This homework is due electronically on Gradescope at 11:59PM EDT, August 30, 2023. To receive full credit all your answers should be carefully justified. **Additionally, make sure to fill out the Gradescope Policy Quiz!**

Please make note of the following:

A. **\LaTeX**: Normally, we require all solutions to be typeset in \LaTeX. We have provided a \LaTeX primer video on Piazza and on the course website under the ‘resources’ tab, and have provided a template, should you choose to use \LaTeX. However, \LaTeX is not strictly required for this first assignment only.

B. **Standard Deductions:**
   - 5 points will be deducted from your homework if you do not select pages when submitting to Gradescope.

C. **Solutions:** Please make sure to keep your solutions clear and precise. While no points will be deducted for overly verbose solutions, clarity and brevity are important skills that can be developed through CIS 1600.

D. **Collaboration:** You may not collaborate with anyone via any means.

E. **Citations:** All solutions must be written in your own words. If you would like to use part of a solution from a problem presented in lecture, recitation, or past homework solutions you may do so with attribution; i.e., provided you add a comment in which you make clear you copied it from these sources.

F. **Outside Resources:** Any usage of resources outside of the course materials on the course website or Canvas is strictly prohibited. Violations may seriously affect your grade in the course.

G. **Late Policy:** We will allow you to drop two homework assignments assigned on a Tuesday and two homework assignments due on a Thursday (i.e. two ‘T’ homeworks and two ‘H’ homeworks). Because of this, we will not accept late homework under any circumstances. If you will be missing school for an extended period of time due to severe illness, please notify the professor.
1. [12 pts] Box Office Battle

Let \( p \), \( q \), and \( r \) be the following propositions.

\( p \): Oppenheimer is a better movie than Barbie.

\( q \): Dili-an Murphy would beat Ryan G-Oh-sling in a fight.

\( r \): The CIS 1600 TAs all watch movies during office hours.

Express the following propositions using \( p \), \( q \), \( r \) and logical operators.

Including a line or two of explanation for your solution may be helpful in guiding your thought process, but don’t worry too much about providing justification. For this problem specifically, we’ll only be grading your final answer.

(a) Dili-an Murphy would beat Ryan G-Oh-sling in a fight and Oppenheimer is a better movie than Barbie.

(b) The CIS 1600 TAs do not all watch movies during office hours and Oppenheimer is a better movie than Barbie.

(c) If Oppenheimer is not a better movie than Barbie or the CIS 1600 TAs all watch movies during office hours, then Dili-an Murphy would not beat Ryan G-Oh-sling in a fight.

(d) The fact that Dili-an Murphy would beat Ryan G-Oh-sling in a fight is sufficient for Oppenheimer to be a better movie than Barbie and for the CIS 1600 TAs to all watch movies during office hours.

(e) Oppenheimer is a better movie than Barbie if and only if Dili-an Murphy would beat Ryan G-Oh-sling in a fight.

(f) It is necessary that Dili-an Murphy beats Ryan G-Oh-sling in a fight for Oppenheimer to be a better movie than Barbie. It is also necessary that Dili-an Murphy beats Ryan G-Oh-sling in a fight for the CIS 1600 TAs to not all watch movies during office hours.

2. [8 pts] Truth of Barbenheimer

Sam Ngiam-enheimer may have conquered building an atomic bomb, but he has yet to master tautologies! Luckily, Barb-Ishaan has come up with practice problems for Ngiam-enheimer to build his skills. Unfortunately, Sam Ngiam-enheimer is feeling lazy (building the atomic bomb took too much brain power.) He asks YOU to determine whether the following logical expressions are tautologies by filling in the truth tables below.

Note: Make sure you fill out the entire table, even if you do not need the entire table to determine whether the given expression is a tautology.
(a) \[ (p \lor q) \lor (p \land \neg q) \land (p \implies \neg q) \]

(b) \[ (\neg p \land q) \implies (p \lor \neg q) \implies (p \lor \neg p) \]

3. [10 pts] An In-Cindy-ary Presidential Challenger

Barbie Cindy is more than just another Barbie Girl living in a Barbie World - she’s President Barbie Cindy. One day, Barbie Suzanna, who studied under Sam Ngiam-enheimer, forces all the Barbies in Barbieland to vote her for president with the threat of relocating Barbieland to Los Alamos. Luckily, in addition to being an expert negotiator, President Barbie Cindy is also an expert in logical quantifiers. She makes a deal with Barbie Suzanna: If Cindy answers the following questions correctly, she will remain president of Barbieland, and Barbieland will not be relocated. Barbie Suzanna agrees, and President Barbie Cindy enlists you in answering the following questions:

For parts (a), (b), and (c), replace each ? with either the universal quantifier (\(\forall\)) or the existential quantifier (\(\exists\)) such that the resulting statement is true. Write the resulting statement in both logical notation and plain English. Then, explain briefly but rigorously why the statement is true. Note that the replacement of ? with quantifiers is the only modification allowed.

(a) \( \forall m \in \mathbb{Z} \quad \exists n \in \mathbb{Z} \quad m + n = 10 \)

(b) \( \exists m \in \mathbb{N} \quad \forall n \in \mathbb{Z} \quad (n \leq m \lor n > 2m) \)

(c) \( \exists m \in \mathbb{Z} \quad \forall n \in \mathbb{Z} \quad \exists p \in \mathbb{Z} \quad 2p - n \leq m \)