Examples of descriptive questions:

1. Let us assume that there is a mobile robot with two arms that can assist humans in household activities (e.g. TIAGo Pro — see image).

    a. For each of the three collaboration levels namely coexistence, cooperation, and collaboration, give an example of a task that the robot can perform with a human. (5 points)

    b. Within each task, describe the activities and roles of the human and the robot. (5 points)

Image source: https://pal-robotics.com/robots/tiago-pro/

2. Let us assume that you have to design a robotic wheelchair to help a person with lower limb impairments to navigate through a busy railway station. (Total 40 points)

    a. Design sensor (input) and actuator (output) interfaces for this robot to enable intuitive, multimodal, bidirectional communication between the person and the robot. (Note: Here, you should name the input and output interfaces, and explain how they can enable multimodal communication.) (7 points)

    b. Explain any two technical challenges involved in multimodal human-to-robot communication based on your design. (5 points)

    c. Explain any two technical challenges involved in multimodal robot-to-human communication based on your design. (5 points)

    d. Software architecture

        i. Design and draw a software architecture (at conceptual level) for your robot. (5 points)

        ii. Explain the functions of each component in your architecture in the text area given below. (8 points)

    e. Design a learning framework based on TAMER to enable a human to teach the robotic wheelchair to drive through a crowd. (10 points)

3. Write a script for a conversation between a human and a service robot in a restaurant setting. The robot is supposed to take orders from the human and deliver the requested food and drinks. During the design of the script, include any THREE of the following concepts associated with verbal communication and highlight how you included it in the script (20%):

        i. Turn-taking

        ii. Backchanneling

        iii. Metacommunication

        iv. Symbol grounding

4. Let us assume that a person is navigating through a busy railway station using a robotic wheelchair. Design this wheelchair such that there is high robot autonomy and high human control. (5%)

Examples of programming tasks

1. Given below is a Bayesian network to predict the user intention for a social robot in a home setup. The robot uses this network to infer the user intention based on information it has collected. (10%)

   1. Implement and visualise the Bayesian network using the pyAgurm library.

   2. Determine the probability of watch_TV = True given the evidence go_to_living_room = True.

   3. Determine the probability of watch_TV = True given the evidences go_to_living_room = True and is_bored = True.

   4. Compare the probability of watch_TV = True in the above two cases. Justify why or why not you observe a change.

2. A robotics company has created a new social companion robot for elderly persons. Since the robot is designed for elderly men and women who are living alone, it has to appeal to both demographic groups equally. Before the company mass produces the robot, it wants to make sure that the robot appeals equally to both elderly men and women. More specifically, the company wants to know whether men and women engage with the robot in the same way. To achieve this, 20 elderly men and 20 elderly women were recruited and asked to interact with the robot in a home setting. The participants were then asked to fill in a questionnaire that measures their engagement with the robot. An overall engagement score was computed based on the responses to the questionnaire. (20%)

   1. Define appropriate null and alternate hypotheses for this study.

   2. Load the empirical data from the file data/advertising_agency_engagement.csv.

   3. Plot appropriate graphs to visualise the data.

   4. Comment on outliers based on your graphs.

   5. Determine whether the data is normally distributed.

   6. Select an appropriate statistical test to validate your hypotheses and justify your choice.

   7. Conduct the statistical test and report the results.

   8. Justify your conclusions about the hypotheses based on the results of the statistical test.