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8) ⓐ For all animals, if it's a rabbit then it hops.

ⓑ For all animals, they are rabbits and they hop.

ⓒ There exists an animal, if it's a rabbit then it hops.

ⓓ There exists an animal, it's a rabbit and it hops.

10) ⓐ $\exists x\ (C(x) \wedge D(x) \wedge F(x))$

ⓑ $\forall x\ ((C(x) \vee D(x) \vee F(x))$

ⓒ $\exists x\ (C(x) \wedge F(x) \wedge \neg D(x))$

ⓓ $\neg\exists x\ (C(x) \wedge D(x) \wedge F(x))$

ⓔ $\forall x\ (C(x) \vee D(x) \vee F(x))$

12) ⓐ True ⓒ False ⓔ False ⓖ False

ⓑ True ⓓ True ⓕ True

28) $P(x)$: x is in the correct place

$T(x)$: x is a tool

$E(x)$: x is in excellent condition

ⓐ $\exists x\ (\neg P(x))$

ⓑ $\forall x\ (T(x) \wedge P(x) \wedge E(x))$

ⓒ $\forall x\ (P(x) \wedge E(x))$

ⓓ $\neg\exists x\ (P(x) \wedge E(x))$

ⓔ $\exists x\ (T(x) \wedge \neg P(x) \wedge E(x))$

32) ⓐ - Expression: $\forall x\ (D(x) \rightarrow F(x))$

- Negation: $\exists x\ (D(x) \wedge \neg F(x))$

- English: There exists a dog that does not have fleas.

ⓑ - Expression: $\exists x\ (H(x) \wedge A(x))$

- Negation: $\forall x\ (H(x) \rightarrow \neg A(x))$

- English: If it's a horse, it can't add.

ⓒ - Expression: $\forall x\ (K(x) \rightarrow C(x))$

- Negation: $\exists x\ (K(x) \wedge \neg C(x))$
- English: There exists a koala that can't climb

ⓓ - Expression: $\forall x\ (M(x) \rightarrow \neg F(x))$

- Negation: $\exists x\ (M(x) \wedge F(x))$
- English: There exists a monkey that can speak French

ⓔ - Expression: $\cancel{\forall x}$ $\exists x\ (P(x) \wedge S(x) \wedge C(x))$

- Negation: $\cancel{\forall x\ (P(x) \rightarrow \neg(S(x) \wedge C(x))}$

~~English:~~ $\forall x\ (\neg P(x) \vee \neg S(x) \vee \neg C(x))$

- English: All pigs can't swim or can't catch fish

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6) ⓐ Randy Goldberg is enrolled in class CS 252.

ⓑ there exists a student who enrolled in class Math 695.

ⓒ There exists a class that Carol Sitea is enrolled in.

ⓓ There exists a student enrolled in both class Math 222 and class CS 252.

ⓔ There exists 2 different students x and y that, if x is enrolled in class Z, then y is also enrolled in class Z.

ⓕ There exists 2 different students x and y that, x is enrolled in class Z if and only if y is enrolled in class Z and vice versa.

10) ⓐ $\forall x\ (F(x, \text{Fred}))$

ⓑ $\forall y\ (F(\text{Evelyn}, y))$

ⓒ $\forall x \exists y\ (F(x, y))$

ⓓ $\neg \exists x\ \forall y\ (F(x, y))$

ⓔ $\forall x\ \exists y\ (F(y, x))$

ⓕ $\neg \exists x\ (F(x, \text{Fred}) \wedge F(x, \text{Jerry}))$

ⓖ $\neg \exists x (F(x, x))$

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10) g) $\exists x \exists y \forall z ((x \neq y \land x \neq z \land y \neq z) \land F(Nancy, x) \land F(Nancy, y$
$\land \neg F(Nancy, y))$

h) $\exists x \forall y \forall z (F(y,x) \land (z \neq x) \land \neg \cancel{\forall y} (F(y,z))))$

i) $\exists x \exists y \forall z (\neg F(x,x) \land F(x,y) \land (z \neq y) \land \neg F(x,z))$

12) a) $\neg I(Jerry)$

b) $\neg C(Rachel, Chelsea)$

c) $\neg C((Jan, Sharon) \land \neg C(Sharon, Jan)$

d) $\cancel{\neg \exists x (x \neq Bob}$ $\neg \exists x (C(x, Bob))$

e) $\forall x (x \neq Joseph \land C(Sanjay, x))$

f) $\exists x (\neg I(x))$

g) $\neg \forall x (I(x))$

h) $\exists x \forall y (I(y) \rightarrow (y = x))$

i) $\exists x \forall y (\neg I(x) \land (I(y) \rightarrow (y \neq x))$

j) $\forall x \exists y (I(x) \rightarrow (I(y) \land (y \neq x) \land C(x,y)))$

k) $\exists x \forall y (I(x) \land \neg C(x,y))$

l) $\exists x \exists y (\neg C(x,y) \land \neg C(y,x) \land (x \neq y))$

m) $\exists x \forall y (C(x,y))$

n) $\exists x \exists y \exists z ((x \neq y) \land \neg C(x,z) \land \neg C(y,z))$

o) $\exists x \exists y \forall z \cancel{((x \neq z)} ((x \neq z \land y \neq z \land x \neq y) \land C(x,z) \lor C(y,z))$

28) a) True

b) False

c) True

d) True

e) False

f) False

g) True

h) False

i) False

j) True

37)

~~(a) Expression: $\forall x \exists y \exists z \forall w (((y \neq z) \wedge M(y) \wedge M(z)) \to (S(x)$~~

~~Expression: $\forall x \exists y \exists z \forall w (S(x) \to (M(y) \wedge M(z) \wedge (y \neq z))$~~

(a) - Expression: $\forall x \exists y \exists z \forall w (S(x) \to (T(x,y) \wedge T(x,z) \wedge (z \neq y \wedge z \neq w \wedge y \neq w) \wedge \neg T(x,w)))$

- Negation: $\exists x \forall y \forall z \exists w (S(x) \wedge (\neg T(x,y) \vee \neg T(x,z) \vee T(x,w) \vee (y \neq z \wedge z \neq w \wedge y \neq w)))$

- English: There exists a student in this class that has not taken ~~every~~ exactly two math classes at this school. ~~except for two math classes~~.

(b) - Expression: $\exists x \forall y ((C(y) \wedge V(x,y)) \to (y \neq Libya))$

- Negation: $\forall x \exists y ((C(y) \wedge V(x,y)) \wedge (y = Libya))$

- English: Everyone has visited Libya

(c) - Expression: $\neg \exists x \forall y ((P(x) \wedge M(y)) \to C(x,y))$

- Negation: $\exists x \exists y ((P(x) \wedge M(y)) \wedge \neg C(x,y))$

- English: Someone hasn't climbed ~~any~~ some mountains in the Himalayas.

(d) - Expression: $\forall x \exists y ((A(x) \wedge A(y) \wedge M(y, \text{Kevin Brown})) \to (M(x, \text{Kevin Brown}) \vee M(x,y)))$

- Negation: $\exists x \forall y ((A(x) \wedge A(y) \wedge M(y, \text{Kevin Brown})) \wedge \neg M(x, \text{Kevin Brown}) \wedge \neg M(x,y)))$

- English: Some movie actors ~~hasn't~~ haven't been in a movie with Kevin Brown nor been in a movie with someone who has been in a movie with Kevin Brown.

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4) (a) Simplification
(b) Disjunctive syllogism
(c) Modus ponens
(d) Addition
(e) Hypothetical syllogism

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15) ⓐ $S(x)$: x is a student in this class

$U(x)$: x understands logic

Scope: all students

$\forall x \ (S(x) \to U(x))$

$S(\text{Xavier})$

$\therefore U(\text{Xavier})$

This is correct, based on universal modus ponens. If all students in this class can understand logic and Xavier is one of them, he must also understand logic.

ⓑ $C(x)$: x is a computer science major

$M(x)$: x is taking discrete mathematics

Scope: people

$\forall x \ (C(x) \to M(x))$

$M(\text{Natasha})$

$\therefore C(\text{Natasha})$

This is incorrect, based on fallacy of affirming the conclusion. There can be other majors that also required people to take discrete mathematics, and Natasha isn't necessarily a computer science major.

ⓒ $P(x)$: x is a parrot

$F(x)$: x likes fruit

Scope: birds

$\forall x \ (P(x) \to F(x))$

$\neg P(\text{pet bird})$

$\therefore \neg F(\text{pet bird})$

This is incorrect, based on fallacy of denying the hypothesis. We only know that parrots ~~don't~~ like fruit, not about other bird species. There can be a bird species that like fruit and the pet bird can belong to that species.

ⓓ $G(x)$: x eats granola everyday

$H(x)$: x is healthy

Scope: people

$\forall x\,(G(x) \to H(x))$
$\neg H(\text{Linda})$
$\therefore \neg G(\text{Linda})$

This is correct, based on universal modus tollens. Since everyone who eats granola everyday are healthy, Linda can't be one of them since she isn't healthy.

9) b S : I eat spicy food
T : there is thunder while I sleep
D : I have strange dream

$S \to D$ (1)
$T \to D$ (2)
$\neg D$ (3)
$\therefore \neg(S \vee T)$

From (1),(3): $S \to D$
$\neg D$
$\therefore \neg S$ (modus tollens) (4)

From (2),(3): $T \to D$
$\neg D$
$\therefore \neg T$ (modus tollens) (5)

From (4),(5): $\neg S$
$\neg T$
$\therefore \neg(S \vee T)$ (conjunction)

Conclusion: I didn't eat spicy food and there is no thunder while I sleep.

[illegible] C: good for corperations
U: good for United States
Y: good for you
B: you buy ~~a~~ lots of stuff

$C \to U$ (1)
$U \to Y$ (2)
$B \to C$ (3)
$\therefore B \to Y$

From (1),(2): $C \to U$
$U \to Y$
$\therefore C \to Y$ (hypothetical syllogism) (4)

From (3),(4): $B \to C$
$C \to Y$
$\therefore B \to Y$ (hypothetical syllogism) (5)

Conclusion: You Buy lots of stuff is good for yourself.