

School of Computing and Information Systems
COMP30026 Models of Computation Problem Set 5

23–27 August 2021

Content: interpretations in predicate logic, clausal form

P5.1 For each of the following predicate logic formulas, give an interpretation that makes the formula true, and one that makes it false:

- (a) $\forall x \forall y (P(x, y))$
- (b) $\forall x \exists y (P(x, y) \wedge P(y, x))$
- (c) $(\forall x \exists y P(x, y)) \wedge (\forall x \exists y P(y, x))$

P5.2 Show that $\forall x(P(x)) \models \exists y(P(y))$ holds, by supposing that an interpretation \mathcal{I} makes $\forall x(P(x))$ true (so $\mathcal{I} \models \forall x(P(x))$), and explaining why it must make $\exists y(P(y))$ true. Does $\exists x(P(x)) \models \forall y(P(y))$ also hold? Recall that part of our definition of *interpretation* is that the *domain* is non-empty.

P5.3 Turn the closed formula $\forall x \forall y \exists z (P(x) \Rightarrow \forall y \exists z (Q(y, z)))$ into a simpler equivalent formula of the form $\varphi \Rightarrow \psi$.

P5.4 Determine whether $\neg \forall x \exists y (\neg P(x) \wedge P(y))$ is valid and/or satisfiable. Then convert the formula to clausal form.

P5.5 Turn the closed formula $\neg \forall x \exists y \left[\forall z (Q(x, z) \wedge P(y)) \wedge \forall u (\neg Q(u, x)) \right]$ into clausal form.

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