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**Assessment Cover Page**

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# Question 1

# Question 2

## Constraint Satisfaction Problem (CSP) Representations

A CSP requires a value, selected from a given domain, to be assigned to each variable so that all constraints relating the variables are satisfied. This is an effective technique for scheduling and timetabling. (Brailsford, 1999) The CSP has variables, domains and constraints. (Ghedira, 2013)

For this problem the:

* **Variables** are the shifts for each doctor for each day, and the medical services performed,
* **Domain** is the possible values for each variable (i.e. the available working hours for the day for that doctor),
* **Constraints** are the rules that must be satisfied. These include that only one doctor will be available for the routine patient check-up, one doctor cannot do his/ her job of medical services on Wednesday and Thursday consecutively, and the total hours worked by each doctor must be equal.

The representation of the problem refers to how we decide to define these variables, what domains we assign to them, and how we express the constraints in mathematical or logical form. () This problem could be represented using binary, integer or categorical variables.

For representation as binary variables, each variable, domain and constraint are inputted with a true or false value. For example, if doctor 1 works on Monday, then this is true, otherwise false. This is the simplest way to represent the problem. The benefit of this representation is it is very efficient and computationally inexpensive. As the problem is relatively simple, this representation allows the solver to explore the search space quickly. The drawback of this representation is that it lacks flexibility. If detailed is required on specific hours or services that the doctors can perform, this representation doesn't allow you to model these nuances without adding complexity. ()

The second possible representation is to use integer variables. This is where each variable represents a number. This representation provides more detail. It calculates the number of hours worked by each doctor, which allows for a more direct way to balance the workload based on hours rather than just the number of workdays. This representation is more complex than the binary representation as there are more potential assignments for each variable. It also has an increased search space, making it more computationally expensive. ()

Finally, a categorical representation could also be applied. In this representation each variable represents the service type a doctor performs on a given day. For example, doctor 1 - Monday - routine check-up. This representation is suitable where there is a service specific scheduling required, for example if one doctor can’t perform a certain task. It has flexibility where it can handle cases where a doctor is specialized in certain services. However, this is the most complex and computationally expensive representation. ()

As the constraints for this problem, involve knowing the working hours, restrictions on one doctor performing the routine patient check-up and a further restriction one doctors days available to work, a combination of all representations would be the preferred model. This is because one of the above representations could only complete a portion of the task.

The combined representation would therefore use binary variables for whether a doctor works on a given day (True or False), categorical variable for the service type a doctor performs on a given day (Routine Check-up, Blood Test, Surgery, None) and integer variable for hours worked.

## Number of Possible Solutions

Following application of the code, there is 280 possible solutions to this problem using CSP.

## Formulation of CSP

## Python Results

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | | Available Hours | Week1 | | Week2 | |
| Dr 1 | Dr 2 | Dr 1 | Dr 2 |
| Monday | Routine Check-up | 7 | 0 | 7 | 0 | 7 |
| Tuesday | Routine Check-up | 7 | 7 | 0 | 7 | 0 |
| Wednesday | Routine Check-up | 7 | 7 | 0 | 7 | 0 |
| Wednesday | Bloods | 4 | 0 | 4 | 4 | 0 |
| Thursday | Surgery | 5 | 0 | 5 | 5 | 0 |
| Friday | Routine Check-up | 7 | 0 | 7 | 0 | 7 |

# Question 3

# References

**There are no sources in the current document.**