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Name (5 points): ________________________________ **Section** (5 points): _______

Section I True / False questions (5 points each)

1. _____ Only universal and existential WFFs have instances.

2. _____ A WFF in predicate logic may contain a free variable.

3. _____ If a WFF begins with the symbols "∀x", then it must be an existential.

4. _____ All valid arguments have a countermodel.

Section II Mark the correct completion (5 points each)

1. The condition on ∀I requires that …

   (a) _____ the instantial name must occur in at least one of the sentences in the assumption of the line to which one applies the rule.

   (b) _____ there is no condition on the application of ∀I.

   (c) _____ the instantial name cannot occur in any sentence in the assumption set of the line to which one applies the rule.

   (d) _____ a free variable must be used in place of an instantial name.

   (e) _____ the instantial name be used in the sentence which results from the application of the rule.

2. The sentence $\forall x(Fx \rightarrow \sim(\exists yGy \ \& \ R))$ is a …

   (a) _____ existential

   (b) _____ conditional

   (c) _____ negation

   (d) _____ universal

   (e) _____ conjunction

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3. The following is NOT a condition on the application of ∃E …

   (a) _____ the instantial name cannot occur in the line that motivates the assumption to be discharged.

   (b) _____ the instantial name cannot occur in the line containing the sentence which is repeated.

   (c) _____ the instantial name must occur in the line which is repeated.

   (d) _____ the instantial name cannot occur in the assumption set of the line containing the sentence which is repeated save for the assumption itself.

4. A finite interpretation may contain all but …

   (a) _____ a universe

   (b) _____ predicate extensions

   (c) _____ truth value specifications

   (d) _____ a proof

Section III Translations (5 points each)

Using the following translation scheme, construct a strictly correct translations that includes all parentheses.

Bx = ‘x is a book’ Hx = ‘x is a hardback’

Px = ‘x is a paperback’ Ex = ‘x exists’

Lxy = ‘x is longer than y’

a = Logic Primer b = ‘Crime and Punishment’

1) Among books, only paperback and hardback exist.

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2) All books are paperbacks.

3) Crime and Punishment is longer than the Logic Primer, only if Crime and Punishment is a hardback.

4) Not all books are hardback if paperbacks exist.

Section IV Proofs (8 points each)

Give a proof for each of the following sequents. You may use both primitive and derived rules.

1. $\forall x(Fx \lor Gx), \forall x(Gx \rightarrow Hx), \exists x{\sim}Fx \vdash \exists xHx$

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2. $\forall x(Px \rightarrow (Qx \,\&\, Rx)), \exists xPx \rightarrow \forall x{\sim}Rx \vdash {\sim}\exists xPx$

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Section V Finite Interpretations (2 points each)

For each of the sentences below, indicate whether it is true or false in this finite interpretation:

U: {a, b, c}
F: {a}
G: {a, b, c}
H: {<a,b>, <b,b>}

1. ________ $(Hba \rightarrow \sim Gb)$
2. ________ $\exists x(Fx \& \sim Gx)$
3. ________ $(\forall xGx \rightarrow \forall xFx)$
4. ________ $\sim\exists xHxx$

Section VI Finite Countermodels (6 points)

Construct a counter-model for the following sequent. Be sure to show your work.

$\exists x(Px \,\&\, Rx), \exists x(Sx \,\&\, Rx) \mid\!- \exists x(Px \,\&\, Sx)$