1. Propositions (6 points)

Let $p$, $q$, and $r$ denote the following propositions:

- $p$ denotes “you get an A on the final exam”
- $q$ denotes “you do every exercise in the book”
- $r$ denotes “you get an A in this class”

Using $p$, $q$, and $r$ construct compound propositions which represent the following English sentences:

1. You get an A in this class but you don’t do every exercise in the book.
2. You get an A on the final exam but you don’t do every exercise in the book; nevertheless you get an A in this class.
3. To get an A in this class, it is necessary for you to get an A on the final.

2. Equivalences (16 points)

1. Show that $((q \lor \neg p) \land p) \rightarrow q$ is a tautology (i.e., $((q \lor \neg p) \land p) \rightarrow q \equiv T$).
   (a) (4 points) Show the equivalence using truth tables
   (b) (4 points) Show the equivalence by establishing a sequence of equivalences. You can only use the equivalences in Table 6 and the first equivalence in Table 7. Show your work by annotating every step.

2. Show that $(p \rightarrow q) \land (p \rightarrow r) \equiv p \rightarrow (q \land r)$
   (a) (4 points) Show the equivalence using truth tables
   (b) (4 points) Show the equivalence by establishing a sequence of equivalences. You can only use the equivalences in Table 6 and the first equivalence in Table 7. Show your work by annotating every step.

3. NAND (4 points)

Consider the NAND operator $\uparrow$, which is defined $p \uparrow q \equiv \neg(p \land q)$.

1. Using truth tables show that $\uparrow$ is not associative, i.e., $p \uparrow (q \uparrow r)$ and $(p \uparrow q) \uparrow r$ are not equivalent.