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① 

$L.H.S \Rightarrow \neg(\exists x\, P(x) \wedge \forall y \neg(M(x,y))) \wedge P(a)$

$\Rightarrow (\neg(\exists x P(x)) \vee \neg(\forall y \neg(M(x,y)))) \wedge P(a)$

$\{\neg(a \wedge b) = \neg a \vee \neg b\}$

$\Rightarrow ((\forall x \neg P(x)) \vee (\exists y\, M(x,y))) \wedge P(a)$

$\left\{ \begin{array}{l} \neg(\forall x\, P(x)) = \exists x \neg P(x) \\ \neg(\exists x\, P(x)) = \forall x \neg P(x) \end{array} \right\}$

$\Rightarrow (\neg P(a) \vee \exists y\, M(a,y)) \wedge P(a)$

{Universal instantiaon}

$\Rightarrow (\neg P(a) \wedge P(a)) \vee (\exists y M(a,y) \wedge P(a))$

{Distributive property}

$\Rightarrow \exists y M(a,y) \wedge P(a)$ { $a \wedge \neg a$ is fallacy }

$\Rightarrow \exists y\, M(a,y) \wedge P(a) \rightarrow \exists y\, M(a,y)$

{Simplification - rules of inference}

$\Rightarrow \boxed{L.H.S \rightarrow \exists z\, M(a,z)}$

{Variable change}

$\therefore$ Proved.

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2.

$$
\begin{aligned}
L.H.S &= (2+2) \\
&= 2 + S(1) && \{S(1) = 2\} \\
&= S(2+1) && \{a + S(b) = S(a+b)\} \\
&= S(2+S(0)) && \{S(0) = 1\} \\
&= S(S(2+0)) && \{a+S(b) = S(a+b)\} \\
&= S(S(2)) && \{a+0 = a\} \\
&= S(S(S(1))) && \{S(1) = 2\} \\
&= S(S(S(S(0)))) && \{S(0) = 1\} \\
&= R.H.S
\end{aligned}
$$

$\therefore (2+2) = S(S(S(S(0))))$

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③ • Computation is a method where each step is deterministic and when the input is finite it gives an output (solution) in finite steps

• Theory of computation is the study that deals with how efficiently problems can be solved on a model of computation using an algorithm.

• In other words, it is the study about ultimate capability of computers, that is, the problems that can be solved, can be partially solved, or cannot solved at all by a computer which is restricted by the limitation of physically realizable and employing methods that are deterministic and end in finite number of steps.

• "Ultimate" because, we are disussing the final form of computers.

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