1. Warmup
    1.
        a. or
        b. and
    2.
        a. P -> Q means ¬(P ^ (¬Q)) which means **((¬P) v Q)**
        b. ¬(P ^ Q) means **((¬P) v (¬Q))**
        c. ¬(P v Q) means **((¬P) ^ (¬Q))**
        d. ¬(P -> Q) means (¬(¬P v Q)) which means **(P ^ (¬Q))**

2. English to Logic
    1. B ^ (¬R)
    2. (¬R) ^ W ^ B
    3. B -> (W <-> (¬R))
    4. (¬W) ^ (¬R) ^ B
    5. W -> ((¬B) ^ (¬R))
    6. (R ^ B) -> (¬W)

3. Legal English to Logic

    Define the terminologies:

    1F = Search the 1st floor
    1A = Occupant on the 1st floor accepts delivery

    2F = Search the 2nd floor
    2A = Occupant on the 2nd floor accepts delivery

    O = Open the package

    We have: ((1F <-> 1A) v O) v ((2F <-> 2A) v O) which abbreviates to

    (1F <-> 1A) v (2F <-> 2A) v O

4. Boolean Expressions in Code
    1. (1 <= n) && (n <= 10)
    2.
        a) !(a < b) means **a >= b**
        b) !((count < 99) || (len != 0) || !atEndFlag)
            means (!(count < 99) && !(len != 0) && !(!atEndFlag)
            means **((count >= 99) && (len == 0) && atEndFlag)**
        c) !(x > 3 && (y == 4 || z <= 5))
            means (!(x > 3) || !((y == 4 || z <= 5))
            means ((x <= 3) || (!(y == 4) && !(z <= 5)))
            means **((x <= 3) || (y != 4 && z > 5))**

3.

a) ((b < c) || (d < a))

b) !((b < c) || (d < a))

means (!(b < c) && !(d < a))

means **((b >= c) && (d >= a))**

c) If 2 rectangles don't overlap, then either their horizontal or vertical intervals should also not overlap, assuming we meant up = positive y-axis and right = positive x-axis.

Hence, for the 2 rectangles to not overlap:
((u_1 < x_2) || (u_2 < x_1)) || ((v_1 < y_2) || (v_2 < y_1))

Therefore, to have 2 rectangles overlapping at least 1 point:
!((u_1 < x_2) || (u_2 < x_1) || (v_1 < y_2) || (v_2 < y_1))
means **((u_1 >= x_2) && (u_2 >= x1) && (v_1 >= y_2) && (v_2 >= y_1))**

5. Models and Entailment

1.

P	Q	¬P	(¬P -> Q)	¬Q	(¬Q -> P)
1	0	0	1	1	1
1	1	0	1	0	1
0	1	1	1	0	1
0	0	1	0	1	0

As highlighted in red, whenever the assumption is True, the conclusion is also True. Hence, we have an entailment.

2.

F	G	H	F -> G	F -> H	G ^ H	(F->G) ^ (F -> H)	F->(G ^ H)
0	0	0	1	1	0	1	1
0	0	1	1	1	0	1	1
0	1	0	1	1	0	1	1
0	1	1	1	1	1	1	1
1	0	0	0	0	0	0	0
1	0	1	0	1	0	0	0

1	1	0	1	0	0	0	0
1	1	1	1	1	1	1	1

As highlighted in red, whenever the assumption is True, the conclusion is also True. Hence, we have an entailment.

6. Valid, Satisfiable, and Unsatisfiable

1. A is valid -> A is True in every model -> (¬A) is False in every model -> (¬A) is **unsatisfiable**.

2. A is satisfiable -> A is True in at least 1 model -> A is False in some, but not all, models -> (¬A) is True in some, but not all, models -> (¬A) is either False in all models or True in some, but not all, models -> (¬A) is **either satisfiable or unsatisfiable**. In other words, (¬A) is **not valid**.

3. A is unsatisfiable -> A is False in every model -> (¬A) is True in every mode -> (¬A) is **valid**.

7. Writing Natural Deduction Proofs

Construct a proof for the argument: $(A \wedge B) \to C, A \to B \therefore A \to C$

1	$(A \wedge B) \to C$	
2	$A \to B$	
3	A	
4	B	$\to$E 2, 3
5	$A \wedge B$	$\wedge$I 3, 4
6	C	$\to$E 1, 5
7	$A \to C$	$\to$I 3–6

NEW LINE NEW SUBPROOF

1. ☺ Congratulations! This proof is correct.

Construct a proof for the argument: $F \to [G \vee (H \wedge I)], \neg G, \neg I \therefore \neg F$

1	$F \to [G \vee (H \wedge I)]$	
2	$\neg G$	
3	$\neg I$	
4	$\quad F$	
5	$\quad G \vee (H \wedge I)$	→E 1, 4
6	$\quad\quad G$	
7	$\quad\quad \neg G$	R 2
8	$\quad\quad \bot$	⊥I 6, 7
9	$\quad\quad H \wedge I$	
10	$\quad\quad I$	∧E 9
11	$\quad\quad \neg I$	R 3
12	$\quad\quad \bot$	⊥I 10, 11
13	$\quad \bot$	∨E 5, 6–8, 9–12
14	$\neg F$	¬I 4–13

NEW LINE NEW SUBPROOF

2. ☺ Congratulations! This proof is correct.

1	$(F \to G) \wedge (F \to H)$	
2	$F \to G$	∧E 1
3	$F \to H$	∧E 1
4	$\quad F$	
5	$\quad G$	→E 2, 4
6	$\quad H$	→E 3, 4
7	$\quad G \wedge H$	∧I 5, 6
8	$F \to (G \wedge H)$	→I 4–7

NEW LINE NEW SUBPROOF

3. ☺ Congratulations! This proof is correct.

Construct a proof for the argument: $F \to G \therefore [(F \land G) \to F] \land [F \to (F \land G)]$

1	$F \to G$	
2	│ F	
3	│ G	$\to$E 1, 2
4	│ $F \land G$	$\land$I 2, 3
5	$F \to (F \land G)$	$\to$I 2–4
6	│ $F \land G$	
7	│ F	$\land$E 6
8	$(F \land G) \to F$	$\to$I 6–7
9	$((F \land G) \to F) \land (F \to (F \land G))$	$\land$I 5, 8

NEW LINE NEW SUBPROOF

4. Congratulations! This proof is correct.

Construct a proof for the argument: $\neg(F \lor G) \therefore \neg F \land \neg G$

1	$\neg(F \lor G)$	
2	│ F	
3	│ $F \lor G$	$\lor$I 2
4	│ $\bot$	$\neg$E 1, 3
5	$\neg F$	$\neg$I 2–4
6	│ G	
7	│ $F \lor G$	$\lor$I 6
8	│ $\bot$	$\neg$E 1, 7
9	$\neg G$	$\neg$I 6–8
10	$\neg F \land \neg G$	$\land$I 5, 9

NEW LINE NEW SUBPROOF

5. Congratulations! This proof is correct.

8. Survey
    a. 4 hours
    b. I learned a bit on the algorithm of constructing natural deduction proof: at least the first step should be deciding if you want to start from the top, the bottom, or both, and if you see what sign what action is recommended.