VIETNAM GENERAL CONFEDERATION OF LABOR

**TON DUC THANG UNIVERSITY**

**FACULTY OF INFORMATION TECHNOLOGY**



**MIDTERM ESSAY**

**DISCRETE STRUCTURES**

*Instructor*: **MAI DUY TAN**

*Executor*: **DANG THANH NHAN– 522H0006**

Class **: 22H50201**

Course  **: 22**

**HO CHI MINH CITY, YEAR 2024**

VIETNAM GENERAL CONFEDERATION OF LABOR

**TON DUC THANG UNIVERSITY**

**FACULTY OF INFORMATION TECHNOLOGY**



**MIDTERM ESSAY**

**DISCRETE STRUCTURES**

*Instructor*: **MAI DUY TAN**

*Executor*: **DANG THANH NHAN**

Class **: 22H50201**

Course  **: 22**

**HO CHI MINH CITY, YEAR 2024**

ACKNOWLEDGEMENT

I would like to express my sincere thanks to the Faculty of Information Technology, especially Mr. Mai Duy Tan, for his time and effort in guiding and supporting me throughout the process of completing this report. Your patience, understanding and support helped me overcome challenges and complete this report to the best of my ability.

**DECLARATION OF AUTHORSHIP**

I hereby declare that this thesis was carried out by myselves under the guidance and supervision of Mr Mai Duy Tan and that the work and the results contained in it are original and have not been submitted anywhere for any previous purposes. The data and figures presented in this thesis are for analysis, comments, and evaluations from various resources by my own work and have been duly acknowledged in the reference part.

In addition, other comments, reviews and data used by other authors, and organizations have been acknowledged, and explicitly cited.

I will take full responsibility for any fraud detected in our thesis. Ton Duc Thang University is unrelated to any copyright infringement caused on my work (if any).

*Ho Chi Minh City, day month year*

*Author*

*(Signature and fullname)*



*Dang Thanh Nhan*

INSTRUCTOR CONFIRMATION EVALUATION SECTION

**Confirmation of instructor**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Ho Chi Minh City, day month year

(signature and fullname)

**Evaluation of instructor**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Ho Chi Minh City, day month year

(signature and fullname)

ABSTRACT

This essay explores key concepts in discrete structures, including conditional statements, logical fallacies, the logic of compound statements, and the fundamentals of the Prolog programming language. It provides an overview of the role and applications of these ideas in logic design and programming.

CONTENTS

[ACKNOWLEDGEMENT i](#_Toc164050598)

[INSTRUCTOR CONFIRMATION EVALUATION SECTION iii](#_Toc164050599)

[ABSTRACT iv](#_Toc164050600)

[CONTENTS 1](#_Toc164050601)

[PART 1 3](#_Toc164050602)

[1.1 Problem 1: Password 3](#_Toc164050603)

[1.1.1 Requirement 3](#_Toc164050604)

[1.1.2 Solution 3](#_Toc164050605)

[1.2 Problem 2: Conditional statements 5](#_Toc164050606)

[1.2.1 Requirement 5](#_Toc164050607)

[1.2.2 Solution 6](#_Toc164050608)

[1.3 Problem 3: Fallacies 9](#_Toc164050609)

[1.3.1 Requirement 9](#_Toc164050610)

[1.3.2 Solution 10](#_Toc164050611)

[PART 2 15](#_Toc164050612)

[2.1 Problem 4: Tarski's world 15](#_Toc164050613)

[2.1.1 Requirement 15](#_Toc164050614)

[2.1.2 Solution 17](#_Toc164050615)

[2.2 Problem 5: Symbolic form 19](#_Toc164050616)

[2.2.1 Requirement 19](#_Toc164050617)

[2.2.2 Solution 19](#_Toc164050618)

[2.3 Problem 6: Equivalence 20](#_Toc164050619)

[2.3.1 Requirement 20](#_Toc164050620)

[2.3.2 Solution 21](#_Toc164050621)

[PART 3 23](#_Toc164050622)

[3.1 Problem 7: Prolog 23](#_Toc164050623)

[3.1.1 Requirement 23](#_Toc164050624)

[3.1.2 Solution 24](#_Toc164050625)

PART 1

1.1 Problem 1: Password

1.1.1 Requirement

A hacker is trying to hack a password. He knows that this password has 3 characters, each of which is a distinct number from 1 to 9. He also learns from his trials that:

a. 472: one number is correct but in an incorrect position.

b. 581: one number is correct but in an incorrect position.

c. 483: one number is correct and in the correct position.

d. 317: two numbers are correct but in incorrect positions.

e. 956: all numbers are incorrect.

Please help him to find the password with good reasoning

* + 1. Solution
* Consider hypothesis e): We notice that 5, 9, and 6 are all incorrect numbers, so we can eliminate 5 from any position. (1)
* Consider hypotheses b) and c): Since they both contain the number 8 and it's in the same position, we can eliminate 8 from those positions. (2)
* Consider hypotheses a) and c): Since they both contain the number 4 and it's in the same position, we can eliminate 4 from those positions. (3)
* From deductions (1) and (2), we can conclude that 1 is one of the numbers in the password, but it's in the **wrong** position. (4)
* From deductions (2) and (3), we can conclude that 3 is one of the numbers in the password, but it's in the **correct** position. (5)
* Consider hypothesis d): We have 1 and 3 are the number in the password (depend on deductions (4) and (5)). Therefore, 7 is an incorrect number. (6)
* Consider hypothesis a): Because 7 is an incorrect number (depend on deduction (6)) and 4 is eliminated (depend on deduction (3)).
* We can deduce that 2 is another number in the password, but it's in the **wrong** position. (7)
* Consider hypotheses b) and d): Since 1 is in the wrong position in both, it must be in the first position. (8)
* Because 1 is the first and 3 is the last number of the password. Hence, 2 is the number in the middle of the password.
* The password is 123.

1.2 Problem 2: Conditional statements

1.2.1 Requirement

State the converse, inverse, contrapositive, and non-conditional-form negation of these conditional statements in natural language:

a. “If a man, holding a belief which he was taught in childhood or persuaded of afterwards, keeps down and pushes away any doubts which arise about it in his mind, purposely avoids the reading of books and the company of men that call in question or discuss it, and regards as impious those questions which cannot easily be asked without disturbing it - the life of that man is one long sin against mankind.”

*The Ethics of Belief* (1877) by William K. Clifford.

b. “If existing agricultural knowledge were everywhere applied, the planet could feed twice its present population.”

*The Lessons of History* (1968) by Will and Ariel Durant.

c. “But even if the initial colonists had consisted of only 100 people and their numbers had increased at a rate of only 1.1 percent per year, the colonists' descendants would have reached that population ceiling of 10 million people within a thousand years.”

*Guns, Germs, and Steel* (1997) by Jared Diamond.

d. “If anyone looked out of their window now, even beady-eyed Mrs. Dursley, they wouldn’t be able to see anything that was happening down on the pavement.”

*Harry Potter and the Philosopher's Stone* (1997) by J. K. Rowling

* + 1. Solution

a. “If a man, holding a belief which he was taught in childhood or persuaded of afterwards, keeps down and pushes away any doubts which arise about it in his mind, purposely avoids the reading of books and the company of men that call in question or discuss it, and regards as impious those questions which cannot easily be asked without disturbing it - the life of that man is one long sin against mankind.”

The Ethics of Belief (1877) by William K. Clifford.

* **Converse:** “If the life of a man is one long sin against mankind, then he holding a belief which he was taught in childhood or persuaded of afterwards, keeps down and pushes away any doubts that arise about it in his mind, purposely avoids the reading of books and the company of men that call in question or discuss it, and regards as impious those questions which cannot easily be asked without disturbing it.”
* **Inverse:** “If a man does not hold a belief which he was taught in childhood or persuaded of afterwards, does not keep down and push away any doubts which arise about it in his mind, does not purposely avoid the reading of books and the company of men that call in question or discuss it, and does not regard as impious those questions which cannot easily be asked without disturbing it - then the life of that man is not one long sin against mankind.”
* **Contrapositive:** “If the life of a man is not one long sin against mankind, then he does not hold a belief which he was taught in childhood or persuaded of afterwards, does not keep down and push away any doubts which arise about it in his mind, does not purposely avoid the reading of books and the company of men that call in question or discuss it, and does not regard as impious those questions which cannot easily be asked without disturbing it.”
* **Non-conditional-form negation:** “A man holding a belief which he was taught in childhood or persuaded of afterwards, keeps down and pushes away any doubts which arise about it in his mind, purposely avoids the reading of books and the company of men that call in question or discuss it, and regards as impious those questions which cannot easily be asked without disturbing it and the life of that man is not one long sin against mankind.”

b. “If existing agricultural knowledge were everywhere applied, the planet could feed twice its present population.”

The Lessons of History (1968) by Will and Ariel Durant.

* **Converse:** "If the planet could feed twice its present population, then existing agricultural knowledge would be everywhere applied."
* **Inverse:** “If existing agricultural knowledge were not everywhere applied, then the planet could not feed twice its present population.”
* **Contrapositive:** “If the planet could not feed twice its present population, then existing agricultural knowledge would not be everywhere applied.”
* **Non-conditional-form negation:** “Existing agricultural knowledge were everywhere applied and the planet could not feed twice its present population.”

c. “But even if the initial colonists had consisted of only 100 people and their numbers had increased at a rate of only 1.1 percent per year, the colonists' descendants would have reached that population ceiling of 10 million people within a thousand years.”

Guns, Germs, and Steel (1997) by Jared Diamond.

* **Converse:** “If the colonists' descendants reached a population ceiling of 10 million people within a thousand years, then the initial colonists would have consisted of only 100 people or their numbers would have increase at a rate of only 1.1 percent per year.”
* **Inverse:** “If the initial colonists had not consisted of only 100 people and their numbers had not increased at a rate of only 1.1 percent per year, the colonists' descendants would not have reached that population ceiling of 10 million people within a thousand years.”
* **Contrapositive:** “If the colonists' descendants had not reached that population ceiling of 10 million people within a thousand years, then the initial colonists would not have consisted of only 100 people and their numbers would not have increased at a rate of only 1.1 percent per year.”
* **Non-conditional-form negation:** “The initial colonists had consisted of only 100 people and their numbers had increased at a rate of only 1.1 percent per year and the colonists' descendants had not reached that population ceiling of 10 million people within a thousand years.”

d. “If anyone looked out of their window now, even beady-eyed Mrs. Dursley, they wouldn’t be able to see anything that was happening down on the pavement.”

Harry Potter and the Philosopher's Stone (1997) by J. K. Rowling

* **Converse:** “If anyone would not be able to see anything that was happening down on the pavement, even beady-eyed Mrs. Dursley, then they would look out of their window now.”
* **Inverse:** “If no one looked out of their window now, even beady-eyed Mrs. Dursley, they would be able to see anything that was happening down on the pavement.”
* **Contrapositive:** “If anyone were able to see anything that was happening down on the pavement, even beady-eyed Mrs, then they would not look out of their window now.”
* **Non-conditional-form negation:** “Anyone looked out of their window now, even beady-eyed Mrs. Dursley and they would be able to see anything that was happening down on the pavement.”
  1. Problem 3: Fallacies

1.3.1 Requirement

Give a real-life example for each type of fallacy in chapter 1. Reference materials are needed. Paraphrase the materials, using your own words.

* + 1. Solution

1. **Ambiguous premises**

* Example: "Customers order a website with the requirement that the website must be aesthetically pleasing and easy to navigate"
* Explanation: The example above is ambiguous premisesbecause:

+ "Aesthetically pleasing" is a subjective term without a clear definition. What one person finds aesthetically pleasing may differ from another's opinion.

+ "Easy to navigate" is also a vague term that could mean different things, such as easy to read, find information, or use the website.

* Reference:<https://www.quora.com/What-is-an-example-of-ambiguity-as-a-logical-fallacy>

1. **Circular reasoning**

* Example:

+ Situation: " On July 19, 2021, Manchester United football club signed Jadon Sancho for a record fee £73m.”

+ Person A: “Surely, he must play very well.”

+ Person B: "Why do you think so?"

+ Person A: "Because he was signed with a record price."

* Explanation: Person A presents a circular argument by stating that the player signed for a record fee must play very well. He uses the fact that "he was signed for a record fee" (the result) to argue that "he must play very well" (the conclusion). However, he does not provide any other reasons or evidence to support the player's performance besides the record fee.
* Reference:

+<https://theathletic.com/4204497/2021/07/19/jadon-sancho-completes-73m-move-to-manchester-united/>

+ <https://s.pro.vn/8hZl>

1. **Jump into conclusion**

* Example: "On the occasion of Tet holiday 2024, director Tran Thanh released the movie 'Mai'. Many people believe that this movie will be great because his previous movies were very good."
* Explanation: In this example, people are jumping to the conclusion that Tran Thanh's movie "Mai" will be excellent solely based on his past successful films. However, this overlooks the fact that each movie is unique, and its quality depends on various factors such as the script, cast, production techniques, and creative ideas. Relying solely on past success without considering specific elements of the current movie could lead to inaccurate or unfounded conclusions.
* Reference: <https://short.com.vn/ex9F>

1. **Converse Error**

* Example:   
  + Teacher said: “If someone studies well, then they will achieve high scores in the exam.”

+ Nam said: “Because I achieve a high scores in the xam, so I study well”

* Explanation:

+ Achieving high scores in the exam (B) could result from various factors other than studying well, such as natural aptitude, prior knowledge, or effective test-taking strategies.

+ Therefore, Nam concluding that “he studied well because he achieved high scores in the exam” illustrates the fallacy of affirming the consequence, or the converse error.

* Reference: <https://www.thoughtco.com/what-is-a-converse-error-3126461>

1. **Inverse Error**

* Example:

+ Lecturer said: “If you have a college degree, you will have a good job.”

+ A student notices they don't have a university degree and concludes, "Since I don't have a university degree, I will not have a good job."

* Explaination:

+ Not having a college degree (not-A) doesn't necessarily mean someone can't get a good job (not-B). There are people without degrees who still get very good jobs.

+ Therefore, concluding that not having a college degree means not having a good job is an example of the inverse fallacy.

* Reference:<https://en.wikipedia.org/wiki/Denying_the_antecedent#:~:text=Denying%20the%20antecedent%2C%20sometimes%20also,Not%20P>.

1. **A Valid Argument with a False Premise and a False Conclusion**

* Example:   
  + Premise 1: All birds have wings.

+ Premise 2: Chickens are a type of bird.

+ Conclusion: Therefore, chickens have wings.

* Explaination:  
  + Premise 1 is false - not all birds have wings (for example, penguins do not have wings).

+ Premise 2 is true - chickens are indeed a type of bird.

+ The conclusion drawn from these two premises is logically valid - if all birds have wings, and chickens are a type of bird, then the logical conclusion is that chickens have wings.

+ However, since Premise 1 is false, the conclusion that chickens have wings is also false. This is an example of a logically valid argument that rests on a false premise, leading to a false conclusion.

* Reference: <https://en.wikipedia.org/wiki/False_premise>

1. **An Invalid Argument with True Premises and a True Conclusion**

* Example:

+ Premise 1: All apples are fruits.

+ Premise 2: Bananas are fruits.

+ Conclusion: Therefore, all bananas are apples.

* Explaination:

+ Premise 1 is true - all apples are indeed a type of fruit.

+ Premise 2 is true - bananas are also a type of fruit. However, the conclusion that "all bananas are apples" is clearly false.

+ This is an invalid argument, even though the premises and conclusion are all true statements. The reason is that the conclusion: "all bananas are apples" does not logically follow from the information given in the premises. The premises only tell us that apples are fruits and bananas are fruits. They do not imply that all bananas must be apples.

* Reference:<https://philosophy.stackexchange.com/questions/17643/invalid-arguments-with-true-premises-and-true-conclusion>

1. **Sound and Unsound Arguments**

* Example:

+ Premise 1: All humans will eventually die.

+ Premise 2: I am a human.

+ Conclusion: Therefore, I’ll eventually die

* Explaination:

+ Premise 1: “All humans will eventually die” is a correct statement, because humans have a certain lifespan.

+ Premise 2: “I am a human” is also a true statement, because the person making this argument is also a human being.

+ Therefore, this example satisfies both conditions of a sound argument by definition: the premises are true and the logical connection between the premises and the conclusion is reasonable.

* Reference:<https://www.linkedin.com/advice/0/what-distinguishes-sound-argument-from-unsound-4nwgf>

PART 2

2.1 Problem 4: Tarski's world

2.1.1 Requirement

Giving the following Tarski's world.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| A |  |  |  |  |  |  |  |  |  |
| B |  |  |  |  |  |  |  |  |  |
| C |  |  |  |  |  |  |  |  |  |
| D |  |  |  |  |  |  |  |  |  |
| E |  |  |  |  |  |  |  |  |  |
| F |  |  |  |  |  |  |  |  |  |
| G |  |  |  |  |  |  |  |  |  |
| H |  |  |  |  |  |  |  |  |  |
| I |  |  |  |  |  |  |  |  |  |

Items are named by their positions. These notations are defined:

* Triangle(x), meaning “x is a triangle,”
* Circle(x), meaning “x is a circle,”
* Square(x), meaning “x is a square,”
* Red(x), meaning “x is red,”
* Green(x), meaning “x is green,”
* Orange(x), meaning “x is orange,”
* RightOf(x, y), meaning “x is to the right of y (but possibly in a different row),”
* LeftOf(x, y), meaning “x is to the left of y (but possibly in a different row),”
* AboveOf(x, y), meaning “x is to the above of y (but possibly in a different column),”
* BelowOf(x, y), meaning “x is to the below of y (but possibly in a different column).”

The domain for all variables is the set of objects in Tarski’s world shown in the picture.

a. Modify the above Tarski's world as follows:

* If % 7 = 0 then add a red square in A5.
* If % 7 = 1 then add a green triangle in F3.
* If % 7 = 2 then delete the item at G7.
* If % 7 = 3 then delete the item at H5.
* If % 7 = 4 then change the item at E4 into an orange square.
* If % 7 = 5 then change the item at E5 into a green circle.
* If % 7 = 6 then change the item at E6 into a red triangle.

(Example: For StudentID 522H1234, we have 1234 % 7 = 2, so we delete item at G7.)

Re-draw your new Tarski's world.

b. Determine the truth or falsity of all the following statements, based on the modified Tarski's world. Give the reasons for your justification.

1. ∀x, Circle(x) → Green(x)
2. ∀x, Triangle(x) → ~Orange(x)
3. ∃x such that Red(x) ∧ Triangle(x)
4. ∃x such that ~Green(x) ∧ BelowOf(x, E4)
5. ∀x, Square(x) → RightOf(E5, x).
6. ∃x such that AboveOf(E5, x) ∧ LeftOf(x, E5).
7. There is a triangle x such that for all squares y, x is above y.
8. For all circles x, there is a square y such that y is to the right of x.
9. There is a circle x and there is a square y such that y is below x.
10. For all circles x and for all triangles y, x and y have the same color.

2.1.2 Solution

Since my StudentID 522H0006, we have 0006 % 7 = 6, so I change the item at E6 into a red triangle.

Re-drawed Tarski's world:

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| A |  |  |  |  |  |  |  |  |  |
| B |  |  |  |  |  |  |  |  |  |
| C |  |  |  |  |  |  |  |  |  |
| D |  |  |  |  |  |  |  |  |  |
| E |  |  |  |  |  |  |  |  |  |
| F |  |  |  |  |  |  |  |  |  |
| G |  |  |  |  |  |  |  |  |  |
| H |  |  |  |  |  |  |  |  |  |
| I |  |  |  |  |  |  |  |  |  |

b. Determine the truth or falsity of all the following statements, based on the modified Tarski's world. Give the reasons for your justification.

1. ∀x, Circle(x) → Green(x)

**Justification:** There is a red circle (at A8). Therefore, the statement is false.

1. ∀x, Triangle(x) → ~Orange(x)

**Justification:** There are six triangles (at A2, C2, D8, E4, E6 and H5) and they are green and red, not orange. Therefore, the statement is true.

1. ∃x such that Red(x) ∧ Triangle(x)

**Justification:** There is a red one triangle at D8. Therefore, the statement is true.

1. ∃x such that ~Green(x) ∧ BelowOf(x, E4)

**Justification:** There is a red square (at F1) which is not green and below E4. Therefore, the statement is true.

1. ∀x, Square(x) → RightOf(E5, x).

**Justification:** There is a square (at C7), which is to the right of E5. Therefore, the statement is false.

1. ∃x such that AboveOf(E5, x) ∧ LeftOf(x, E5).

**Justification:** There is a square (at F1) which is below E5 and to the left of E5. Therefore, the statement is true.

1. There is a triangle x such that for all squares y, x is above y.

**Justification:** The triangle (at A2) is above all of squares in the Tarski's world. Therefore, the statement is true.

1. For all circles x, there is a square y such that y is to the right of x.

**Justification:** There is no square to the right of the circle (at A8). Therefore, the statement is false.

1. There is a circle x and there is a square y such that y is below x.

**Justification:** There is a square (at C7), which is below circle (at A8). Therefore, the statement is true.

1. For all circles x and for all triangles y, x and y have the same color.

**Justification:** There is no triangle, which is same color with the orange circle (at H2). Therefore, the statement is false.

2.2 Problem 5: Symbolic form

2.2.1 Requirement

Let p = “it is windy”; q = “it is thundering”; r = “it is raining”; s = “it is lightning”.

There are some statements:

a. It is windy but it isn’t raining.

b. It is windy, thundering but it isn’t raining.

c. It is raining without thundering and lightning.

d. Windiness is a necessary condition for rain.

e. Windiness is a sufficient condition for rain.

f. Whenever it is lightning, it will be thundering.

g. The necessary and sufficient condition for thundering is lightning.

Using p, q, r, s and logical connectives to write the symbolic form of:

* If % 2 = 0
  + Write statements a, d, f, g.
* If % 2 = 1
  + Write statements b, c, e, g.

(Example: For StudentID 522H1234, we have 1234 % 2 = 0, so he/she need to solve a, d, f, g.)

2.2.2 Solution

Since my student ID ends in 0006, which mean 0006 % 2 = 0, I need to solve statements a, d, f, and g.

1. It is windy but it isn't raining.

**Symbolic form:** p ∧ ¬r

d. Windiness is a necessary condition for rain.

**Symbolic form:** p → r

f. Whenever it is lightning, it will be thundering.

**Symbolic form:** s → q

g. The necessary and sufficient condition for thundering is lightning.

**Symbolic form:** (q ↔ s)

2.3 Problem 6: Equivalence

2.3.1 Requirement

Let p, q, r be statement variables. Prove that the following pair of statements are logically equivalent by 2 methods: (a) using truth table; and (b) using logical equivalence laws.

* If % 3 = 0
  + ~ [(~ p ∧ ~ ~ q) ∨ ~ (p ∨ r)] ≡ (r ∨ p) ∧ (~ q ∨ p)
* If % 3 = 1
  + ~ [ (~ p ∨ q) ∨ ~ (p ∧ ~ (p ∨ q))] ≡ p ∧ ~ (p ∨ q)
* If % 3 = 2
  + ~ (p ∨ ~ (q ∧ r)) ∧ ~ (~q ∨ (p ∨ q)) ≡ (r ∧ q) ∧ ~ (q ∨ p)

(Example: For StudentID 522H1234, we have 1234 % 3 = 1, so he/she needs to prove for the second pair.)

2.3.2 Solution

Since my student ID ends in 0006, which means 0006 % 3 = 0, I need to prove the logical equivalence of the first pair of statements:

~ [(~ p ∧ ~ ~ q) ∨ ~ (p ∨ r)] ≡ (r ∨ p) ∧ (~ q ∨ p)

1. Using truth table:

* Left-hand side statement: ~ [(~ p ∧ ~ ~ q) ∨ ~ (p ∨ r)]

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| p | q | r | ~ p | ~ ~ q | (~ p ∧ ~ ~ q) | ~ (p ∨ r) | ~ [(~ p ∧ ~ ~ q) ∨ ~ (p ∨ r)] |
| T | T | T | F | T | F | F | T |
| T | T | F | F | T | F | F | T |
| T | F | T | F | F | F | F | T |
| T | F | F | F | F | F | F | T |
| F | T | T | T | T | T | F | F |
| F | T | F | T | T | T | T | F |
| F | F | T | T | F | F | F | T |
| F | F | F | T | F | F | T | F |

* Right-hand side statement: (r ∨ p) ∧ (~ q ∨ p)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| p | q | r | ~q | (r ∨ p) | (~ q ∨ p) | (r ∨ p) ∧ (~ q ∨ p) |
| T | T | T | F | T | T | T |
| T | T | F | F | T | T | T |
| T | F | T | T | T | T | T |
| T | F | F | T | T | T | T |
| F | T | T | F | T | F | F |
| F | T | F | F | F | F | F |
| F | F | T | T | T | T | T |
| F | F | F | T | F | T | F |

* Based on 2 truth tables above shows that the two statements are logically equivalent.

1. using logical equivalence laws.

~ [(~ p ∧ ~ ~ q) ∨ ~ (p ∨ r)]

º ~ (~ p ∧ ~ ~ q) ∧ ~ [~ (p ∨ r)] (Using De Morgan’s laws)

* + ~ (~ p ∧ ~ ~ q) º ~ (~ p) ∨ ~ (~ ~ q) (Using De Morgan’s laws)
  + ~ [~ (p ∨ r)] º (p ∨ r)

º (p ∨ ~ q) ∧ (p ∨ r)

º (~ q ∨ p) ∧ (r ∨ p) (Using Commutative laws)

º (r ∨ p) ∧ (~ q ∨ p) (Using Commutative laws)

* Therefore, the two statements are logically equivalent.

PART 3

3.1 Problem 7: Prolog

3.1.1 Requirement

Go to SWI-Prolog's website: http://www.swi-prolog.org/, download and install SWI-Prolog.

1. Find and run the file **{SWI-Prolog}\demo\likes.pl** on your computer. Execute the following queries and capture the results. Use debug mode to explain how to calculate these results.

**mild(dahl)**.

**indian(X)**.

**likes(sam, X).**

1. Write file **hello1.pl to** print "Hello World". Capture the result.
2. Write a file **hello2.pl** that allows printing "Hello nam", with "nam" entered by the user. Capture the result.

3.1.2 Solution

a. Execute queries and capture the results. Use debug mode to explain how to calculate these results.

* **mild(dahl).**
* A screenshot of a computer

  Description automatically generated **The result:**
* **Explanation:**

A screenshot of a computer program

Description automatically generated

1. **[trace]:** This indicates that the debugger mode (trace) has been enabled, which will show the step-by-step execution of the query.
2. **?- mild(dahl).:** This is the query being executed, which is checking if the food "dahl" is considered "mild" according to the knowledge base.
3. **Call: (12) mild(dahl) ? creep:** This shows that Prolog is calling the mild/1 predicate with the argument dahl, and it is executing in "creep" mode, which means it will step through the execution one clause at a time.
4. **Exit: (12) mild(dahl) ? creep:** This indicates that the call to mild(dahl) has succeeded and Prolog is exiting from that goal.
5. **true.:** The final output shows that the query mild(dahl) is true, meaning that the food "dahl" is considered a "mild" food according to the knowledge base.

* **indian(X).**
* A screenshot of a computer

  Description automatically generated **The result:**
* **Explanation:**

A screenshot of a computer program

Description automatically generated

1. **Call: (12) indian(\_14306) ? creep:** Prolog is calling the indian/1 predicate, with a variable \_14306 as the argument. The creep mode indicates that it will step through the execution one clause at a time.
2. **Exit: (12) indian(curry) ? creep:** Prolog finds the first solution, which is that X = curry satisfies the indian/1 predicate.
3. **Redo: (12) indian(\_14306) ? creep:** Prolog backtracks and tries to find more solutions.
4. **Exit: (12) indian(dahl) ? creep:** Prolog finds the second solution, which is that X = dahl satisfies the indian/1 predicate.
5. **Redo: (12) indian(\_14306) ? creep:** Prolog backtracks and tries to find more solutions.
6. **Exit: (12) indian(tandoori) ? creep:** Prolog finds the third solution, which is that X = tandoori satisfies the indian/1 predicate.
7. **Redo: (12) indian(\_14306) ? creep:** Prolog backtracks and tries to find more solutions.
8. **Exit: (12) indian(kurma) ? creep:** Prolog finds the fourth solution, which is that X = kurma satisfies the indian/1 predicate.

* **likes(sam, X).**
* **The result:**

A screenshot of a computer

Description automatically generated

* A screenshot of a computer

  Description automatically generated**Explaination:**

1. **Call: (12) likes(sam, \_14308) ? creep:** Prolog starts by calling the likes/2 predicate, with a variable \_14308 as the second argument.
2. **Call: (13) indian(\_14308) ? creep:** Prolog then calls the indian/1 predicate to check if the food is an Indian food. It finds that \_14308 matches curry, and exits successfully. However, it fails the mild(curry) check.
3. **Redo: (13) indian(\_14308) ? creep:** Prolog backtracks and tries the next indian/1 clause. It finds that \_14308 matches dahl, and exits successfully. It also finds that dahl is mild, so the overall likes(sam, dahl) succeeds. Prolog outputs X = dahl.
4. **Prolog continues the backtracking process**, checking the other indian/1 clauses (tandoori and kurma), and successfully finding that Sam likes these foods as well.
5. **Redo: (12) likes(sam, \_14308) ? creep:** After exhausting the indian/1 and mild/1 checks, Prolog backtracks to the likes/2 predicate and tries the chinese/1 clause. It finds that \_14308 matches chow\_mein, chop\_suey, and sweet\_and\_sour, and adds these to the solutions.
6. **Redo: (12) likes(sam, \_14308) ? creep:** Prolog continues backtracking and checks the italian/1 clause. It finds that \_14308 matches pizza and spaghetti, and adds these to the solutions.
7. **Redo: (12) likes(sam, \_14308) ? creep:** Finally, Prolog checks the fact likes(sam, chips), and adds chips to the solutions.
8. Write file **hello1.pl to** print "Hello World". Capture the result.

* **File hello1.pl:**

A screenshot of a computer

Description automatically generated

* **The result:**

A screenshot of a computer

Description automatically generated

1. Write a file **hello2.pl** that allows printing "Hello nam", with "nam" entered by the user. Capture the result.

* A screenshot of a computer

  Description automatically generated**File hello2.pl:**
* A screenshot of a computer error

  Description automatically generated**The result:**

**REFERENCE**

**English**

1. <https://en.wikipedia.org/wiki/Fallacy>
2. <https://www.quora.com/What-is-an-example-of-ambiguity-as-a-logical-fallacy>
3. <https://www.scribbr.com/fallacies/circular-reasoning-fallacy/>
4. <https://www.researchgate.net/publication/43536057_Jumping_to_a_Conclusion_Fallacies_and_Standards_of_Proof>
5. <https://www.quora.com/What-is-an-inverse-fallacy-argument>
6. <https://www.thoughtco.com/what-is-a-converse-error-3126461>
7. <https://en.wikipedia.org/wiki/False_premise>
8. <https://en.wikipedia.org/wiki/Denying_the_antecedent#:~:text=Denying%20the%20antecedent%2C%20sometimes%20also,Not%20P>
9. <https://www.linkedin.com/advice/0/what-distinguishes-sound-argument-from-unsound-4nwgf>
10. <https://www.tutorialspoint.com/prolog/index.htm>