If Jim is in the basement, then he is doing Zwift.

p — q

p	q	$p \to q$
T	T	T
T	F	F
F	T	T
F	F	T

] true by default (not F, so must be T)

```
if (p)
{
    if (q)
    {
        s
    }
}
```

⇒

```
if (p and q)
{
    s
}
```

$p \to (q \to s) \stackrel{?}{\equiv} (p \wedge q) \to s$

$p \to (q \to s) \equiv \sim p \vee (\sim q \vee s)$ — if/then to or

$\equiv (\sim p \vee \sim q) \vee s$ — associativity

$\equiv (\sim (p \wedge q)) \vee s$ — DeMorgan

$\equiv (p \wedge q) \to s$ — if/then to or

note semantics are really $(p \wedge q) \leftrightarrow s$

(program doesn't execute s anyway if p or q are F)

but we're just looking at the → case for simplicity)

If Jim is in the basement, then he is doing Zwift.

p — q

$p \to q$

If Jim is doing Zwift, then he's in the basement.

$q \to p$ converse not $\equiv$

p	q	$p \to q$	$q \to p$
T	T	T	T
T	F	F	T
F	T	T	F
F	F	T	T

If Jim is not in the basement, then he's not on Zwift

$\sim p \to \sim q$ inverse $\equiv$ converse

$\equiv \sim\sim p \vee \sim q \equiv p \vee \sim q \equiv \sim q \vee p \equiv q \to p$

If Jim is not doing Zwift, then he's not in the basement

$\sim q \to \sim p$ contrapos $\equiv$ original

$\equiv \sim\sim q \vee \sim p \equiv q \vee \sim p \equiv \sim p \vee q \equiv p \to q$

Jim is in the basement only if he's doing Zwift.

$p \to q$

unequivocally F if Jim in basement but not Zwifting

F when $p \wedge \sim q$

T when $\sim (p \wedge \sim q)$

$\equiv \sim p \vee \sim\sim q$

$\equiv \sim p \vee q$

$\equiv p \to q$

Jim in the basement is sufficient for him to be doing Zwift.

false when in basement, not Zwifting (same as original)

$p \to q$

Jim in the basement is necessary for him to be doing Zwift.

Jim in the basement is necessary for him to be doing Zwift. $= p \to q$

$q \to p$

false when Zwifting not in basement (same as converse)

Biconditional: p if and only if q or p is necessary and sufficient for q

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

(negation of exclusive or)

Arguments

If Mamadi scored 20 points, then the Charge won.
Mamadi scored 20 points.
∴ the Charge won

$p \to q$
p
$\therefore q$
valid

If Mamadi scored 20 points, then the Charge won.
The Charge won.
∴ Mamadi scored 20 pts

$p \to q$
q
$\therefore p$
invalid (converse error)

If Azzi didn't play, then UConn lost. $p \to q$
Azzi didn't play. p
∴ UConn lost $\therefore q$

valid form, but F conclusion b/c not sound (premise not true in this case)

premises all T + argument form valid

p	q	p→q	p	q
T	T	T	T	T
T	F	F	T	F
F	T	T	F	T
F	F	T	F	F

p→q	q	p
T	T	T
F	F	T
T	T	F
T	F	F

critical row w/ conclusion F so invalid

critical row – all premises T
valid argument if conclusion T on all critical rows
(conclusion T whenever premises T; premises T guarantees conclusion T)

p
$\therefore p \vee q$
generalization
disjunctive addition
disingenuity

specialization
$p \wedge q$
$\therefore p$
conjunctive simplification

$p \to q$
p
$\therefore q$
modus ponens

modus tollens
$p \to q$
$\sim q$
$\therefore \sim p$
$\sim q \to \sim p$

$p \vee q$
$\sim p$
$\therefore q$
elimination
disjunctive syllogism

hypothetical syllogism
transitivity
$p \to q$
$q \to r$
$\therefore p \to r$

$p \vee q$
$p \to r$
$q \to r$
$\therefore r$
cases
dilemma

$p \to c$
$\therefore \sim p$
contradiction

p
q
$\therefore p \wedge q$
conjunction
conjunctive addition

Epp §2.3 Ex. 37

ℓ = "The House is next to a lake"
k = "The treasure is in the kitchen"
e = "The tree in the front yard is an elm"
f = "The treasure is under the flagpole"

1) $\ell \to \sim k$
2) $e \to k$
3) ℓ
4) $e \vee f$

premises

k = "The treasure is in the kitchen"
e = "The tree in the front yard is an elm"
f = "The treasure is under the flagpole"
o = "The tree in the front yard is an oak"
g = "The treasure is in the garage"

2) $e \rightarrow k$
3) ℓ
4) $e \vee f$
5) $o \rightarrow g$

premises

addition

6) $\sim k$	1, 5, modus ponens
7) $\sim e$	2, 6, modus tollens
8) f	4, 7, elimination

dig up that flagpole!