Instructions: Complete the homework problems below on *separate* sheets of paper (and not all jammed up between the questions). This is to be turned in and graded, so make sure your work is neat and easy to ready - there is nothing wrong with using a separate sheet of paper for each problem. Each solution should be accompanied with supporting work or an explanation why the solution is correct. Your work will be graded on correctness as well as the clarity of your explanations.

(6pts)   1.   (a) Make a truth table for the statement $P \to (\neg Q \vee R)$.

(b) If Tommy **lies** when he says, "if I ate pizza, then either I didn't eat cucumber sandwiches or I did eat raisins," what can you conclude about what Tommy ate? Explain.

(6pts)   2. Can you distribute conjunctions over disjunctions? Disjunctions over conjunctions? Let's find out. Remember, two statements are logically equivalent if they are true in exactly the same cases.

(a) Are the statements $P \vee (Q \wedge R)$ and $(P \vee Q) \wedge (P \vee R)$ logically equivalent?

(b) Are the statements $P \wedge (Q \vee R)$ and $(P \wedge Q) \vee (P \wedge R)$ logically equivalent?

(6pts)   3. Use De Morgan's Laws, and any other logical equivalence facts you know to simplify the following statements. Show all your steps, justifying each. Your final statements should have negations only appear directly next to the propositional variables (P, Q, etc.), and no double negations.

(a) $\neg((\neg P \wedge Q) \vee \neg(R \vee \neg S))$.

(b) $\neg((\neg P \to \neg Q) \wedge (\neg Q \to R))$ (careful with the implications).

(6pts)   4. Can you chain implications together? That is, if $P \to Q$ and $Q \to R$, does that means the $P \to R$? Can you chain more implications together? Let's find out:

(a) Prove that the following is a valid argument form:
$$\begin{array}{c} P \to Q \\ Q \to R \\ \hline \therefore \quad P \to R \end{array}$$

(b) Prove that the following is a valid argument form:
$$\begin{array}{c} P_1 \to P_2 \\ P_2 \to P_3 \\ \vdots \\ P_8 \to P_9 \\ \hline \therefore \quad P_1 \to P_9. \end{array}$$
I suggest you don't go through the trouble of writing out a 512 row truth table. You should still be able to explain why this is argument form is valid (using part (a)).

(6pts)   5. Consider the statement, "if you study logic, then you will be happy."

(a) Rephrase the implication in at least 3 different ways. At least one of the ways should use necessary/sufficient language.

(b) State the converse of the implication, and rephrase the converse in at least 3 different ways.