Minimal HW

Problem 1:

a. Quixote Media had the largest annual revenue - **F.**

b. Nadir Software had the lowest net profit and Acme Computer had the largest annual revenue - **T.**

c. Acme Computer had the largest net profit or Quixote Media had the largest net profit - **T.**

d. If Quixote Media had the smallest net profit, then Acme Computer had the largest annual revenue - **T** since the conclusion is true even if the condition is False.

e. Nadir Software had the smallest net profit if and only if Acme Computer had the largest annual revenue - **T** since the condition and conclusion are both True**.**

Problem 2:

p: It is below freezing.

q: It is snowing.

a. It is below-freezing and snowing: $p \land q$.

b. It is below freezing and not snowing: $p \land \neg q$.

c. It is not below freezing and it is not snowing: $\neg p \land \neg q$.

d. It is either snowing or below freezing: $q \lor p$.

e. If it is below freezing, it is also snowing: $p \to q$

f. Either it is below freezing or snowing, but it is not snowing if it is below freezing: $(p \lor q) \land (p \to \neg q)$.

g. That it is below freezing is necessary and sufficient for it to be snowing: $p \leftrightarrow q$.

Problem 3:

a. $p \to \neg p : 2^1$ rows.

b. $(p \lor \neg r)(q \lor \neg s) : 2^4$ rows.

c. $qp\neg s\neg r\neg tu : 2^6$ rows.

d. $(prt) \to (qt) :\ 2^4$ rows.

Problem 4:

p	$\neg p$	$p \land \neg p$	$p \lor \neg p$
T	F	F	T
F	T	F	T

p	q	$p \lor \neg q$	$(p \lor \neg q) \to q$
T	T	T	T
F	F	T	F
T	F	T	F
F	T	F	T

p	q	$p \lor q$	$p \land q$	$(p \lor q) \to (p \land q)$
T	T	T	T	T
F	F	F	F	T
T	F	T	F	F
F	T	T	F	F

p	q	$p \to q$	$\neg q \to \neg p$	$(p \to q) \iff (\neg q \to \neg p)$
T	T	T	T	T
F	F	T	T	T
T	F	F	F	T
F	T	T	T	T

p	q	$p \to q$	$q \to p$	$(p \to q) \to (q \to p)$
T	T	T	T	T
F	F	T	T	T
T	F	F	T	T
F	T	T	F	F

Problem 5:

$p1$: I do not know.

$p2$: I do not know.

$p3$: No, not everyone wants coffee.

$\neg p3 \land \neg(p3 \lor p2 \lor p1) \to (\neg p3 \land p3) \lor (\neg p3 \land p2) \lor (\neg p3 \land p1)$

$F \lor (T \land p2) \lor (T \land p1) \equiv T$ so either $p1$ or $p2$ wants a coffee.

Problem 6:

a. $rich \land happy$ negation: $\neg rich \lor \neg happy$

b. $bicycle \lor run$ negation: $\neg bicycle \land \neg run$

c. $walks \lor takesbus$ negation: $\neg walks \land \neg takesbus$

d. $smart \land hardworking$ negation: $\neg smart \lor \neg hardworking$

Problem 7:

p	q	$p \land q$	$p \lor q$	$(p \land q) \to p$	$p \to (p \lor q)$
T	T	T	T	T	T
F	T	F	T	T	T
T	F	F	T	T	T
F	F	F	F	T	T

$\neg p$	$\neg q$	$p \to q$	$\neg p \to (p \to q)$	$(p \land q) \to (p \to q)$	$\neg(p \to q) \to p$	$\neg(p \to q) \to \neg q$
F	F	T	T	T	T	T
T	F	T	T	T	T	T
F	T	F	T	T	T	T
T	T	T	T	T	T	T

Problem 8:

a. if p is true then the conditional statement/hypothesis is T since p is a conclusion and is true.

b. if p is true then $p \lor q$ is also true which is a conclusion of the conditional statement.

c. $p \to q$ must be false if only if q is false and p is true hence $\neg p \to (p \to q)$ which $F \to F$ is true.

d. $p \land q$ must be true if only if p and q is true. This makes $p \to q$ true.

e. $\neg(p \to q)$ must be true if $p \to q$ is false. This makes p true which is the only case.

f. $\neg(p \to q)$ must be true if $p \to q$ is false. This makes q false which is the only case.

Problem 9:

$(p \to r) \land (q \to r) \equiv (p \lor q) \to r$

$(\neg p \lor r) \land (\neg q \lor r) \equiv (\neg p \land \neg q) \lor r$

$p \land \neg r \land q \land \neg r \equiv \neg(\neg p \land \neg q) \land \neg r$

$p \land q \land \neg r \equiv (p \land q) \land \neg r$

Problem 10:

$P(x)$ - can speak Russian.

$Q(x)$ - knows the computer language C++

a. There is a student at your school who can speak Russian and who knows C++: $\exists x(P(x) \land Q(x))$
b. There is a student at your school who can speak Russian but who doesn't know C++: $\exists x(P(x) \land \neg Q(x))$
c. Every student at your school either can speak Russian or knows C++: $\forall x(P(x) \lor Q(x))$
d. No student at your school can speak Russian or knows C++: $\forall x \neg(P(x) \lor Q(x)) \equiv \forall x(\neg P(x) \land \neg Q(x))$

Problem 11:

a. $\forall n(n^2 \geq 0)$: True since any integer squared is always positive.
b. $\exists n(n^2 = 2)$: False since $\sqrt{2}$ is not an integer.
c. $\forall n(n^2 \geq n)$: True since $n \times n$ will always be larger or equal to n
d. $\exists n(n^2 < 0)$: False since a squared integer can not be negative at all.

Problem 12:

$P(x)$ consists of the integers $0, 1, 2, 3, 4$

a. $\exists x P(x)$: $P(0) \lor P(1) \lor P(2) \lor P(3) \lor P(4)$
b. $\forall x P(x)$: $P(0) \land P(1) \land P(2) \land P(3) \land P(4)$
c. $\exists x \neg P(x)$: $\neg P(0) \lor \neg P(1) \lor \neg P(2) \lor \neg P(3) \lor \neg P(4)$
d. $\forall x \neg P(x)$: $\neg P(0) \land \neg P(1) \land \neg P(2) \land \neg P(3) \land \neg P(4)$
e. $\neg \exists x P(x)$: $\neg(P(0) \lor P(1) \lor P(2) \lor P(3) \lor P(4))$
f. $\neg \forall x P(x)$: $\neg(P(0) \land P(1) \land P(2) \land P(3) \land P(4))$

Problem 13:

$P(x)$ - students in the class

$H(x)$ - can speak Hindi

$F(x)$ - friendly

$B(x)$ - born in California

$M(x)$ - been in a movie

$L(x)$ - taken a course in logic programming

a. $\exists x(P(x) \land H(x))$
b. $\forall x(P(x) \to F(x))$
c. $\exists x(P(x) \land \neg B(x))$
d. $\exists x(P(x) \land M(x))$
e. $\neg \forall x(\neg L(x))$

Problem 14:

$M(x, y)$ - x has sent y an e-mail message (assume that all messages are received).

$T(x, y)$ - x has telephoned y .

a. $\neg M(Chou, Koko)$

b. $\neg(M(Arlene, Sarah) \vee T(Arlene, Sarah))$

c. $\neg M(Deborah, Jose)$

d. $\forall x M(x, Ken)$

e. $\forall x \neg T(x, Nina)$

f. $\forall x(T(x, Avi) \vee M(x, Avi))$

g. $\exists x \forall y(x \neq y \rightarrow M(x, y))$

h. $\exists x \forall y(y \neq x \rightarrow (M(x, y) \vee T(x, y))$

i. $\exists x \exists y(x \neq y \rightarrow M(x, y) \wedge M(y, x))$

j. $\exists x M(x, x)$

k. $\exists x \forall y(x \neq y \rightarrow (\neg M(x, y) \wedge \neg T(x, y))$

l. $\exists x \forall y(x \neq y \wedge M(x, y) \vee T(x, y))$

m. $\exists x \exists y(x \neq y \wedge M(x, y) \vee T(x, y))$

n. $\exists x \exists y(x \neq y \wedge \forall z((x \neq z \wedge y \neq z) \rightarrow (M(x, z) \vee M(y, z) \vee T(x, z) \vee T(y, z)))$