CS 245 - Clicker Questions

C. Bruni, A. Gao and C. Roberts

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Outline

Introduction to CS245

CQ 1: Did you bring your iClicker today?

A) Yes

B) No

CQ 2: The set, $B \subseteq \mathbb{N}$, of Natural Numbers which can be defined by an English sentence of length ≤ 200 characters, is

A) finite

B) infinite

C) cannot be determined

CQ 3: Consider the argument below.

The sun rises from the West. (premise)
If the sun rises from the West, then I will eat my hat. (premise)

I will eat my hat. (conclusion)

Is the above argument valid?

A) Yes, it is valid.
B) No, it is not valid.
C) I don't know...

CQ 4: Let R be the set of all sets that are not members of themselves. Formally,

$$R = \{x | x \notin x\}$$

Is R a member of itself?

A) Yes, R is a member of itself.

B) No, R is not a member of itself.

C) Both (A) and (B) are true.

D) Neither (A) nor (B) is true.

E) I give up...

Propositional Logic: Introduction, Syntax and Translations

CQ 1: Which of the following is a proposition?
(If there are multiple answers, choose your favourite one.)

(A) Where is the Student Life Centre?

(B) There are infinitely many pairs of primes that differ by 2. (This is the twin prime conjecture.)

(C) Open the window please!

(D) $1 \geq 5$.

(E) Playing video games.

CQ 2: Which of the following is a simple proposition?

(A) Does Lidia drink coffee and tea?

(B) Lidia drinks coffee.

(C) Lidia does not drink coffee.

(D) Lidia drinks coffee and tea.

(E) Lidia drinks coffee if and only if she drinks tea.

CQ 3: Let p denote any propositional symbol.

Which symbol can appear as the first one in a well-formed propositional formula? Choose the largest set.

(A) $\neg$
(B) $\neg$, (
(C) p, $\neg$
(D) p, (
(E) p, $\neg$, (

CQ 4: Which of the following is a well-formed propositional formula?

(A) a

(B) $\neg a$

(C) ab

(D) $(\neg a \wedge b)$

(E) $(a \wedge b \wedge c)$

CQ 8: Suppose that we want to prove that every well-formed propositional formula φ has some property$R$. We denote this by $R(\varphi)$. Consider following facts list of facts we could prove.

1. $R(p)$ is true for every propositional variable p.
2. If $R(\alpha)$, then $R(\neg\alpha)$.
3. If $R(\alpha)$ and $R(\beta)$, then $R((\alpha \star \beta))$, for a particular binary connective $\star$.
4. If $R(\alpha)$ and $R(\beta)$, then $R((\alpha \star \beta))$, for every binary connective $\star$.

To use the principle of structural induction, which of the above facts do we need to prove?

A) 1 and 2

B) 2 and 3

C) 1, 2 and 3

D) 1, 2 and 4

E) None of the above

Propositional Logic: Semantics

CQ 1: Consider the formula: $((a \to g) \land ((\neg a) \to s))$.
Consider a truth valuation t: $a^t = 1$, $g^t = 1$, and $s^t = 1$.

Under t, this formula evaluates to

(A) 0

(B) 1

(C) Cannot be determined

CQ 2: Consider the formula: $((a \to g) \wedge ((\neg a) \to s))$.
Which of the following truth valuations makes the formula false?

(A) $a^t = 1$, $g^t = 1$, $s^t = 0$.

(B) $a^t = 0$, $g^t = 1$, $s^t = 1$.

(C) $a^t = 0$, $g^t = 1$, $s^t = 0$.

(D) $a^t = 0$, $g^t = 0$, $s^t = 1$.

(E) None of the above

CQ 3: Assume that the following proposition is true.

If Alice is rich, she pays your tuition.

Assuming that Alice is rich, does she pay your tuition?

(A) Yes

(B) No

(C) Maybe

CQ 4: Assume that the following proposition is true.

If Alice is rich, she pays your tuition.

Assuming that Alice is not rich, does she pay your tuition?

(A) Yes
(B) No
(C) Maybe

CQ 5: Every tautology is satisfiable.

(A) True

(B) False

(C) Cannot be determined

CQ 6: No contradiction is satisfiable.

(A) True

(B) False

(C) Cannot be determined

CQ 7: Which of the following is correct?

(A) If I found a valuation under which a formula is true, the formula is a tautology.

(B) If I found a valuation under which a formula is true, the formula MAY BE a contradiction.

(C) If I found a valuation for which a formula is true, the formula is satisfiable.

(D) If I found a valuation under which a formula is false, the formula is a contradiction.

(E) If I found a valuation under which a formula is false, the formula is NOT satisfiable.

CQ 8: Consider the formula:

$$((p \wedge q \rightarrow r) \wedge (p \rightarrow q)) \rightarrow (p \rightarrow r)$$

The above formula is

(A) a tautology.

(B) satisfiable but not a tautology.

(C) a contradiction.

CQ 9: Consider the formula:

$$((p \vee q) \leftrightarrow ((p \wedge (\neg q)) \vee ((\neg p) \wedge q))).$$

The above formula is

(A) a tautology.

(B) satisfiable but not a tautology.

(C) a contradiction.

Propositional Logic: Logical Equivalence

CQ 9: Consider the formula $(\alpha \wedge (\beta \wedge \gamma))$, where α, β, and γ are well-formed formulas.

Which logical identity can we use to transform this formula?

(A) Associativity

(B) Distributivity

(C) Simplification II

(D) Two of (A), (B), and (C)

(E) All of (A), (B), and (C)

CQ 10: Consider the formula $(\alpha \wedge (\beta \vee \gamma))$, where α, β, and γ are well-formed formulas.
Which logical identity can we use to transform this formula?

(A) Associativity

(B) Distributivity

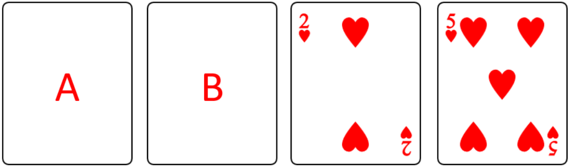
(C) Simplification II if $\alpha \equiv \beta$ or $\alpha \equiv \gamma$.

(D) Two of (A), (B), and (C)

(E) All of (A), (B), and (C)

CQ 11: Each card has a letter on one side and a natural number on the other side. How many cards do you have to turn over to determine whether the following claim is true?

Claim: For each card, if the card has a vowel on one side, then it has an even number on the other side.



(A) 0
(B) 1
(C) 2
(D) 3
(E) 4

Propositional Logic: Adequate Set of Connectives

CQ 12: Which of the following is INCORRECT?

(A) $\vee$ is definable in terms of $\wedge$ and $\neg$.

(B) $\wedge$ is definable in terms of $\vee$ and $\neg$.

(C) $\vee$ is definable in terms of $\rightarrow$ and $\neg$.

(D) $\wedge$ is definable in terms of $\rightarrow$ and $\neg$.

(E) $\neg$ is definable in terms of $\wedge$ and $\vee$.

Propositional Logic: Tautological Consequence

CQ 1: Let $\Sigma = \{(p \to q), (q \to r)\}$.
Which of the following is correct?

(A) No truth valuation satisfies Σ.

(B) At least one truth valuation satisfies Σ and at least one truth valuation does not satisfy Σ.

(C) Every truth valuation satisfies Σ.

CQ 2: Let $\Sigma = \emptyset$.

Which of the following is correct?

(A) No truth valuation satisfies Σ.

(B) At least one truth valuation satisfies Σ and at least one truth valuation does not satisfy Σ.

(C) Every truth valuation satisfies Σ.

CQ 3:

$$\{(p \wedge q)\} \vDash p$$

(A) True
(B) False
(C) Cannot be determined

CQ 4:

$$\{(p \vee q)\} \vDash p$$

(A) True

(B) False

(C) Cannot be determined

CQ 5:

$$\{(p \to q)\} \models (q \to p)$$

(A) True

(B) False

(C) Cannot be determined

CQ 6:

$$\emptyset \models \big((p \to q) \to p\big).$$

(A) True

(B) False

(C) Cannot be determined

CQ 7: Consider the tautological consequence $\Sigma \models A$.

If Σ is the empty set $\emptyset$, then

(A) the tautological consequence holds for **any** A.

(B) the tautological consequence holds when A is a tautology.

(C) the tautological consequence does NOT hold for **any** A.

CQ 8: Consider the tautological consequence $\Sigma \models A$.

If Σ is not satisfiable, then

(A) the tautological consequence holds for **any** A.

(B) the tautological consequence holds when A is a tautology.

(C) the tautological consequence does NOT hold for **any** A.

CQ 9: Consider the tautological consequence $\Sigma \models A$.

If A is a tautology,
then the tautological consequence holds for **any** Σ.

(A) True

(B) False

(C) Cannot be determined

CQ 10: Consider the tautological consequence $\Sigma \models A$.

If A is a contradiction,
then the tautological consequence DOES NOT hold for any Σ.

(A) True

(B) False

(C) Cannot be determined

Propositional Logic: Translations

CQ 5: Consider the sentence:

If I ace CS 245 then I can get a job at Google ; otherwise I will apply for the Geek Squad.

Define the propositional variables:
a: I ace CS 245.
g: I can get a job at Google.
s: I will apply for the Geek Squad.

Which of the following is a translation of this sentence into propositional logic?

(A) $((a \to g) \wedge ((\neg s) \to a))$
(B) $((g \to a) \wedge ((\neg s) \to a))$
(C) $((a \to g) \wedge ((\neg a) \to s))$
(D) $((a \to g) \vee ((\neg a) \to s))$
(E) None of the above

CQ 6: Consider the sentence:

Nadhi eats a fruit only if the fruit is an apple.

Define the propositional variables:
n: Nadhi eats a fruit.
a: The fruit is an apple.

Which of the following is a translation of this sentence into propositional logic?

(A) $(n \to a)$
(B) $(a \to n)$
(C) $(n \leftrightarrow a)$
(D) $(n \wedge a)$
(E) $(n \vee a)$

CQ 7: Consider the sentence:

Sidney carries an umbrella unless it is sunny.

Define the propositional variables:
u: Sidney carries an umbrella.
s: It is sunny.

Which of the following is a translation of this sentence into propositional logic?

(A) $(u \vee s)$
(B) $(u \wedge s)$
(C) $((u \vee s) \wedge (\neg(u \wedge s)))$
(D) Two of (A), (B), and (C)
(E) All of (A), (B), and (C)

Propositional Logic: Formal Deduction

CQ 1: To show that $\{(p \to q), (q \to r)\} \vdash_{ND} (p \to r)$, which inference rule should we apply first?

(A) $\to$e on $(p \to q)$

(B) $\to$e on $(q \to r)$

(C) $\to$i to produce $(p \to r)$

(D) Two of (A), (B), and (C)

(E) All of (A), (B), and (C)

CQ 2: If we were to apply $\rightarrow$i to produce $(p \rightarrow (q \rightarrow r))$, what are the first and the last lines of the subproof?

(A) p and r

(B) p and $(q \rightarrow r)$

(C) p and $(p \rightarrow (q \rightarrow r))$

(D) $(p \rightarrow (q \rightarrow r))$ and $(q \rightarrow r)$

CQ 3: If we were to apply $\vee$e on the formula $(p \vee q)$ to produce $((p \to q) \vee (q \to p))$, what are the first and the last lines of the two subproofs?

(A) First subproof: p and $(p \to q)$.
Second subproof: q and $(q \to p)$.

(B) First subproof: $(p \vee q)$ and $(p \to q)$.
Second subproof: $(p \vee q)$ and $(q \to p)$.

(C) First subproof: p and $((p \to q) \vee (q \to p))$.
Second subproof: q and $((p \to q) \vee (q \to p))$.

(D) First subproof: $(p \vee q)$ and $((p \to q) \vee (q \to p))$.
Second subproof: $(p \vee q)$ and $((p \to q) \vee (q \to p))$.

CQ 4: If we were to apply $\neg$i to produce $(\neg p)$, what are the first and the last lines of the subproof?

(A) p and $\perp$

(B) p and $(\neg p)$

(C) $(\neg p)$ and $\perp$

(D) $(\neg p)$ and $(\neg p)$

CQ 5: Consider the proof of *modus tollens* below.

1.	$(p \to q)$	Premise
2.	$(\neg q)$	Premise
3.	p	Assumption
4.	q	$\to$e: 1, 3
5.	$\perp$	
6.	$(\neg p)$	$\neg$i: 3–5

Which of the following is a correct justification for line 5?

(A) $\neg$i : 2, 4

(B) $\neg$e : 2, 4

(C) $\perp$i : 2, 4

(D) $\perp$e : 2, 4

(E) More than one of the above

CQ 6:

$$\{(\neg p)\} \vdash_{ND} (p \rightarrow q).$$

(A) True

(B) False

(C) Cannot be determined

CQ 7:

$$\emptyset \vdash_{ND} ((p \to q) \to p).$$

(A) True

(B) False

(C) Cannot be determined

Midterm Feedback

CQ 1: In terms of difficulty, I thought the mid-term exam was:

(A) too easy

(B) just right

(C) too hard

CQ 2: In terms of length, I thought the mid-term exam was:

(A) too short

(B) just right

(C) too long

Predicate Logic: Introduction and Syntax

CQ 1: Let

- 0 be a constant symbol,
- x be a variable symbol,
- f be a unary function symbol and
- P be a binary predicate symbol.

Then

$$(\forall x\ P(f(x), 0))$$

can express that the square of any real number is non-negative.

(A) True

(B) False

(C) Cannot be determined

CQ 2: Let

- 0 be a constant symbol,
- x be a variable symbol,
- f be a unary function symbol and
- P be a binary predicate symbol.

Then

$$(\forall x\ P(f(x), 0))$$

can express that the absolute value of any real number is non-negative.

(A) True

(B) False

(C) Cannot be determined

CQ 3: Let

- 0 be a constant symbol,
- x be a variable symbol,
- f be a unary function symbol and
- P be a binary predicate symbol.

Then

$$(\forall x \; P(f(x), 0))$$

can express that for every natural number, its successor is strictly positive.

(A) True

(B) False

(C) Cannot be determined

Predicate Logic: Semantics

CQ 1: Let

- x, y be variable symbols and
- $<$ be a binary predicate symbol.

Let the domain be $\mathbb{Z}$ and let $<$ have its usual meaning. Then

$$(\forall x(\exists y(y < x)))$$

is satisfied.

(A) True

(B) False

(C) Cannot be determined

CQ 2: Let

- x, y be variable symbols and
- $<$ be a binary predicate symbol.

Let the domain be $\mathbb{N}$ and let $<$ have its usual meaning. Then

$$(\forall x(\exists y(y < x)))$$

is satisfied.

(A) True

(B) False

(C) Cannot be determined

CQ 3: Under an interpretation $\mathcal{I}$, a Predicate Logic term with no variables always evaluates to an element of the domain.

(A) True

(B) False

(C) Cannot be determined

CQ 4: Under an interpretation $\mathcal{I}$, a Predicate Logic formula with no variables always evaluates to an element of the domain.

(A) True

(B) False

(C) Cannot be determined

CQ 5: Let

- 0 be a constant symbol,
- x be a variable symbol,
- f be a unary function symbol and
- P be a binary predicate symbol.

Then

$$(\forall x\ P(f(x), 0))$$

is always satisfied.

(A) True

(B) False

(C) Cannot be determined

CQ 6: Let $\mathcal{L}$ be a language containing a constant symbol 0, a variable symbol x, a function symbol $f^{(1)}$, and a predicate symbol $P^{(2)}$. Let $\mathcal{I}$ be an interpretation having

- domain $\mathcal{D} = \{0, 1\}$
- $0^{\mathcal{I}}$ is 0
- f is the identity function
- P is equality.

Let $E : x \mapsto 1$ be an environment. Then

$$\mathcal{I} \not\models_E P(f(x), 0).$$

(A) True
(B) False
(C) Cannot be determined

CQ 7: Let

- 0 be a constant symbol,
- x be a variable symbol,
- f be a unary function symbol and
- P be a binary predicate symbol.

Then

$$\emptyset \models (\forall x\ P(f(x), 0)),$$

in other words, $(\forall x\ P(f(x), 0))$ is always satisfied.

(A) True

(B) False

(C) Cannot be determined

CQ 8: Consider the formula $(x^2 \geq 1)$, where the symbols 1, ^{2} and $\geq$ have their usual meanings. Let the domain, $\mathcal{D}$, for this formula be the positive integers. In this domain, the given formula is

(A) Always satisfied

(B) Sometimes satisfied

(C) Never satisfied

(D) Cannot be determined

CQ 9: Consider the formula $(x^2 \geq 1)$, where the symbols 1, ^{2} and $\geq$ have their usual meanings. Let the domain, $\mathcal{D}$, for this formula be $\mathbb{N}$, the natural numbers. In this domain, the given formula is

(A) Always satisfied

(B) Sometimes satisfied

(C) Never satisfied

(D) Cannot be determined

CQ 10: Consider the formula $(x^2 \geq 1)$, where the symbols 1, ^{2} and $\geq$ have their usual meanings. Let the domain, $\mathcal{D}$, for this formula be $[-1, 1]$, the closed interval $-1 \leq x \leq 1$. In this domain, the given formula is

(A) Always satisfied

(B) Sometimes satisfied

(C) Never satisfied

(D) Cannot be determined

CQ 11: Consider the formula $(x^2 \geq 1)$, where the symbols 1, ^{2} and $\geq$ have their usual meanings. Let the domain, $\mathcal{D}$, for this formula be $(-1, 1)$, the open interval $-1 < x < 1$. In this domain, the given formula is

(A) Always satisfied

(B) Sometimes satisfied

(C) Never satisfied

(D) Cannot be determined

CQ 12: Using z as the new variable, the correct formula resulting from the substitution $(\exists x(x+y=0))[1-x/y]$ is

(A) $(\exists y(y+(1-z)=0))$.

(B) $(\exists x(x+(1-z)=0))$.

(C) $(\exists z(z+(1-x)=0))$.

(D) $(\exists x(x+(1-x)=0))$.

(E) Cannot be determined.

Predicate Logic: Natural Deduction

CQ 1: In Predicate Natural Deduction, the $\forall$e inference rule is most similar to The Propositional Natural Deduction inference rule

(A) $\wedge$e.

(B) $\wedge$i.

(C) $\vee$e.

(D) $\vee$i.

CQ 2: In Predicate Natural Deduction, the $\exists$i inference rule is most similar to The Propositional Natural Deduction inference rule

(A) $\wedge$e.

(B) $\wedge$i.

(C) $\vee$e.

(D) $\vee$i.

CQ 3: In Predicate Natural Deduction, the $\forall$i inference rule is most similar to The Propositional Natural Deduction inference rule

(A) $\wedge$e.

(B) $\wedge$i.

(C) $\vee$e.

(D) $\vee$i.

CQ 4: In Predicate Natural Deduction, the $\exists$e inference rule is most similar to The Propositional Natural Deduction inference rule

(A) $\wedge$e.

(B) $\wedge$i.

(C) $\vee$e.

(D) $\vee$i.

CQ 5: Consider this proof fragment.

1.	$(\forall x\,(P(x) \land Q(x)))$	Premise
2.	u fresh	Assumption
3.	$(P(u) \land Q(u))$	
4.	$Q(u)$	$\land$e: 3
5.	$(\forall x\ Q(x))$	

The correct missing justification on line 3 is

(A) $\forall$e: 1.

(B) $\forall$e: 2–3.

(C) $\forall$i: 1.

(D) $\forall$i: 2–3.

(E) None of A-D.

CQ 6: Consider this proof fragment.

1.	$(\forall x\, (P(x) \wedge Q(x)))$	Premise
2.	u fresh	Assumption
3.	$(P(u) \wedge Q(u))$	$\forall$e: 1
4.	$Q(u)$	$\wedge$e: 3
5.	$(\forall x\ Q(x))$	

The correct missing justification on line 5 is

(A) $\forall$e: 4.

(B) $\forall$e: 2-4.

(C) $\forall$i: 4.

(D) $\forall$i: 2-4.

(E) None of A-D.

CQ 7: Consider this proof fragment.

1.	$(\exists x\,(P(x) \wedge Q(x)))$	Premise
2.	$(P(u) \wedge Q(u))$, u fresh	Assumption
3.	$Q(u)$	$\wedge$e: 2
4.	$(\exists x\; Q(x))$	
5.	$(\exists x\; Q(x))$	

The correct missing justification on line 4 is

(A) $\exists$e: 3.

(B) $\exists$e: 2–3.

(C) $\exists$i: 3.

(D) $\exists$i: 2–3.

(E) None of A-D.

CQ 8: Consider this proof fragment.

1.	$(\exists x\,(P(x) \wedge Q(x)))$	Premise
2.	$(P(u) \wedge Q(u))$, u fresh	Assumption
3.	$Q(u)$	$\wedge$e: 2
4.	$(\exists x\; Q(x))$	$\exists$i: 3
5.	$(\exists x\; Q(x))$	

The correct missing justification on line 5 is

(A) $\exists$e: 4.

(B) $\exists$e: 1, 2-4.

(C) $\exists$i: 4.

(D) $\exists$i: 1, 2-4.

(E) None of A-D.

CQ 9: One can prove that

$$\{((\forall x\, P(x)) \vee (\forall x\, Q(x)))\} \vDash (\forall x (P(x) \vee Q(x))).$$

From this it follows that

$$\{((\forall x\, P(x)) \vee (\forall x\, Q(x)))\} \vdash (\forall x (P(x) \vee Q(x))).$$

The reason is

(A) soundness.

(B) completeness.

(C) contrapositive of soundness.

(D) contrapositive of completeness.

(E) None of A-D.

CQ 10: One can prove that

$$\{(\forall x (P(x) \vee Q(x)))\} \not\models ((\forall x\, P(x)) \vee (\forall x\, Q(x))).$$

From this it follows that

$$\{(\forall x (P(x) \vee Q(x)))\} \nvdash ((\forall x\, P(x)) \vee (\forall x\, Q(x))).$$

The reason is

(A) soundness.

(B) completeness.

(C) contrapositive of soundness.

(D) contrapositive of completeness.

(E) None of A-D.

CQ 11: One can prove that

$$\{(\forall x\,(P(x) \land Q(x)))\} \vdash ((\exists x\; P(x)) \land (\exists y\; Q(y))).$$

From this it follows that

$$\{(\forall x\,(P(x) \land Q(x)))\} \models ((\exists x\; P(x)) \land (\exists y\; Q(y))).$$

The reason is

(A) soundness.

(B) completeness.

(C) contrapositive of soundness.

(D) contrapositive of completeness.

(E) None of A-D.

Program Verification

CQ 1: The following piece of code (from Slide 244) correctly computes $x!$.

```
y = 1;
z = 0;
while (z != x) {
z = z + 1;
y = y * z;
}
```

(A) True

(B) False

(C) Cannot be determined

CQ 2: Let C be a "do-nothing" program (e.g. only a comment). Then the Hoare triple $(\!|\ \alpha\ |\!)\ \ C\ \ (\!|\ \alpha\ |\!)$ is satisfied under partial correctness.

(A) True

(B) False

(C) Cannot be determined

CQ 3: Let C be a "do-nothing" program (e.g. only a comment). Then the Hoare triple $(\!|\ \alpha\ |\!)\ C\ (\!|\ \alpha\ |\!)$ is satisfied under total correctness.

(A) True

(B) False

(C) Cannot be determined

CQ 4: The correct precondition in the annotated program

$(\!|\ ???\ |\!)$

```
x = y + z ;
```

$(\!|\ x > 0\ |\!)$

is

(A) $(\!|\ x > 0\ |\!)$

(B) $(\!|\ y > 0\ |\!)$

(C) $(\!|\ z > 0\ |\!)$

(D) $(\!|\ y + z > 0\ |\!)$

(E) None of the above.

CQ 5: A correct postcondition in the following program

$(\!| \ x > 0 \ |\!)$

```
x = x + 1 ;
```

$(\!| \ ??? \ |\!)$

is

(A) $(\!| \ x > 0 \ |\!)$

(B) $(\!| \ x > 1 \ |\!)$

(C) $(\!| \ x > -1 \ |\!)$

(D) $(\!| \ x > 2 \ |\!)$

(E) None of the above.

CQ 6: This program

$(\!|\ \mathit{true}\ |\!)$

```
if (y > x) {
```

$(\!|\ (y > x)\ |\!)$ — if-then-else

$(\!|\ (((y > x) \wedge (x = x)) \vee ((y \leq x) \wedge (x = y)))\ |\!)$ — implied(a)

```
    z = x ;
```

$(\!|\ (((y > x) \wedge (z = x)) \vee ((y \leq x) \wedge (z = y)))\ |\!)$ — Assignment

```
} else {
```

$(\!|\ (\neg(y > x))\ |\!)$ — if-then-else

$(\!|\ (((y > x) \wedge (y = x)) \vee ((y \leq x) \wedge (y = y)))\ |\!)$ — implied(b)

```
    z = y ;
```

$(\!|\ (((y > x) \wedge (z = x)) \vee ((y \leq x) \wedge (z = y)))\ |\!)$ — Assignment

```
}
```

$(\!|\ (((y > x) \wedge (z = x)) \vee ((y \leq x) \wedge (z = y)))\ |\!)$ — if-then-else

is annotated correctly.

(A) True

(B) False

(C) Cannot be determined

CQ 7: Suppose that you have just finished annotating a specification according to the appropriate inference rules for the code and the given pre- and post- conditions. Then it follows that you have finished proving that the specification is satisfied under partial correctness.

(A) True

(B) False

(C) Cannot be determined

CQ 8: A correct choice of loop invariant for the program

$(\!|\ n \geq 0\ |\!)$

```
x = 0 ;
y = 0 ;
while (x < n) {
     x = x + 1 ;
     y = y + x ;
}
```

$(\!|\ y = \frac{n(n+1)}{2}\ |\!)$

is

(A) $(\!|\ y = \frac{x(x+1)}{2}\ |\!)$

(B) $(\!|\ y = \frac{x(x-1)}{2}\ |\!)$

(C) $(\!|\ x = \frac{y(y+1)}{2}\ |\!)$

(D) $(\!|\ x = \frac{y(y-1)}{2}\ |\!)$

(E) None of the above.

CQ 9: The Hoare triple

$\llparenthesis\ n \geq 0\ \rrparenthesis$

```
x = 0 ;
y = 0 ;
while (x < n) {
    x = x + 1 ;
    y = y + x ;
}
```

$\llparenthesis\ y = \frac{n(n+1)}{2}\ \rrparenthesis$

is satisfied under partial correctness.

(A) True

(B) False

(C) Cannot be determined

CQ 10: The Hoare triple

$\llparenthesis\, n \geq 0 \,\rrparenthesis$

```
x = 0 ;
y = 0 ;
while (x < n) {
    x = x + 1 ;
    y = y + x ;
}
```

$\llparenthesis\, y = \frac{n(n+1)}{2} \,\rrparenthesis$

is satisfied under total correctness.

(A) True

(B) False

(C) Cannot be determined

CQ 11: A correct choice of the missing assertion for the program

$(\!|\ (((A[1] = x) \wedge (A[2] = y)) \wedge (A[3] = z))\ |\!)$

```
t = A[1] ;
A[1] = A[2] ;
A[2] = A[3] ;
```

$(\!|\ \mathit{missing}\ |\!)$

```
A[3] = t ;
```

$(\!|\ (((A[1] = y) \wedge (A[2] = z)) \wedge (A[3] = x))\ |\!)$

is

(A) $(\!|\ (((A\{t \leftarrow 2\}[1] = y) \wedge (A\{t \leftarrow 3\}[2] = z)) \wedge (A\{t \leftarrow 1\}[3] = x))\ |\!)$

(B) $(\!|\ (((A\{t \leftarrow 3\}[1] = y) \wedge (A\{t \leftarrow 3\}[2] = z)) \wedge (A\{t \leftarrow 3\}[3] = x))\ |\!)$

(C) $(\!|\ (((A\{2 \leftarrow t\}[1] = y) \wedge (A\{3 \leftarrow t\}[2] = z)) \wedge (A\{1 \leftarrow t\}[3] = x))\ |\!)$

(D) $(\!|\ (((A\{3 \leftarrow t\}[1] = y) \wedge (A\{3 \leftarrow t\}[2] = z)) \wedge (A\{3 \leftarrow t\}[3] = x))\ |\!)$

(E) None of the above.

Undecidability

CQ 1: The program

```
t = A[1] ;
A[1] = A[2] ;
A[2] = A[3] ;
A[3] = t ;
```

always halts, for any input A. This contradicts the fact that the Halting Problem is undecidable.

(A) True

(B) False

(C) Cannot be determined

CQ 2: The Scheme program

```
(define (loop x) (loop loop))
```

never halts, for any input. This contradicts the fact that the Halting Problem is undecidable.

(A) True

(B) False

(C) Cannot be determined

CQ 3: Recall that we proved in the previous lecture that the decision problem of whether an arbitrary propositional formula is satisfiable, is decidable. Similarly we can prove that the decision problem of whether an arbitrary propositional formula is valid (a.k.a. a tautology), is decidable. The decision problem of whether an arbitrary predicate formula is valid, is also decidable.

(A) True

(B) False

(C) Cannot be determined

Final Exam Review Session

CQ 1: If my schedule permits, then I would attend a review session before the final exam.

(A) True

(B) False

(C) I will decide later