

Due: 09.09.19

Instructor: Dr. P. Kumar

## INSTRUCTIONS:

Problems to be discussed in Tutorial in the week of Monday 9th Sep 2019.

1. **(Free and Bound Variables)** Indicate the variables that are free and bound. Also show the scope of the quantifiers.

(a)  $(x)(P(x) \wedge R(x)) \rightarrow (x)P(x) \wedge Q(x)$

(b)  $(x)(P(x) \wedge (\exists x)Q(x)) \vee ((x)P(x) \rightarrow Q(x))$

(c)  $(x)(P(x) \leftrightarrow Q(x) \wedge (\exists x)R(x)) \wedge S(x)$

2. **(Universe of discourse)**

If the universe of discourse is the set  $\{a, b, c\}$ , eliminate the quantifiers in the following formulas

1.  $(x)P(x)$

2.  $(x)R(x) \wedge (x)S(x)$

3.  $(x)R(x) \wedge (\exists x)S(x)$

4.  $(x)(P(x) \rightarrow Q(x))$

5.  $(x)\neg P(x) \vee (x)P(x)$

3. **(Truth Values of Predicates)** Find the truth values of

1.  $(x)(P(x) \vee Q(x))$ , where  $P(x) : x = 1, Q(x) : x = 2$ , and the universe of discourse is  $\{1, 2\}$

2.  $(x)(P \rightarrow Q(x)) \vee R(a)$ , where  $P : 2 > 1, Q(x) : x \leq 3, R(x) : x > 5$ , and  $a : 5$ , with the universe being  $\{-2, 3, 6\}$

4. **(Implication)** Show that  $(\exists z)(Q(z) \wedge R(z))$  is not implied by the formulas  $(\exists x)(P(x) \wedge Q(x))$  and  $(\exists y)(P(y) \wedge R(y))$ , by assuming universe of discourse which has two elements.