Birla Institute of Technology & Science, Pilani
1st Semester 2023-24
CS F214 - Logic in Computer Science – Comprehensive Examination – Part A (Closed Book)

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Time: 60 minutes **Dec 20, 2023** **Marks: 33M**

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Instructions:

- Answer all the questions in the separate answer sheet provided.
- Use the last page of the Part B answer sheet for rough work.
- No rechecks will be entertained for the overwritten answers.
- MCQ Questions can have more than one option correct. Marks will be awarded only when all correct options are marked.
- Questions 1 to 13 are for 1M. Questions 14 to 18 are for 2M. Q19 is for 6M. Q20 is for 4M.
- **IF YOU HAVE A DOUBT / CLARIFICATION, make your assumption, state it and write. PLEASE DON'T CALL THE INSTRUCTOR.**

1. Which of the following is/are TRUE?
    a. Disproving a sequent in propositional logic is a decidable problem
    b. Proving a sequent in propositional logic is a decidable problem
    c. Proving a sequent in predicate logic is an undecidable problem
    d. Disproving a sequent in predicate logic is a decidable problem

2. Which of the following is/are TRUE?
    a. Checking the validity of a predicate logic formula is undecidable
    b. Checking the satisfiability of a predicate logic formula is undecidable
    c. Checking for semantic entailment of a predicate logic sequent is decidable
    d. None of the above are TRUE

3. Which of the following is/are TRUE?
    a. Propositional Logic is both sound and complete
    b. Predicate Logic is both sound and complete
    c. Temporal Logic is sound
    d. Floyd Hoare's Logic is not sound

4. Which of the following is/are TRUE?
    a. Temporal Logic (LTL/CTL) accepts Brouwer's argument
    b. Temporal Logic (LTL/CTL) does not accept Brouwer's argument
    c. Brouwer's argument is not applicable to Temporal Logic
    d. LEM and PBC have no connection with Temporal Logic proofs

5. Which of the following is/are TRUE?
    a. Every formula in LTL can be expressed in CTL
    b. Every formula in CTL can be expressed in LTL
    c. Not every LTL formula can be expressed in CTL
    d. Not every CTL formula can be expressed in LTL

6. Which of the following sets is/are adequate to represent LTL formulas?
    a. *{ X, U }*
    b. *{ G, W }*
    c. *{ F, R }*
    d. *{ X, R }*

7. Which of the following sets is/are adequate to represent a propositional logic formula?
    a. {¬, ∨}
    b. {¬, ∧}
    c. {→, ∧}
    d. {¬,→}

8. Which of the following is/are constructs of an imperative language?
    a. Iteration
    b. Assignment
    c. Conditional
    d. Sequencing

9. Consider the following code snippet:

```
/* Phi1: a < 5 */
a = a * a;
/* Phi2 */
a = a + 12;
/* Phi3 */
```

    Which of the following is/are true about the conditions Phi2 and Phi3?
    a. Phi2 is a < 25
    b. Phi2 → a <= 25
    c. Phi3 is a < 37
    d. a <= 37 → Phi3

10. Assume that the area function has the following contract:

```
/* Pre: x > 0 ∧ y > 0 */
area(x, y) { ... }
/* Post: area(x, y) = 0.5 * x * y */
```

Then which of the following is the most appropriate pre-condition?

```
/*Pre: ? */
A = area(a, b);
 /*Post:  A > 10 */
```

    a. a > 10;
    b. b > 20;
    c. a * b > 20;
    d. a * b > 20 ∧ a > 0 ∧ b > 0

11. Which of the following is/are true regarding the program and logical variables?
    a. Program variables refer to the actual variables used in the program
    b. Logical variables are required because we may want to refer to old values of program variables or relate old and new values of program variables.
    c. Logical variables (which are not program variables) do not occupy memory when the program is run.
    d. Program variables do not occupy memory when the code is run.

12. Given the following code snippet:

```
i = 0;
/* PRE: a is an array with n integers, i=0 and x is some integer */
while (i < n){
  if (a[i] == x)
        break;
  else
        i++;
}
```

Which of the following is the most appropriate loop invariant (expressed in English)?

a. The first i elements contain x
b. The first i elements do not contain x
c. The first i - 1 elements do not contain x
d. The first i - 1 elements contain x.

13. Consider the following program:

```
/* PRE: a > 10 ∧ i = 0*/
while (a != 0)
{
  a -= 2;
  i++;
}
return i;
```

The program aims to calculate the value of a/2 and set it to i.
Which of the following is/are TRUE about this program?

a. The program is partially correct
b. The program is totally correct
c. The program is neither partially correct nor totally correct
d. There is not enough evidence to prove whether a program is totally correct or partially correct.

14. Which of the following LTL formulas is/are equivalent to $\neg\big(\mathbf{X}(\phi\ \mathbf{U}\ \psi)\big)$
    a. $\mathbf{X}\neg\big((\phi\ \mathbf{W}\ \psi)\wedge\mathbf{F}\ \psi\big)$
    b. $\mathbf{X}\neg\big((\phi\ \mathbf{W}\ \psi)\wedge\neg(\mathbf{G}\ \neg\psi)\big)$
    c. $\mathbf{G}\neg\big((\phi\ \mathbf{W}\ \psi)\wedge\mathbf{F}\ \neg\psi\big)$
    d. None of the above
15. Which of the following LTL formulas is/are equivalent to $\mathbf{X}\big(\mathbf{F}(\phi\vee\psi)\big)$
    a. $\mathbf{X}(\mathbf{F}\phi\vee\mathbf{F}\psi)$
    b. $\mathbf{X}(\mathbf{F}\phi\wedge\mathbf{F}\psi)$
    c. $\neg\Big(\mathbf{X}\big((\neg\mathbf{F}\phi)\wedge(\neg\mathbf{F}\psi)\big)\Big)$
    d. None of the above
16. Which of the following LTL formulas is/are equivalent to $\mathbf{G}\big(\mathbf{F}(\phi\vee\psi)\big)$
    a. $\mathbf{G}(\mathbf{F}\phi\wedge\mathbf{F}\psi)$
    b. $\mathbf{G}(\mathbf{F}\phi\vee\mathbf{F}\psi)$
    c. $\neg\Big(\mathbf{G}\big((\neg\mathbf{F}\phi)\wedge(\neg\mathbf{F}\psi)\big)\Big)$
    d. None of the above
17. Which of the following rightly represents the following statement:
"Action q must respond to action p"
    a. $\mathbf{AG}\ (p\rightarrow\mathbf{AF}\ q)$
    b. $\mathbf{G}\ (p\rightarrow\ \mathbf{F}\ q)$
    c. $\mathbf{EG}\ (p\rightarrow\ \mathbf{AF}\ q)$
    d. $\mathbf{AG}\ (q\rightarrow\ \mathbf{AF}\ p)$

18. Consider the following program:

```
/* PRE: a > 10 ∧ i = 0*/
while (a != 0)
{
a -= 2;
   i++;
}
return i;
```

The program aims to calculate the value of a/2 and set it to i.
Which of the following is/are TRUE about this program?

a. The program is partially correct
b. The program is totally correct
c. The program is neither partially correct nor totally correct
d. There is not enough evidence to prove whether a program is totally correct or partially correct.

19. Consider Figure 1. For each of the following CTL formulas, state whether the formula holds TRUE or NOT. Consider s_o as the starting state. **6M**

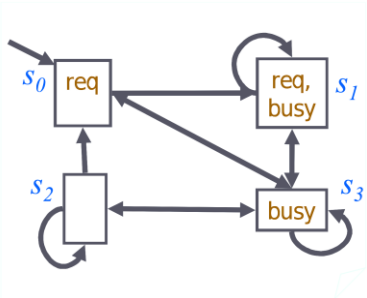

Figure 1

a. $(\mathbf{AX}\ busy)$
b. $(\mathbf{EG}\ busy)$
c. $\mathbf{A}\ (req\ \mathbf{U}\ busy)$
d. $\mathbf{E}\ (\neg req\ \mathbf{U}\ busy)$
e. $\mathbf{AG}\ (req \rightarrow \mathbf{AF}\ busy)$
f. $\mathbf{AX}\ (req \vee busy)$

20. Consider the below given transition system in Figure 2. **2+2=4M**

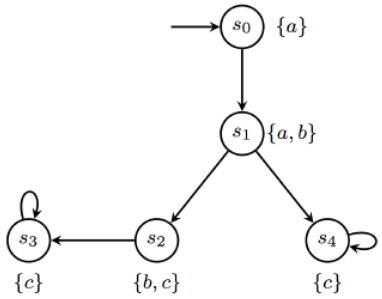

Figure 2

For each of the CTL formulae below, write the set of states in which the formula holds true.
(a) $\mathbf{A}[a\ \mathbf{U}\ (\mathbf{AF}\ c)]$ (b) $\mathbf{EF}\ \mathbf{AG}\ c$. Consider s_o as the starting state.

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