, 2)$
   c) The random variables X_3 and Y_3, where $X_3 \sim \mathcal{G}amma(2, 10)$ and $Y_3 \sim \mathcal{B}in(4, 0.5)$
   d) The random variables X_4 and Y_4, where $X_4 \sim \mathcal{E}xp(0.05)$ and $Y_4 = 3X_4 + 2$
   e) The random variables X_5 and Y_5, where $X_5 \in \{-1, 1\}$ and is uniformly distributed, while $Y_5 = X_5 + n$, where $n \sim \mathcal{N}(0, 0.5)$.

Deliverable

Deliver the following:

1) An executable file for the GUI
   Note You can have one GUI for the three sections, or a different GUI for each section.
2) All the source codes (**.m** files)
3) The outputs of the GUI for the test cases.
4) The file used to generate the RVs used for the test cases.
5) A complete .pdf report documenting all the previous outputs, with proper titles, subtitles, labeling, captioning and **commenting**.
6) A video recording showing the running GUI and how it is used to generate the required plots.

GENERAL INSTRUCTIONS & GRADING CRITERIA

Instructions

1) This is a team project, for teams of $2 \sim 3$ students.
2) All team members are accountable for all the parts of the project.
3) Reports are not to be shared with others.
4) Any copied reports, either fully or partially, will receive 0 points. This applies to both the original and the copy.
5) Late submission will be penalized at the rate of 10% per day for a maximum of 5 days, after which no submissions will be considered.

Project Grading Criteria

Grading of each part will depend on:

- **50%:** Completeness and correctness of the **deliverable**.
- **10%:** Clarity of the **GUI design and ease of use**.
- **20%:** **Report** writing and organization.
- **20%:** Comprehensiveness and clarity of content in the **recorded video**.