# CS F222 Discrete Structures for Computer Science

## Assignment

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## Question:

**20.** Write a program to determine whether a relation is a function from a set X to a set Y.

## Solution:

***Note:*** *The Source Code is in Java.*

1. **Check if User input is a Relation:**

A relation is a collection of ordered pairs, where each pair represents some kind of connection between two sets. In the case of this program, the two sets are the Domain and the Range.

To check if the user input ordered pairs (in the (x, y) format) are relations, the program sees if the set of all x from the input ordered pairs is a subset of the Domain, and the set of all y from the input ordered pairs is a subset of the Range.

1. **Check if Relation is a Function:**

A function is a special kind of relation. For a relation to be considered a function,

1. More than one x values from the ordered pairs cannot be related to the same y elements.
2. Set of x values should be the same as the Domain set.

To achieve this, the code first traverses through the set of relations and checks if the x terms from the ordered pairs are repeating. If it does then the method returns ‘false,’ else it will add the element to a temporary HashSet. This repeats till all the x terms are added to the temporary set. Next the method checks if this new set is the same as the Domain set. It then returns a ‘true’ value if it is and a ‘false’ if it is not.

The program also contains a class to store input as ordered pairs. It is also made to discard duplicate elements.

The program has an if-else statement which calls the Boolean methods mentioned above and outputs either of the three strings:

1. **Both methods return ‘true’ value:** "The input is a valid Relation and is a Function of the Domain and the Codomain."
2. **Only the method checking relations returns ‘true’ value:** "The input is a valid Relation but is Not a Function of the Domain and the Codomain."
3. **Both methods return ‘false’ value:** "The input is Not a valid Relation of the Domain and the Codomain."

## Application:

**Traffic Light System:** The timings of traffic lights are controlled by functions that analyze traffic flow and optimize signal timing for efficiency and safety.

* **Speed function:** Calculates the average speed of vehicles on a specific road section. Analyzing speed variations helps identify crowding points and bottlenecks requiring improvement.
* **Density function:** Calculates the number of vehicles present on a road section per unit length. High density indicates congestion and potential risks, aiding in traffic management decisions.
* **Flow Rate Function:** Determines the volume of vehicles passing a specific point on a road during a given time interval. Analyzing flow rate helps understand traffic patterns and predict future trends, enabling initiative-taking traffic management strategies.
* **Queue Length Function:** Calculates the length of the line of vehicles waiting at a specific point, such as traffic lights. Identifying long queues enables authorities to intervene and optimize signal timing or implement alternative routing options to reduce wait times.
* **Travel Time Function:** Measures the average time it takes for vehicles to travel between two points. Analyzing travel time allows authorities to identify congested areas and implement measures to improve traffic flow and reduce travel time.
* **Predictive Functions:** Machine learning and statistical modeling techniques are frequently used to predict future traffic conditions. These functions analyze historical data and real-time traffic information to forecast potential congestion, enabling initiative-taking traffic management strategies and informing travelers about anticipated delays.
* **Traffic Simulation Functions:** Computer simulations are used to model and analyze traffic flow under different scenarios. These simulations help assess the impact of potential infrastructure changes, traffic management strategies, and weather conditions on traffic flow, allowing for informed decision-making.