

SML

```
| datatype Boolean = F | T;  
| val truth_values = [(F,F),(F,T),(T,F),(T,T)];
```

cs113 Lab1: slide 2

ttgen table

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

SML

```
| fun conjunction(F,-) = F  
|   | conjunction(T,q) = q;  
| map conjunction truth_values;
```

```
> map conjunction truth_values;  
val it = [F, F, F, T]: Boolean list
```

cs113 Lab1: slide 3

ttgen table

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

SML

```
fun disjunction(F,q) = q  
  | disjunction(T,-) = T;  
map disjunction truth_values;
```

```
> map disjunction truth_values;  
val it = [F, T, T, T]: Boolean list
```

cs113 Lab1: slide 4

ttgen table

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

SML

```
| fun exclusive_or(F,F) = F  
|   | exclusive_or(F,T) = T  
|   | exclusive_or(T,F) = T  
|   | exclusive_or(T,T) = F;  
| map exclusive_or truth_values;
```

```
> map exclusive_or truth_values;  
val it = [F, T, T, F]: Boolean list
```

ttgen table

p	$\neg p$
F	T
T	F

SML

```
| val truth_values_negation = [(F),(T)];  
| fun negation(F) = T  
|   | negation(T) = F;  
| map negation truth_values_negation;
```

```
> map negation truth_values_negation;  
val it = [T, F]: Boolean list
```

cs113 Lab1: slide 6

ttgen table

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

SML

```
fun equivalence(F,F) = T
  | equivalence(F,T) = F
  | equivalence(T,F) = F
  | equivalence(T,T) = T;
fun problem18(p,q) = equivalence(exclusive_or(p,q), conjunction(disjunction(p,q), negation(conjunction(p,q))));
map problem18 truth_values;
```

```
> map problem18 truth_values;
val it = [T, T, T, T]: Boolean list
```

cs113 Lab1: slide 7

ttgen table

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

SML

```
val p = "The dollar is at an all-time high";  
val q = "the stock market is at a record low";  
fun problem9(p,q) = equivalence(negation(disjunction(p,q)),conjunction(negation(p),negation(q)));  
map problem9 truth_values;
```

```
> map problem9 truth_values;  
val it = [T, T, T, T]: Boolean list
```

cs113 Lab1: slide 8

ttgen table

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

SML

```
| val p = "-5 < x";  
| val q = "x <= 0";  
| fun problem10(p,q) = equivalence(negation(conjunction(p,q)),disjunction(negation(p),negation(q)));  
| map problem10 truth_values;
```

```
> map problem10 truth_values;  
val it = [T, T, T, T]: Boolean list
```


cs113 Lab1: slide 9

ttgen table

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

SML

```
| fun problem12(p,q) = conjunction(conjunction(p,negation(q)),disjunction(negation(p),q));  
| map problem12 truth_values;
```

```
> map problem12 truth_values;  
val it = [F, F, F, F]: Boolean list
```

cs113 Lab1: slide 10

ttgen table

p	q	r	$(p \oplus q)$	$((p \oplus q) \wedge r)$	$(p \wedge r)$	$(q \wedge r)$	$((p \wedge r) \oplus (q \wedge r))$	$((p \oplus q) \wedge r) \leftrightarrow ((p \wedge r) \oplus (q \wedge r))$
F	F	F	F	F	F	F	F	T
F	F	T	F	F	F	F	F	T
F	T	F	T	F	F	F	F	T
F	T	T	T	T	F	T	T	T
T	F	F	T	F	F	F	F	T
T	F	T	T	T	T	F	T	T
T	T	F	F	F	F	F	F	T
T	T	T	F	F	T	T	F	T

SML

```
val truth_values = [(F,F,F),(F,F,T),(F,T,F),(F,T,T),(T,F,F),(T,F,T),(T,T,F),(T,T,T)];  
fun problem13(p,q,r) = equivalence(conjunction(exclusive_or(p,q),r),exclusive_or(conjunction(p,r),conjunction(q,r)));  
map problem13 truth_values;
```

```
> map problem13 truth_values;  
val it = [T, T, T, T, T, T, T, T]: Boolean list
```