# Homework Assignment #1
# ECGR 5100

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## Problems

1. Translate the following English passages into propositions and logical connectors.

   (a) "You can see the movie only if you are over 18 years old or you have permission of a parent." Use $m$, $e$, and $p$ as the symbols.

   (b) "You can use Linux or you can upgrade your Windows operating system. However, to upgrade Windows you need to have a 64-bit processor running at 1 GHz or faster, and 16 GB of free hard disk space."

   **Soln-1 a.** Considering following prepositions,

   - **m** = You can see the movie
   - **e** = You are over 18 years old
   - **p** = you have permission of a parent.

   Prepositional logic for the above sentence can be written as follows using logical connectors:

   $$((e \vee p) \rightarrow m)$$

   **Soln-1 b.** Considering following prepositions,

   - **L** = You can use Linux
   - **W** = You can upgrade window's operation system
   - **P** = You have 64-bit processor
   - **G** = Your processor runs at 1 GHz or faster
   - **H** = You have 16 GB free hard disk space

Prepositional logic for the above sentence can be written as follows using logical connectors:

$$((L \vee (W \leftrightarrow (P \wedge G \wedge H))))$$

2. Are these system specifications consistent?

   "If the filesystem is not locked, then new messages will be queued. If the filesystem is not locked, then the system is functioning normally, and conversely. If new messages are not queued, then they will be sent to the message buffer. If the filesystem is not locked, then new messages will be sent to the message buffer. New messages will nto be sent to the message buffer."

   In other words, does this lead to a contradiction?

   **Soln-2.** A system is considered consistent if assignment of true value to the variable results in true expression. For the given system above let's consider following logical expression:

   - **L** = Filesystems are locked.
   - **Q** = New messages will be queued.
   - **N** = The system is functioning normally.
   - **B** = New messages will be sent to message buffer.

   The given specifications can be expressed as follows:

   - If the file system is not locked, the new messages will be queued: $(\neg L \rightarrow Q)$
   - If the file system is not locked, then the system is functioning normally and conversely: $(\neg L \rightarrow N)$
   - If new messages are not queued, then they will be sent to the message buffer: $(\neg Q \rightarrow B)$
   - If the file system is not locked, then new messages will be sent to the message buffer: $(\neg L \rightarrow B)$
   - New messages will not be sent to the message buffer: $(\neg B)$

   To get consistency, take N false in order that $(\neg N)$ be true. This require that both L and Q be true, by the two conditional statements that have N as their consequence. The first conditional statement $(\neg L \rightarrow Q)$ is of the form $(F \rightarrow T)$, which is true. Finally, the $(\neg L \rightarrow B)$ can be satisfied by taking B to be false. Therefore, this set of specifications is consistent.

3. Show that $p \leftrightarrow q$ and $(p \wedge q) \vee (\neg p \wedge \neg q)$ are logically equivalent using algebra. (Use the Theorems/Postulates in Rosen's textbook or the ones listed in the notes from Harris & Harris.)

   **Soln-3.**

   L.H.S. $= p \leftrightarrow q$

$= (p \to q) \wedge (q \to p)$
$= (p \vee \neg q) \wedge (q \vee \neg p)$ [*because* $(p \to q) = (p \vee \neg q)$]
$= ((p \vee \neg q) \wedge q) \vee ((p \vee \neg q) \wedge \neg p)$
$= ((p \wedge q) \vee (\neg q \wedge q)) \vee ((p \wedge \neg p) \vee (\neg q \wedge \neg p))$ [*because* $(\neg Q \wedge Q) = 0$]
$= (p \wedge q) \vee (\neg p \wedge \neg q)$
L.H.S. = R.H.S.

Q.E.D

4. Show that $(p \vee q) \wedge (\neg p \vee r) \to (q \vee r)$ is a tautology using algebra.

**Soln-4.** We know that $L \to Q = \neg L \vee Q$
L.H.S. $= \neg((p \vee q) \wedge (\neg p \vee r)) \vee (q \vee r)$
$= \neg(p \vee q) \vee \neg(\neg p \vee r) \vee (q \vee r)$
$= (\neg p \wedge \neg q) \vee (p \wedge \neg r) \vee q \vee r$
$= (\neg p \wedge \neg q) \vee q \vee (p \wedge \neg r) \vee r$
$= ((\neg p \vee q) \wedge (\neg q \vee q)) \vee ((p \vee r) \wedge (\neg r \vee r))$
$= ((\neg p \vee q) \wedge 1) \vee ((p \vee r) \wedge 1)$
$= (\neg p \wedge 1) \vee (q \wedge 1) \vee (p \wedge 1) \vee (r \wedge 1)$
$= \neg p \vee q \vee p \vee r$
$= (\neg p \vee p) \vee (q \vee r)$ [*because* $(\neg P \vee P) = 1$]
$= 1 \vee (q \vee r) = 1$
Therefore it's a tautology.

Q.E.D

5. For the first four problems, enumerate the truth tables that describe the relationships between the propositions.

**Soln-5.**

| **E** | **P** | **M** |
|---|---|---|
| F | F | F |
| F | T | T |
| T | F | T |
| T | T | T |

Table 1: Truth table for Q-1 (a)

| **G** | **H** | **L** | **P** | **W** | $L \vee (W \leftrightarrow (P \wedge G \wedge H))$ |
|---|---|---|---|---|---|
| F | F | F | F | F | T |
| F | F | F | F | T | F |
| F | F | F | T | F | T |
| F | F | F | T | T | F |
| F | F | T | F | F | T |
| F | F | T | F | T | T |
| F | F | T | T | F | T |
| F | F | T | T | T | T |
| F | T | F | F | F | T |
| F | T | F | F | T | F |
| F | T | F | T | F | T |
| F | T | F | T | T | F |
| F | T | T | F | F | T |
| F | T | T | F | T | T |
| F | T | T | T | F | T |
| F | T | T | T | T | T |
| T | F | F | F | F | T |
| T | F | F | F | T | F |
| T | F | F | T | F | T |
| T | F | F | T | T | F |
| T | F | T | F | F | T |
| T | F | T | F | T | T |
| T | F | T | T | F | T |
| T | F | T | T | T | T |
| T | T | F | F | F | T |
| T | T | F | F | T | F |
| T | T | F | T | F | F |
| T | T | F | T | T | T |
| T | T | T | F | F | T |
| T | T | T | F | T | T |
| T | T | T | T | F | T |
| T | T | T | T | T | T |

Table 2: Truth table for Q-1 (b)

| **Specification** | **Condition** | **Truth Value** |
|---|---|---|
| $\neg L \to Q$ | $F \to T$ | T |
| $\neg L \to N$ | $F \to F$ | T |
| $\neg Q \to B$ | $F \to F$ | T |
| $\neg L \to B$ | $F \to F$ | T |
| $\neg B$ | T | T |

Table 3: Truth table for Q-2

| **p** | **q** | $p \leftrightarrow q$ | $p \wedge q$ | $\neg p$ | $\neg q$ | $\neg p \wedge \neg q$ | $(p \wedge q) \vee (\neg p \wedge \neg q)$ |
|---|---|---|---|---|---|---|---|
| F | F | T | F | T | T | T | T |
| F | T | F | F | T | F | F | F |
| T | F | F | F | F | T | F | F |
| T | T | T | T | F | F | T | T |

Table 4: Truth table for Q-3

| **p** | **q** | **r** | $((p \vee q) \wedge (\neg p \vee r)) \to (q \vee r)$ |
|---|---|---|---|
| F | F | F | T |
| F | F | T | T |
| F | T | F | T |
| F | T | T | T |
| T | F | F | T |
| T | F | T | T |
| T | T | F | T |
| T | T | T | T |

Table 5: Truth table for Q-4

6. From proposition One: $(p \wedge q) \to p$, can you infer proposition Two: $p \vee q$? Can you prove this with a truth table? (Do not simply write a truth table, explain how the truth table demonstrates the inference.

   **Soln-6.**Given preposition One: $(p \wedge q) \to p$.

   We know from De Morgans's law that $p \to q = (\neg p \vee q)$

   $(p \wedge q) \to p = \neg(p \wedge q) \vee p$

   $= \neg p \vee q \vee p$

   $= (\neg p \vee p) \vee q$ $[because\ (\neg P \vee P) = 1]$

   $= 1 \vee q$

   $= 1$ [Tautology]

With this given condition we can say that if $(p \wedge q)$ is true then p is true. Also, if p is true then $(p \vee q)$ will always be true. Therefore, we can infer $(p \vee q)$ from $(p \wedge q) \to p$.

| **p** | **q** | $(p \wedge q) \to p$ |
|---|---|---|
| F | F | T |
| F | T | T |
| T | F | T |
| T | T | T |

Table 6: Truth table for Q-6

7. Use propositional calculus to determine which person did which exercise and what beverage they drank after their workout.

   After an invigorating workout, five fitness-conscious friends know that nothing is more refreshing than a tall cool glass of mineral water! Each person (including Annie) has a different, favorite form of daily exercise (one likes to Rollerblade), and each drinks a different form brand of mineral water (one is Crystal). From the information provided, determine the type of exercise and brand of water each person prefers.

   - The friends are Annie, Ben, Meg, Page, and Tim.
   - The exercises are: **A**erobics, **B**icycling, **J**ogging, **R**ollerblading, and **W**alking.
   - The brands of water are Ocean, Crystal, Mountain, Purity, and Creek.
   - The one who bicycles in pursuit of fitness drinkes Ocean.
   - Tim enjoys Aerobics every morning before work. Ben is neither the one who drinks Creek nor the one who imbibes Ocean.
   - Page (who is neither the one who jogs nor the one who walks to keep in shape) drinks Purity.
   - Meg drinks Mountain but not after jogging.

   **Soln-7.** Given that each person has different form of exercises and different forms of drinks. We consider following logical expressions for each person, drink, and exercise:

   **A** = Annie, **B** = Ben, **M** = Meg, **P** = Page, **T** = Tim

   **Ae** = Aerobics, **Bi** = Bicycles, **Jo** = Jogging, **Wa** = Walk

   **Oc** = Ocean, **Cry** = Crystal, **Mo** = Mountain, **Pu** = Purity, **Cr** = Creek

   Given:

   1. $Bi \to Oc$
   2. $T \to Ae$

3. $B \to \neg(Cr \wedge Oc)$

4. $P \to \neg(Jo \wedge Wa)$

5. $P \to Pu$

6. $M \to Mo$

7. $M \to Jo$

If Annie drives bicycles then

8. $A \to Bi$ [Assuming]

9. $A \to Oc$ [8, 1 Hypothetical Syllogism]

10. $P \to Ro$ [4 = Page Doesnt Jog and Walk, 8 = Annie rides Bicycle, 2 = Tim does Aerobics]

11. $M \to Wa$ [7 = Meg Doesnt Jog, 8, 2, 10]

12. $B \to Cry$ [3, 5, 6]

13. $T \to Cr$ [5, 6, 9, 12]

| **Person** | **Ae** | **Bi** | **Jo** | **Ro** | **Wa** | **Oc** | **Cry** | **Mo** | **Pu** | **Cr** |
|---|---|---|---|---|---|---|---|---|---|---|
| Annie | F | **T** | F | F | F | **T** | F | F | F | F |
| Ben | F | F | **T** | F | F | F | **T** | F | F | F |
| Meg | F | F | F | F | **T** | F | F | **T** | F | F |
| Page | F | F | F | **T** | F | F | F | F | **T** | F |
| Tim | **T** | F | F | F | F | F | F | F | F | **T** |

Table 7: Truth table for Q-7

8. Read the journal *Science* news article: Write a paragraph summarizing the *implications* of the policy change.

   Write a second paragraph taking a stand for or against the change and justify why it is good for science.

   **Soln-8 a.** Public access policy announced by the US government states that US research agencies should make the results of federally funded research free to read as soon as they are published. This is a significant shift that will lift the 1 year subscription paywall and promote accessibility to research results and will also improve people's trust in science. This implies that US taxpayers will not have to pay to access results of the research funded by their tax money. On the other hand, the new policy does not describe how the cost of production and editing these research papers will be funded. Thus, making publishing more difficult for authors. Another implication is that without subscription revenues open-access business model will require authors pay a fee to make their papers immediately available for free to the public.

   **Soln-8 b.** Free access to federally funded research and data is very important for accelerating discovery, encouraging collaboration, and ensuring government accountability. The value of these research data can be observed from the early days of COVID 19 pandemic. Researchers rapidly shared their data through a wide variety of online resources which not only accelerated discovery but also allowed the translation of research into prevention strategies, treatments, vaccines, and standards of care that ultimately saved lives, despite the ongoing toll of the pandemic. Open access policy provides free flow of information that will benifit underfunded groups of students and researchers who cannot pay high subscription cost. US taxpayers fund billions of dollars of research every year in various fields of science. A portion of this grant can be saved to pay the publication cost in pay-to-publish model. Open access policy can be a big advancement moving forward, as in the long run it will make science data more accesible to public which may induce trust in science and scientific procedure.