CS540 - HW08

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Problem 1

1. $p \implies (q \implies r) \equiv \neg p \vee \neg q \vee r$
2. $\neg\beta : \neg((p \implies q) \implies (p \implies r))$
   2.1. $(p \implies q) \implies (p \implies r) \equiv \neg(\neg p \vee q) \vee (\neg p \vee r) \equiv (p \wedge \neg q) \vee (\neg p \vee r)$
   2.2. $\neg\beta : \neg(p \wedge \neg q) \wedge \neg(\neg p \vee r) \equiv (\neg p \vee q) \wedge p \wedge \neg q$
3. Result:
   3.1. $\neg p \vee \neg q \vee r$
   3.2. $\neg p \vee q$
   3.3. p
   3.4. $\neg q$
4. Resolution:
   4.1. Consider 3.1 and 3.2 $\implies \neg p \vee q$
   4.2. Consider 4.1 and 3.3 $\implies r$
   4.3. Consider 4.2 and 3.4 $\implies \emptyset$

Thus, we have a negation. Thus, we prove $(p \implies q) \implies (p \implies r)$.

Problem 2

1. Jump

1. Everything that can jump, jumps higher than a building
2. Variables: x - object in a real world.
   Domain: literally everything - animals, people, words, punctuation marks and etc.
3. Predicates: canJump(x) - ability to jump [boolean],
   jumpsHigher(x, constant) - whether x jumps higher than 'constant' [boolean]
4. $\forall x$ jump$(x) \implies$ jumpsHigher(x, Builidng)

2. Politicians

1. Among 100 politicians at least 1 is Honest and for any 2 out of 100 at least 1 is Liar.
2. Variables: x, y - politicians
   Domain: 100 politicians in a party
3. Predicates: Honest(x) - [boolean], Liar(x) - [boolean]
4. $\exists x$ Honest$(x) \wedge \forall x, y$ (Liar$(x) \vee$ Liar(y))

Problem 3

1.

	Madison	Seattle	Boston	Vancouver	Winnipeg	Montreal
Madison	0	1,617	931	1,654	597	800
Seattle	1,617	0	2,486	121	1,153	2,283
Boston	931	2,486	0	2,501	1,344	250
Vancouver	1,654	121	2,501	0	1,159	2,291
Winnipeg	597	1,153	1,344	1,159	0	1,132
Montreal	800	2,283	250	2,291	1,132	0

2.

For the following 2 problems:
, - separator for citites inside a cluster
; - separator for clusters
every cluster is written on a new line
complete linkage - greatest distance between classes

Iteration	closest pair of clusters	distance	all clusters
1	Vancouver; Seattle	121	Vancoever, Seattle; Madison; Boston; Winnipeg; Montreal;
2	Boston; Montreal	250	Vancoever, Seattle; Madison; Boston, Montreal; Winnipeg;
3	Madison; Winnipeg	597	Vancoever, Seattle; Boston, Montreal; Madison, Winnipeg;
4	Boston, Montreal; Madison, Winnipeg	1,344	Vancoever, Seattle; Boston, Montreal, Madison, Winnipeg;

3.

Iteration	closest pair of clusters	distance	all clusters
1	Madison; Boston	931	Madison, Boston; Seattle; Vancoever; Winnipeg; Montreal
2	Montreal; Winnipeg	1,132	Madison, Boston; Seattle; Vancoever; Winnipeg, Montreal
3	Vancoever; Montreal, Winnipeg	2,291	Madison, Boston; Seattle; Vancoever, Montreal, Winnipeg
4	Madison, Boston; Seattle	2,486	Madison, Boston, Seattle; Vancoever, Montreal, Winnipeg

Problem 4

1: $c_1 = 1$, $c_2 = 10$

	Iter 1	Iter 2
y_1	1	1
y_2	1	1
y_3	1	1
y_4	2	2
y_5	2	2
y_6	2	2
c_1	2	2
c_2	7	7
Energy	$8 + 2 = 10$	10

2: $c_1 = 1$, $c_2 = 2$

	Iter 1	Iter 2	Iter 3
y_1	1	1	1
y_2	2	1	1
y_3	2	2	2
y_4	2	2	2
y_5	2	2	2
y_6	2	2	2
c_1	0	1	1
c_2	5.4	6.25	6.25
Energy	0 + 23.2 = 23.2	2 + 8.75 = 10.75	10.75

3: Best solution

The first solution is better, since it results in less energy.