Reminders

On your workdesk:

- Writing implements: pens, correction devices
- A water bottle (optional) **turned off** (not silent mode), **face down**

Phones, tablets or other internet enabled devices
should be **turned off** and **placed inside a bag**

Bags should be placed **at the sides of the room**

No communication with other test-takers allowed:
raise hand for attention and blank sheets

No toilet breaks during quiz-taking

Submit sheets to front

At least one seat between test-takers

Write your name on pages 1 and 3 of the questionnaires
BEFORE clock is at 18:26:
Late sheets will NOT be accepted

SHEETS CAN ONLY BE TURNED OVER BY 17:05

This sheet can be used for scratch-work—if so, write name and attach to submission

Modus ponens	p $\underline{p \to q}$ $\therefore q$
Modus tollens	$\neg q$ $\underline{p \to q}$ $\therefore \neg p$
Hypothetical syllogism	$p \to q$ $\underline{q \to r}$ $\therefore p \to r$
Disjunctive syllogism	$p \vee q$ $\underline{\neg p}$ $\therefore q$
Addition	$\underline{p}$ $\therefore p \vee q$
Simplification	$\underline{p \wedge q}$ $\therefore p$
Conjunction	p $\underline{\neg q}$ $\therefore p \wedge q$
Resolution	$p \vee q$ $\underline{\neg p \vee r}$ $\therefore q \vee r$
Universal instantiation	$\underline{\forall x P(x)}$ $\therefore P(c)$
Universal generalization	$\underline{P(c) \text{ for an arbitrary } c}$ $\therefore \forall x P(x)$
Existential instantiation	$\underline{\exists x P(x)}$ $\therefore P(c)$ for some element c
Existential generalization	$\underline{P(c) \text{ for some element } c}$ $\therefore \exists x P(x)$
Universal modus ponens	$\forall x \in D, (P(x) \to Q(x))$ $\underline{P(a) \text{ where } a \in D}$ $\therefore Q(a)$
Universal modus tollens	$\forall x \in D, (P(x) \to Q(x))$ $\underline{\neg Q(a) \text{ where } a \in D}$ $\therefore \neg P(a)$

VIOLATIONS WILL RESULT IN ZERO MARKS FOR THIS TEST

<u>DO NOT</u> TURN OVER THESE SHEETS OR VIEW TEST QUESTIONS BEFORE 17:05

Identity laws	$p \wedge \mathbf{T} \equiv p$ $p \vee \mathbf{F} \equiv p$
Domination laws	$p \vee \mathbf{T} \equiv \mathbf{T}$ $p \wedge \mathbf{F} \equiv \mathbf{F}$
Idempotent laws	$p \wedge p \equiv p$ $p \vee p \equiv p$
Double negation / complement law	$\neg(\neg p) \equiv p$
Commutative laws	$p \wedge q \equiv q \wedge p$ $p \vee q \equiv q \vee p$
Associative laws	$(p \wedge q) \wedge r \equiv p \wedge (q \wedge r)$ $(p \vee q) \vee r \equiv p \vee (q \vee r)$
Distributive laws	$p \wedge (q \vee r) \equiv (p \wedge q) \vee (p \wedge r)$ $p \vee (q \wedge r) \equiv (p \vee q) \wedge (p \vee r)$
De Morgan's laws	$\neg(p \wedge q) \equiv \neg p \vee \neg q$ $\neg(p \vee q) \equiv \neg p \wedge \neg q$
Absorption laws	$p \wedge (p \vee q) \equiv p$ $p \vee (p \wedge q) \equiv p$
Negation / complement laws	$p \wedge \neg p \equiv \mathbf{F}$ $p \vee \neg p \equiv \mathbf{T}$

$p \to q \equiv \neg p \vee q \equiv\not\equiv q \to \neg p$	$p \leftrightarrow (p \to q) \wedge (q \to p) \equiv \neg p \leftrightarrow \neg q \equiv (p \wedge q) \vee (\neg p \wedge \neg q)$
$p \vee q \equiv \neg p \to q$	$\neg(p \leftrightarrow q) \equiv p \leftrightarrow \neg q$
$p \wedge q \equiv \neg(p \to \neg q)$	
$\neg(p \to q) \equiv p \wedge \neg q$	
$(p \to q) \wedge (p \to r) \equiv p \to (q \wedge r)$	
$(p \to r) \wedge (q \to r) \equiv (p \vee q) \to r$	
$(p \to q) \vee (p \to r) \equiv p \to (q \vee r)$	
$(p \to r) \vee (q \to r) \equiv (p \wedge q) \to r$	

$\neg \exists x P(x)$	$\forall x \neg P(x)$
$\neg \forall x P(x)$	$\exists x \neg P(x)$

$\forall x \forall y P(x,y) \equiv \forall y \forall x P(x,y)$
$\forall x \exists y P(x,y) \equiv \neg[\exists x \forall y \neg P(x,y)]$
$\exists x \forall y P(x,y) \equiv \neg[\forall x \exists y \neg P(x,y)]$
$\exists x \exists y P(x,y) \equiv \exists y \exists x P(x,y)$