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?

$$
\begin{aligned}
-((x-y)+(x-z)) &= -(x-y)-(x-z) \\
-((x-y)+(x-z)) \cdot z &= -(x-y)-(x-z) \cdot z \\
\sim (p \wedge q) &\equiv \sim p \vee \sim q \\
\sim (p \wedge q) \wedge r &\equiv \sim p \vee \sim q \wedge r
\end{aligned}
$$

Which of the following are true?

$$\begin{aligned}
(x+y)+z &= x+(y+z) \\
(x-y)+z &= x-(y+z) \\
(p \vee q) \vee r &\equiv p \vee (q \vee r) \\
(p \vee q) \wedge r &\equiv p \vee (q \wedge r)
\end{aligned}$$

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 tollens

$\forall\, x \in A,\ P(x) \to Q(x)$
$a \in A$
$\sim Q(a)$
$\therefore \sim P(a)$

Existential instantiation

$\exists\, x \in A \mid P(x)$
Let $a \in A \mid P(a)$
$\therefore a \in A \wedge P(a)$

Universal modus ponens

$\forall\, x \in A,\ P(x) \to Q(x)$
$a \in A$
$P(a)$
$\therefore Q(a)$

Existential Generalization

$a \in A$
$P(a)$
$\therefore \exists\, x \in A \mid P(x)$

Hypothetical conditional

Suppose p
  q
$\therefore p \to q$

Universal generalization

Suppose $a \in A$
  $P(a)$
$\therefore \forall\, x \in A,\ P(x)$

Hypothetical division into cases

$p \vee q$
Suppose p
  r
Suppose q
  r
$\therefore r$

(Extra # 2)

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

(b) $\forall\ x \in A, x \in B \vee R(x)$

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

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

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

	Suppose $a \in A$	
(i)	$a \in B \wedge R(a)$	by supposition, (b), and UI
	Suppose $a \in B$	
(ii)	$Q(a) \vee \sim P(a)$	by supposition, (c), 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) $\forall\, x \in A, P(x) \to R(x)$

(b) $\exists\, x \in A \mid P(x)$

(c) $\forall\, x \in A, Q(x) \vee x \in B$

(d) $\forall\, x \in A, P(x) \to \sim Q(x)$

(e) $\therefore \exists\, y \in B \mid R(y)$

	Let $a \in A \mid P(a)$	
(i)	$a \in A \wedge P(a)$	By (b) and EI
(ii)	$a \in A$	By (i) and specialization
(iii)	$P(a)$	By (i) and specialization
(iv)	$\sim Q(a)$	by (ii), (iii), (d), and UMP
(v)	$Q(a) \vee a \in B$	by (ii), (c), and UI
(vi)	$a \in B$	by (iv), (v), and elimination
(vii)	$R(a)$	by (ii), (iii), (a), and UMP
(viii)	$\therefore \exists\, y \in B \mid R(y)$	by (vi), (vii), and EG