1. a) CMPT333 → variable
   b) cmpt333 → constant
   c) 333 → constant
   d) "cmpt333" → constant
   e) p(X, x) → non-ground atomic formula
   f) p(3,4,5) → ground atomic formula
   g) "p(3,4,5)" → constant

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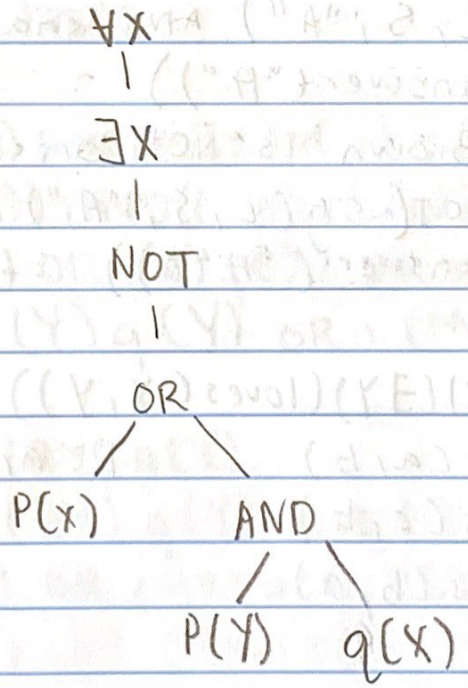
2. csg("CMPT 333", S, G) AND snap(S, "C. Brown", A, P))
→ answer(G)

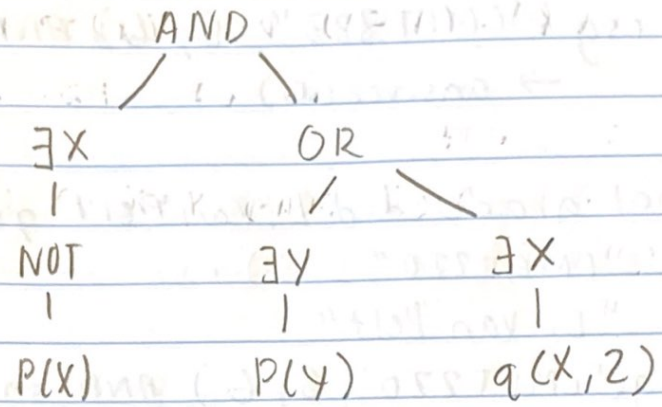
What grade did L. Van Pelt get in "CMPT 220"?
C: "CMPT 220"
N: "L. Van Pelt"
csg("CMPT 220", S, G) AND snap(S, "L. Van Pelt", A, P)
→ answer(G)

3. a. (∀x)((∃Y)(NOT(p(X) OR (p(Y) AND q(X)))))
↳ (∀X)(∃Y) NOT (P(x) OR P(Y) AND q(X))
b. (∃X)((NOT p(X)) AND ((∃Y)(p(Y)) OR (∃X)(q(X, Z))))
↳ (∃X) NOT p(X) AND ((∃Y) p(Y) OR (∃X) q(X, Z))

4. a.



4b.



5. $(\exists X)$ NOT P(X) AND $((\exists Y)$ P(Y) OR $(\exists X)$ q(X,2))
↳ $(\exists X)$ NOT P(X) AND $((\exists Y)$ P(Y) OR $(\exists M)$ q(M,2))

6. 1. C. Brown is an A Student
N: "C. Brown"
G: "A"
$(\forall C)$(sg(C, S, "A") AND snap(S, "C. Brown", A, P)
→ answer("A"))

2. C. Brown is NOT an A student
$(\exists C)$(NOT(sg(C, S, "A") AND snap(S, "C. Brown", A, P)
→ answer("A")))

7. a) $(\forall X)(\exists Y)$(loves(X, Y))
True [loves(a, b) D: a, b, c
loves(c, b)
False - loves(b, a)

b) P(X) → NOT P(X)
True: P(X): False
False: P(X): True

c) $(\exists X)$ P(X) → $(\forall X)$ P(X)
True: P(X): False
False: P(X): True

7d. $(p(X,Y) \text{ AND } p(Y,Z)) \rightarrow p(X,Z)$

True: Domain of all real numbers

P: $X < Y$

Thus, $X<Y$ AND $Y<Z \rightarrow X<Z$

False - No such domain exists

8. a) $(p(x) \text{ OR } q(Y)) \equiv (q(Y) \text{ OR } p(X))$

True based on commutative law for AND

b) $(p(X,Y) \text{ AND } p(X,Y)) \equiv p(X,Y)$

True based on Idempotence of AND

c) $(p(X) \rightarrow \text{False}) \equiv \text{NOT } p(X)$

True because when, P(X) = True, both sides will return false and when False, both sides return true.

9. a) $(\exists x)(\text{NOT } p(X)) \text{ AND } ((\exists Y)p(Y))) \text{ OR } ((\exists X)q(X,Z))))$

↳ $(\exists x)(\text{NOT } p(X)) \text{ AND } ((\exists Y)p(Y))) \text{ OR } ((\exists M)q(M,Z))))$

b) $(\exists x)(\exists X)p(X) \text{ OR } (X)q(X) \text{ OR } r(X))$

↳ $(\exists X)p(X) \text{ OR } (Y)q(Y) \text{ OR } r(M)$

10. a) $p(X,Y) \text{ AND } (\exists Y)\, q(Y)$

↳ $p(X,Y) \text{ AND } (\exists Y)\, q(Y) \text{ AND } (\exists X)\, r(X)$

b) $(\exists X)(p(X,Y) \text{ OR } (\exists X)p(Y,X))$

↳ $(\exists X)\, p(X,Y) \text{ OR } (\exists M)\, p(Y,M)$

11 $p(X,Y) \text{ AND } (\exists X)\, q(X) \equiv (\exists x)(p(X,Y) \text{ AND } q(x))$

Yes, the law $(E \text{ AND } (QX)F) \rightarrow (QX)(E \text{ AND } F)$ implies the two statements because you can reorder the quantifiers outside of the AND

12 a. $(\exists X)(\text{NOT } p(x))$ AND $((\exists Y)\, p(Y))$ OR $((\exists X)\, q(X, Z))$

$(\exists X)(\exists Y)(\text{NOT } p(x)$ AND $p(Y)$ OR $q(X, Z))$

b. $(\exists X)(\exists X) p(X)$ OR $(X) q(X)$ OR $r(X)$

↳ $(\exists X)(X)(p(x)$ OR $q(X)$ OR $r(X))$

13. $((Q_1 X) E) \rightarrow (Q_2 Y) F)$

↳ $(Q_1 X)(Q_2 Y)(E \rightarrow Y)$

14. 1. $\text{NOT}((\exists X)(\exists Y)\, p(X, Y))$

↳ $\equiv (\forall X)(\forall Y)(\text{NOT } p(X, Y))$

2. $\text{NOT}((\exists x) p(X)$ OR $(\exists Y) q(X, Y)$

↳ $\equiv (\forall X)(\forall Y)(\text{NOT}(p(x)$ OR $q(X, Y)))$

15. No, it is not true that E is a tautology whenever $(\exists X)E$ is a tautology because just because 'there exists an X such that E is true' is a tautology, that doesn't mean that E will always be true.