CSCI-C 241 HW #3 Assigned Thursday, September 6th, 2018
Instructor: Wennstrom Due Tuesday, September 11th, 2018

Remember that when writing semi-formal proofs for this class, you need to use the style I introduced in the lectures. In particular, you must follow the following guidelines:

- Always write the claim before the proof. Clearly label where the proof starts and where it ends.
- Clearly indicate all assumptions.
- Only use one rule per step, cite the name of the rule, and indicate which formulas and/or subproofs you used.
- Indent all subproofs, and indicate what kind of subproofs they are.
- Only use the eight natural deduction rules: $\wedge$-Elimination, $\wedge$-Introduction, Application ($\rightarrow$-Elim.), Direct Proof ($\rightarrow$-Intro.), Double Negation ($\neg$-Elim.), Proof by Contradiction ($\neg$-Intro.), Weakening ($\vee$-Intro.), and Proof by Cases ($\vee$-Elim.).

For this assignment, you won't need proof by cases.

1. Provide semi-formal natural deduction proofs of the following claims. You may only use the eight natural deduction inference rules.
   (a) $(P \wedge Q) \rightarrow R, P \wedge S, \neg \neg Q \vdash R$
   (b) $X \wedge \big(X \rightarrow (Z \wedge Y)\big) \vdash X \wedge Y$
   (c) $A \wedge \neg \neg B \vdash B \vee (A \rightarrow \neg C)$
   (d) $(K \vee L) \rightarrow N, K \wedge M \vdash N \wedge M$
   (e) $(A \wedge B) \rightarrow C, B, A \wedge \neg D \vdash C \wedge \neg D$
   (f) $(A \wedge B) \rightarrow C, B \vdash (A \wedge \neg D) \rightarrow (C \wedge \neg D)$
   (g) $Z \rightarrow \neg X, Z \wedge \neg \neg Y \vdash \neg X \vee Y$
   (h) $\vdash \big((Z \rightarrow \neg X) \wedge (Z \wedge \neg \neg Y)\big) \rightarrow \big(\neg X \vee Y\big)$
   (i) $(W \wedge X) \rightarrow \neg Y, X \vdash \neg(W \wedge Y)$
   (j) $\vdash (M \rightarrow \neg N) \rightarrow \neg(M \wedge N)$
   (k) $Z \rightarrow A, B \rightarrow A, \neg A \vdash \neg Z \wedge \neg B$