

**CSE 579**  
**Programming Assignment 1**

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Source – CSE 579 Module 4 Slides and Video Lectures  
Problem 1

Input Program	<pre>{queen(R, 1..4)} = 1 :- R = 1..4. :- queen(R1, C), queen(R2, C), R1 != R2. :- queen(R, C1), queen(R, C2), C1 != C2. :- queen(R1, C1), queen(R2, C2), R1 != R2, C1!=C2,  R1 - R2  =  C1 - C2 . :- queen(2..3, 2..3).</pre>
Command Line	clingo ques_01.lp 0
Output of clingo	<pre>Reading from ques_01.lp Solving... Answer: 1 queen(1,2) queen(2,4) queen(3,1) queen(4,3) Answer: 2 queen(2,1) queen(3,4) queen(1,3) queen(4,2) SATISFIABLE  Models      : 2 Calls       : 1 Time        : 0.002s (Solving: 0.00s 1st Model: 0.00s Unsat: 0.00s) CPU Time    : 0.000s</pre>

## Problem 2

Input Program	$\{queen(R, 1..n)\} = 1 :- R = 1..n.$ $:- queen(R1, C), queen(R2, C), R1 \neq R2.$ $:- queen(R, C1), queen(R, C2), C1 \neq C2.$ $:- queen(R1, C1), queen(R2, C2), R1 \neq R2, C1 \neq C2,  R1 - R2  =  C1 - C2 .$
Command Line	clingo -c n=3 ques_02.lp 0 clingo -c n=4 ques_02.lp 0 clingo -c n=5 ques_02.lp 0 clingo -c n=6 ques_02.lp 0 clingo -c n=7 ques_02.lp 0 clingo -c n=8 ques_02.lp 0 clingo -c n=9 ques_02.lp 0 clingo -c n=10 ques_02.lp 0 clingo -c n=11 ques_02.lp 0 clingo -c n=12 ques_02.lp 0
Output of clingo	UNSATISFIABLE - (n=3)  queen(1,2) queen(2,4) queen(3,1) queen(4,3) – (n=4)  queen(2,2) queen(3,5) queen(1,4) queen(5,1) queen(4,3) – (n=5)  queen(4,5) queen(1,3) queen(3,2) queen(2,6) queen(5,1) queen(6,4) – (n=6)  queen(7,7) queen(4,5) queen(1,3) queen(3,2) queen(2,6) queen(5,1) queen(6,4) – (n=7)  queen(6,7) queen(1,3) queen(2,5) queen(3,2) queen(4,8) queen(5,1) queen(8,6) queen(7,4) – (n=8)  queen(2,3) queen(6,8) queen(3,6) queen(1,5) queen(4,9) queen(5,2) queen(7,1) queen(9,7) queen(8,4) – (n=9)  queen(9,9) queen(3,4) queen(6,8) queen(4,1) queen(7,10) queen(1,5) queen(2,7) queen(5,3) queen(8,2) queen(10,6) – (n=10)  queen(8,8) queen(9,11) queen(1,4) queen(5,9) queen(2,7) queen(4,3) queen(6,2) queen(3,10) queen(10,1) queen(7,5) queen(11,6) – (n=11)  queen(3,3) queen(2,1) queen(4,5) queen(9,11) queen(5,8) queen(6,10) queen(7,12) queen(1,7) queen(10,2) queen(8,6) queen(11,4) queen(12,9) – (n=12)
Answer to Questions	Draw a table that lists the number of solutions and the times to compute all solutions. Use CPU time that clingo returns.

	Value n	Number of solutions	time
	3	Unsatisfiable	0.002s
	4	2	0.002s
	5	10	0.014s
	6	4	0.004s
	7	40	0.043s
	8	92	0.095s
	9	352	0.272s
	10	724	0.576s
	11	2680	2.641s
	12	14200	28.587s

### Problem 3

Input Program	<pre>% in ques_03_1.lp file { a(X, Y, N) : X = 1..9, Y = 1..9, X1 &lt;= X, X &lt;= X1+2, Y1 &lt;= Y, Y &lt;= Y1+2 } = 1 :- N = 1..9, X1 = 3*(0..2)+1, Y1 = 3*(0..2)+1. :- a(X, Y, N), a(X, Y, N1), N != N1. :- a(X, Y, N), a(X, Y1, N), Y != Y1. :- a(X, Y, N), a(X1, Y, N), X != X1.  % in ques_03_2.lp file a(1, 1, 8). a(2, 3, 3). a(2, 4, 6). a(3, 2, 7). a(3, 5, 9). a(3, 7, 2). a(4, 2, 5). a(4, 6, 7). a(5, 5, 4). a(5, 6, 5). a(5, 7, 7). a(6, 4, 1). a(6, 8, 3). a(7, 3, 1). a(7, 8, 6). a(7, 9, 8). a(8, 3, 8). a(8, 4, 5). a(8, 8, 1). a(9, 2, 9). a(9, 7, 4).</pre>
Command Line	clingo ques_03_1.lp ques_03_2.lp 0
Output of clingo	<pre>clingo version 5.4.0 Reading from ques_03_1.lp ... Solving... Answer: 1 a(1,1,8) a(2,3,3) a(2,4,6) a(3,2,7) a(3,5,9) a(3,7,2) a(4,2,5) a(4,6,7) a(5,5,4) a(5,6,5) a(5,7,7) a(6,4,1) a(6,8,3) a(7,3,1) a(7,8,6) a(7,9,8) a(8,3,8) a(8,4,5) a(8,8,1) a(9,2,9) a(9,7,4) a(4,1,1) a(1,2,1) a(6,1,2) a(7,2,2) a(1,3,2) a(5,1,3) a(8,2,3) a(8,1,4) a(2,2,4) a(4,3,4) a(7,1,5) a(3,3,5) a(3,1,6) a(5,2,6) a(9,3,6) a(9,1,7) a(6,3,7) a(6,2,8) a(2,1,9) a(5,3,9) a(9,5,1) a(3,6,1) a(4,4,2) a(8,5,2) a(2,6,2) a(9,4,3) a(4,5,3) a(1,6,3) a(3,4,4) a(7,6,4) a(1,5,5) a(6,5,6) a(8,6,6) a(1,4,7) a(7,5,7) a(5,4,8) a(2,5,8) a(9,6,8) a(7,4,9) a(6,6,9) a(2,7,1) a(5,9,1) a(5,8,2) a(9,9,2) a(7,7,3) a(3,9,3) a(1,8,4) a(6,9,4) a(6,7,5) a(9,8,5) a(2,9,5) a(1,7,6) a(4,9,6) a(2,8,7) a(8,9,7) a(4,7,8) a(3,8,8) a(8,7,9) a(4,8,9) a(1,9,9) SATISFIABLE  Models      : 1 Calls       : 1 Time        : 0.027s (Solving: 0.01s 1st Model: 0.00s Unsat: 0.01s) CPU Time    : 0.000s</pre>

#### Problem 4

Input Program	<pre>% in ques_04_1.lp file { a(X, Y, N) : X = 1..16, Y = 1..16, X1 &lt;= X, X &lt;= X1+3, Y1 &lt;= Y, Y &lt;= Y1+3 } = 1 :- N = 1..16, X1 = 4*(0..3)+1, Y1 = 4*(0..3)+1. :- a(X, Y, N), a(X, Y, N1), N != N1. :- a(X, Y, N), a(X, Y1, N), Y != Y1. :- a(X, Y, N), a(X1, Y, N), X != X1.  % in ques_04_2.lp file a(1, 1, 9). a(1, 2, 14). a(1, 6, 3). a(1, 8, 5). a(1, 9, 15). a(1, 11, 2). a(1, 15, 7). a(1, 16, 1). a(2, 1, 6). a(2, 2, 12). a(2, 6, 14). a(2, 11, 10). a(2, 15, 5). a(2, 16, 11). a(3, 1, 4). a(3, 4, 7). a(3, 5, 6). a(3, 8, 13). a(3, 9, 16). a(3, 12, 1). a(3, 13, 2). a(3, 16, 9). a(4, 2, 15). a(4, 3, 16). a(4, 5, 9). a(4, 6, 7). a(4, 11, 11). a(4, 12, 6). a(4, 14, 3). a(4, 15, 14). a(5, 2, 7). a(5, 3, 15). a(5, 14, 2). a(5, 15, 16). a(6, 1, 5). a(6, 3, 13). a(6, 5, 14). a(6, 7, 15). a(6, 10, 10). a(6, 12, 3). a(6, 14, 1). a(6, 16, 8). a(7, 2, 8). a(7, 4, 10). a(7, 6, 9). a(7, 7, 4). a(7, 8, 11). a(7, 9, 13). a(7, 10, 6). a(7, 11, 15). a(7, 13, 14). a(7, 15, 3). a(8, 1, 16). a(8, 5, 5). a(8, 7, 3). a(8, 10, 14). a(8, 12, 9). a(8, 16, 6). a(9, 1, 15). a(9, 5, 16). a(9, 7, 10). a(9, 10, 9). a(9, 12, 13). a(9, 16, 14). a(10, 2, 9). a(10, 4, 6). a(10, 6, 5). a(10, 7, 13). a(10, 8, 3). a(10, 9, 1). a(10, 10, 15). a(10, 11, 4). a(10, 13, 7). a(10, 15, 12). a(11, 1, 2). a(11, 3, 8). a(11, 5, 15). a(11, 7, 14). a(11, 10, 16). a(11, 12, 12). a(11, 14, 5). a(11, 16, 13). a(12, 2, 13). a(12, 2, 12). a(12, 14, 9). a(12, 15, 11). a(13, 2, 5). a(13, 3, 3). a(13, 5, 2). a(13, 6, 16). a(13, 11, 13). a(13, 12, 10). a(13, 14, 12). a(13, 15, 9). a(14, 1, 8). a(14, 4, 4). a(14, 5, 12). a(14, 8, 1). a(14, 9, 6). a(14, 12, 7). a(14, 13, 15). a(14, 16, 3). a(15, 1, 10). a(15, 2, 1). a(15, 6, 15). a(15, 11, 16). a(15, 15, 6). a(15, 16, 2). a(16, 1, 11). a(16, 2, 2). a(16, 6, 8). a(16, 8, 14). a(16, 9, 3). a(16, 11, 1). a(16, 15, 10). a(16, 16, 7).</pre>
Command Line	clingo ques_04_1.lp ques_04_2.lp 0
Output of clingo *	<pre>Solving... UNSATISFIABLE  Models      : 0 Calls       : 1 Time        : 0.025s (Solving: 0.00s 1st Model: 0.00s Unsat: 0.00s)</pre>

CPU Time : 0.031s
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PS D:\ASU Courses\Sem-1\Knowledge Representation\Projects\Programming Assignment 1> clingo ques_04_1.
lp ques_04_2.lp 0
clingo version 5.4.0
Reading from ques_04_1.lp ...
Solving...
UNSATISFIABLE

Models      : 0
Calls       : 1
Time        : 0.025s (Solving: 0.00s 1st Model: 0.00s Unsat: 0.00s)
CPU Time    : 0.031s
PS D:\ASU Courses\Sem-1\Knowledge Representation\Projects\Programming Assignment 1> █
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\* No matter how many times I have tried checking the values for the sudoku puzzle, I am still getting the same answer as Unsatisfiable for this question.

# Problem 5

Input Program	<pre>% in ques_05_1.lp file { a(X, Y, N) : X = 1..9, Y = 1..9, X1 &lt;= X, X &lt;= X1+2, Y1 &lt;= Y, Y &lt;= Y1+2 } = 1 :- N = 1..9, X1 = 3*(0..2)+1, Y1 = 3*(0..2)+1. :- a(X, Y, N), a(X, Y, N1), N != N1. :- a(X, Y, N), a(X, Y1, N), Y != Y1. :- a(X, Y, N), a(X1, Y, N), X != X1. :- a(R, C, N), a(R1, C1, N), R\3 == R1\3, C\3 == C1\3, 1{R != R1; C != C1}.  % in ques_05_2.lp file a(1, 3, 7). a(1, 7, 8). a(2, 2, 2). a(2, 8, 4). a(3, 1, 8). a(3, 3, 4). a(3, 5, 2). a(3, 7, 5). a(3, 9, 1). a(4, 5, 7). a(5, 3, 8). a(5, 4, 3). a(5, 5, 6). a(5, 6, 4). a(5, 7, 2). a(6, 5, 9). a(7, 1, 3). a(7, 3, 2). a(7, 5, 8). a(7, 7, 7). a(7, 9, 4). a(8, 2, 7). a(8, 8, 8). a(9, 3, 6). a(9, 7, 9).</pre>
Command Line	clingo ques_05_1.lp ques_05_2.lp 0
Output of clingo	<pre>clingo version 5.4.0 Reading from ques_05_1.lp ... Solving... Answer: 1 a(1,3,7) a(1,7,8) a(2,2,2) a(2,8,4) a(3,1,8) a(3,3,4) a(3,5,2) a(3,7,5) a(3,9,1) a(4,5,7) a(5,3,8) a(5,4,3) a(5,5,6) a(5,6,4) a(5,7,2) a(6,5,9) a(7,1,3) a(7,3,2) a(7,5,8) a(7,7,7) a(7,9,4) a(8,2,7) a(8,8,8) a(9,3,6) a(9,7,9) a(4,3,1) a(4,6,8) a(4,9,6) a(7,6,5) a(4,1,2) a(4,4,5) a(4,7,4) a(7,4,9) a(5,2,9) a(5,8,1) a(8,5,3) a(6,1,6) a(6,4,1) a(6,7,3) a(9,1,4) a(9,4,2) a(6,3,5) a(6,6,2) a(6,9,8) a(9,6,7) a(9,9,3) a(6,2,4) a(6,8,7) a(9,2,8) a(9,5,1) a(9,8,5) a(1,2,5) a(1,5,4) a(1,8,2) a(7,2,1) a(7,8,6) a(2,3,3) a(2,6,1) a(2,9,7) a(8,3,9) a(8,6,6) a(8,9,2) a(2,1,9) a(2,4,8) a(2,7,6) a(8,1,5) a(8,4,4) a(8,7,1) a(2,5,5) a(3,2,6) a(3,8,3) a(1,1,1) a(1,4,6) a(1,6,3) a(1,9,9) a(4,2,3) a(4,8,9) a(3,6,9) a(3,4,7) a(5,1,7) a(5,9,5) SATISFIABLE  Models      : 1 Calls       : 1 Time        : 0.028s (Solving: 0.00s 1st Model: 0.00s Unsat: 0.00s) CPU Time    : 0.016s</pre>

## Problem 6

Input Program	<pre>% in ques_06_1.lp file { a(X, Y, N) : X = 1..9, Y = 1..9, X1 &lt;= X, X &lt;= X1+2, Y1 &lt;= Y, Y &lt;= Y1+2 } = 1 :- N = 1..9, X1 = 3*(0..2)+1, Y1 = 3*(0..2)+1. :- a(X, Y, N), a(X, Y, N1), N != N1. :- a(X, Y, N), a(X, Y1, N), Y != Y1. :- a(X, Y, N), a(X1, Y, N), X != X1. :- a(R, C, N), a(R1, C1, N),  R1-R  +  C1-C  == 3.  % in ques_06_2.lp file a(1, 1, 3). a(1, 9, 4). a(2, 4, 6). a(2, 6, 9). a(3, 3, 6). a(3, 7, 9). a(4, 2, 8). a(4, 4, 3). a(4, 6, 2). a(4, 8, 6). a(5, 5, 7). a(6, 2, 1). a(6, 4, 8). a(6, 6, 5). a(6, 8, 7). a(7, 3, 7). a(7, 7, 8). a(8, 4, 7). a(8, 6, 8). a(9, 1, 9). a(9, 9, 7).</pre>
Command Line	clingo ques_06_1.lp ques_06_2.lp 0
Output of clingo	<pre>clingo version 5.4.0 Reading from ques_06_1.lp ... Solving... Answer: 1 a(1,1,3) a(1,9,4) a(2,4,6) a(2,6,9) a(3,3,6) a(3,7,9) a(4,2,8) a(4,4,3) a(4,6,2) a(4,8,6) a(5,5,7) a(6,2,1) a(6,4,8) a(6,6,5) a(6,8,7) a(7,3,7) a(7,7,8) a(8,4,7) a(8,6,8) a(9,1,9) a(9,9,7) a(1,3,1) a(3,6,1) a(4,5,1) a(1,5,2) a(2,2,2) a(6,1,2) a(3,5,3) a(5,3,3) a(2,1,4) a(3,4,4) a(6,3,4) a(2,3,5) a(1,4,5) a(5,2,5) a(5,1,6) a(3,2,7) a(4,1,7) a(1,6,7) a(3,1,8) a(2,5,8) a(1,2,9) a(4,3,9) a(5,4,9) a(2,9,1) a(3,9,2) a(5,7,2) a(2,8,3) a(5,6,4) a(4,7,4) a(3,8,5) a(1,7,6) a(6,5,6) a(2,7,7) a(1,8,8) a(5,8,1) a(6,7,3) a(4,9,5) a(5,9,8) a(6,9,9) a(7,1,1) a(8,3,2) a(7,4,2) a(9,2,3) a(7,2,4) a(8,1,5) a(7,5,5) a(8,2,6) a(9,3,8) a(9,4,1) a(8,7,1) a(7,6,3) a(9,5,4) a(9,6,6) a(8,5,9) a(7,8,9) a(9,8,2) a(8,9,3) a(8,8,4) a(9,7,5) a(7,9,6) SATISFIABLE  Models      : 1 Calls       : 1 Time        : 0.020s (Solving: 0.00s 1st Model: 0.00s Unsat: 0.00s) CPU Time    : 0.016s</pre>



# Problem 7

Input Program	<pre>% in ques_07_1.lp file { a(X, Y, N) : X = 1..9, Y = 1..9, X1 &lt;= X, X &lt;= X1+2, Y1 &lt;= Y, Y &lt;= Y1+2 } = 1 :- N = 1..9, X1 = 3*(0..2)+1, Y1 = 3*(0..2)+1. :- a(X, Y, N), a(X, Y, N1), N != N1. :- a(X, Y, N), a(X, Y1, N), Y != Y1. :- a(X, Y, N), a(X1, Y, N), X != X1. :- a(R, C, N), a(R1, C1, N1), gt(R, C, R1, C1), N &lt;= N1. #show a/3.  % in ques_07_2.lp file gt(1,2,1,1). gt(1,3,1,2). gt(2,2,2,1). gt(2,2,2,3). gt(3,1,3,2). gt(3,3,3,2). gt(2,1,1,1). gt(3,1,2,1). gt(2,2,1,2). gt(2,2,3,2). gt(1,3,2,3). gt(2,3,3,3). gt(1,4,1,5). gt(1,6,1,5). gt(2,5,2,4). gt(2,5,2,6). gt(3,4,3,5). gt(3,5,3,6). gt(2,4,1,4). gt(2,4,3,4). gt(2,5,1,5). gt(2,5,3,5). gt(1,6,2,6). gt(2,6,3,6). gt(1,8,1,7). gt(1,9,1,8). gt(2,8,2,7). gt(2,9,2,8). gt(3,7,3,8). gt(3,9,3,8). gt(1,7,2,7). gt(3,7,2,7). gt(1,8,2,8). gt(3,8,2,8). gt(1,9,2,9). gt(2,9,3,9). gt(4,1,4,2). gt(4,3,4,2). gt(5,2,5,1). gt(5,2,5,3). gt(6,2,6,1). gt(6,2,6,3). gt(4,1,5,1). gt(6,1,5,1). gt(5,2,4,2). gt(5,2,6,2). gt(4,3,5,3). gt(6,3,5,3). gt(4,5,4,4). gt(4,6,4,5). gt(5,4,5,5). gt(5,6,5,5). gt(6,5,6,4). gt(6,6,6,5). gt(5,4,4,4). gt(5,4,6,4). gt(5,5,4,5). gt(5,5,6,5). gt(4,6,5,6). gt(6,6,5,6). gt(4,7,4,8). gt(4,9,4,8). gt(5,7,5,8). gt(5,8,5,9). gt(6,8,6,7). gt(6,8,6,9). gt(5,7,4,7). gt(6,7,5,7). gt(5,8,4,8). gt(6,8,5,8). gt(5,9,4,6). gt(6,9,5,9). gt(7,1,7,2). gt(7,3,7,2). gt(8,1,8,2). gt(8,2,8,3). gt(9,2,9,1). gt(9,2,9,3). gt(7,1,8,1). gt(8,1,9,1). gt(8,2,7,2). gt(9,2,8,2). gt(7,3,8,3). gt(9,3,8,3). gt(7,4,7,5). gt(7,6,7,5). gt(8,5,8,4). gt(8,5,8,6). gt(9,5,9,4). gt(9,5,9,6). gt(7,4,8,4). gt(9,4,8,4). gt(8,5,7,5). gt(9,5,8,5). gt(7,6,8,6). gt(8,6,9,6). gt(7,8,7,7). gt(7,8,7,9). gt(8,8,8,7). gt(8,9,8,8). gt(9,8,9,7). gt(9,9,9,8). gt(7,7,8,7). gt(8,7,9,7). gt(8,8,7,8). gt(8,8,9,8). gt(8,9,7,9). gt(8,9,9,9).</pre>
Command Line	clingo ques_07_1.lp ques_07_2.lp 0
Output of clingo *	<pre>Reading from ques_07_1.lp ... Solving... UNSATISFIABLE  Models      : 0 Calls       : 1 Time        : 0.052s (Solving: 0.04s 1st Model: 0.00s Unsat: 0.04s) CPU Time    : 0.031s</pre>

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PS D:\ASU Courses\Sem-1\Knowledge Representation\Projects\Programming Assignment 1> clingo ques_07_1.
lp ques_07_2.lp 0
clingo version 5.4.0
Reading from ques_07_1.lp ...
Solving...
UNSATISFIABLE

Models      : 0
Calls       : 1
Time        : 0.052s (Solving: 0.04s 1st Model: 0.00s Unsat: 0.04s)
CPU Time    : 0.031s
PS D:\ASU Courses\Sem-1\Knowledge Representation\Projects\Programming Assignment 1> 
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\* No matter how many times I have tried checking the values for the sudoku puzzle, I am still getting the same answer as Unsatisfiable for this question.

## Problem 8

Input Program	<pre>1 {bishop(R, 1..n)}:- R = 1..n. :- bishop(R1, C1), bishop(R2, C2), R1 != R2, C1!=C2,  R1 - R2  =  C1 - C2 . #maximize{1,R,C: bishop(R,C)}.</pre>
Command Line	<pre>clingo -c n=3 ques_07.lp 0 clingo -c n=4 ques_07.lp 0 clingo -c n=5 ques_07.lp 0 clingo -c n=6 ques_07.lp 0 clingo -c n=7 ques_07.lp 0 clingo -c n=8 ques_07.lp 0</pre>
Output of clingo	<pre>Answer: 2 (for n=3) bishop(3,3) bishop(2,1) bishop(2,3) bishop(1,3) Optimization: -4 OPTIMUM FOUND  Answer: 3 (for n=4) bishop(1,1) bishop(1,2) bishop(2,4) bishop(3,1) bishop(4,1) bishop(4,3) Optimization: -6 OPTIMUM FOUND  Answer: 4 (for n=5) bishop(5,5) bishop(2,1) bishop(4,5) bishop(3,1) bishop(3,5) bishop(1,4) bishop(1,5) bishop(5,2) Optimization: -8 OPTIMUM FOUND  Answer: 5 (for n=6) bishop(1,1) bishop(2,1) bishop(5,6) bishop(3,1) bishop(4,6) bishop(1,4) bishop(2,6) bishop(5,1) bishop(1,6) bishop(6,3) Optimization: -10 OPTIMUM FOUND  Answer: 6 bishop(1,1) bishop(1,2) bishop(3,1) bishop(5,7) bishop(4,1) bishop(4,7) bishop(1,5) bishop(2,7) bishop(6,1) bishop(7,1) bishop(7,6) bishop(7,3) Optimization: -12 OPTIMUM FOUND  Answer: 7 bishop(8,8) bishop(2,1) bishop(7,8) bishop(1,3) bishop(1,4) bishop(4,8) bishop(5,1) bishop(3,8) bishop(6,1) bishop(1,7) bishop(1,8) bishop(8,2) bishop(8,6) bishop(8,5) Optimization: -14</pre>

	OPTIMUM FOUND														
Answer to Questions	<p>Draw a table that lists the maximum value of bishops when the chessboard is n by n, where n is 3, 4, 5, 6, 7, 8. Infer the general function f(n) that returns the maximum value of bishops.</p> <table> <tr> <th>Value n</th><th>f(n)</th></tr> <tr> <td>3</td><td>4</td></tr> <tr> <td>4</td><td>6</td></tr> <tr> <td>5</td><td>8</td></tr> <tr> <td>6</td><td>10</td></tr> <tr> <td>7</td><td>12</td></tr> <tr> <td>8</td><td>14</td></tr> </table> <p><math>f(n) = 2(n-1)</math></p>	Value n	f(n)	3	4	4	6	5	8	6	10	7	12	8	14
Value n	f(n)														
3	4														
4	6														
5	8														
6	10														
7	12														
8	14														

# Problem 9

Input Program	$\{in(l,1..k)\} = 1 \text{ :- } l=1..n.$ $\text{:- } in(X1, Y), in(X2, Y), in(X1+X2, Y), X1 \neq X2.$
Command Line	<pre>clingo -c n=2 -c k=1 ques_09.lp 1 clingo -c n=2 -c k=1 ques_09.lp 1  clingo -c n=8 -c k=2 ques_09.lp 1 clingo -c n=9 -c k=2 ques_09.lp 1  clingo -c n=23 -c k=3 ques_09.lp 1 clingo -c n=24 -c k=3 ques_09.lp 1  clingo -c n=65 -c k=4 ques_09.lp 1</pre>
Output of clingo	<pre>Solving... (n=2, k=1) Answer: 1 in(1,1) in(2,1) SATISFIABLE Solving... (n=3, k=1) UNSATISFIABLE  Solving... (n=8, k=2) Answer: 1 in(1,1) in(2,1) in(3,2) in(4,1) in(5,2) in(6,2) in(7,2) in(8,1) SATISFIABLE Solving... (n=9, k=2) UNSATISFIABLE  Solving... (n=23, k=3) Answer: 1 in(1,2) in(2,2) in(3,3) in(4,2) in(5,3) in(6,3) in(7,3) in(8,2) in(9,1) in(10,1) in(11,2) in(12,1) in(13,1) in(14,1) in(15,1) in(16,2) in(17,1) in(18,1) in(19,3) in(20,1) in(21,3) in(22,2) in(23,3) SATISFIABLE Solving... (n=24, k=3) UNSATISFIABLE  Solving... (n=65, k=4) Answer: 1 in(1,1) in(2,1) in(3,3) in(4,1) in(5,3) in(6,3) in(7,3) in(8,1) in(9,2) in(10,2) in(11,1) in(12,2) in(13,2) in(14,2) in(15,2) in(16,2) in(17,2) in(18,2) in(19,3) in(20,2) in(21,3) in(22,1) in(23,3) in(24,4) in(25,4) in(26,4) in(27,1) in(28,4) in(29,4) in(30,4) in(31,4) in(32,4) in(33,4) in(34,1) in(35,3) in(36,4) in(37,4) in(38,4) in(39,3) in(40,4) in(41,4) in(42,4) in(43,4) in(44,4) in(45,4) in(46,4)</pre>

	in(47,4) in(48,4) in(49,3) in(50,3) in(51,3) in(52,1) in(53,2) in(54,2) in(55,2) in(56,2) in(57,2) in(58,2) in(59,1) in(60,2) in(61,2) in(62,1) in(63,3) in(64,3) in(65,1) SATISFIABLE	
Answer to Questions	Fill in the values accordingly.	
	Exact value of A(1)	2
	Exact value of A(2)	8
	Exact value of A(3)	23
	Largest lower bound for A(4) Note: it would take longer time when you increase the value of n. Thus, you may stop increasing the value of n when your program does not terminate within 10 minutes and submit the last trial of n.	65