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2-3

(2) ~~$\forall(x)(P(x)\land P(y)\land$ ... $R(x,y,z)$~~

$\forall(x)\forall(y)(P(x)\land P(y)\land\neg E(x,y))\to$

$(\exists! z)(L(z)\land R(x,y,z))$.

(3) (1). 令 $P(x)$, $L(x,y)$ $R(x,y)$ $Q(x,y)$ 表示 x是实数,

x与y之和, x与y之积. x大于y.

$\exists(x)\exists(y)\exists(z)Q(L(x,y),R(x,z))$.

$R(x)$: x是实数 $G(x,y)$, x大于y

$(\exists x)(\exists y)(\exists z)(R(x)\land R(y)\land R(z)\land G(x+y)x\cdot z)$

2-4.

(4) (c). $(\forall x)(P(x)\to Q(x))\Leftrightarrow$

~~$(\forall x)(\neg P(x)\lor Q(x))$~~.

$(P(a)\to Q(a))\land(P(b)\to Q(b))\land(P(c)\to Q(c$

(3) (b). $(P\to Q(-2))\land(P\to Q(3))\land(P\to Q(6))\lor R(5)$.

$(T\to T)\land(T\to T)\land(T\to F)\lor F\Leftrightarrow F$.

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1.(6) (b) $((\forall u)(P(u) \to (R(u) \vee Q(u))) \wedge$

$\exists v R(v)) \to (\exists z) S(x, z)$.

2-5.

1.(c) $(\forall x)(\forall y)((P(x, y) \to P(f(x), f(y))) \Leftrightarrow$

$(\forall x)((P(x, 1) \to P(f(x), 2)) \Leftrightarrow$

$(P(1,1) \to P(2,2)) \wedge (P(1,2) \to P(2,1))$

$\wedge (P(2,1) \to P(1,2)) \wedge (P(2,2) \to P(1,1))$.

$\Leftrightarrow (T \to F) \wedge (T \to F) \wedge (F \to T) \wedge (F \to T)$

$\Leftrightarrow F \wedge F \wedge T \wedge T \Leftrightarrow F$.

4. 证明：$(\exists x)(A(x) \to B(x)) \Leftrightarrow (\exists x)(\neg A(x) \vee B(x))$

$\Leftrightarrow (\exists x) \neg A(x) \vee (\exists x) B(x)$. $\Leftrightarrow \neg (\forall x) A(x) \vee (\exists x) B(x)$

$\Leftrightarrow (\forall x) A(x) \to (\exists x) B(x)$.

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(7). $(\forall x)(\forall y)(P(x)\rightarrow Q(y)) \Leftrightarrow$

$(\forall x)(\forall y)(\neg P(x) \vee Q(y)) \Leftrightarrow$

$\forall x \neg P(x) \vee \forall y Q(y) \Leftrightarrow$

$\neg (\exists x) P(x) \vee \forall y Q(y) \Leftrightarrow$

$(\exists x) P(x) \rightarrow (\forall y) Q(y)$.

2-6.

(1) b) 化为前束范式.

$(\exists x)(\neg((\exists y)P(x,y)) \rightarrow ((\exists z)Q(z) \rightarrow R(x))$. $\Leftrightarrow$

$(\exists x)(\exists y) P(x,y) \vee ((\exists z)Q(z) \rightarrow R(x)) \Leftrightarrow$

$(\exists x)(\exists y) P(x,y) \vee (\neg(\exists z)Q(z) \vee R(x)) \Leftrightarrow$

$(\exists x)(\exists y) P(x,y) \vee ((\forall z)\neg Q(z) \vee R(x)) \Leftrightarrow$

$(\exists x)(\exists y)(\forall z)(P(x,y) \vee \neg Q(z) \vee R(x))$

(2) c) $(\forall x)P(x) \rightarrow (\exists x)((\forall z)Q(x,z) \vee (\forall z)R(x,y,z$

$\Leftrightarrow \neg(\forall x)P(x) \vee (\exists x)(((\forall z)Q(x,z) \vee (\forall z)R(x,y,z))$

$\Leftrightarrow (\exists x)\neg P(x) \vee (\exists x)((\forall z)Q(x,z) \vee (\forall z)R(x,y,z))$

$\Leftrightarrow (\exists x)\neg P(x) \vee (\exists x)(((\forall z)Q(x,z) \vee (\forall r)R(x,y,r)$

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$\Leftrightarrow (\exists x)(\forall z)(\forall R_1)(\neg P(x) \vee Q(x,z) \vee R(x,y,R_1))$

即:前束合取范式. 接下来换成前束析取范式:

$\Leftrightarrow (\exists x)(\forall z)(\forall R_1)((P(x) \wedge Q(x,z) \wedge R(x,y,R_1)) \vee$
$(P(x) \wedge Q(x,z) \wedge \neg R(x,y,R_1)) \vee (P(x) \wedge \neg Q(x,z) \wedge$
$R(x,y,R_1)) \vee (P(x) \wedge \neg Q(x,z) \wedge \neg R(x,y,R_1)) \vee$
$(\neg P(x) \wedge Q(x,z) \wedge \neg R(x,y,R_1)) \vee$
$(\neg P(x) \wedge \neg Q(x,z) \wedge R(x,y,R_1)) \vee$
$(\neg P(x) \wedge \neg Q(x,z) \wedge \neg R(x,y,R_1))$

2-7

(1) c) 证明:

(1)	$(\forall x)(A(x) \to B(x))$	P
(2)	$(A(u) \to B(u))$	~~ES~~ US(1)
(3)	$\neg B(u) \to \neg A(u)$	T(2)E
(4)	$(\forall x)(C(x) \to \neg B(x))$	P
(5)	$C(u) \to \neg B(u)$	US(4) ~~(4)~~
(6)	~~$(\forall x)(C$~~ $C(u) \to \neg A(u)$	T(3)(5)I
(7)	$(\forall x)(C(x) \to \neg A(x))$	UG(6).

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d) 证明: (1) $(\forall x)(A(x) \vee B(x))$ P

(2) $A(u) \vee B(u)$ US(1)

(3) $(\forall x)(B(x) \rightarrow \neg C(x))$ P

(4) $B(u) \rightarrow \neg C(u)$ US(3)

(5) $(\forall x) C(x)$ P

(6) $C(u)$ US(5)

(7) $\neg B(u)$ T(4)(6)I

(8) $A(u)$ T(2)(7)I

(9) $(\forall x) A(x)$ UG(8)

(2) b) 证明: $(\forall x) P(x) \vee (\exists x) Q(x) \Leftrightarrow$

$\neg(\forall x) P(x) \rightarrow (\exists x) Q(x) \Leftrightarrow$

$(\exists x) \neg P(x) \rightarrow (\exists x) Q(x)$

(1) $(\exists x) \neg P(x)$ P(附加条件)

(2) $\neg P(u)$ ES(1)

(3) $(\forall x)(P(x) \vee Q(x))$ P

(4) $P(u) \vee Q(u)$ ES(3)

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(5) $Q(u)$ T(2)(4) I.

(6) $(\exists x)\,Q(x)$ EG(5)

(7) $(\exists x)\,\neg P(x) \rightarrow (\exists x)\,Q(x)$ CP.