Directions: Evaluate the following formulas as true or false in the model defined below. Be prepared to provide your reasoning in class.

Symbol					
Piece	pawn	knight	bishop	rook	queen
Value	1	3	3	5	9

Universe: Chess pieces on the left.

Names: k,q,b,n,r,p left to right

One-place predicates:
K,Q,B,N,P, R for King, Queen, Bishop, Knight, Rook, Pawn
D,L for Dark, Light

Two-Place predicates:
S, W, E for Stronger, Weaker, Equally strong as, in accord with value chart with strength/value of king beng infinite.
T for Taller.
A for Adjacent

T/F		T/F	
T	Kk v (Kr → Nq) Proof: A disjunction is true iff one of the disjuncts is true. The first disjuncts says King is a king, which is true.	T	∀x(Sxq → x=k) Proof: This wff says that if anything is stronger than Queen, it is King. True.
T	~Kk → (Kr → Nq) Proof: A conditional is true whenever the antedent is false. The antecedent asserts that King is not a king, which is false.	F	∀x((Lx & ~Txx) → Px) Proof: This wff says that everything that is light and not taller than itself is a pawn. Queen and Knight both satisfy antecedent condition. Hence false.
F	∃x(Qx & Rx) Proof: This wff asserts that something is both a queen and a rook. Nothing is both a queen and a rook. Hence, false.	F	∀x((Lx & ~Txx) → ~((Px v x=n) → Qx)) Proof: This wff says that for everything that is light and not taller than itself it is not a Pawn and not Knight and not a Queen. This is false since Queen is light and not taller than itself and is a queen.
T	∃x∃y(Exy & x=y) Proof: This wff asserts that there are two things that are equal in strength and identical. Everything is equal in strength and identical to itself.	F	∀x∀y((Exy & ~x=y) → (~x=b → Kx)) Proof: This wff says that if two things are equal in power and not identical, then the first thing is Bishop or a king. This is false because the antedent condition is satisfied by x=n and y=b.
F	∀x∀y(Exy → ~x=y) Proof: This wff asserts that for any two things, if one is equal in strength to the other, then they are not identical. Bishop and Knight are equal but not identical, hence false.	T	∀x∀y(Axy → Ayx) Proof: This wff is true iff anytime the antecedent condition is satisfied the consequent is satisfied. For any two objects *a* and *b*, if A*ab* then A*ba*, hence true.
T	∃x∃y(Txy & Syx) Proof: This wff asserts that there are two objects *a* and *b*, such that *a* is taller than *b* and *b* is stronger than *a*. Bishop is taller than Rook, and Rook is stronger than Bishop. Hence, true. (Note: Remember italicized letters are metalinguistic and stand for any object. In particular, b does not stand for Bishop in this proof.)	T	∀x∃yAxy Proof: This says that every object has at least one object adjacent to it. True.
T	Kp ↔ ∃ySyy Proof: This wff is true iff Kp → ∃ySyy and ∃ySyy → Kp. Both of these conditionals are true because the antecedents of both are always false.	T	∀x∃y∃z(Ayx & Azx) Proof: This says that for every object *a* there are two objects *b* and *c* adjacent to *a*. This is true whenever *a* = *b*.
F	∀xWpx Proof: This says that Pawn is weaker than everything. The pawn is not weaker than itself. Hence false.	F	∀x∃y∃z(Ayx & Azx & ~y=z) Proof: This wff is false if for at least one object there are not two non identical objects adjacent to it. This is false of both King and Pawn.
T	Kp ↔ (Sqp & Wbn)	T	∀x∀y((Axy & Exy & ~x=y) →(x=b v Axr))

Directions: Evaluate the following formulas as true or false in the model defined below. Be prepared to provide your reasoning in class.

	Proof: Kp is false. (Sqp & Wbn) is false because Bishop is not stronger than Knight. Hence, the biconditional is true.		Proof: This is true iff anytime the antecedent condition is satisfied the consequent is satisfied. The antecent is satisfied only when x=b and y=n, or x=n v y=b. In both of these cases one of the disjuncts in the consequent conditions is true. Hence, true.
T	∃x(Dx & ∀y(~Sxy → x=y)) Proof: This wff asserts that there is an object that is dark and that it is stronger than every object except itself. This is satisfied by King.	T	∀x∃y(Axy & (Wxy v Txy)) Proof: This says that everything has something next to it that it is either weaker than or taller than. This is true.
T	∃x(Dx → Lx) Proof: This wff says that there is something that is either not dark or it is light. This is true of every light object.	T	~∃x∃y∃z(Axy & Ayz & Axz) Proof: This says that there are no three objects *a,b,c* such that A*ab*, A*bc*, and A*ac*. Since there are no three objects that satisfy this condition (whether identical or non identical) the non-negated proposition is false making the negated proposition true.
F	∀x(Dx → Lx) Proof: This wff says that everything that is light is dark. No dark object is light.	F	∀x∀y(~Axy → (Wxy v Wyx)) Proof: This wff is false iff there exist at least two things that are not adjacent and they are of equal strength. Everything is not adjacent to itself and equal in strength to itself. Hence false.
T	∀x(Bx → x=b) Proof: This wff says that everything that is a bishop is identical to the bishop. Only Bishop is a bishop. True.	F	∃x(x=b & ∀z(z=b → Ezk)) Proof: This wff is true iff something is identical to Bishop and anything that is identical to Bishop is equal in strength to the king. In other words, Bishop is equal in strength to the King. False.
F	∀x∀y((Exy & ~x=y) →(Dx & Ly)) Proof: This wff is false if two objects satisfy the antecedent and fail to satisfy the consequent. Knight = x and Bishop = y satisfies the antecedent but not the consequent, hence false.	T	∃x∀y(x=p → ~Syx) Proof: This wff is true iff there is something that is either not the pawn or nothing is stronger than it. The king is not the pawn. Therefore true.
F	∀x∀y((Exy & ~x=y) → (Bx v Ky)) Proof: This wff is false if two objects satisfy the antecedent and fail to satisfy the consequent. Knight = x and Bishop = y satisfies the antecedent but not the consequent, hence false.	T	∃x∀y(~Syx ↔ x=p) Proof: Both conditionals must be evaluated. Left to right, this wff asserts there is some object such that every object is stronger than it, or it is Pawn. This is true of Pawn, hence true. Right to left, asserts that there is something that is not Pawn or it is not the case that every object is stronger than it. Something is not Pawn, e.g. Queen, hence true. Hence the biconditional is true.
T	∀x∀y((Exy & ~x=y) → (Dx v Dy)) Proof: This wff is true iff anytime the antecedent condition is satisfied the consequent is satisfied. Only Knight and Bishop satisfy the antecedent. Since Bishop is dark, the consequent will be satisfied whether Bishop = x or Bishop = y. Hence, true.	F	∀x∀y(Axy v (~(Lx & Ly) → (Dx & Dy)) Proof: This wff says that for any objects *a* and *b*, either they are adjacent or the they are both light or both dark. Pawn and King are not adjacent and they are neither both light nore both dark. False.
T	Db → (Lk → ~~Db) Proof: The antecedent condition of this wff is always true. The consequent is always true as well, since Lk is always false. Hence true.	T	∀x∀y(Txy ↔ Axy) Proof: Left to right the conditional asserts that for any two objects *a* and *b*, if *a* is taller than *b*, then *a* is adjacent to *b*. King is taller than Pawn but not adjacent to Pawn. Hence false. Right to left it asserts that if *a* is adjacent to *b*, then it is taller than *b*. Pawn is adjacent to Rook but not taller than Rook. Hence false. Hence biconditional is true.
T	∀x(Dx → ∃y~Tyx) Proof: This wff is true iff anytime the antecedent condition is satisfied the consequent is satisfied. For every dark thing (and in fact every thing) there is something that is not taller than it, namely itself.)	T	∀x∀y∀z((Axy & Axz & Lx & Ly) → (x=b v x=r)) Proof: This wff asserts that for any three objects *a, c* and *d*, if *a* is adjacent to both *c* and *d* and *a* and *c* are both light, then *a* is identical to Bishop or a is identical to Rook. Since no two light objects are adjacent to each other, the antecedent is always false. Hence, true
T	∀x∀y∀z((Sxy & Syz) → Wzy) Proof: This wff is true iff anytime the antecedent condition is satisfied the consequent is satisfied. For the antecedent to be true, both conjuncts must be true. Since any two objects that satisfy Syz in the antecedent necessarily satisfy Wzy in the consequent, the wff is true.	T	∀x∀y(Sxy ↔ Txy) Proof: Left to right, the conditional says that for any two objects *a* and *b*, if *a* is stronger than *b*, then *a* is taller than *b*. Rook is stronger than Bishop but not taller than Bishop, hence false. Right to left, if *a* is taller than *b*, then *a* is stronger than *b*. Bishop is taller than Rook, but not stronger than Rook. Hence false. Hence biconditional is true.