DGD 1

Q1. For each of the following sentences, determine whether it is a proposition or not. If it is a proposition, what is its truth value? If it is not a proposition, explain.

Q2. For each sentence in Q1 that was deemed to be a proposition, write (in English) the negation of the proposition.

a. There are no black flies in Maine.

Q1. It is a proposition.
Truth value: F

Q2. Negation: It is not the case that there are no black flies in Maine.

Another possible way to negate:
There is one or more black flies in Maine.

b. $2^n \geq 100$.

Q1. It is not a proposition.

Explanation: Without knowing what n is, the statement does not have a truth value.

Q2. N/A

c. $2^5 \geq 100$.

Q1. It is a proposition.
Truth value: F

Q2. Negation: It is not the case that $2^5 \geq 100$.

Another possible way to negate: $2^5 < 100$.

c. A student in MAT1348 must get a mark of 40% or higher on the final exam in order to pass the course.

Q1. It is a proposition.
Truth value: T

Q2. Negation: It is not the case that a student in MAT1348 must get a mark of 40% or higher on the final exam in order to pass the course.

d. Do unicorns exist?

Q1. It is not a proposition.

Explanation: It is not a declarative statement (it's a question).

Q2. N/A

e. All unicorns have rainbow-coloured manes.

Q1. It is a proposition.

Truth value: F (assuming the definition of "unicorn" includes toy unicorns and there are toy unicorns that do not have rainbow manes)

Q2. Negation: It is not the case that all unicorns have rainbow-coloured manes.

Another possible way to negate:

There exists at least one unicorn that does not have a rainbow-coloured mane.

Q3. Let p, q, and r be the following propositions:

p : Grizzly bears have been seen in the area.

q : Hiking is safe on the trail.

r : Berries are ripe along the trail.

Write each of the following compound propositions using the variables p, q, and r, and appropriate logical connectives:

a. If berries are ripe along the trail, then hiking is safe if and only if grizzly bears have not been seen in the area.

r q not p

Initial Simplification: if r, then (q if and only if $\neg p$)

Final Answer: $\boxed{r \to (q \leftrightarrow \neg p)}$

b. If berries are ripe along the trail and grizzly bears have been seen in the area, then hiking is not safe.

r p not q

Initial Simplification: if (r and p), then $\neg q$

Final Answer: $\boxed{(r \land p) \to \neg q}$

c. If $\underbrace{\text{grizzly bears have been seen in the area}}_{p}$, then $\underbrace{\text{hiking is safe}}_{q}$.

Initial Simplification: if p, then q

Final Answer: $\boxed{p \to q}$

d. Either $\underbrace{\text{hiking is safe}}_{q}$ or $\underbrace{\text{berries are ripe along the trail}}_{r}$, but not both.

Initial Simplification: either q or r but not both

Final Answer: $\boxed{q \oplus r}$

Q4. Construct a truth table for each of the following compound propositions and determine whether it is a tautology, contradiction, or contingency:

a. $p \oplus p$

b. $(p \to q) \wedge (\neg p \to q)$

c. $\neg(p \vee q) \leftrightarrow (\neg p \wedge \neg q)$

d. $\neg(p \vee q) \leftrightarrow (\neg p \to q)$

e. $\neg p \to (q \to r)$

a)

p	$p \oplus p$
T	F
F	F

Since $p \oplus p$ is always F, it's a contradiction.

b)

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

Since $(p \to q) \wedge (\neg p \to q)$ is sometimes T and sometimes F, it's a contingency.

c)

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

← since it is always T, it's a tautology

d)

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

← since it's always F, it's a contradiction

e)

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

← Since it is sometimes T and sometimes F, it's a contingency

Q5. Which of the following pairs of propositions are logically equivalent? Verify your answer with a truth table. For those which are not logically equivalent, give all counterexamples.

a. $A \oplus B$ and $\neg(A \leftrightarrow B)$

b. $p \to c$ and $\neg p \vee c$

c. $\big((x \oplus y) \wedge \neg(x \vee y)\big)$ and $(p \leftrightarrow \neg p)$.

d. $A \to B$ and $B \to A$.

e. $\neg(P \vee Q \vee R)$ and $\neg P \vee \neg Q \vee \neg R$.

f. $\neg(P \vee Q \vee R)$ and $\neg P \wedge \neg Q \wedge \neg R$.

g. $\neg(A \to B)$ and $A \wedge \neg B$.

Q2 a)

A	B	$A \oplus B$	$A \leftrightarrow B$	$\neg(A \leftrightarrow B)$	$(A \oplus B) \leftrightarrow \neg(A \leftrightarrow B)$
T	T	F	T	F	T
T	F	T	F	T	T
F	T	T	F	T	T
F	F	F	T	F	T

The biconditional statement $(A \oplus B) \leftrightarrow \neg(A \leftrightarrow B)$ is a tautology.
$\therefore\ (A \oplus B) \equiv \neg(A \leftrightarrow B)$

Q2 b)

p	c	$p \to c$	$\neg p \vee c$	$(p \to c) \leftrightarrow (\neg p \vee c)$
T	T	T	T	T
T	F	F	F	T
F	T	T	T	T
F	F	T	T	T

The biconditional statement $(p \to c) \leftrightarrow (\neg p \vee c)$ is a tautology
$\therefore\ p \to c \equiv \neg p \vee c$

Q2 c)

p	x	y	$x \oplus y$	$x \vee y$	$(x \oplus y) \wedge \neg(x \vee y)$	$p \leftrightarrow \neg p$	$[(x \oplus y) \wedge \neg(x \vee y)] \leftrightarrow [p \leftrightarrow \neg p]$
T	T	T	F	T	F	F	T
T	T	F	T	T	F	F	T
T	F	T	T	T	F	F	T
T	F	F	F	F	F	F	T
F	T	T	F	T	F	F	T
F	T	F	T	T	F	F	T
F	F	T	T	T	F	F	T
F	F	F	F	F	F	F	T

The biconditional statement $[(x \oplus y) \wedge \neg(x \vee y)] \leftrightarrow [p \leftrightarrow \neg p]$ is a tautology $\therefore\ (x \oplus y) \wedge \neg(x \vee y) \equiv p \leftrightarrow \neg p$

Q2 d)

A	B	$A \to B$	$B \to A$	$(A \to B) \leftrightarrow (B \to A)$
T	T	T	T	T
T	F	F	T	F
F	T	T	F	F
F	F	T	T	F

$A \to B$ is not logically equivalent to $B \to A$

Counterexamples:

when $A = T$, $B = F$, $(A \to B) \leftrightarrow (B \to A)$ is F

when $A = F$, $B = T$, $(A \to B) \leftrightarrow (B \to A)$ is F

Q2 e)+f)

P	Q	R	① $\neg(P\vee Q\vee R)$	② $\neg P\vee\neg Q\vee\neg R$	③ $\neg P\wedge\neg Q\wedge\neg R$	①$\leftrightarrow$②	①$\leftrightarrow$③
T	T	T	F	F	F	T	T
T	T	F	F	T	F	F	T
T	F	T	F	T	F	F	T
T	F	F	F	T	F	F	T
F	T	T	F	T	F	F	T
F	T	F	F	T	F	F	T
F	F	T	F	T	F	F	T
F	F	F	T	T	F	T	T

$\neg(P\vee Q\vee R)$ is <u>not</u> logically equiv. to $\neg P\vee\neg Q\vee\neg R$

exercise: give the 6 counterexamples

①$\leftrightarrow$③ is a tautology

$\therefore \neg(P\vee Q\vee R)\equiv\neg P\wedge\neg Q\wedge\neg R$

Q2 g)

A	B	$\neg(A\to B)$	$A\wedge\neg B$	$\neg(A\to B)\leftrightarrow A\wedge\neg B$
T	T	F	F	T
T	F	T	T	T
F	T	F	F	T
F	F	F	F	T

$\neg(A\to B)\leftrightarrow A\wedge\neg B$ is a tautology $\therefore \neg(A\to B)\equiv A\wedge\neg B$.

Q6. Considering Q5 f and g, write the negation of each of the following propositions in English.

a. $\underbrace{\text{You are at least 12 years old}}_{a}$, $\vee$ or $\underbrace{\text{you are taller than 5 feet}}_{b}$, $\vee$ or $\underbrace{\text{you have a golden ticket}}_{c}$.

Negation: $\neg(a\vee b\vee c)\equiv\neg a\wedge\neg b\wedge\neg c$

you are less than 12 years old and you are ≤ 5 feet tall, and you do not have a golden ticket.

b. In order for you to ride the roller coaster, it is necessary that you are at least 12 years old, or you are taller than 5 feet, or you have a golden ticket.

p: You can ride the roller coaster. q: $a\vee b\vee c$ from Q6a)

Q2b says $p\to q$ or $p\to a\vee b\vee c$

Negation: $\neg(p\to q)\equiv p\wedge\neg q$

$\neg(p\to a\vee b\vee c)\equiv p\wedge\neg a\wedge\neg b\wedge\neg c$

Negation: you can ride the roller coaster, and you are <12 years old, and you are ≤ 5 feet tall, and you do not have a golden ticket.

*bonus: write the converse of Q6b as well as the contrapositive, and each of their respective negations.