[§1.1] 2. (a) This is not a declarative sentence so it is $\boxed{\text{not a proposition.}}$

(b) This is not a declarative sentence either; $\boxed{\text{not a proposition.}}$

(c) Google indicates black flies do exist in Maine, so this is a $\boxed{\text{FALSE proposition.}}$

(d) No value is assigned to x; $\boxed{\text{not a proposition.}}$

(e) The moon is made of rock, not green cheese; $\boxed{\text{FALSE proposition.}}$

3. (a) "Mei does not have an MP3 player."
   (b) "There is pollution in New Jersey."
   (c) "$2 + 1 \neq 3$."
   (d) "The summer in Maine is not hot or not sunny."

6.

Smartphone	RAM (MB)	ROM (GB)	Camera (MP)
A	256	32	8
B	288	64	4
C	128	32	5

(a) $\boxed{\text{TRUE.}}$ $288 > 256$ and $288 > 128$.

(b) $\boxed{\text{TRUE.}}$ $32 \not> 64$ but $5 > 4$.

(c) $\boxed{\text{FALSE.}}$ $288 > 256$ and $64 > 32$, but $4 \not> 8$.

(d) $\boxed{\text{FALSE.}}$ "If p then q" is false:

p: "B has more RAM and more ROM than C" is true; $(288 > 128) \wedge (64 > 32)$.
q: "B has a higher resolution camera than C" is false; $4 \not> 5$.

(e) $\boxed{\text{FALSE.}}$ "p if and only if q" is false:

p: "A has more RAM than B" is false; $256 \not> 288$.
q: "B has more RAM than A" is true; $288 > 256$.

10. (b) "The election is decided or the votes have been counted."
    (d) "If the votes have been counted, then the election is decided."
    (f) "If the election is not decided, then the votes have not been counted."

12. (a) "If you have the flu, then you miss the final examination."
    (c) "If you miss the final examination, then you do not pass the course."
    (e) "If you have the flu, then you do not pass the course, or if you miss the final examination, then you do not pass the course."

17. These are all of the form "if p then q," which is true when q is true or p is false.

(a) p is true and q is false, so the statement is $\boxed{\text{FALSE.}}$

(b) p is false, so the statement is $\boxed{\text{TRUE.}}$

(c) p is false, so the statement is $\boxed{\text{TRUE.}}$

(d) p is false (monkeys cannot fly) so the statement is $\boxed{\text{TRUE.}}$

22. (a) "If one gets promoted, then one has washed the boss's car."

(d) "If he cheats, then Willy gets caught."

32. (a)

p	$\neg p$	$p \to \neg p$
T	F	F
F	T	T

(e)

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

37. (a)

p	q	r	$\neg q$	$\neg q \vee r$	$p \to (\neg q \vee r)$
T	T	T	F	T	T
T	T	F	F	F	F
T	F	T	T	T	T
T	F	F	T	T	T
F	T	T	F	T	T
F	T	F	F	F	T
F	F	T	T	T	T
F	F	F	T	T	T

(d)

p	q	r	$\neg p$	$p \to q$	$\neg p \to r$	$(p \to q) \wedge (\neg p \to r)$
T	T	T	F	T	T	T
T	T	F	F	T	T	T
T	F	T	F	F	T	F
T	F	F	F	F	T	F
F	T	T	T	T	T	T
F	T	F	T	T	F	F
F	F	T	T	T	T	T
F	F	F	T	T	F	F

[§1.3] 1. (a)

p	$p \wedge \mathbf{T}$
T	T
F	F

(b)

p	$p \vee \mathbf{F}$
T	T
F	F

(c)

p	$p \wedge \mathbf{F}$	$\mathbf{F}$
T	F	F
F	F	F

(d)

p	$p \vee \mathbf{T}$	$\mathbf{T}$
T	T	T
F	T	T

(e)

p	$p \vee p$
T	T
F	F

(f)

p	$p \wedge p$
T	T
F	F

6. $\neg(p \wedge q) \equiv \neg p \vee \neg q$ as shown in class on January 13:

p	q	$p \wedge q$	$\neg(p \wedge q)$	$\neg p$	$\neg q$	$\neg p \vee \neg q$
T	T	T	F	F	F	F
T	F	F	T	F	T	T
F	T	F	T	T	F	T
F	F	F	T	T	T	T

7. (a) $[\neg(p \wedge q) \equiv \neg p \vee \neg q]$ "Jan is not rich or not happy."
   (b) $[\neg(p \vee q) \equiv \neg p \wedge \neg q]$ "Carlos will neither bicycle nor run tomorrow."
   (c) $[\neg(p \vee q) \equiv \neg p \wedge \neg q]$ "Mei neither walks nor takes the bus to class."
   (d) $[\neg(p \wedge q) \equiv \neg p \vee \neg q]$ "Ibrahim is not smart or not hard working."

9. (a)

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

(c)

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

(e)

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

11. (a)

$$\begin{aligned}
(p \wedge q) \rightarrow p &\equiv p \vee \neg(p \wedge q) && \text{by logical equivalence involving conditionals (LEIC)}\\
&\equiv p \vee (\neg p \vee \neg q) && \text{by the first De Morgan law}\\
&\equiv (p \vee \neg p) \vee q && \text{by associativity}\\
&\equiv \mathbf{T} \vee q && \text{by negation}\\
&\equiv \mathbf{T} && \text{by the identity laws}
\end{aligned}$$

(c)

$$\begin{aligned}
\neg p \rightarrow (p \rightarrow q) &\equiv (p \rightarrow q) \vee p && \text{by LEIC and by double negation}\\
&\equiv (q \vee \neg p) \vee p && \text{by LEIC}\\
&\equiv q \vee (\neg p \vee p) && \text{by associativity}\\
&\equiv q \vee \mathbf{T} && \text{by negation}\\
&\equiv \mathbf{T} && \text{by the identity laws}
\end{aligned}$$

(e)

$$\begin{aligned}
\neg(p \rightarrow q) \rightarrow p &\equiv p \vee (p \rightarrow q) && \text{by LEIC}\\
&\equiv p \vee (q \vee \neg p) && \text{by LEIC}\\
&\equiv q \vee (p \vee \neg p) && \text{by commutativity and by associativity}\\
&\equiv q \vee \mathbf{T} && \text{by negation}\\
&\equiv \mathbf{T} && \text{by the identity laws}
\end{aligned}$$

17. $\neg(p \leftrightarrow q) \equiv p \leftrightarrow \neg q$ because both sides are true (or both sides are false) for all combinations of truth values of p and q:

p	q	$\neg q$	$p \leftrightarrow q$	$\neg(p \leftrightarrow q)$	$p \leftrightarrow \neg q$
T	T	F	T	F	F
T	F	T	F	T	T
F	T	F	F	T	T
F	F	T	T	F	F

32. <u>Proof by counterexample.</u> Suppose

$$\begin{aligned}
p &: \text{true}\\
q &: \text{false}\\
r &: \text{false}
\end{aligned}$$

Then $(p \wedge q)$ is false, so $(p \wedge q) \rightarrow r$ is true.

Since $(p \rightarrow r)$ is false, $(p \rightarrow r) \wedge (q \rightarrow r)$ is false.

Therefore $(p \wedge q) \rightarrow r$ is not logically equivalent to $(p \rightarrow r) \wedge (q \rightarrow r)$.