Chapter 3 roadmap:

- Propositions, boolean logic, logical equivalences. **Game 1** (last week Monday)
- Conditional propositions. **SML** (last week Wednesday)
- Arguments. **Game 2** (last week Friday)
- Predicates and quantification. **SML** (Monday)
- Quantified arguments. **Game 3** (Wednesday)
- Review for test. (Today)
- Test 1 (next week Monday)
- Begin Chapter 4, Proofs (next week Wednesday)

Today:

- General comments on tests in this course
- Broad overview of everything so far
- Test 1 specifics
- Warnings and clarifications

Project proposal due Wednesday, Feb 14.
Which of the following are true?

\[-((x - y) + (x - z)) = -(x - y) - (x - z)\]

\[-((x - y) + (x - z)) \cdot z = -(x - y) - (x - z) \cdot z\]

\[\sim (p \land q) \equiv \sim p \lor \sim q\]

\[\sim (p \land q) \land r \equiv \sim p \lor \sim q \land r\]
Which of the following are true?

\[(x + y) + z = x + (y + z)\]
\[(x - y) + z = x - (y + z)\]
\[(p \lor q) \lor r \equiv p \lor (q \lor r)\]
\[(p \lor q) \land r \equiv p \lor (q \land r)\]
1. Write a function `leastSigDigs` that takes a list of ints and returns a list of the least significant digits in those lists. For example, `leastSigDigs[283, 7234, 5, 2380]` would return `[3, 4, 5, 0]`.

2. Write a function `hasEmpty` that takes a list of lists (of any type) and determines whether or not the list of lists contains an empty list. For example, `hasEmpty([[1,2,3], [4,5], [], [6,7]])` would return `true`. 
**Universal instantiation**

\[ \forall x \in A, \ P(x) \]
\[ a \in A \]
\[ \therefore P(a) \]

**Universal modus ponens**

\[ \forall x \in A, \ P(x) \rightarrow Q(x) \]
\[ a \in A \]
\[ P(a) \]
\[ \therefore Q(a) \]

**Universal generalization**

Suppose \( a \in A \)

\[ P(a) \]
\[ \therefore \forall x \in A, \ P(x) \]

**Suppose**

\[ a \in A \]
\[ P(a) \]
\[ \therefore Q(a) \]

**Existential Generalization**

\[ \exists x \in A \mid P(x) \]

Let \( a \in A \mid P(a) \)
\[ \therefore a \in A \land P(a) \]

**Hypothetical conditional**

Suppose \( p \)

\[ q \]
\[ \therefore p \rightarrow q \]

**Hypothetical division into cases**

\[ p \lor q \]
Suppose \( p \)
\[ r \]
Suppose \( q \)
\[ r \]
\[ \therefore r \]
(Extra # 2)

(a) \( \forall x \in A, P(x) \)

(b) \( \forall x \in A, x \in B \lor R(x) \)

(c) \( \forall y \in B, Q(y) \lor \sim P(y) \)

(d) \( \forall x \in A, R(x) \rightarrow Q(x) \)

(e) \( \therefore \forall x \in A, Q(x) \)

Suppose \( a \in A \)

(i) \( a \in B \land R(a) \)

Suppose \( a \in B \)

(ii) \( Q(a) \lor \sim P(a) \)

by supposition, (b), and UI

(iii) \( P(a) \)

by supposition, (a), and UI

(iv) \( Q(a) \)

by (ii), (iii), and elimination

Suppose \( R(a) \)

(v) \( Q(a) \)

by supposition, (c), and UMP

(vi) \( Q(a) \)

by (i), (iv), (v), and HDC

(vii) \( \therefore \forall x \in A, Q(x) \)

by supposition, (vi), and UG
(Extra # 3)

(a) $\forall x \in A, P(x) \rightarrow R(x)$
(b) $\exists x \in A \mid P(x)$
(c) $\forall x \in A, Q(x) \lor x \in B$
(d) $\forall x \in A, P(x) \rightarrow \neg Q(x)$
(e) $\therefore \exists y \in B \mid R(y)$

Let $a \in A \mid P(a)$

(i) $a \in A \land P(a)$
(ii) $a \in A$
(iii) $P(a)$
(iv) $\neg Q(a)$
(v) $Q(a) \lor a \in B$
(vi) $a \in B$
(vii) $R(a)$
(viii) $\therefore \exists y \in B \mid R(y)$

By (b) and EI
By (i) and specialization
By (i) and specialization
by (ii), (iii), (d), and UMP
by (ii), (c), and UI
by (iv), (v), and elimination
by (ii), (iii), (a), and UMP
by (vi), (vii), and EG